International Seminar:
'Strengthening Agroforestry Programs in Higher Education for Food Security In Sub-Saharan Africa – SAPHE'

Analysis of adaptive genetic variation
EXAMPLES

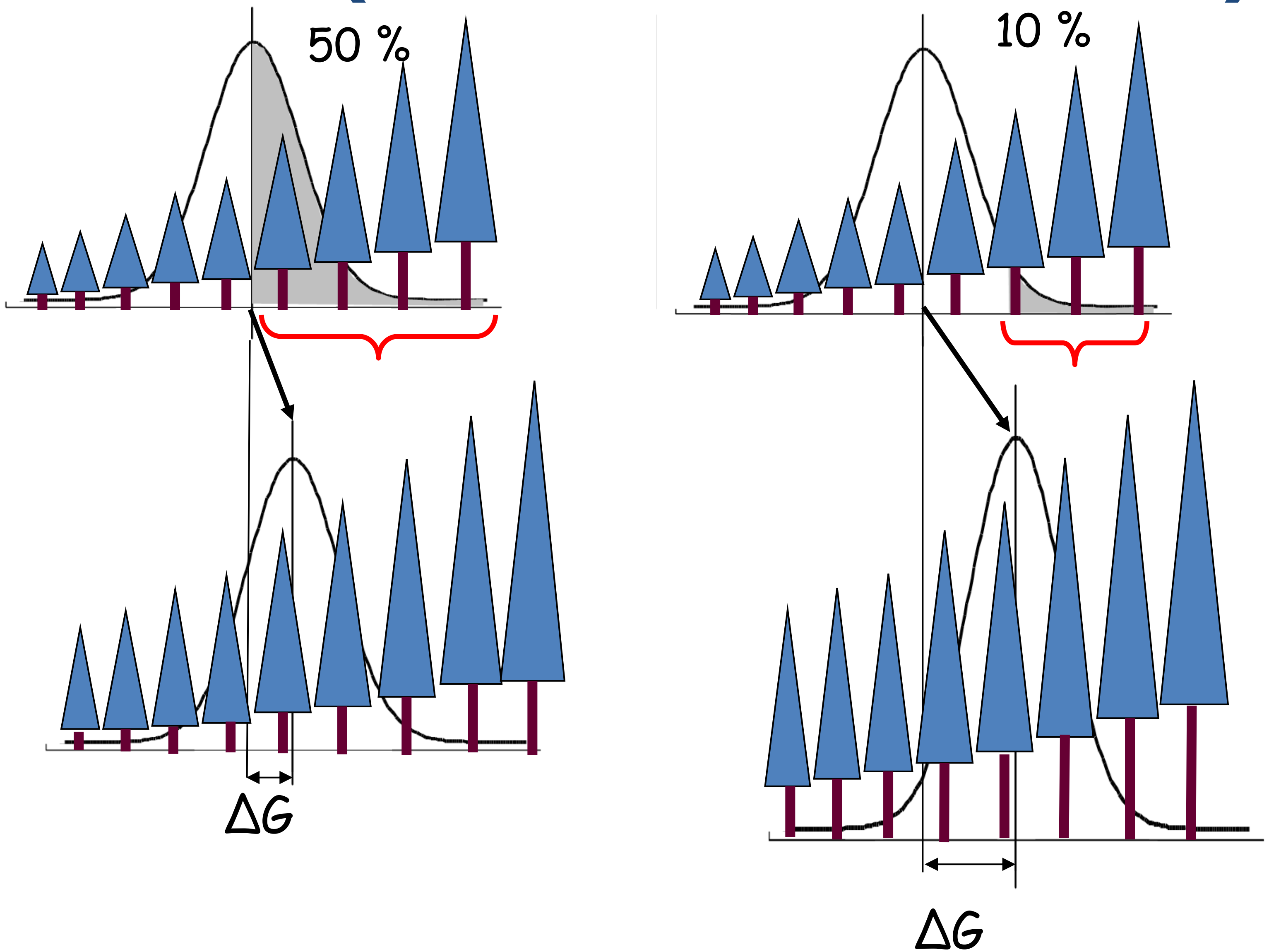
Eduardo Notivol

Unidad de Recursos Forestales

Centro de Investigación y Tecnología Agroalimentaria de Aragón

enotivol@cita-aragon.es

Selection (Natural or artificial)



