How land use determines soil nutrient content and nutritional status of Holm-oak in dehesas of C-W Spain

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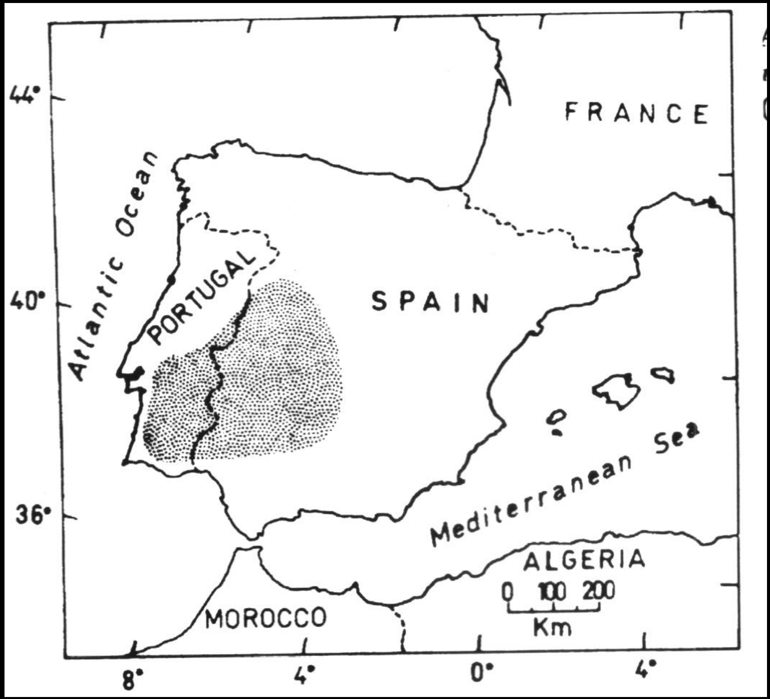
International Symposium, Bordeaux, IX/2004

Dehesas is probably the most extended agroforestry system in Europe, with more than 3 millions hectares in SW Spain and Portugal.

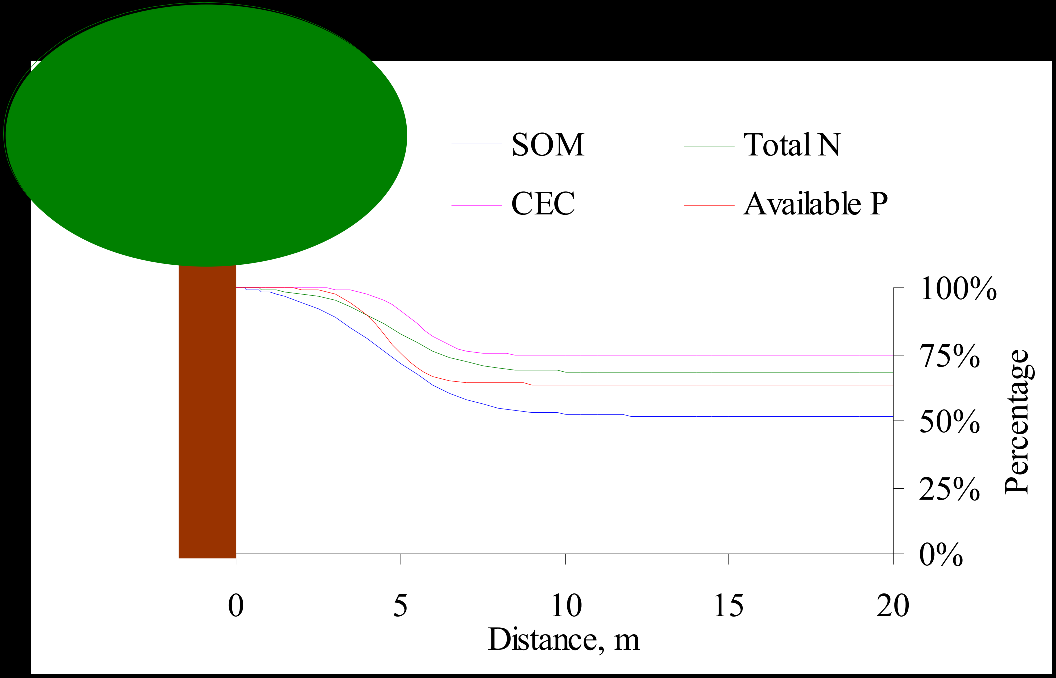


DEHESA SOIL FERTILITY

Most of the dehesas are located in soils with a very low fertility, where trees play a major role in the improvement of the soil fertility.

Escudero (1985) Rev. Ecol. Biol. Sol 22: 149-159

Gallardo *et al*. (2000) Plant and Soil 222: 71-82.



This pattern has been shown in grazed dehesas (silvopastoral system)

DEHESA LAND USE

A multipurpose agro-silvo-pastoral systems of extensive utilization, where apart of native grasses, shrubs and periodical crops are combined with widely spaced and scattered oak trees.

GRAZED DEHESAS

Different types of livestock are ususally employed in order to make best use of the varied resources.

CROPPED DEHESAS

Periodical crops aim:

• To control shrub encroachment.

• To favour the grass layer.

• To obtain a fodder complement for cattle.

ENCROACHED DEHESAS

Dehesa encroachment occurs:

- As a natural process.
- To favour tree regeneration
- To favour hunting.

DEHESA LAND USE

Different uses could determine differences in soil fertility and tree nutritional status, which could affect the productivity of the trees and dehesa profitability.

No study has focussed the consquences of the land uses for soil fertility and tree functioning and productivity of dehesas.

AIMS

- To determine how land use affects the soil fertility of dehesas.
- To determine how land use affects the nutritional status of holm-oaks.
- To cope arguments in favour of a better management, conservation and profitability of dehesas.

The content of N, P, K, Ca and Mg in soils and tree leaves in four dehesas of CW Spain, with three types of land use or vegetation structure: cropped, grazed and encroached plots.