2 mechanisms

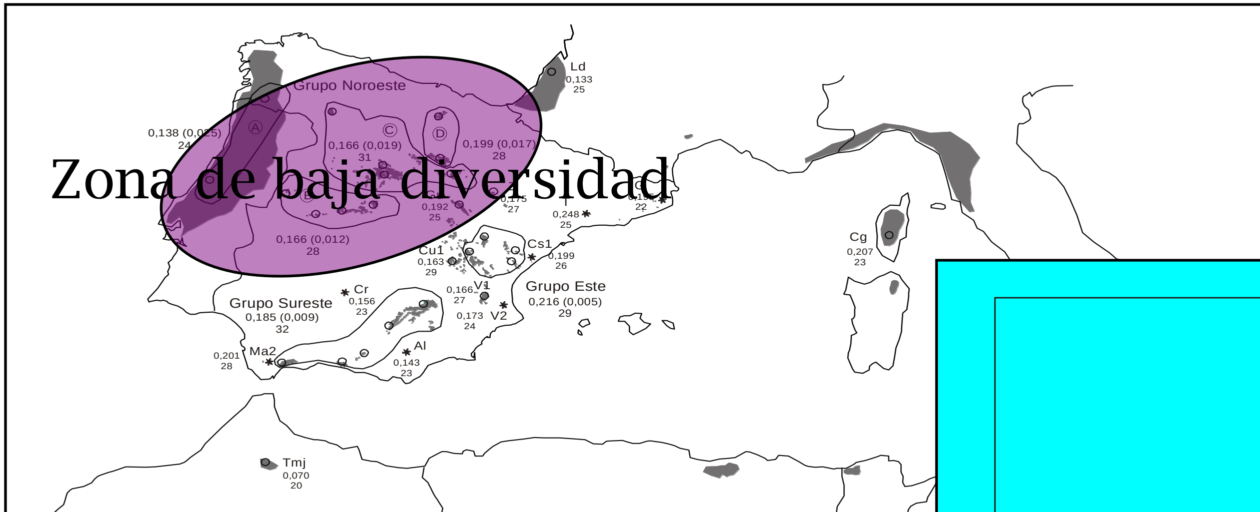
δS

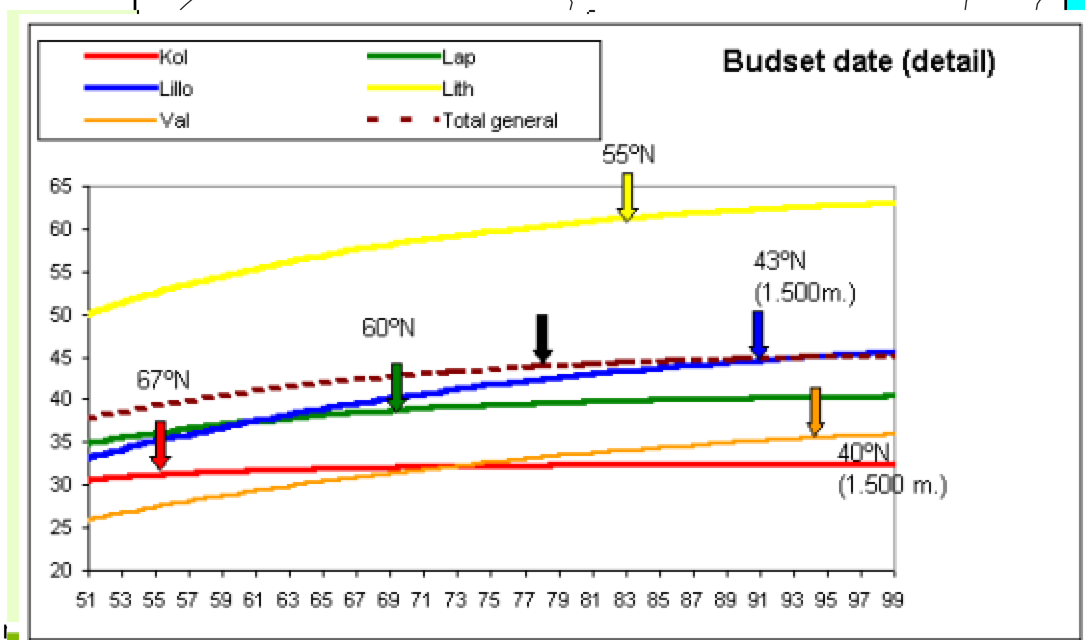
Phenotypic Plasticity

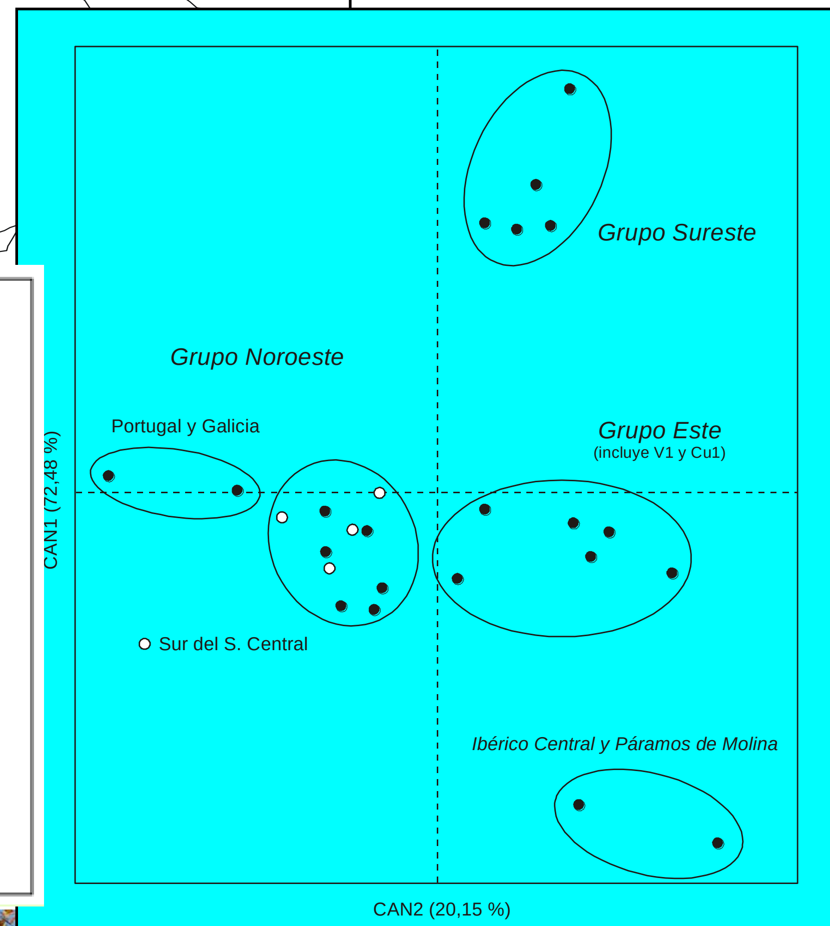
Additive genetic variance

$$R = h^2 \delta S = \frac{\sigma^2_{aditive}}{\sigma^2_{phenotypic}} \delta S$$

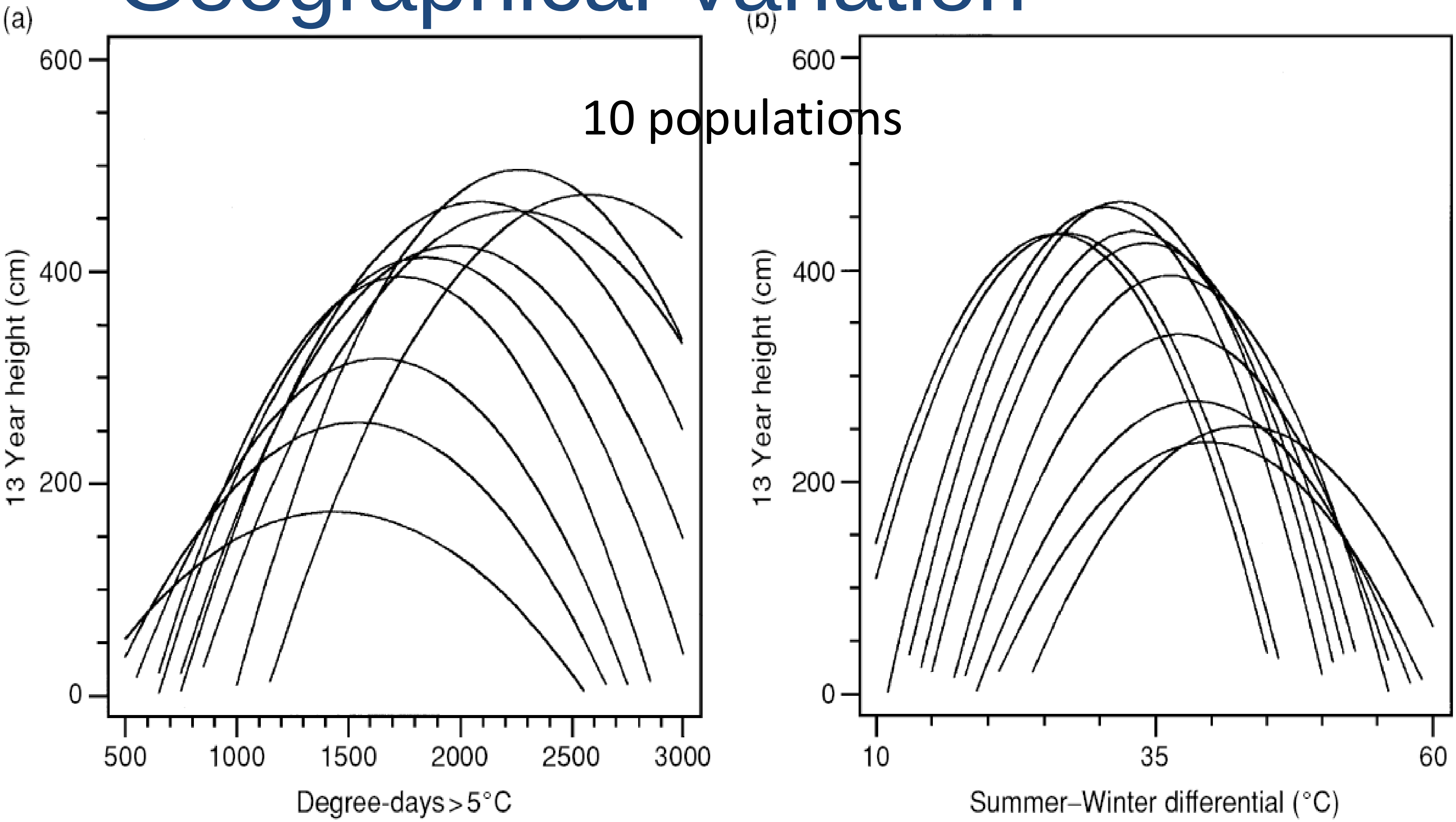
Variation Structure: Geographical







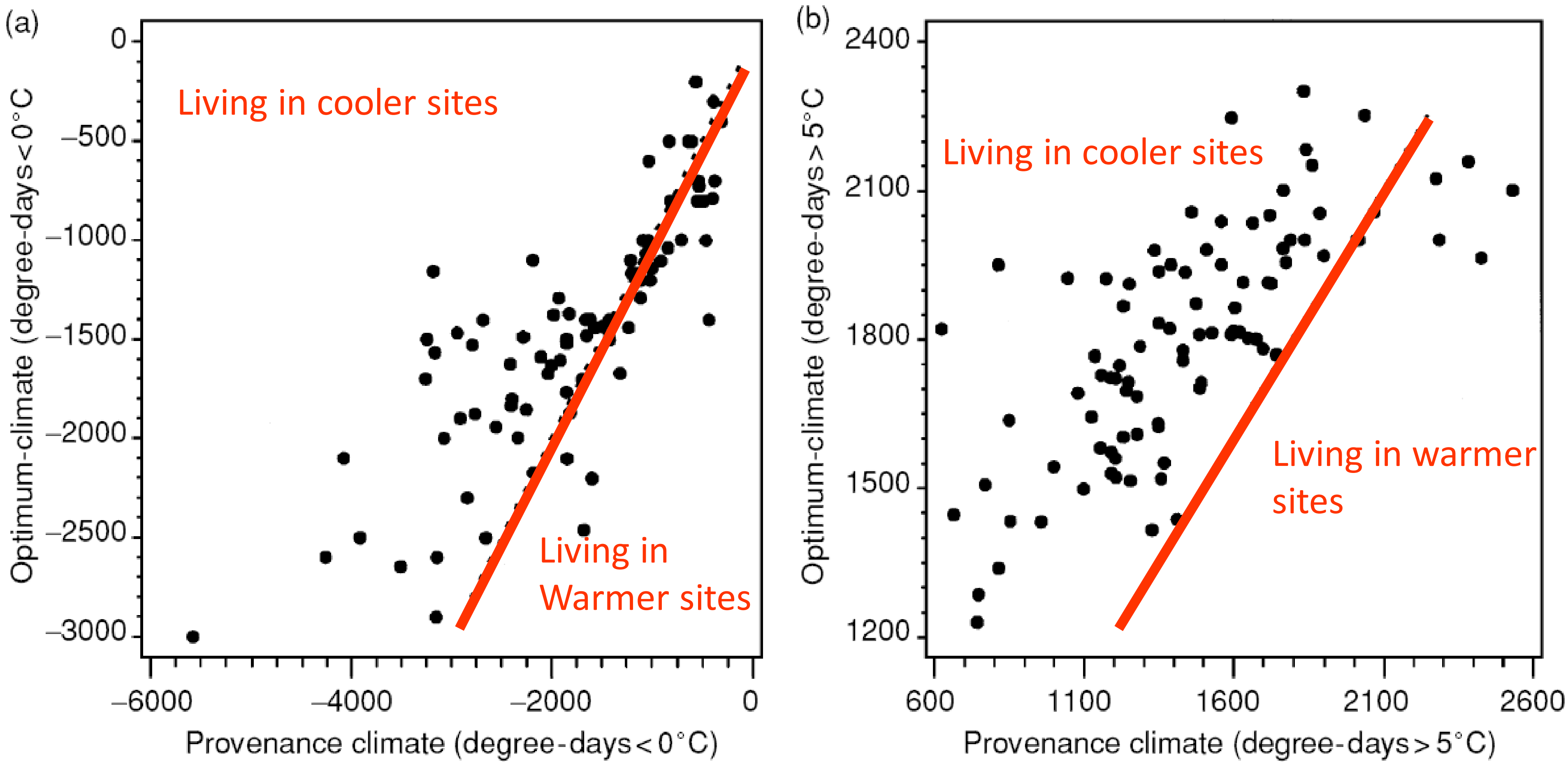
Geographical Variation



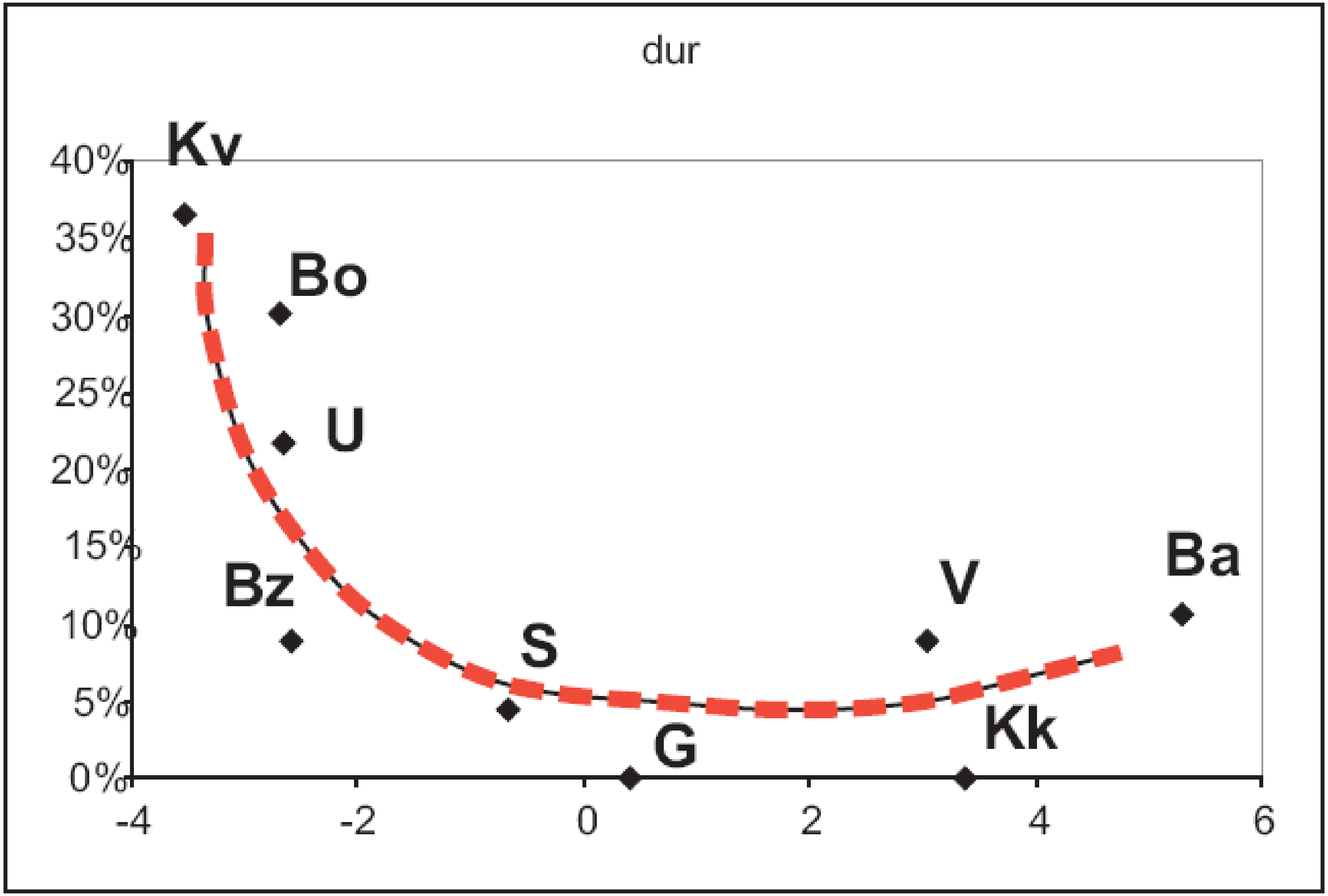
Rehfeldt, G.E., N.M. Tchebakova, Y.I. Parfenova, W.R. Wykoff, N.A. Kouzmina, and L.I. Milyutin. 2002. Intraspecific responses to climate in *Pinus sylvestris*. *Global Change Biology* 8: 1-18.

Climatic suboptimum!

110 populations   47 sities



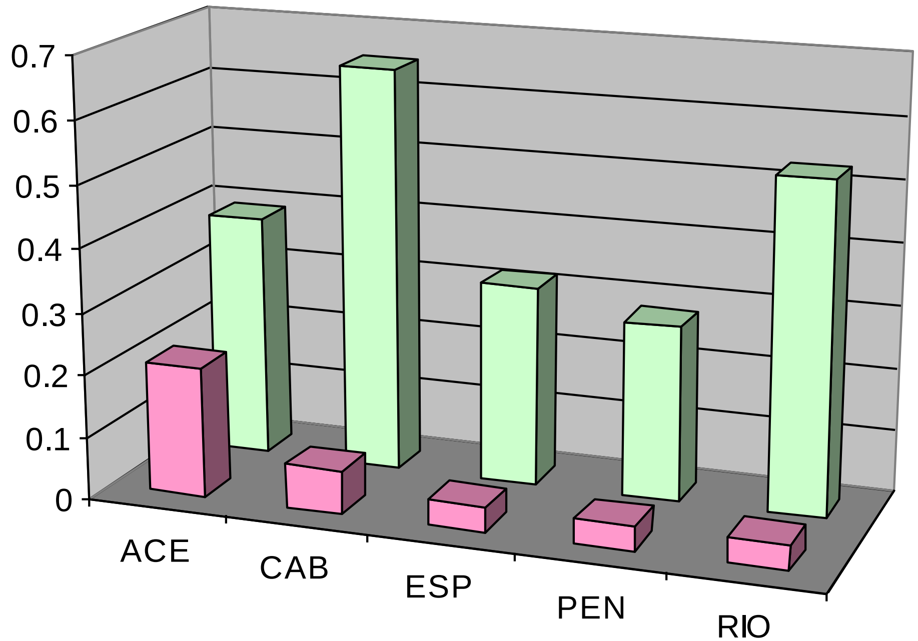
Rehfeldt, G.E., N.M. Tchebakova, Y.I. Parfenova, W.R. Wykoff, N.A. Kouzmina, and L.I. Milyutin. 2002. Intraspecific responses to climate in *Pinus sylvestris*. *Global Change Biology* 8: 1-18.


dur
Kv
Bo
U
Bz
S
G
V
Kk
Ba
40%
35%
30%
25%
20%
15%
10%
5%
0%
-4
-2
0
2
4
6

Phenotypic Plasticity

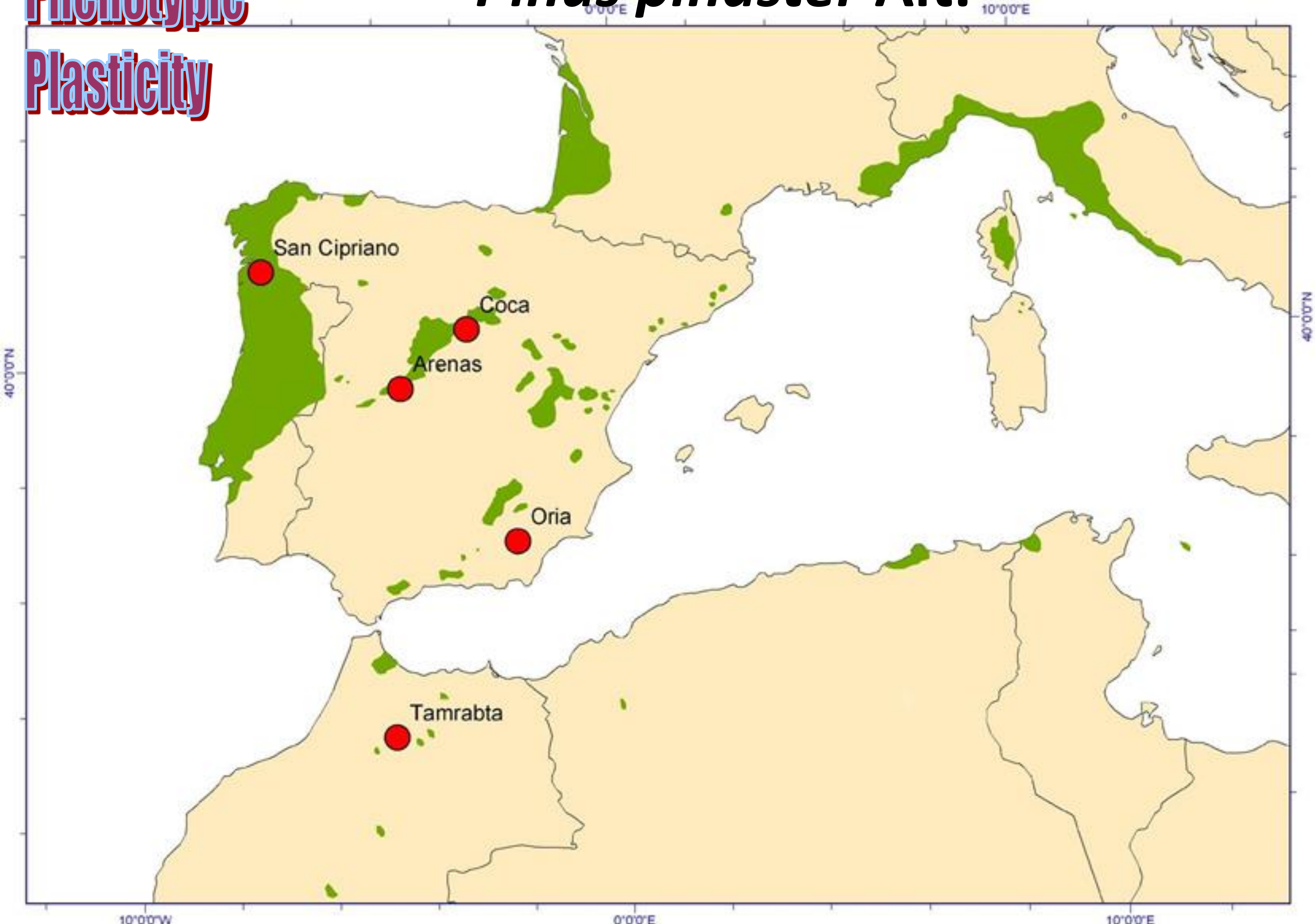
Height growth

Pinus pinaster, 32 y.o. provenance trial



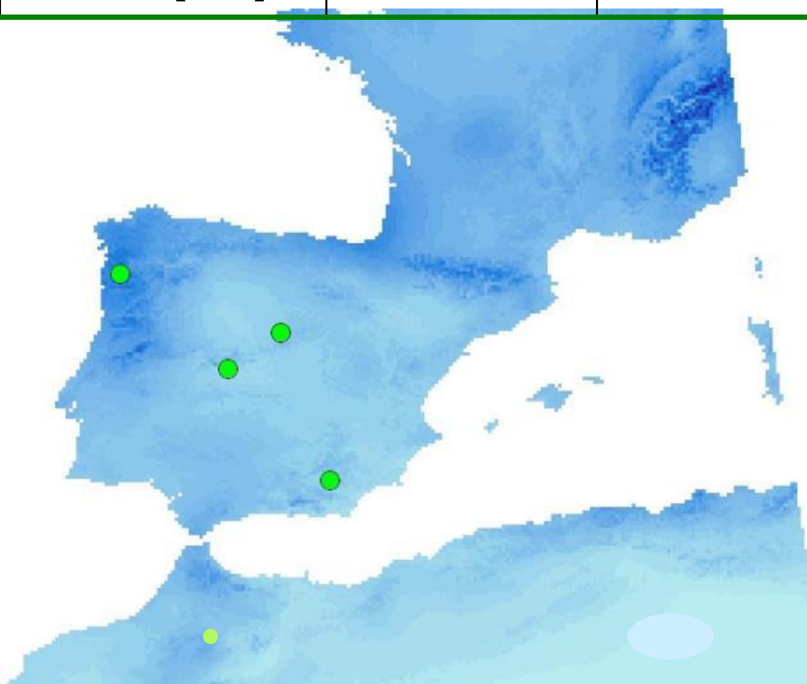
Phenotypic Plasticity

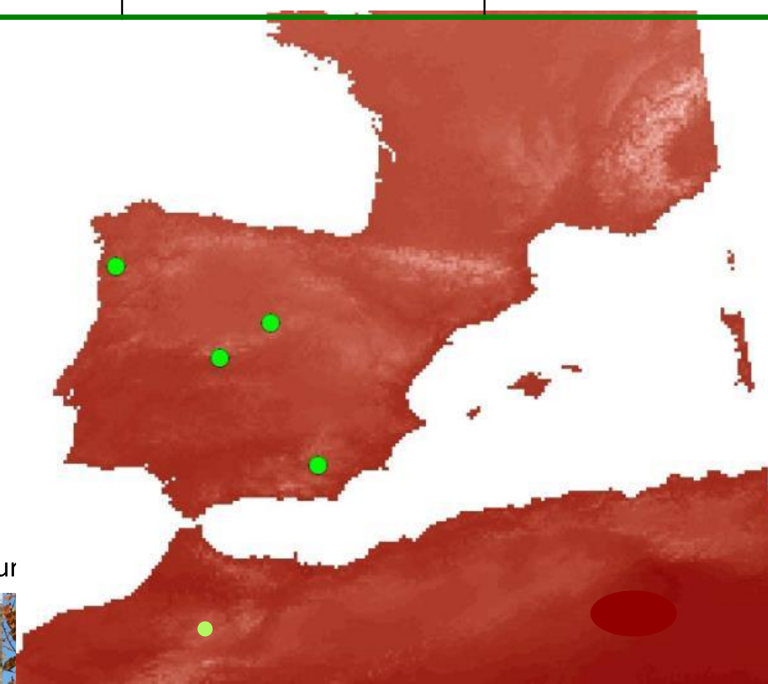
Pinus pinaster Ait.



Spain climate

	Arenas	Coca	Oria	Tamrabta	S.Cipriano
Lat (N)	40º 30’	41º 14’	37º 30’	33º 20’	42º 7’
Long (W)	4º 24’	3º 30’	2º 20’	5º	8º 22’
Elev (m)	1000	810	1300	1750	364
P (mm)	692	434	351.5	850	1334
T (ºC)	14.6	12.02	14.4	20.5	12.4
TM (ºC)	34.2	31.01	30.0	29.1	25.9
Tm (ºC)	0.28	-2.3	3.0	1.2	1.85





Traits

- i) Soil-to-leaf hydraulic conductance
- ii) Biomass allocation
- iii) WUE (Water use efficiency)
- iv) rooting system architecture and topology
- v) Xylem anatomy

Height and diameter

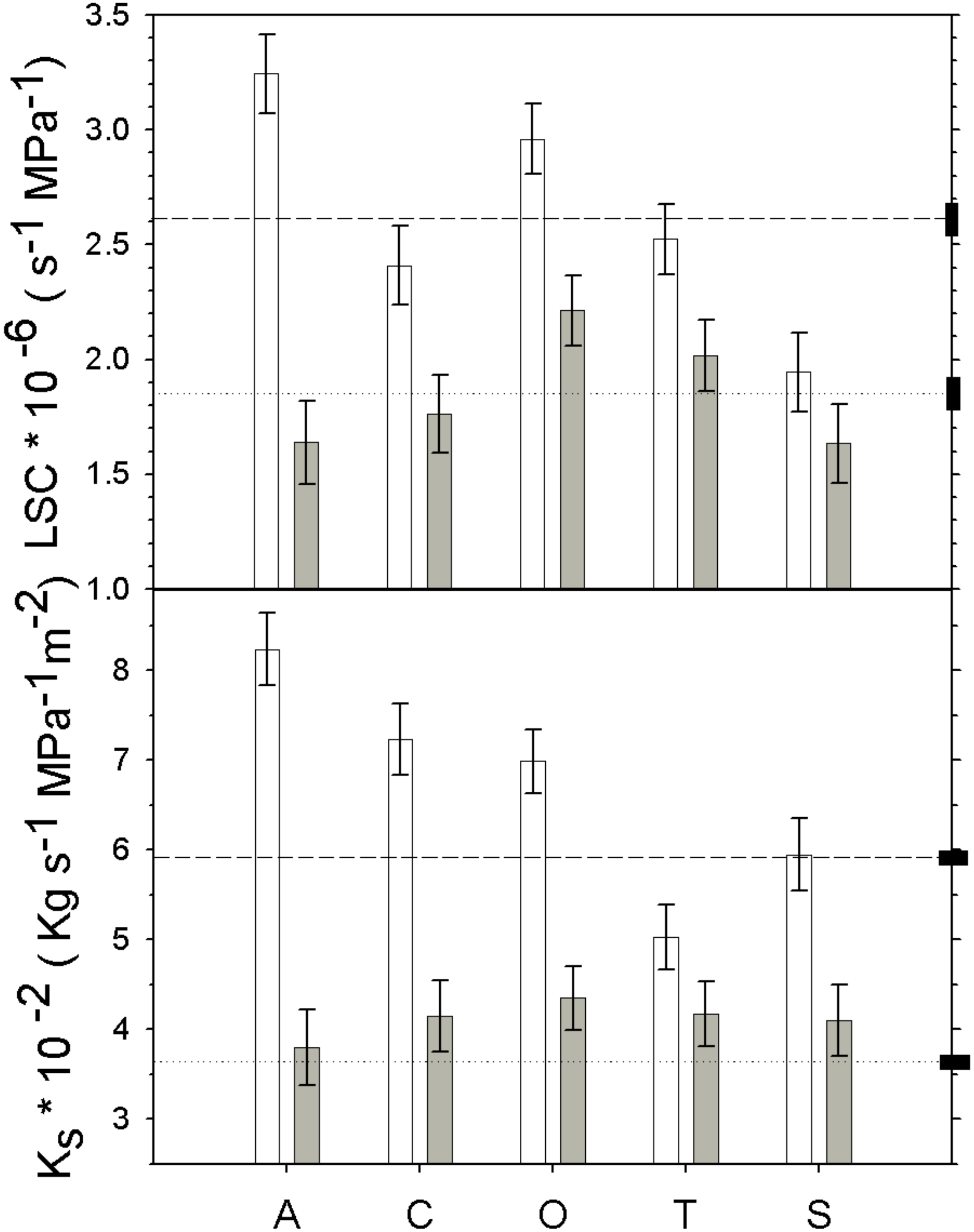
Some ‘surprising’ results: variation exists!

Anova summary

	Conductivity				13	H	D			Allocation						Rooting S			
S	***	***			**										***	***	***	***	***
P	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
PxS	***	***		***	***											*		**	
F	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
FxS	***	**			***	***	**						*		**	**	**	**	