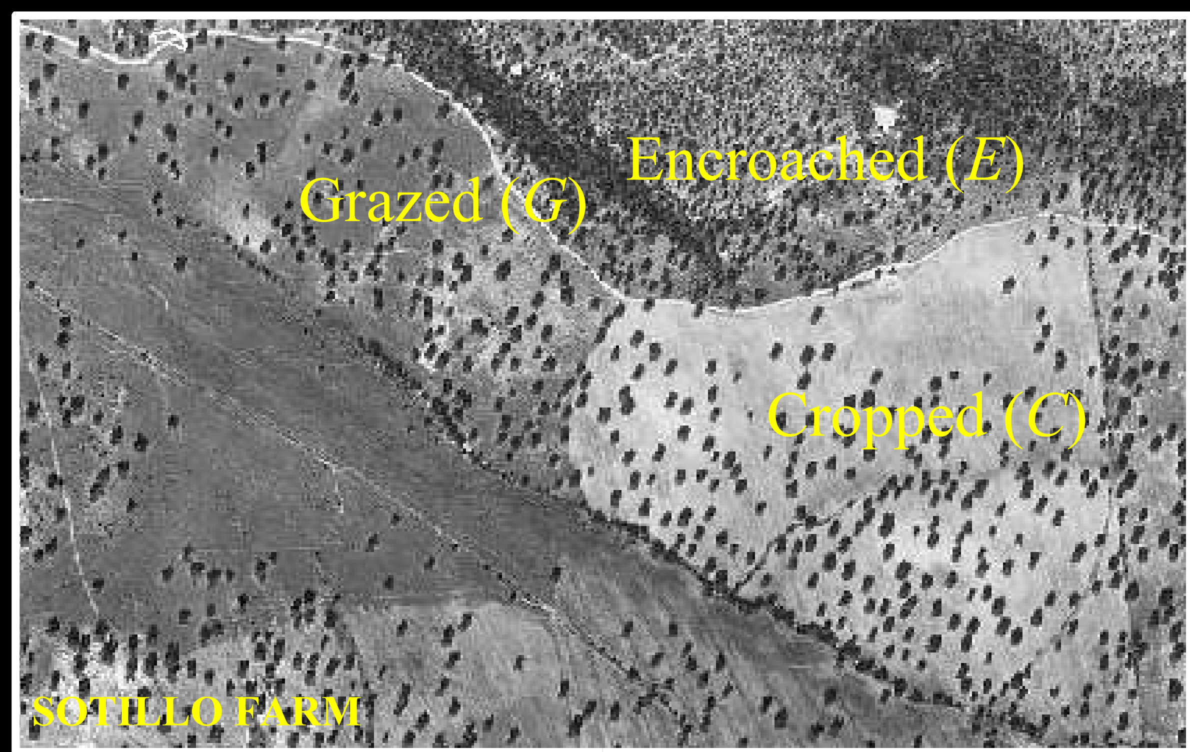
STUDY AREA

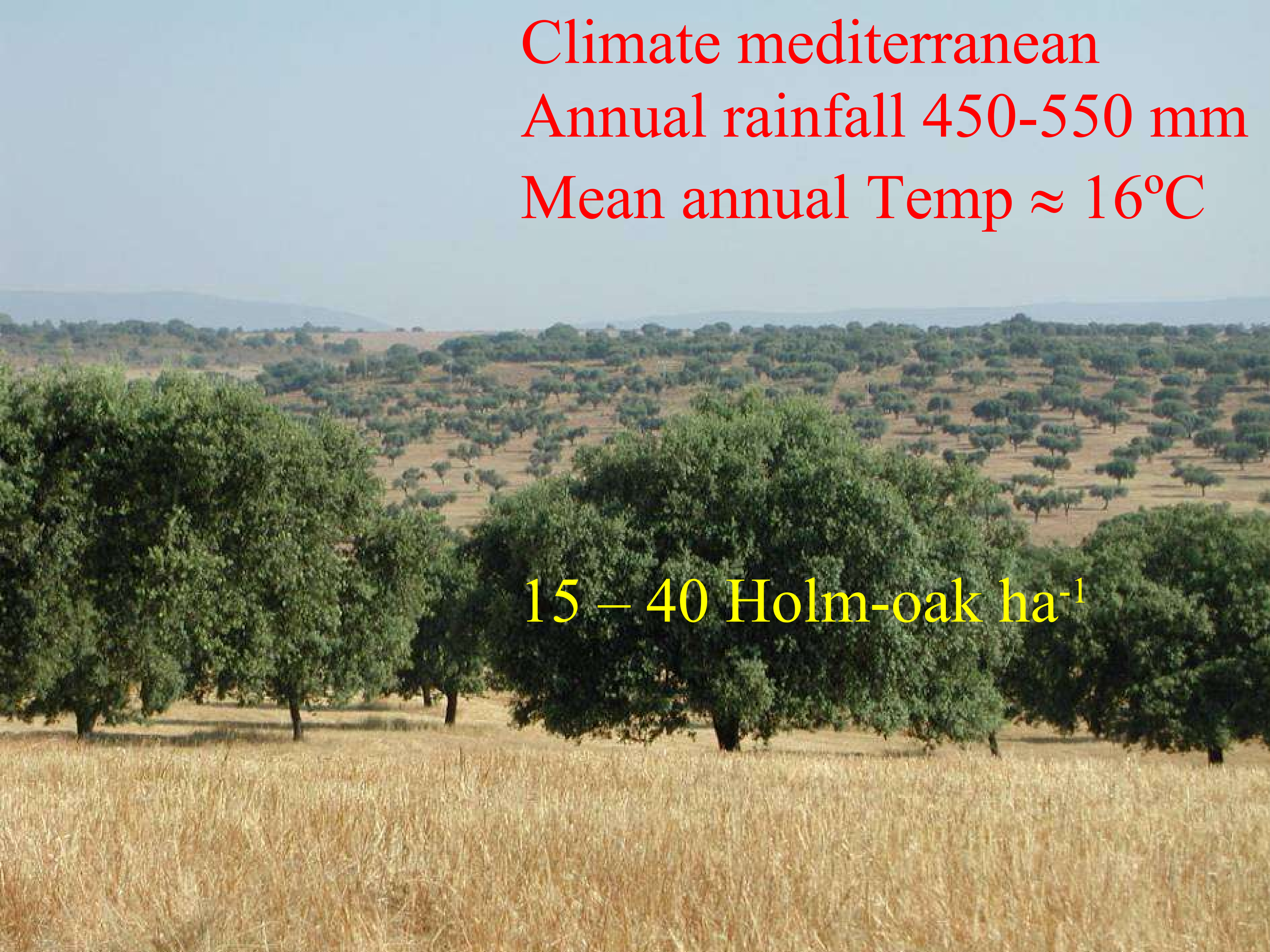
Four dehesas in
Cuatro Lugares County

4 FARMS x 3 LAND USES (*C*, *G*, *E*)
1 farm: crop fertilized *vs* no fertilized

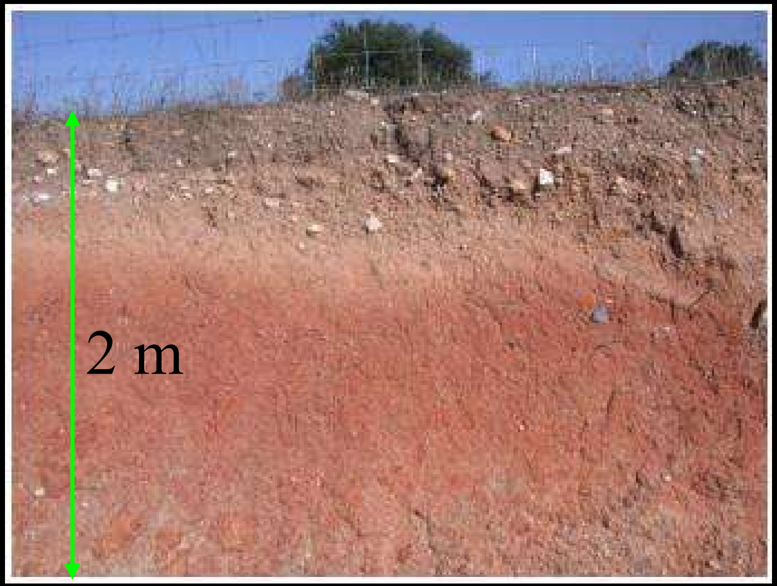
Coordenates
34°4’N, 6°13’W

Altitude: 380 m
Slope: 2%



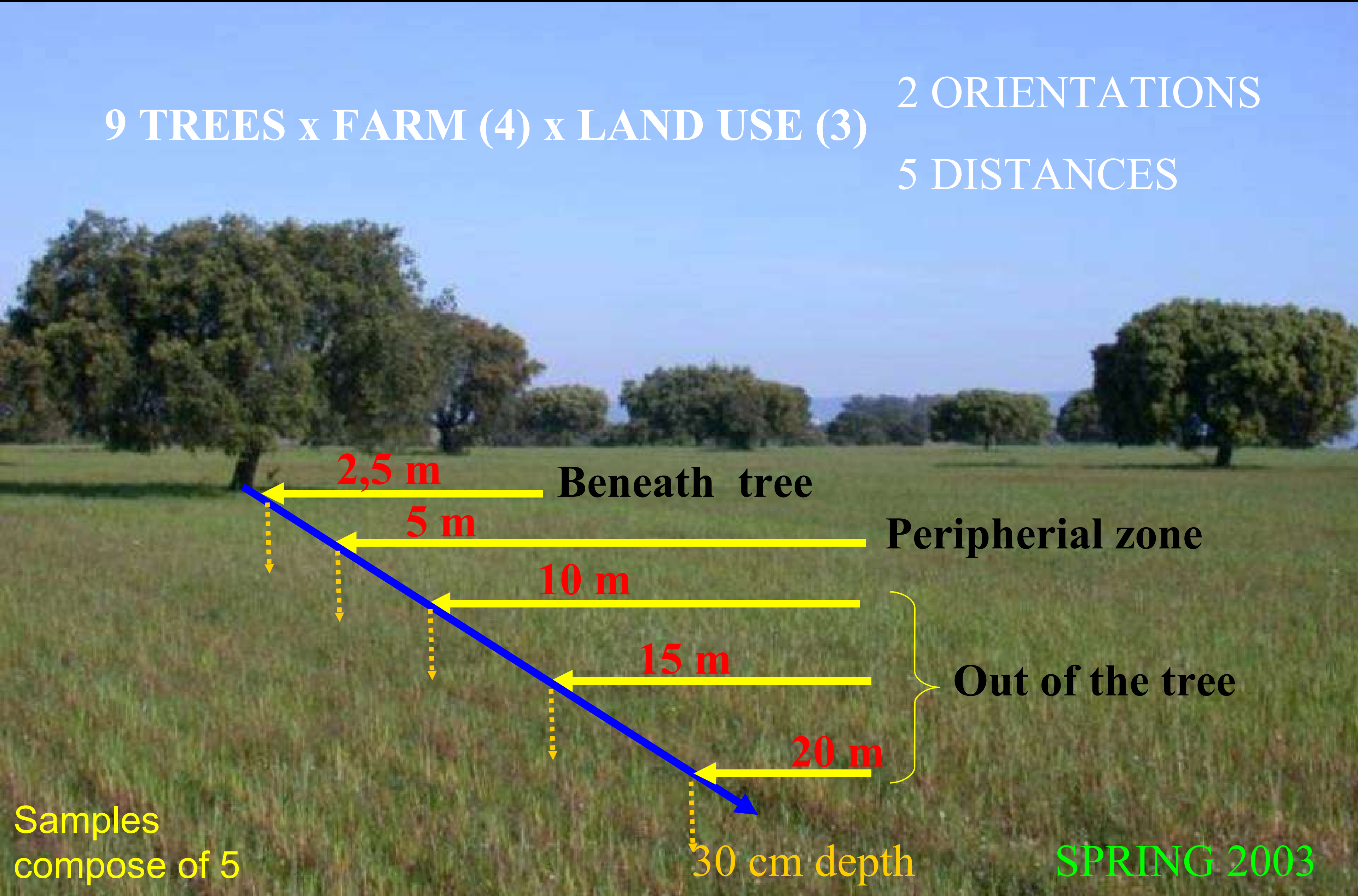

Climate mediterranean
Annual rainfall 450-550 mm
Mean annual Temp ≈ 16ºC
15 – 40 Holm-oak ha^{-1}