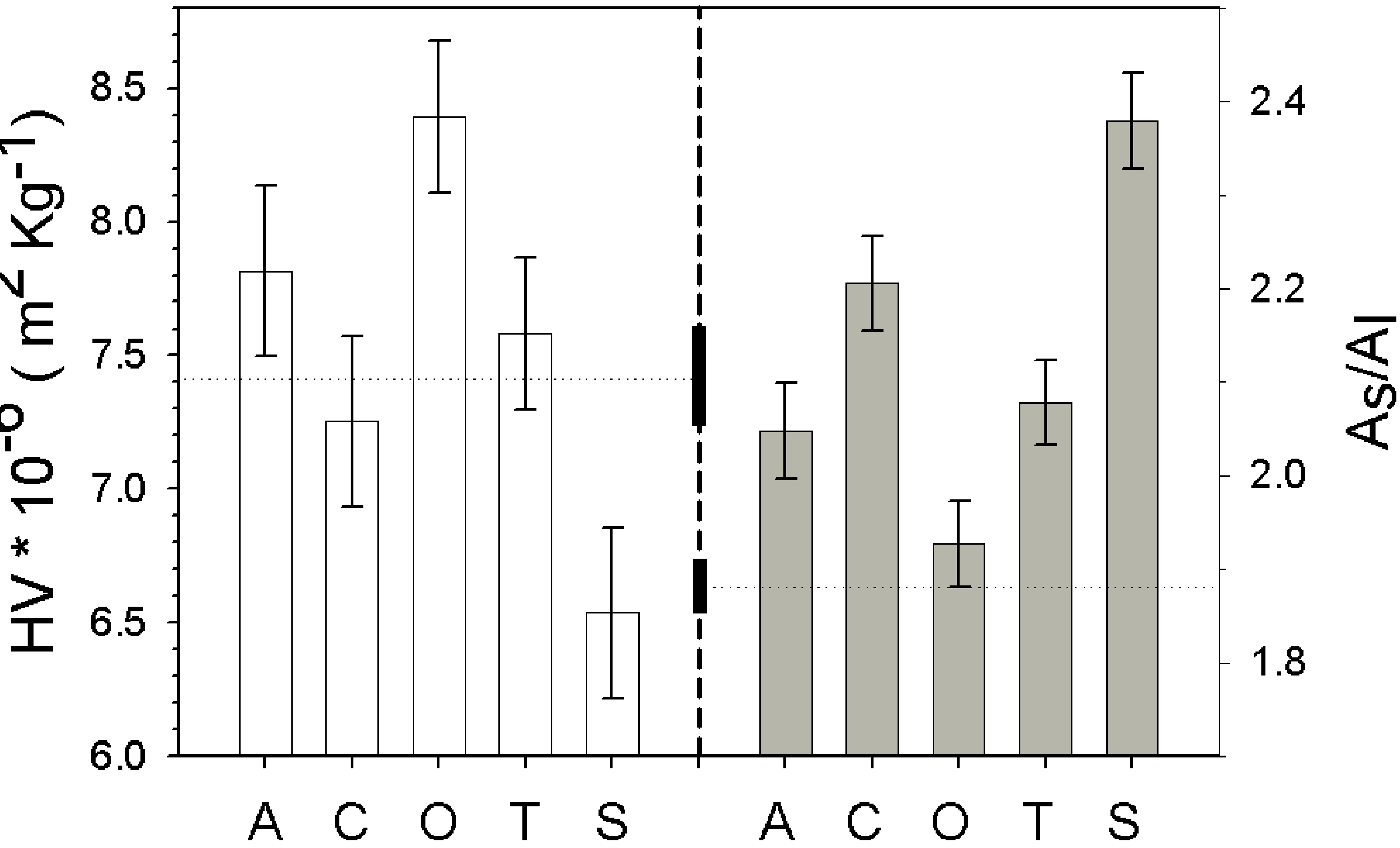
Wood Anatomy

	L	W
F	***	**



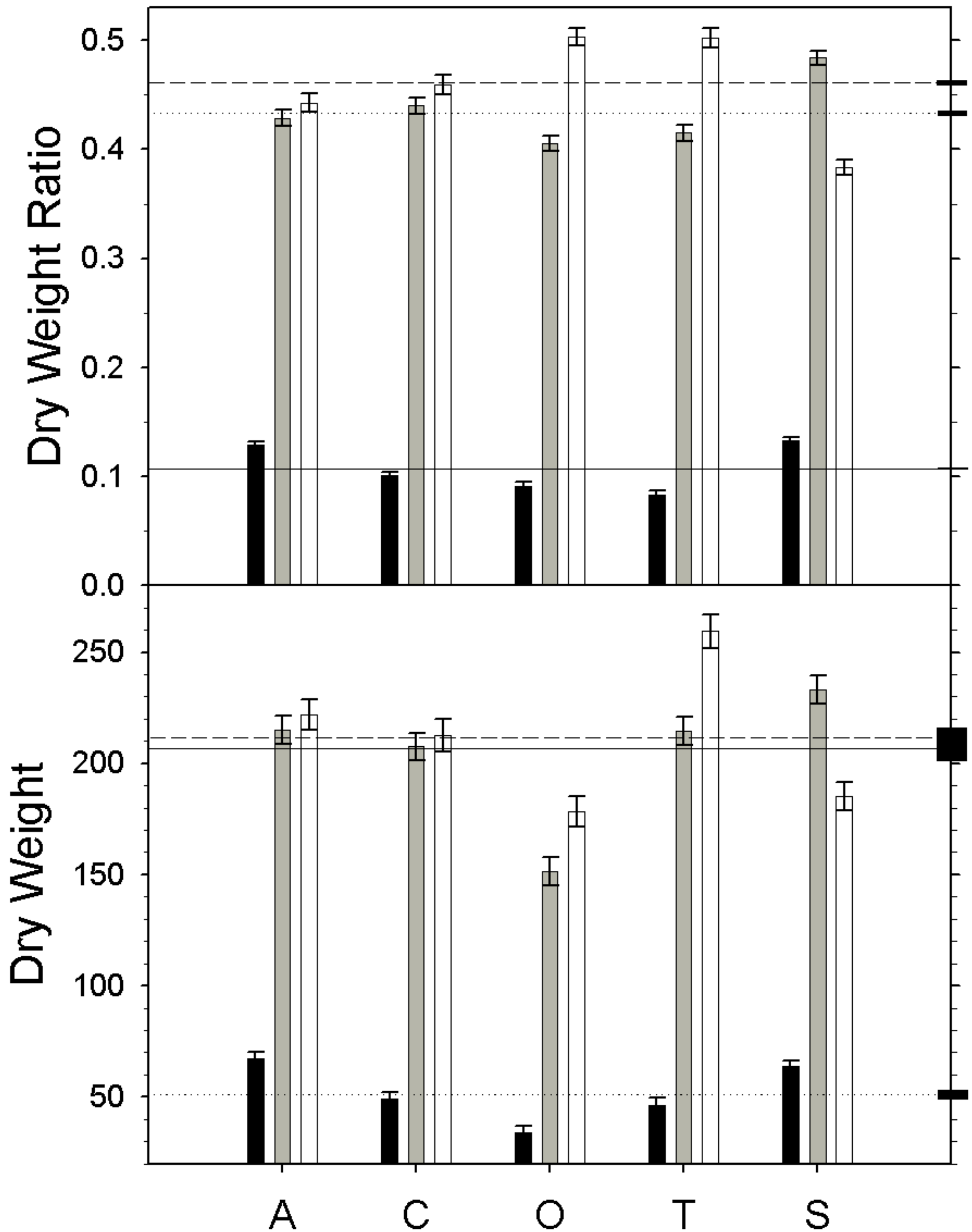
Leaf specific conductivity *(K / leaf weight)*

Xylem specific conductivity (*K / xylem area*)