SOILS
Chromic Luvisols and Eutric Leptosols



Hor	Depth cm	Texture	Bd g cm^{-3}	pH water	CEC	Na^{+}	K^{+}	Ca^{++}	Mg^{++}	M.O. %	Total N g kg^{-1}	Avail P mg kg^{-1}
					meq kg^{-1}							
Eutric Leptosol												
Ap	0-9	Loam	1,45	5,2	210	13,1	1,6	28,7	10,4	2.56	1,20	10,5
Bw	9-25	Loam	1,44	5,4	182	19,0	28,7	38,0	29,0	1.59	0,72	8,8
R	> 25	Silt-Loam	1,60	5,8	195	23,0	10,4	61,9	63,8	0,42	0,30	6,2
Chromic Luvisol												
Ap	0-20	Loamy sand	1,49	5,4	130	13,2	1,5	16,5	5,1	2,20	0,93	7,8
Bt1	20-40	Clay-Loam	1,65	5,3	146	7,2	16,5	14,1	11,1	1,13	0,68	5,5
Bt2	40-70	Silty-Clay	1,43	4,9	158	7,5	5,1	11,0	16,5	0,98	0,31	5,2
Bt3	70-100	Sandy-Loam	1,46	5,0	170	7,8	2,20	12,8	18,8	0,75	0,15	4,2
BC	>100	Clay-Loam	1,53	4,9	153	8,3	0,93	11,7	16,5	0,10	0,09	4,2

Soil sampling protocol



PARAMETERS ANALYSED

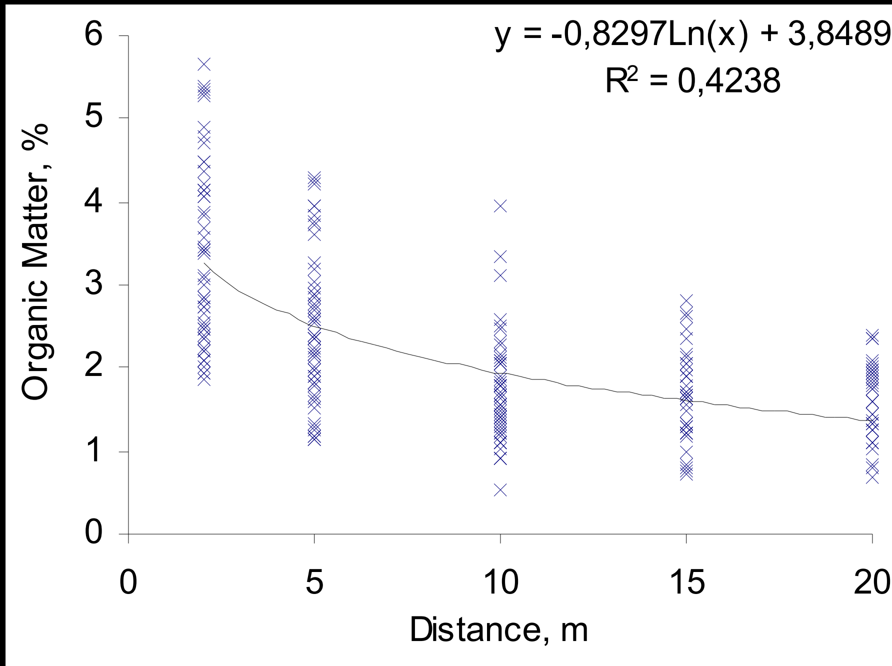
SOIL FERTLITY:

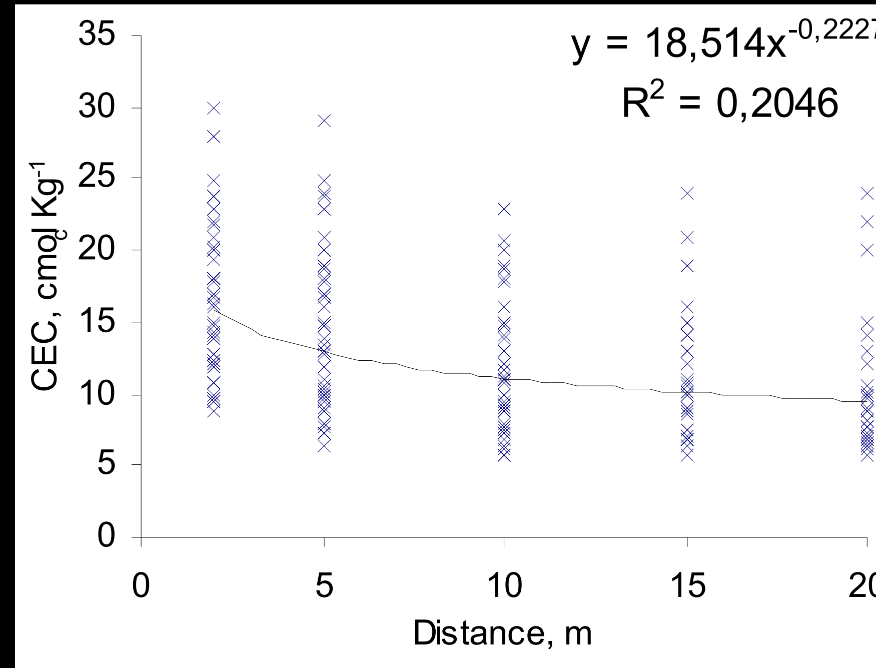
- SOM (Walkley and Black),
- Total N (semi-micro Kjeldahl),
- Mineral N (2.0 N KCl extraction):
  - NH_4^+ (FIAS)
  - NO_3^- (FIAS with Cd column reduction)
- Available P (Olsen)
- CEC (1.0 M Ammonium acetate, pH 7.0)
- Exchangeable base cations (1.0 M Ammonium acetate extr. & spectrometry)

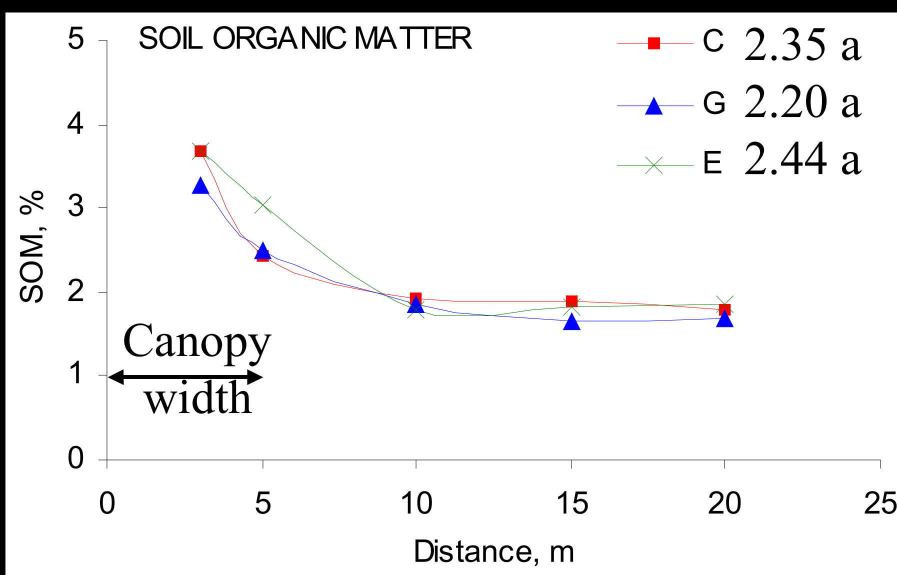
TREE NUTRITIONAL STATUS: Current year leaves at maturity (August).

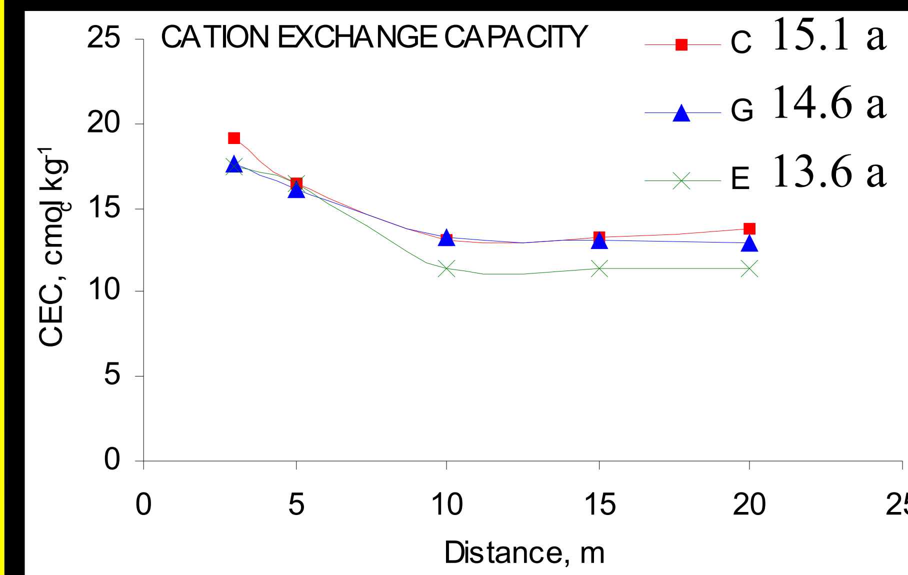
- 9 trees per farm and land use
- N (Semi-micro Kjeldahl)
- P (Wet digestion $HNO_3/HClO_4$ & vanadomolybdophosphoric yellow)
- Ca, Mg and, K (Wet digestion $HNO_3/HClO_4$ & and spectrometry)


RESULTS

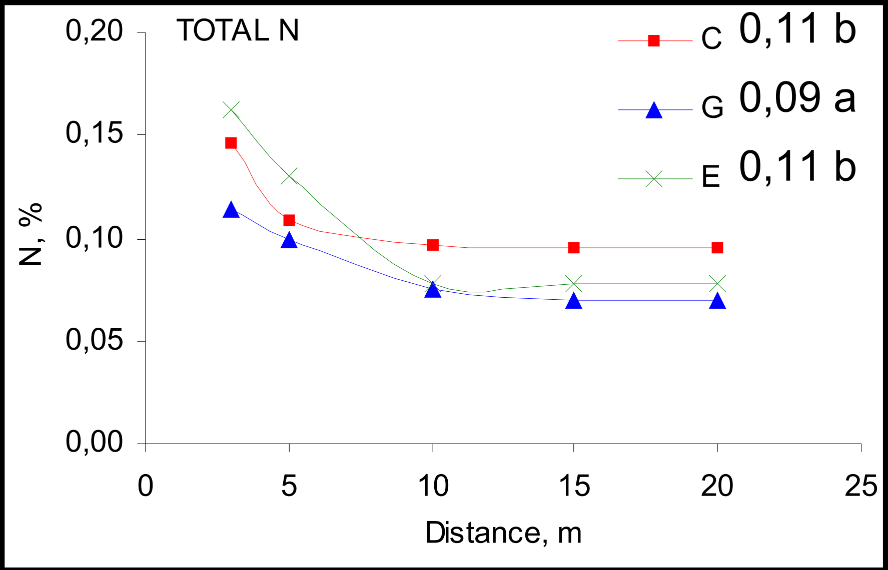

y = -0,8297Ln(x) + 3,8489
R2 = 0,4238
Organic Matter, %
Distance, m
0
1
2
3
4
5
6
0
5
10
15
20

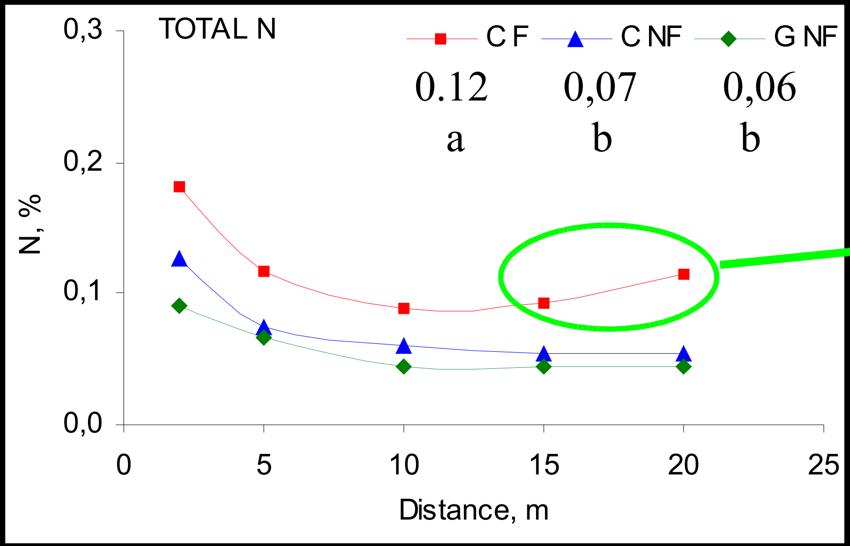

y = 18,514x-0,2227
R2 = 0,2046
CEC, cmolc Kg-1
Distance, m
0
5
10
15
20
25
30
35
0
5
10
15
20

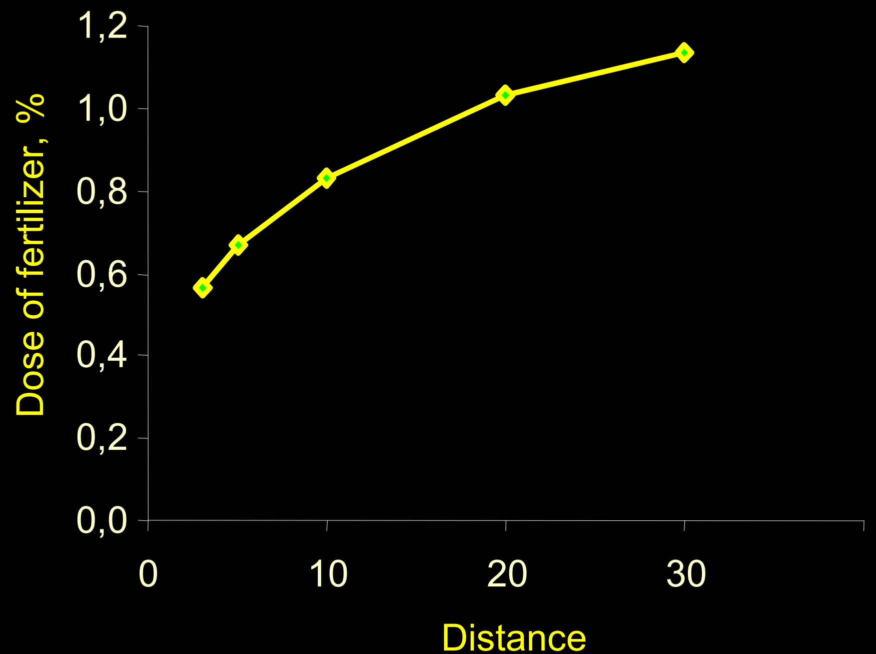

SOIL ORGANIC MATTER
C 2.35 a
G 2.20 a
E 2.44 a
SOM, %
Canopy width
Distance, m
0
1
2
3
4
5
0
5
10
15
20
25


CATION EXCHANGE CAPACITY
C 15.1 a
G 14.6 a
E 13.6 a
CEC, cmolc kg-1
Distance, m
0
5
10
15
20
25
0
5
10
15
20
25