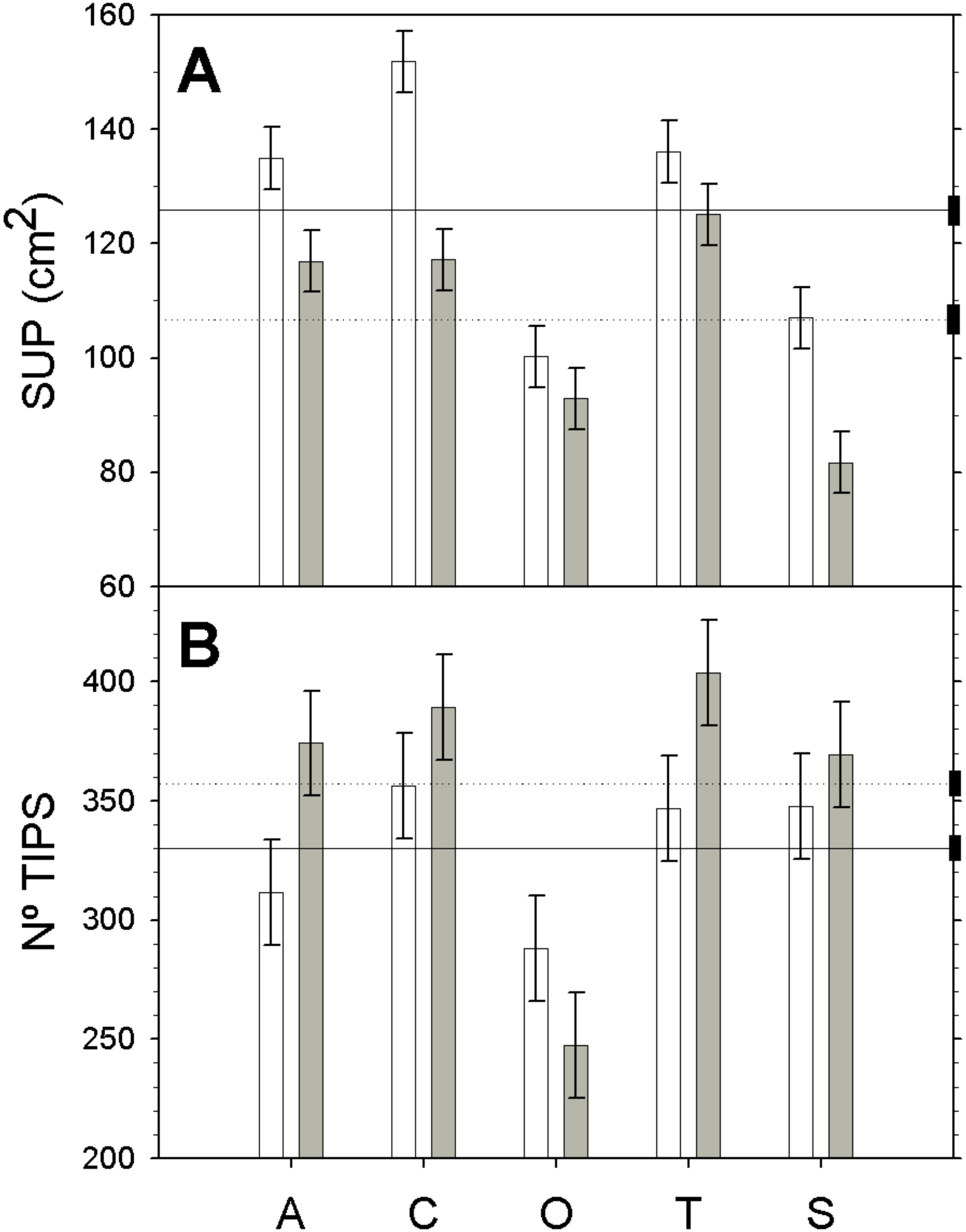
Cross xylem area / leaf weight

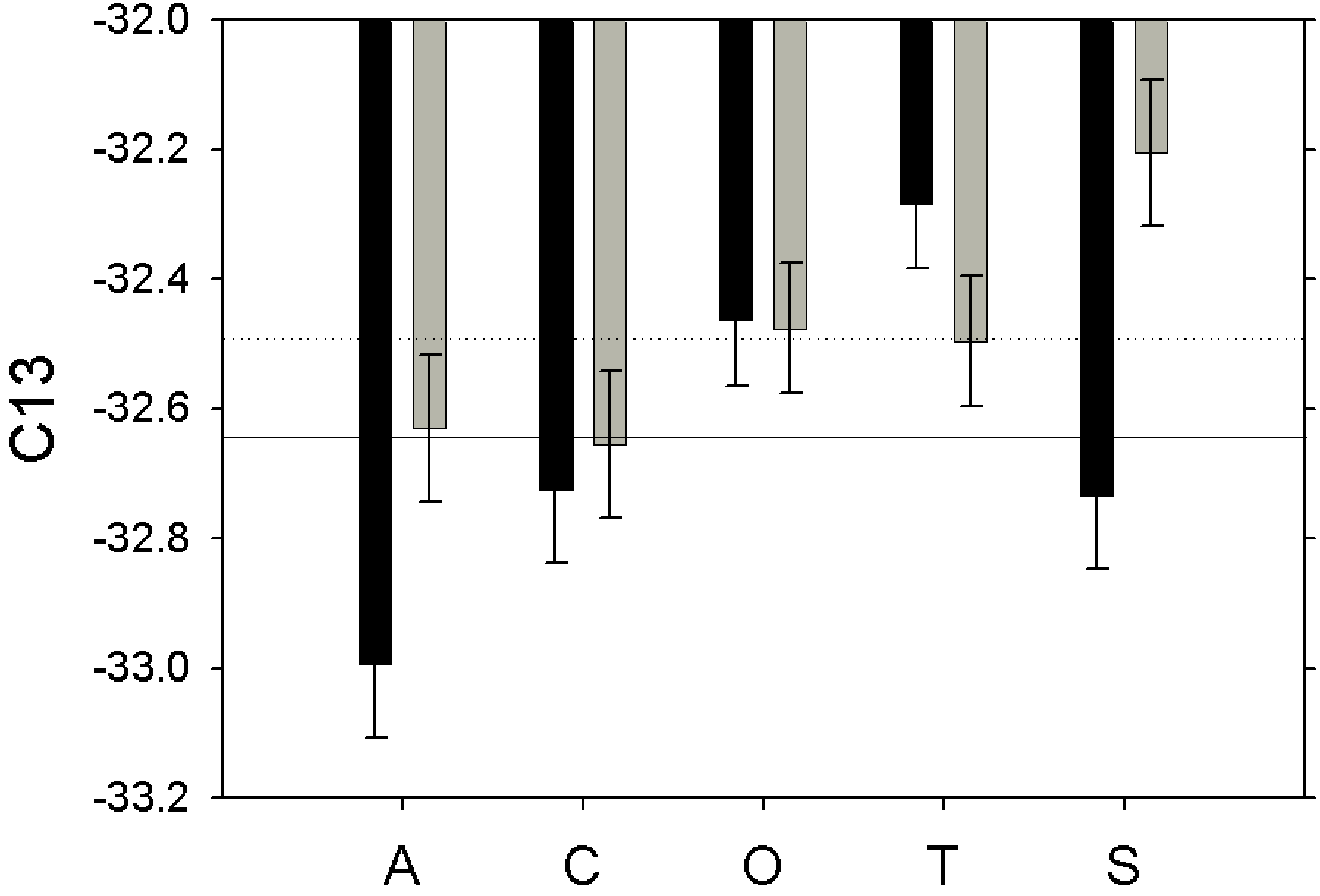
Leaf area / xylem area



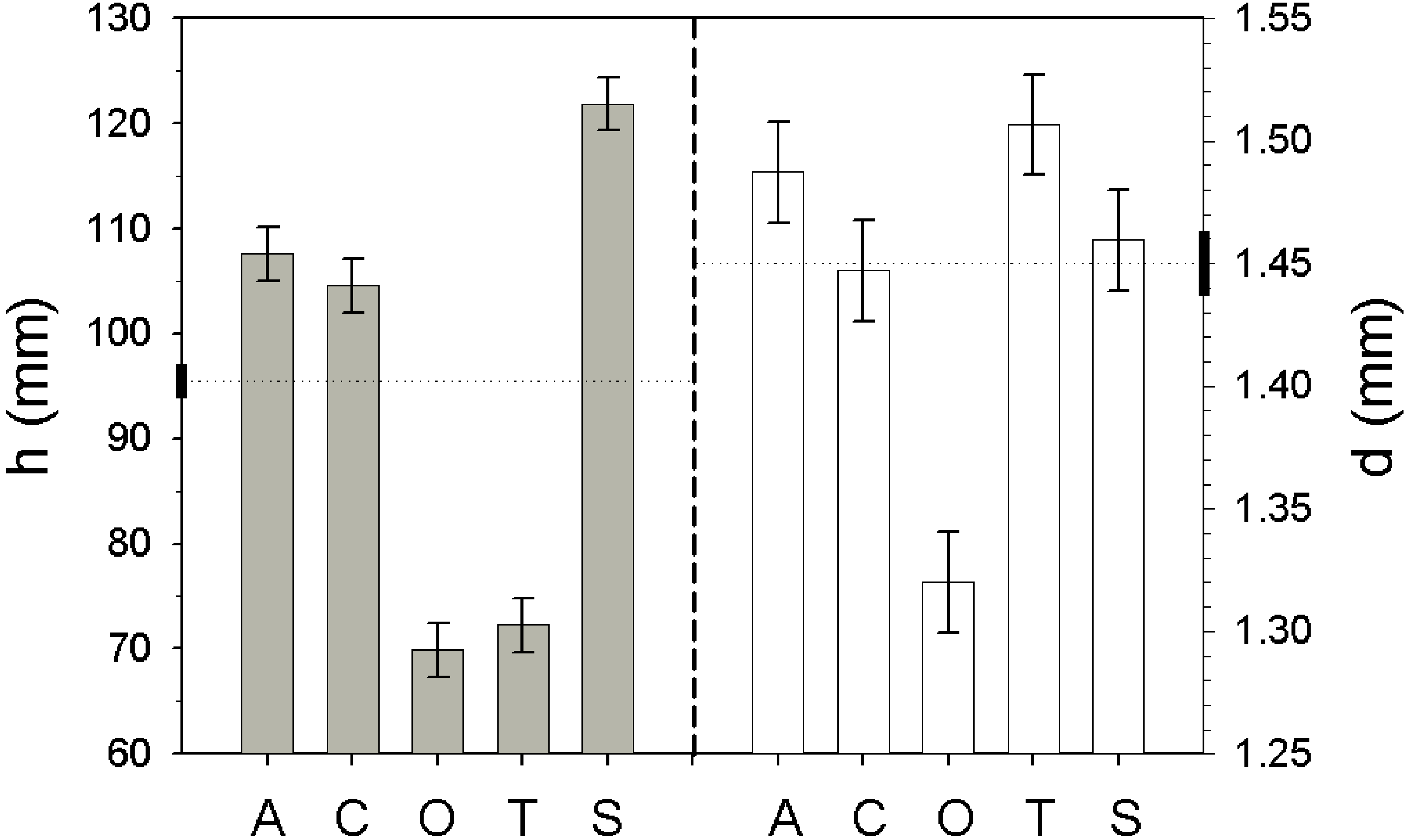
Stem Leaf Root

Rooting system



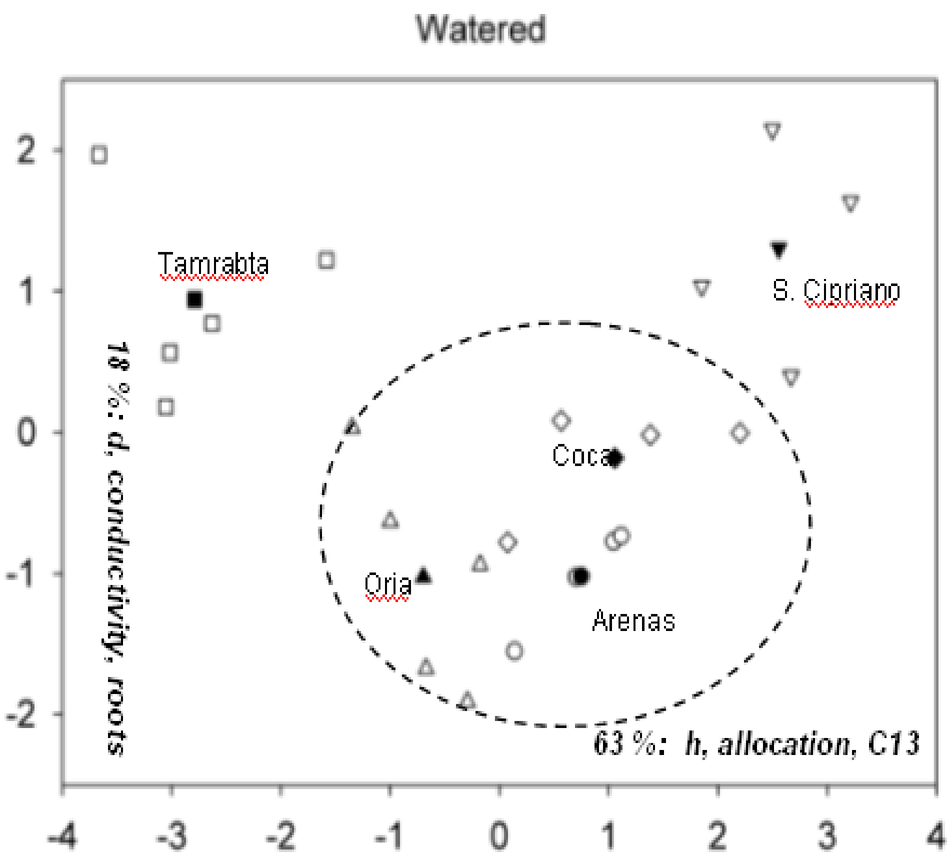


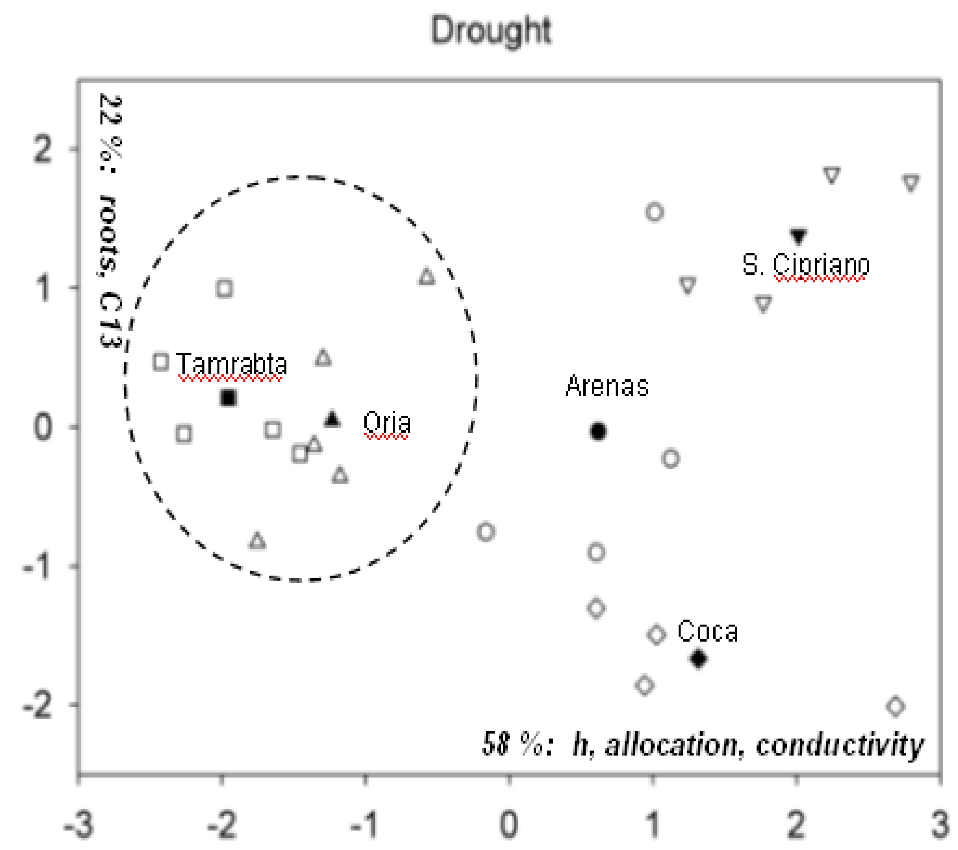
C13
-32.0
-32.2
-32.4
-32.6
-32.8
-33.0
-33.2
A
C
O
T
S


h (mm)
d (mm)
130
120
110
100
90
80
70
60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
A C O T S
A C O T S

Plasticity for drought (physiology, morphology, WUE)

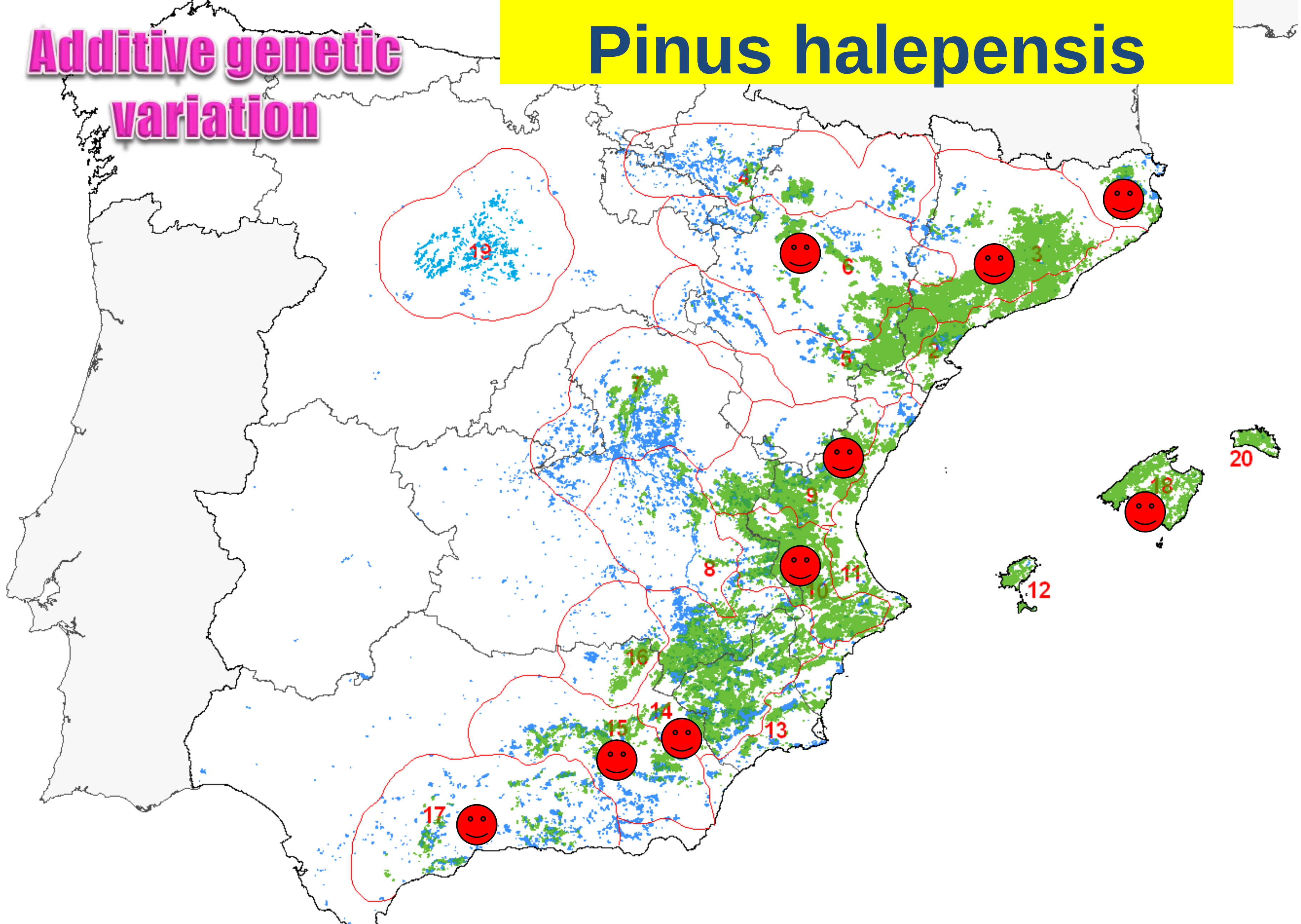
Pinus pinaster, Provenance/Progeny trial under controlled environment