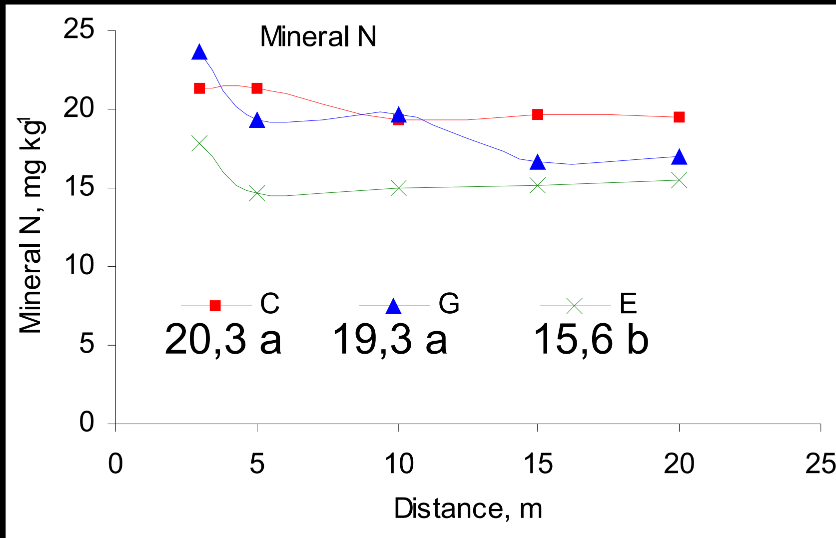
Soil Total NITROGEN

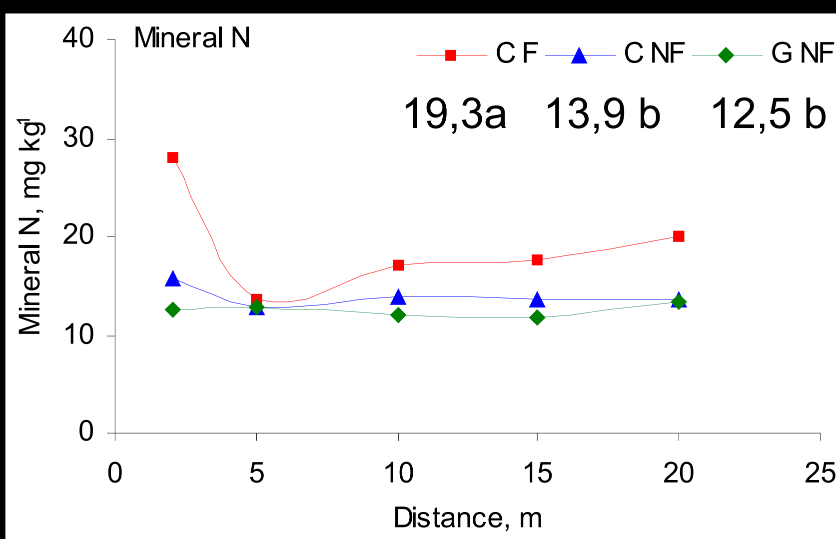






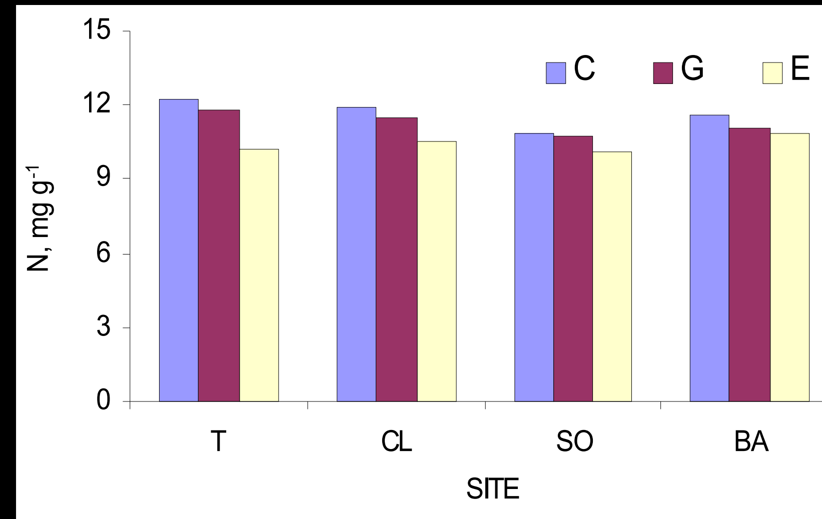
Soil Mineral NITROGEN

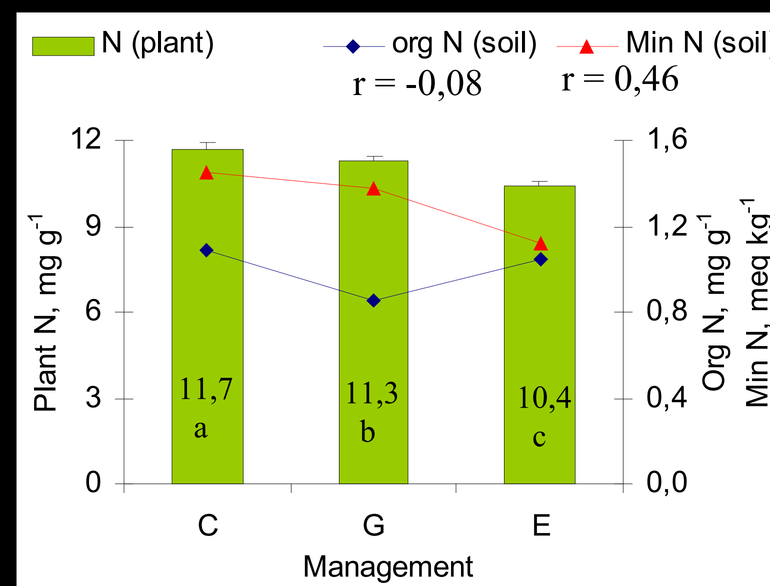




Ratio Mineral N / Total N =
1,9% (*C*), 2,3% (*G*) and 1,5% (*E*)