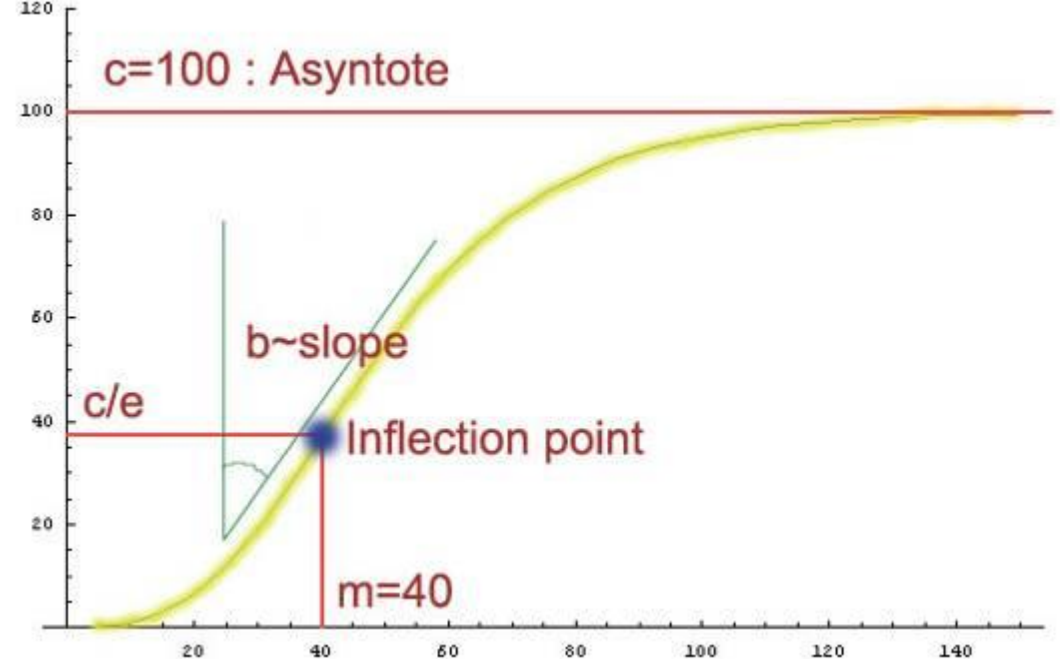




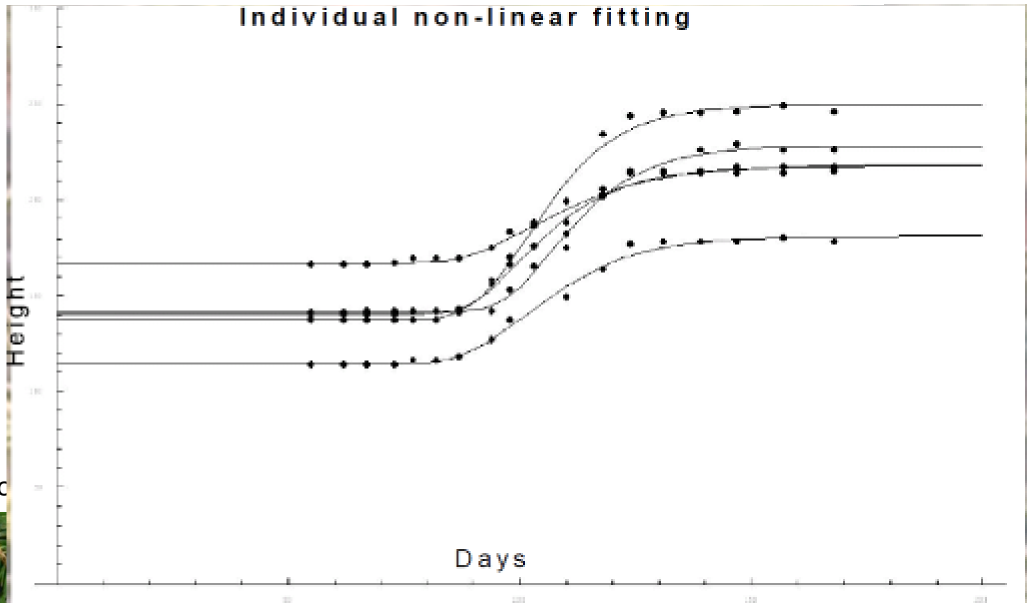
Additive genetic variation

Pinus halepensis





Gompertz model: $H = h + c\, e^{-e^{-b(-m+t)}}$

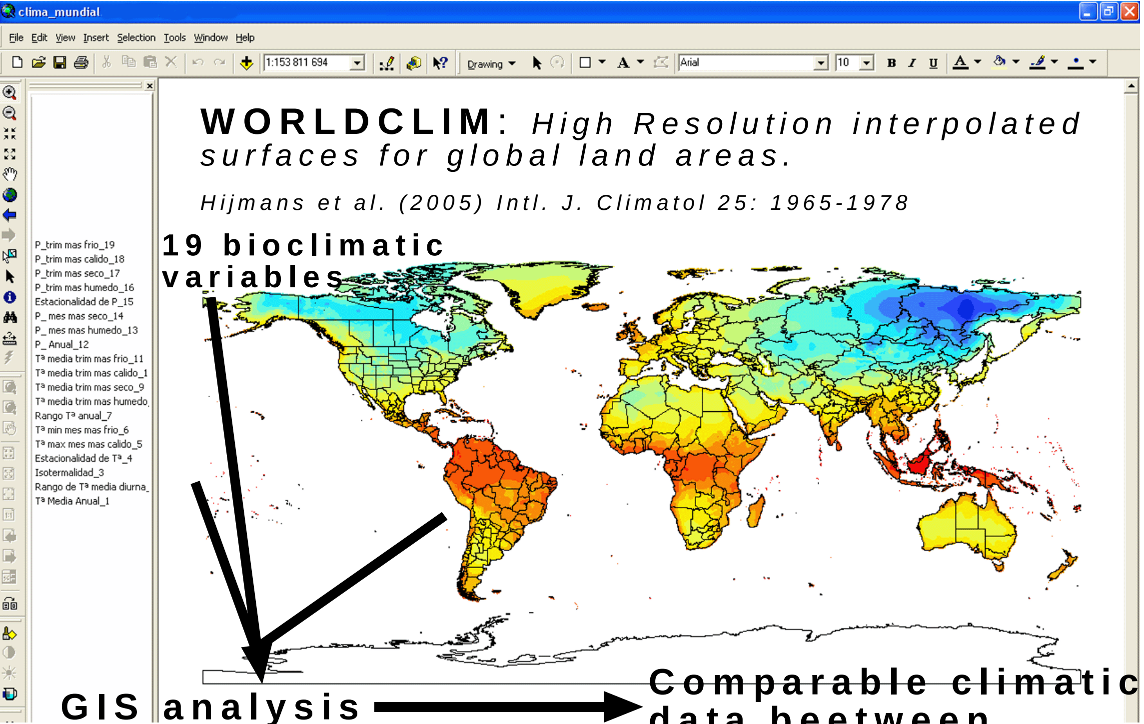


c, b, m,
t10, t90 & dur

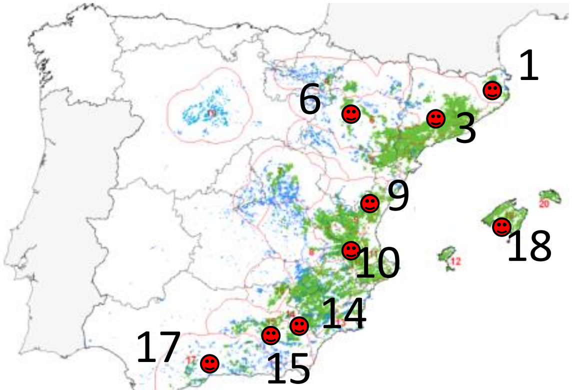
Spain climate

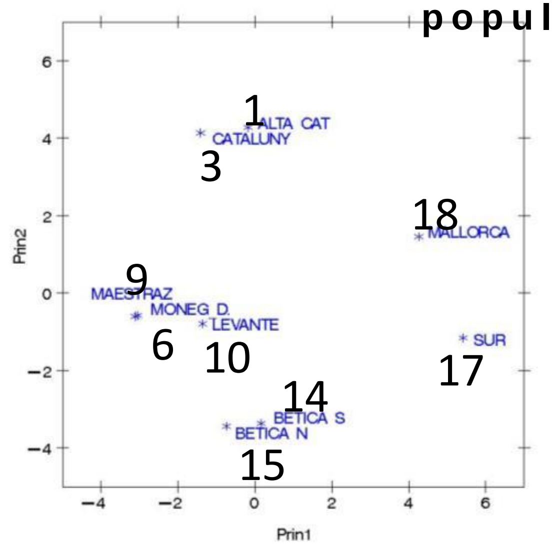
GIS

ESRI Grids
Spatial Analyst
Neighbourhood statistics
25 Km radius



GIS analysis → Comparable climatic data beetween populations





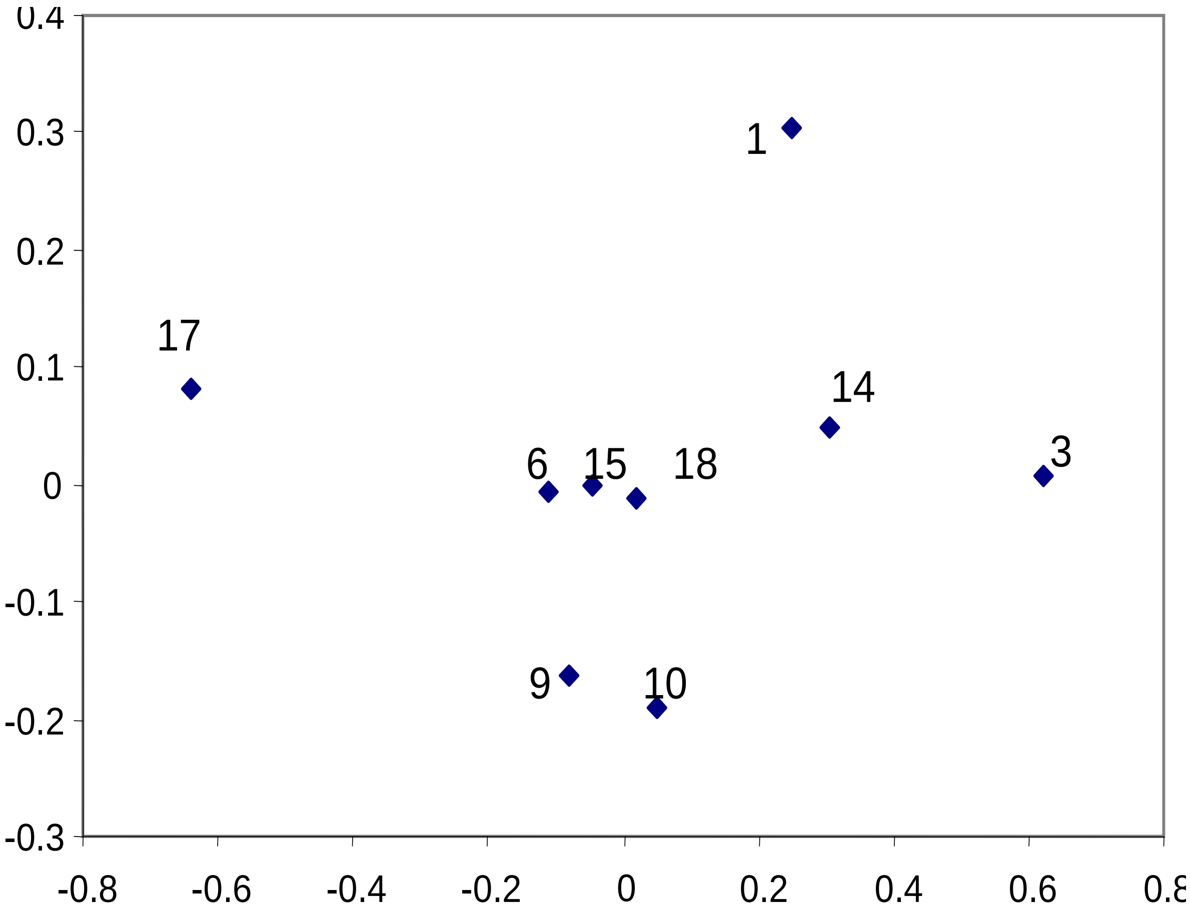
BIO1 = Annual Mean Temperature
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (P2/P7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO5 = Max Temperature of Warmest Month
BIO6 = Min Temperature of Coldest Month
BIO7 = Temperature Annual Range (P5-P6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Month
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter
BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter

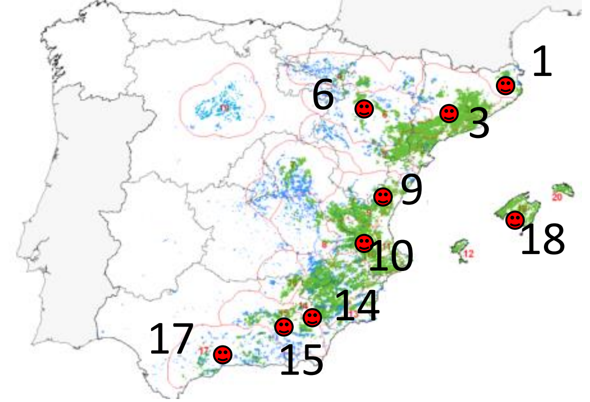
Results

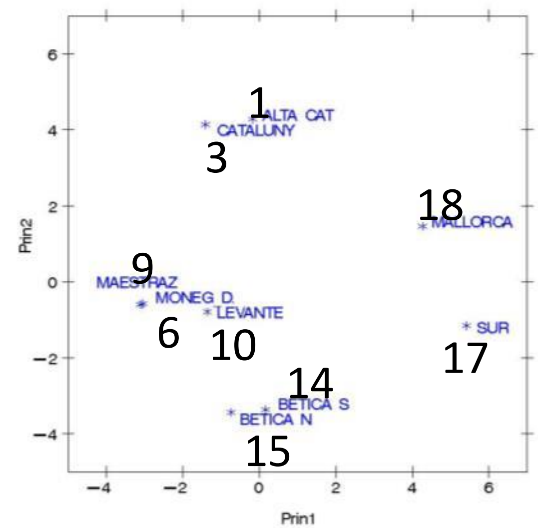
- Very accurately fitting (error<3%)
- Population effect significant for **t10, t90 & dur**
- But not for **c, b, m**
- PCA 1&2 absorbed 90% variation, but not clear grouping of populations (not very different?)
- CVa: Additive coefficient of variance as adaptive potential index

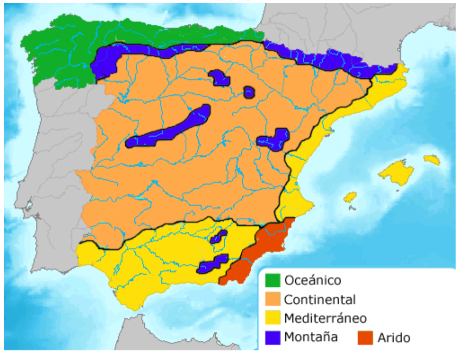
Multivariate analysis: Geographical grouping?