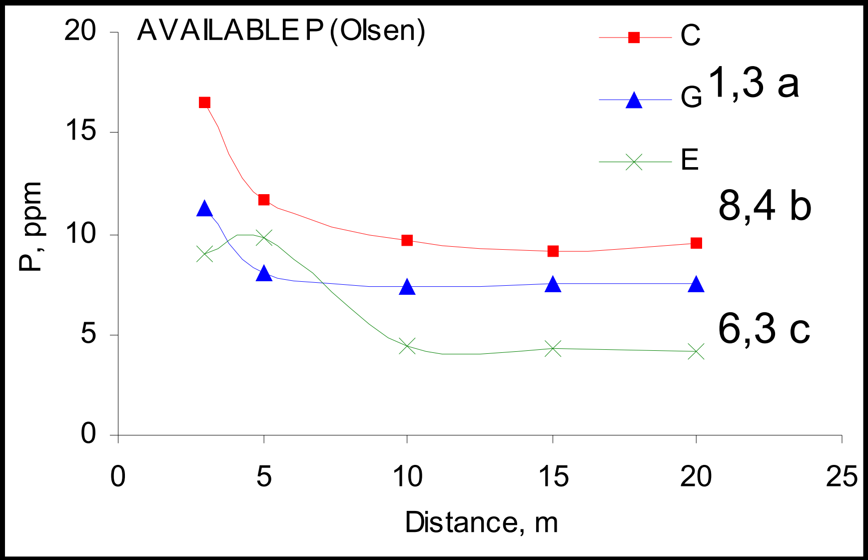
Tree Leaves NITROGEN

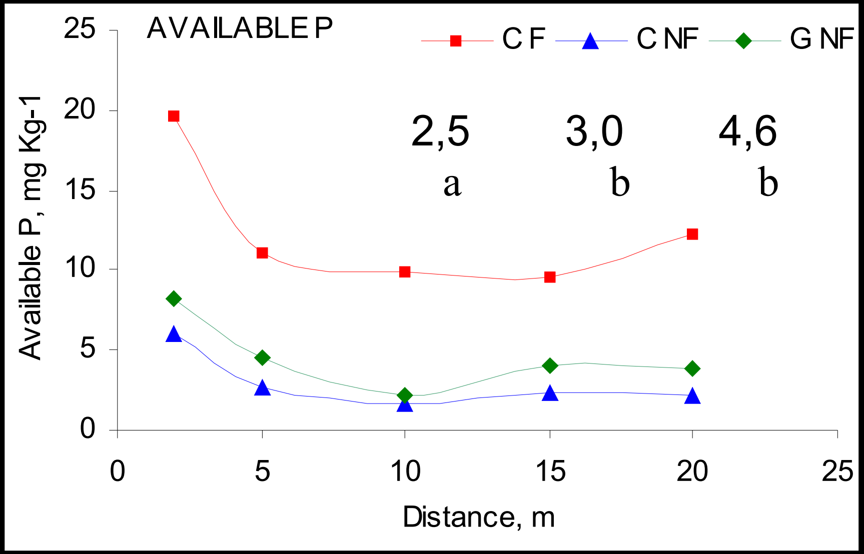


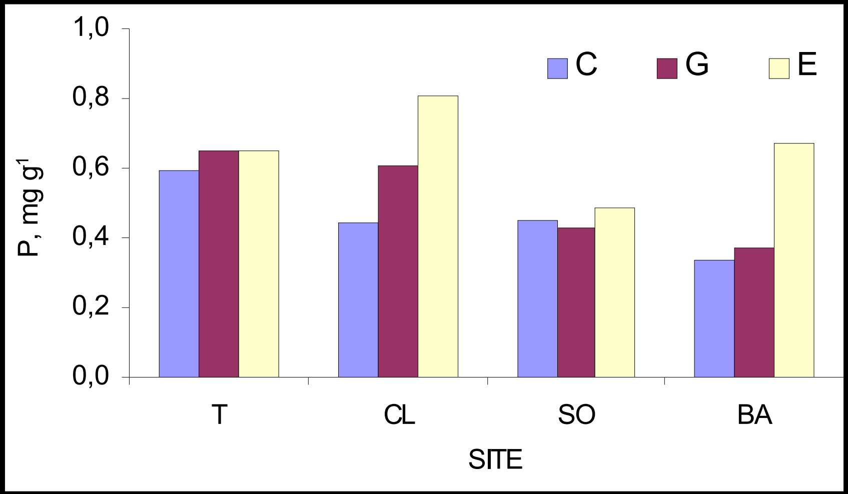


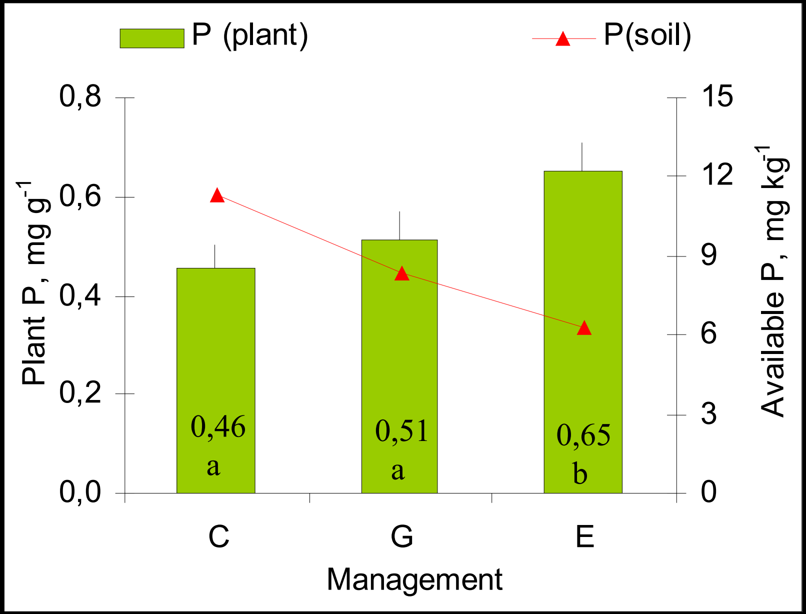
European range: 9,9 – 21,6 mg N g^{-1}

PHOSPHORUS





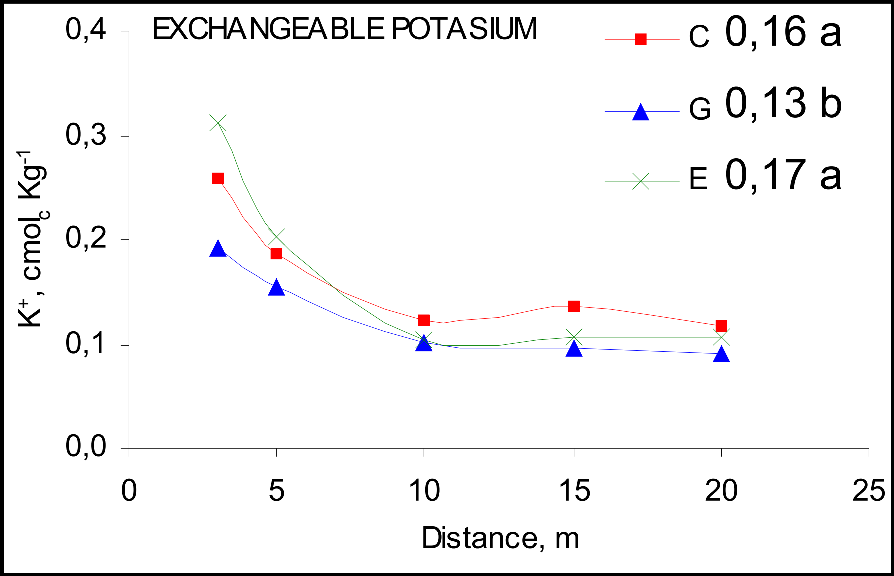


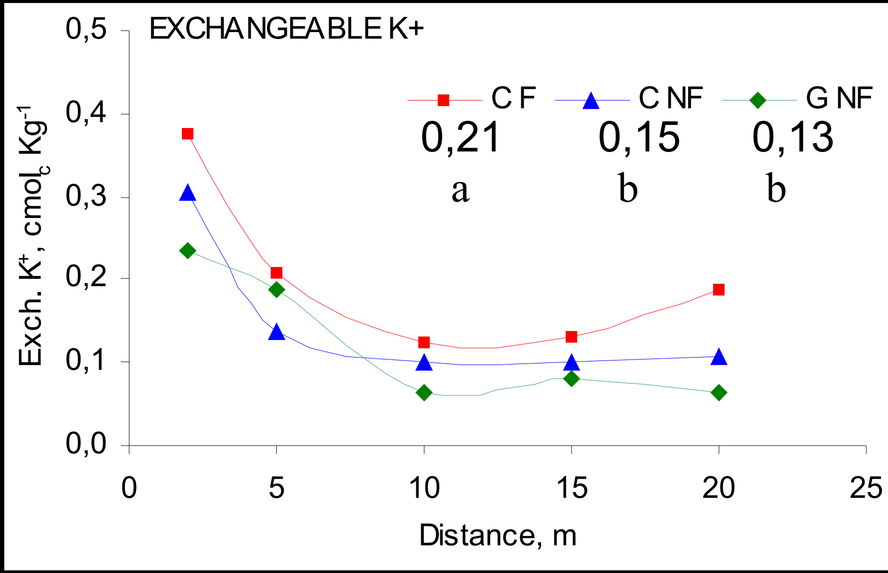


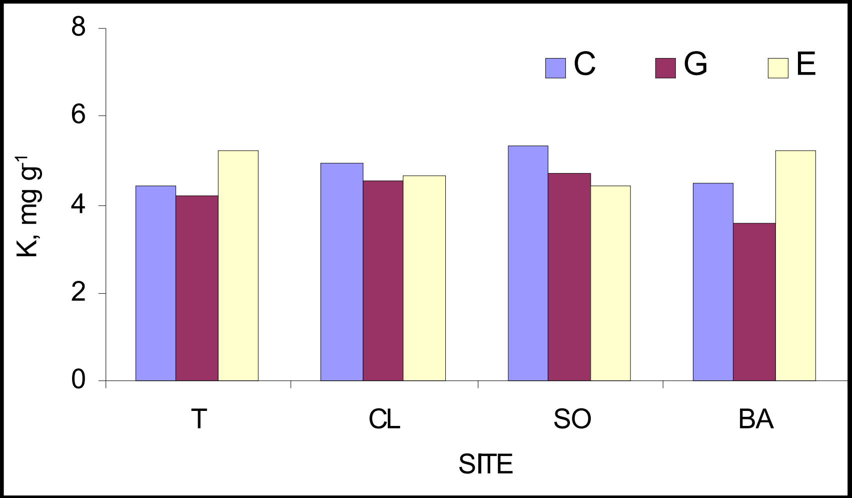
European range: 0,56 – 1,98 mg P g^{-1}

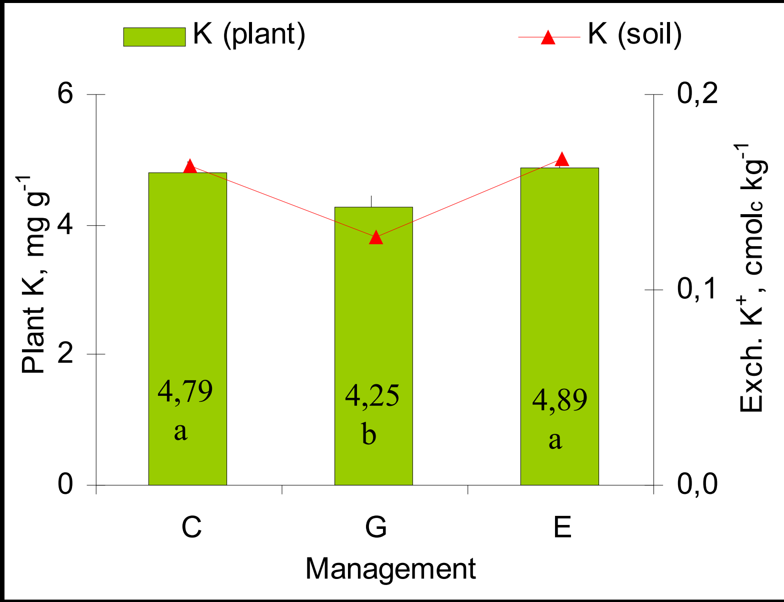
Plant and Soil P correlation: r = 0,16 (n.s.)

POTASSIUM





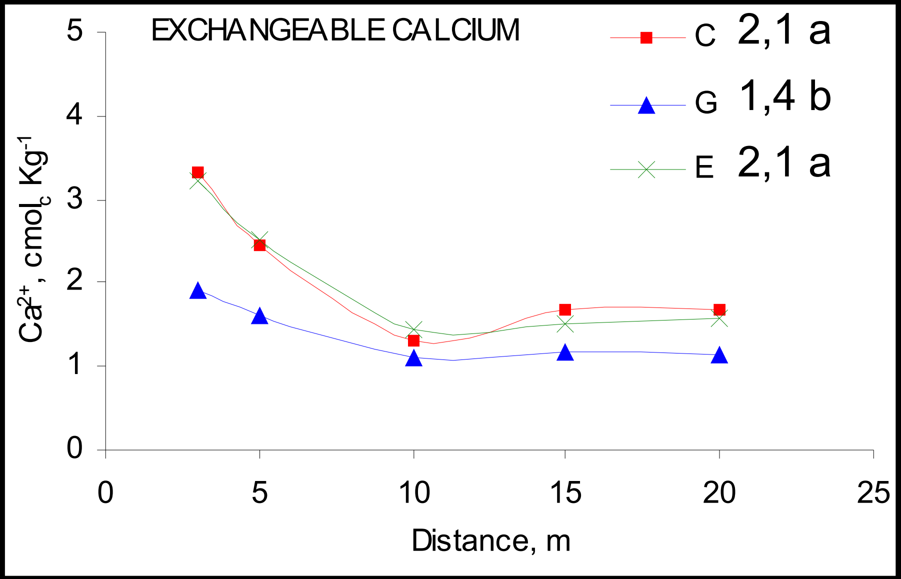


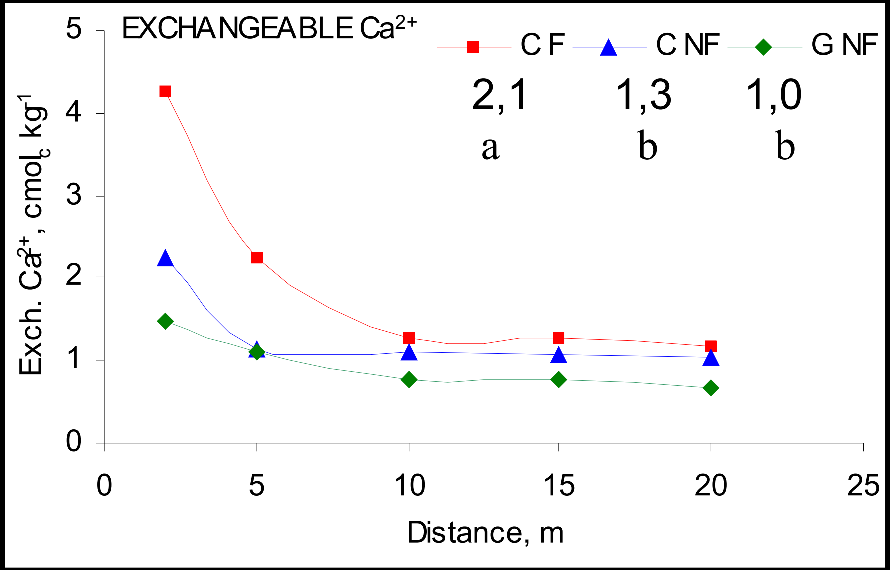


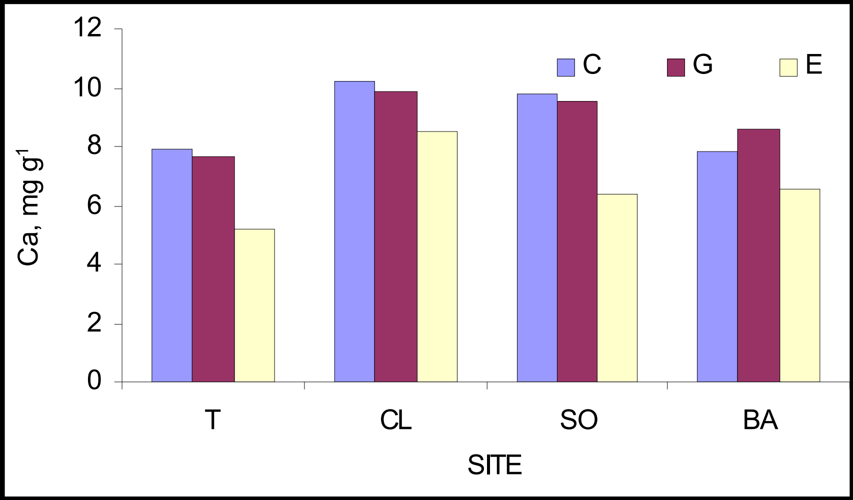
European range: 3,6 – 11,9 mg K g^{-1}

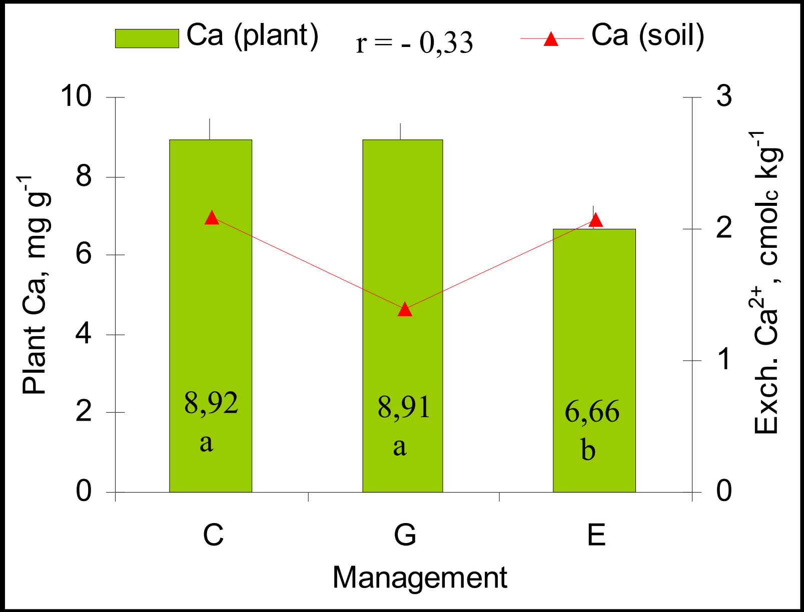
Plant and Soil K correl.: $r = 0,46$ ($p<0,05$)