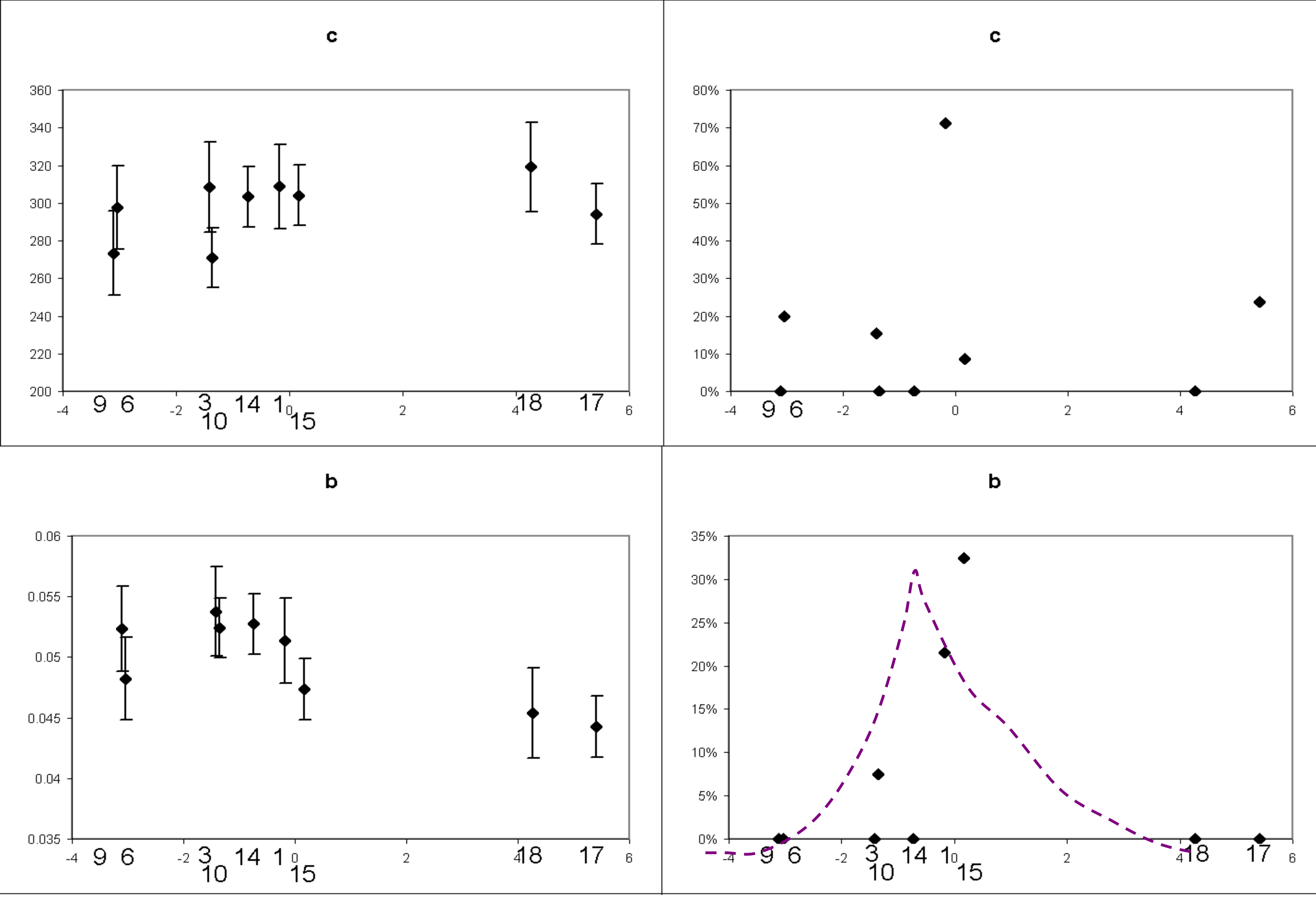
Canonical Discriminant (c, b, m, t10, t90 & dur)



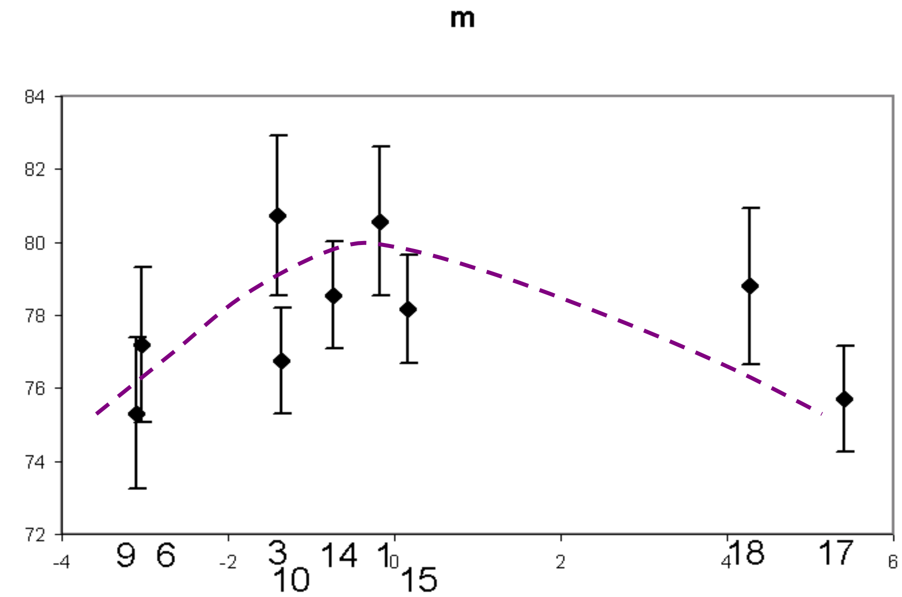


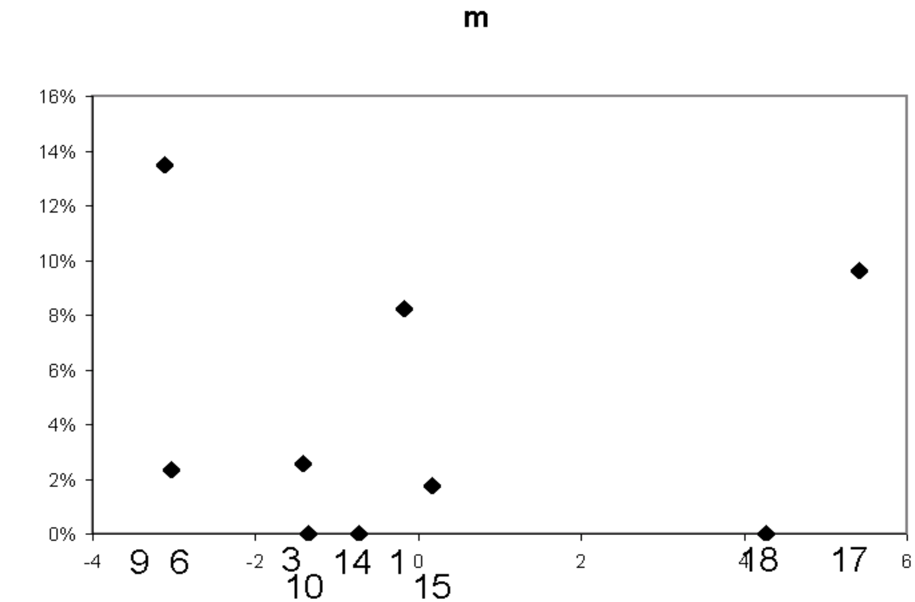


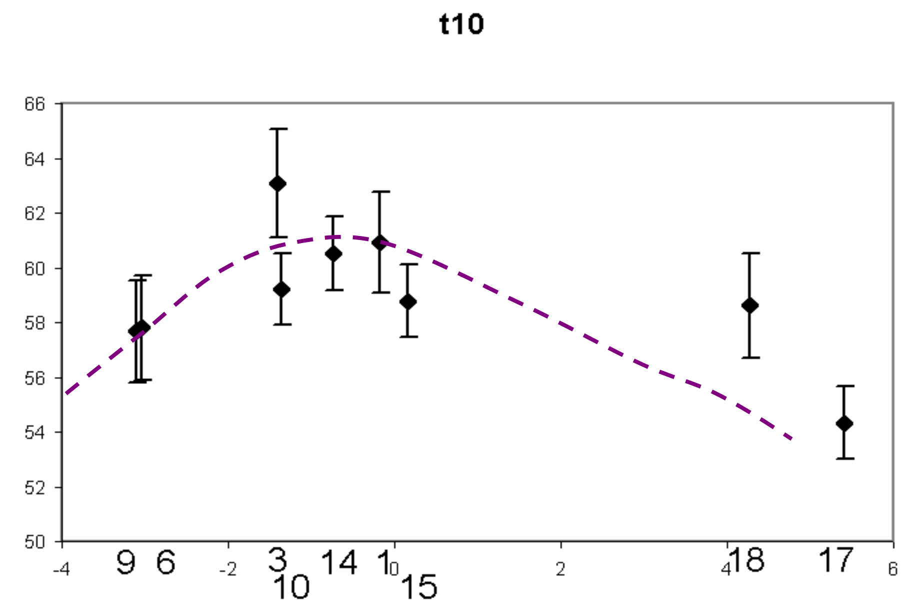


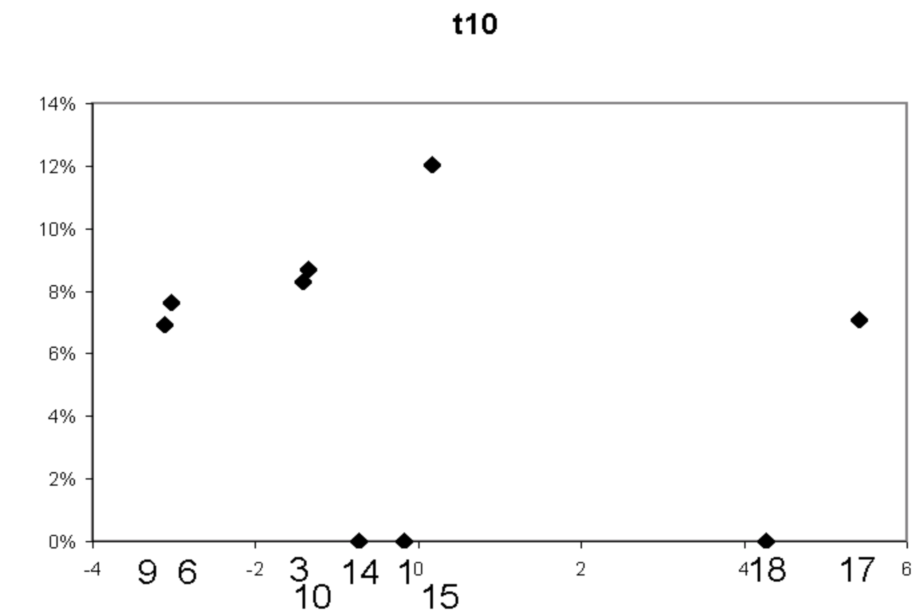

c
360
340
320
300
280
260
240
220
200
-4
-2
0
2
4
6
9 6
3
10
14 1
15
18
17
c
80%
70%
60%
50%
40%
30%
20%
10%
0%
9 6
b
0.06
0.055
0.05
0.045
0.04
0.035
b
35%
30%
25%
20%
15%
10%
5%
0%