CALCIUM





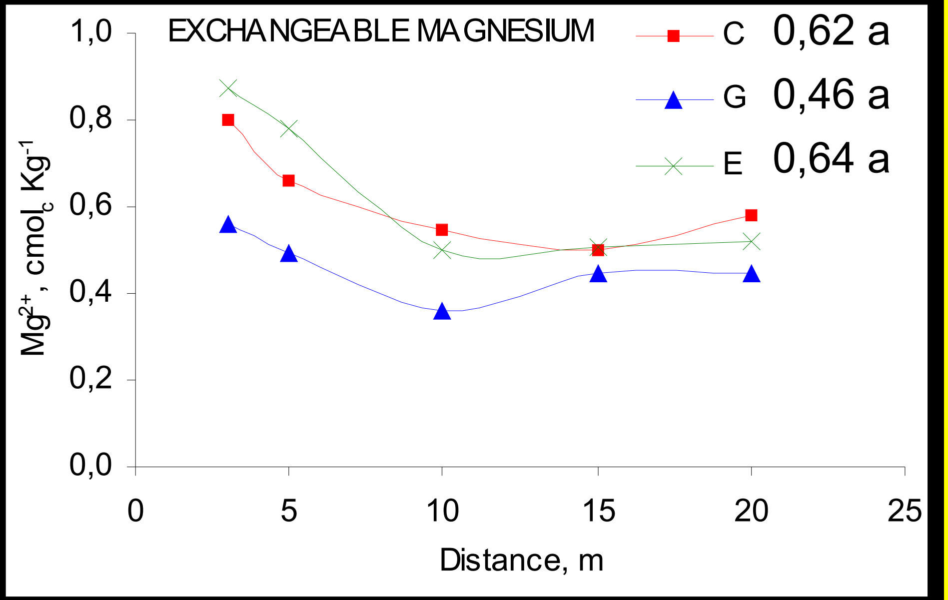


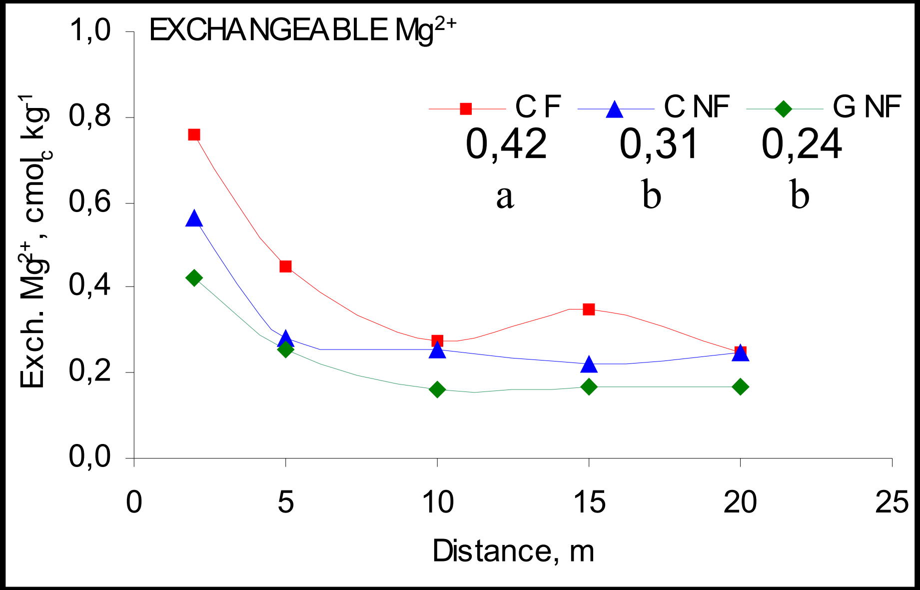


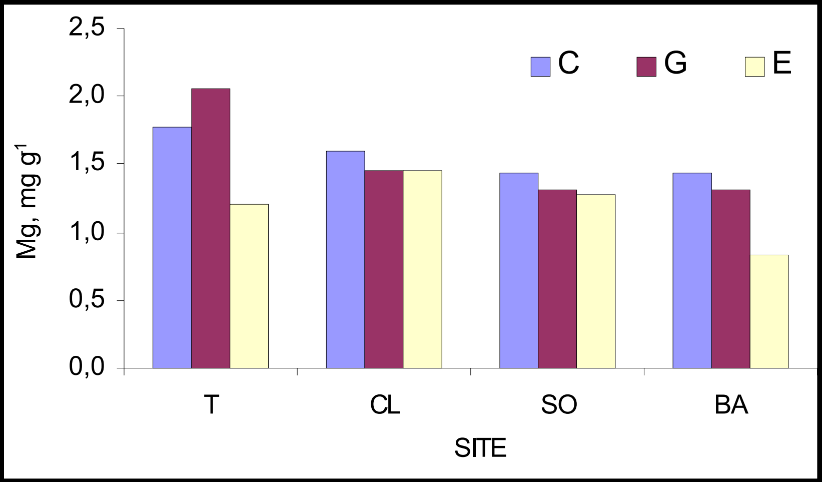
European range: 1,9 – 11,4 mg P g^{-1}

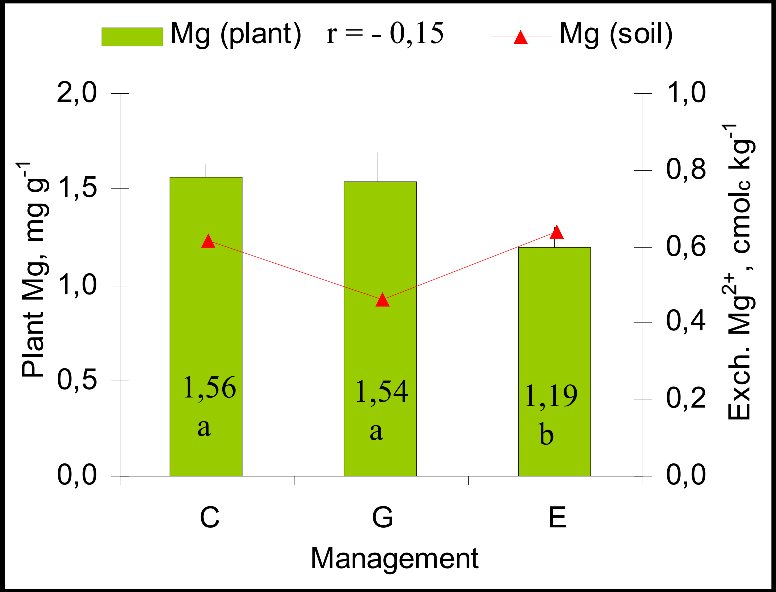
Plant and Soil P correl.: r = - 0,33 (n.s.)

MAGNESIUM





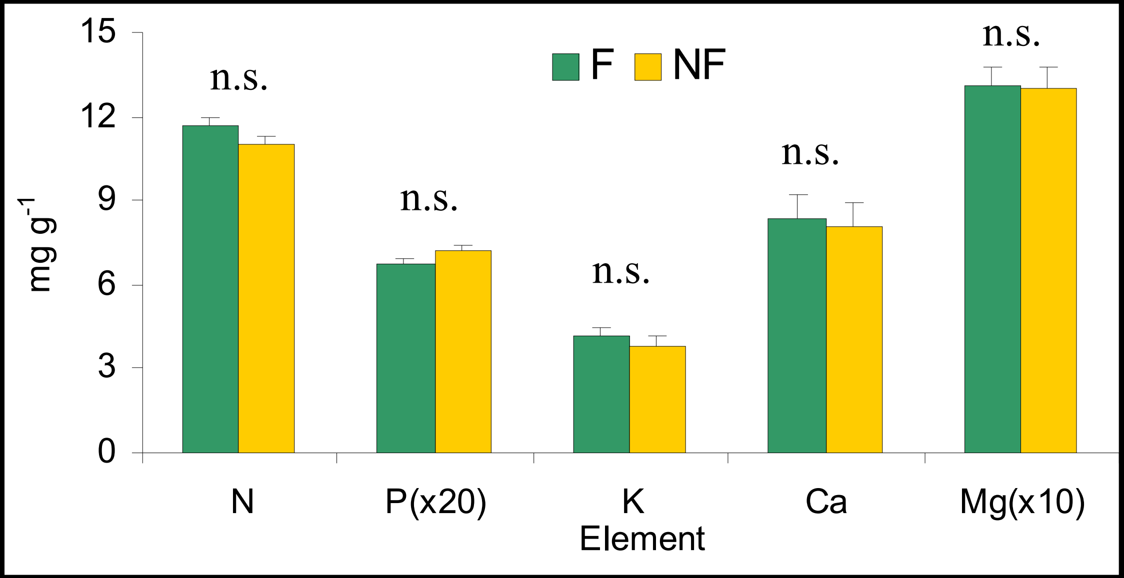




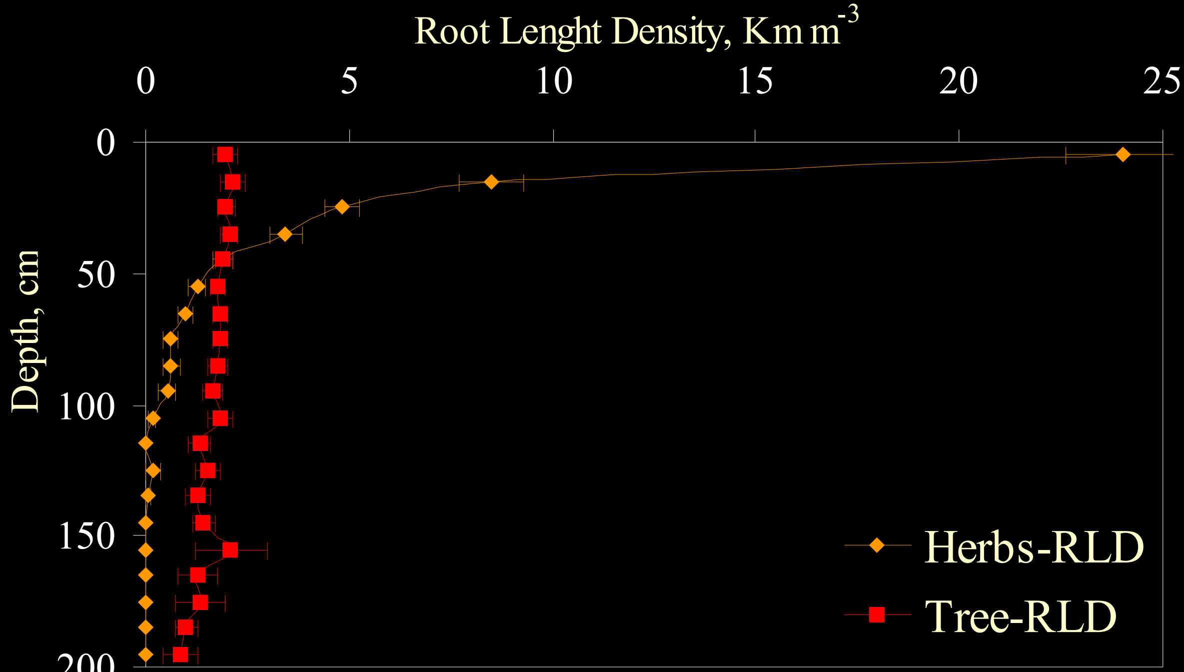
European range: 0,77 – 3,7 mg P g^{-1}

Plant and Soil P correl.: r = - 0,15 (n.s.)

No effect of fertilization on the nutritional status of the holm-oaks.



Variation of Root Length Densities with soil depth of holm-oak and herbaceous plants in dehesas.



Moreno *et al*. 2003

CONCLUSIONS

1. Holm-oak trees contribute significantly to increase the soil fertility of the dehesa (SOM, Total and Mineral -N, P-Olsen, CEC, Exchangeable Ca^{2+}, Mg^{2+} and K^{+}), with a sharp decrease of their effects with the distance, irrespective of the land use.

2. Land uses determined slight differences on soil fertility:

   2.1 Cropping dehesa increased significantly the content of organic and mineral N, available P, and exchangeable K^{+}, and Ca^{2+} (mostly due to the fertilization and in a less extension to an accelerated mineralisation).

   2.2 Dehesa encroachment increased significantly the content of org-N and exchangeable K^{+} and Ca^{2+} (by an increament of organic matter). By contrast, contents of min-N and avail-P decreased significantly (probably indicating competence between trees and shrubs).

CONCLUSIONS

3. Soil nutrient contents were mostly no correlated with foliar contents, indicating a certain independence of the trees from the nutrients located in the first soil horizon, and possibly a low competence for nutrients with herbaceous plants.

5. Encroachment affected negatively the N, Ca and Mg contents of tree leaves, but affected positively K and P contents. The case of P is very important owing to P is the most limitant nutrient in most of the dehesas.