Mean
CVa

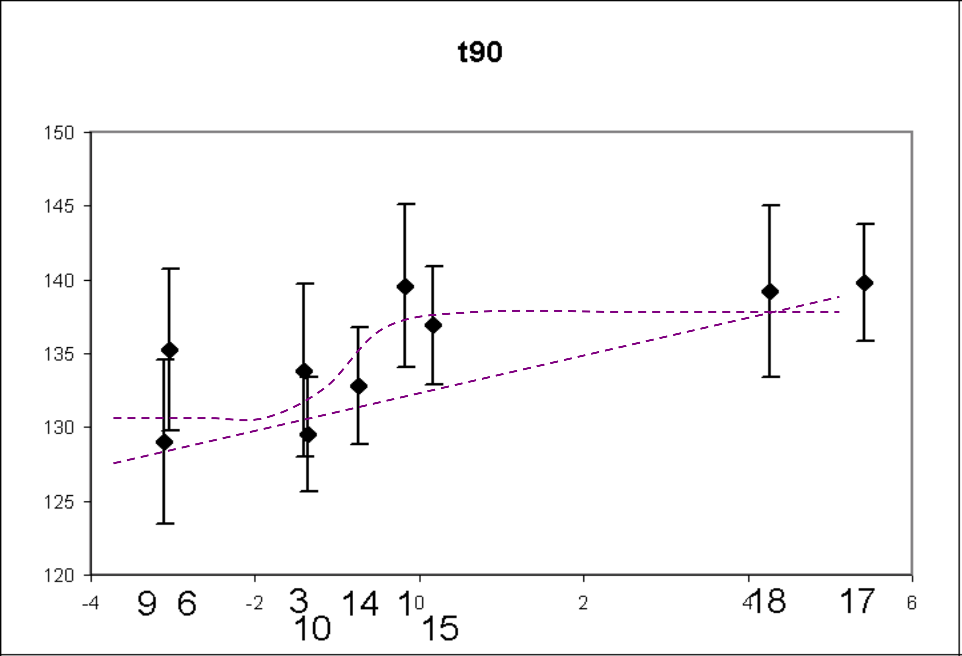

m
84
82
80
78
76
74
72
-4
-2
0
2
4
6
9 6 3 10 14 1 15 18 17

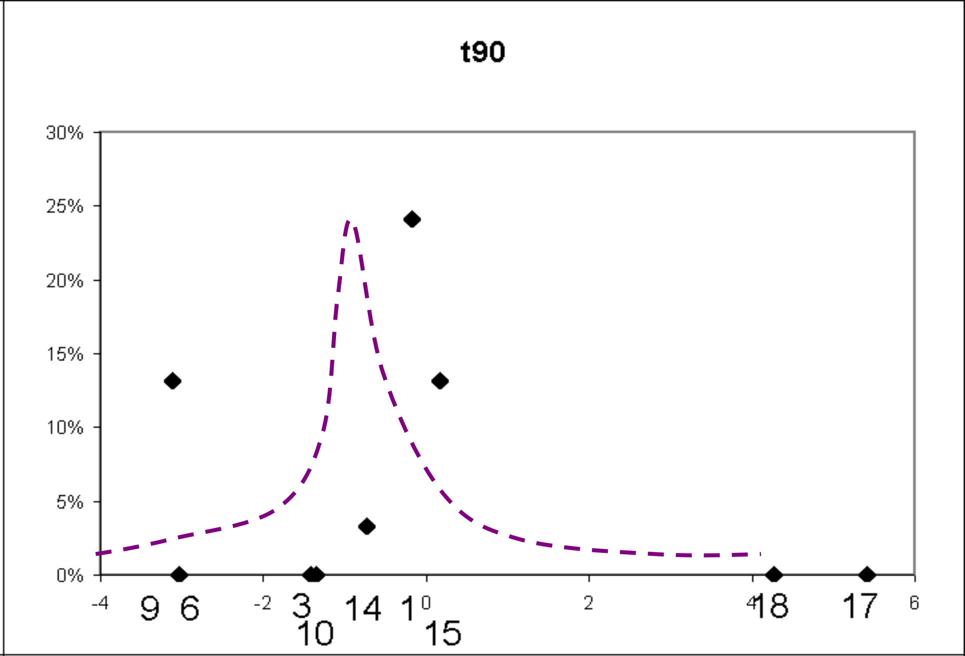

m
16%
14%
12%
10%
8%
6%
4%
2%
0%
-4
-2
0
2
4
6
9 6 3 10 14 1 15 18 17

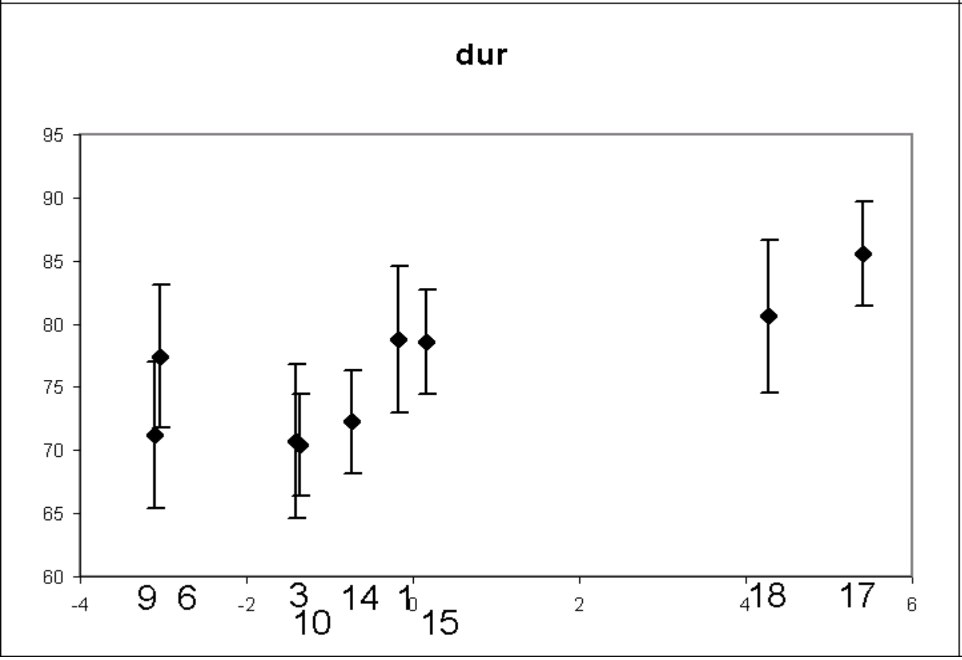

t10
66
64
62
60
58
56
54
52
50
-4
-2
0
2
4
6
9 6 3 10 14 1 15 18 17

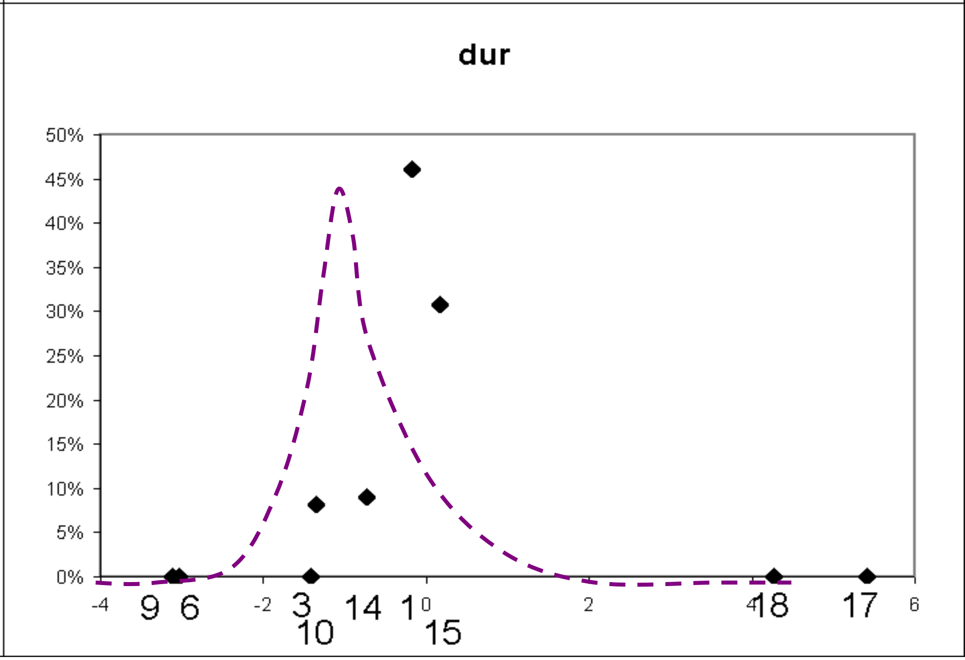

t10
14%
12%
10%
8%
6%
4%
2%
0%
-4
-2
0
2
4
6
9 6 3 10 14 1 15 18 17


Mean
CVa









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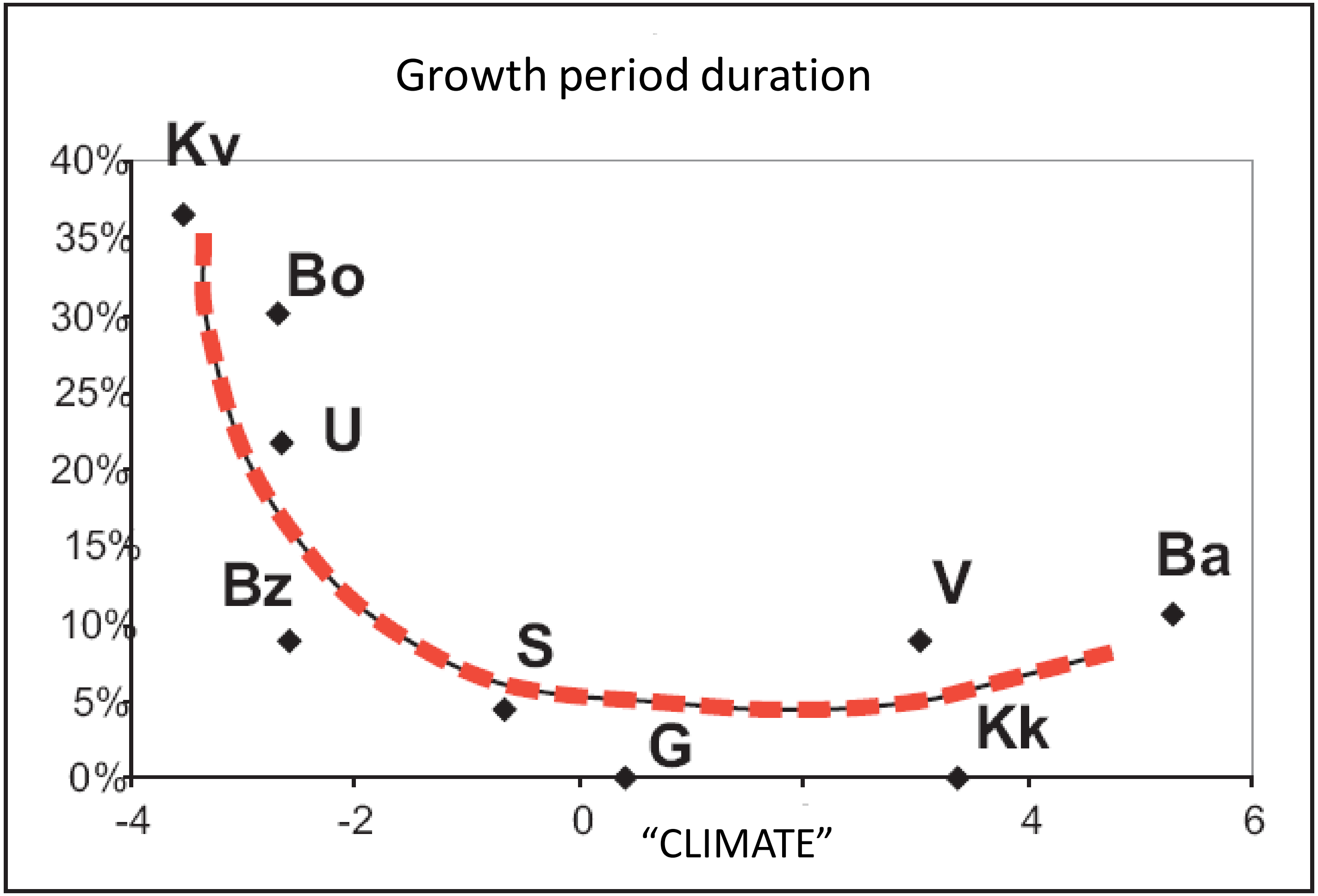
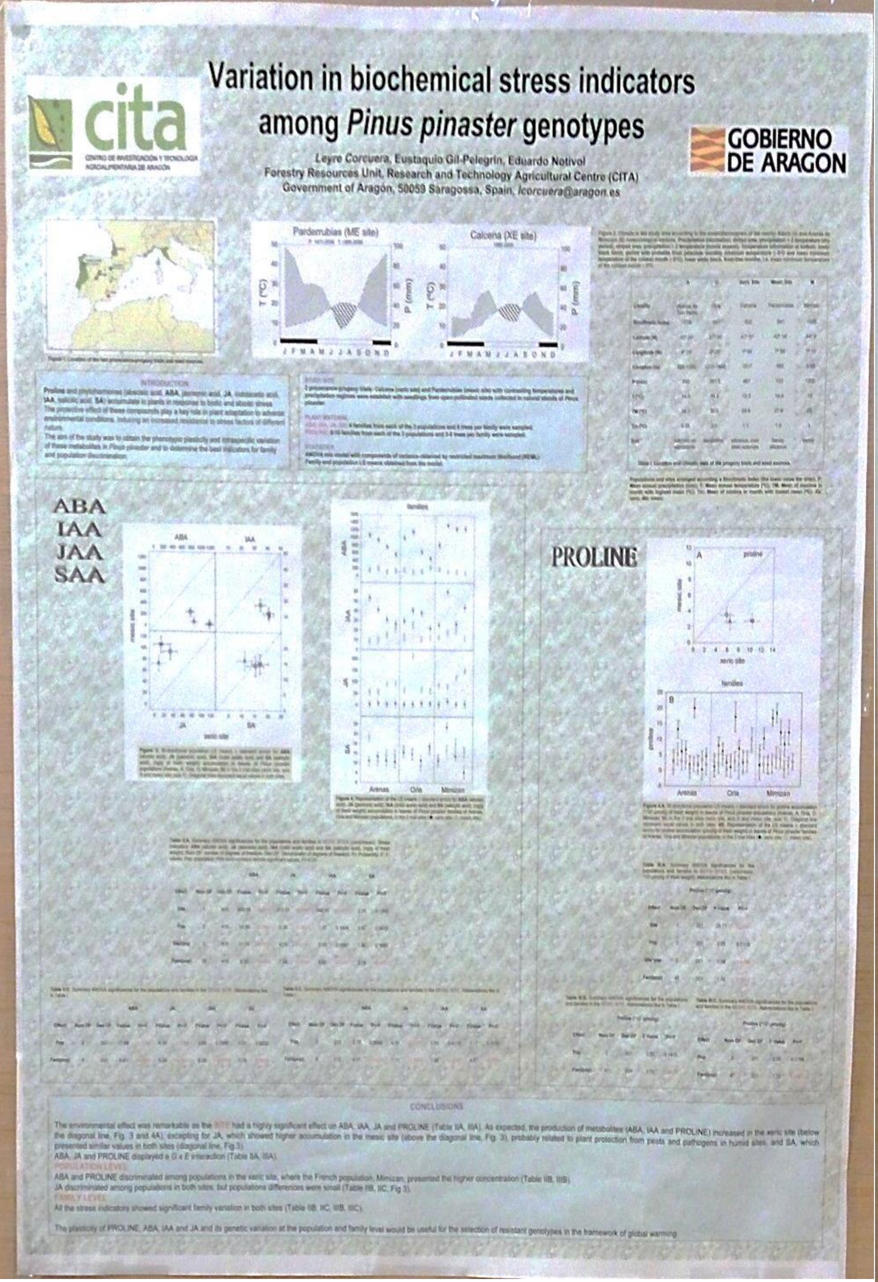
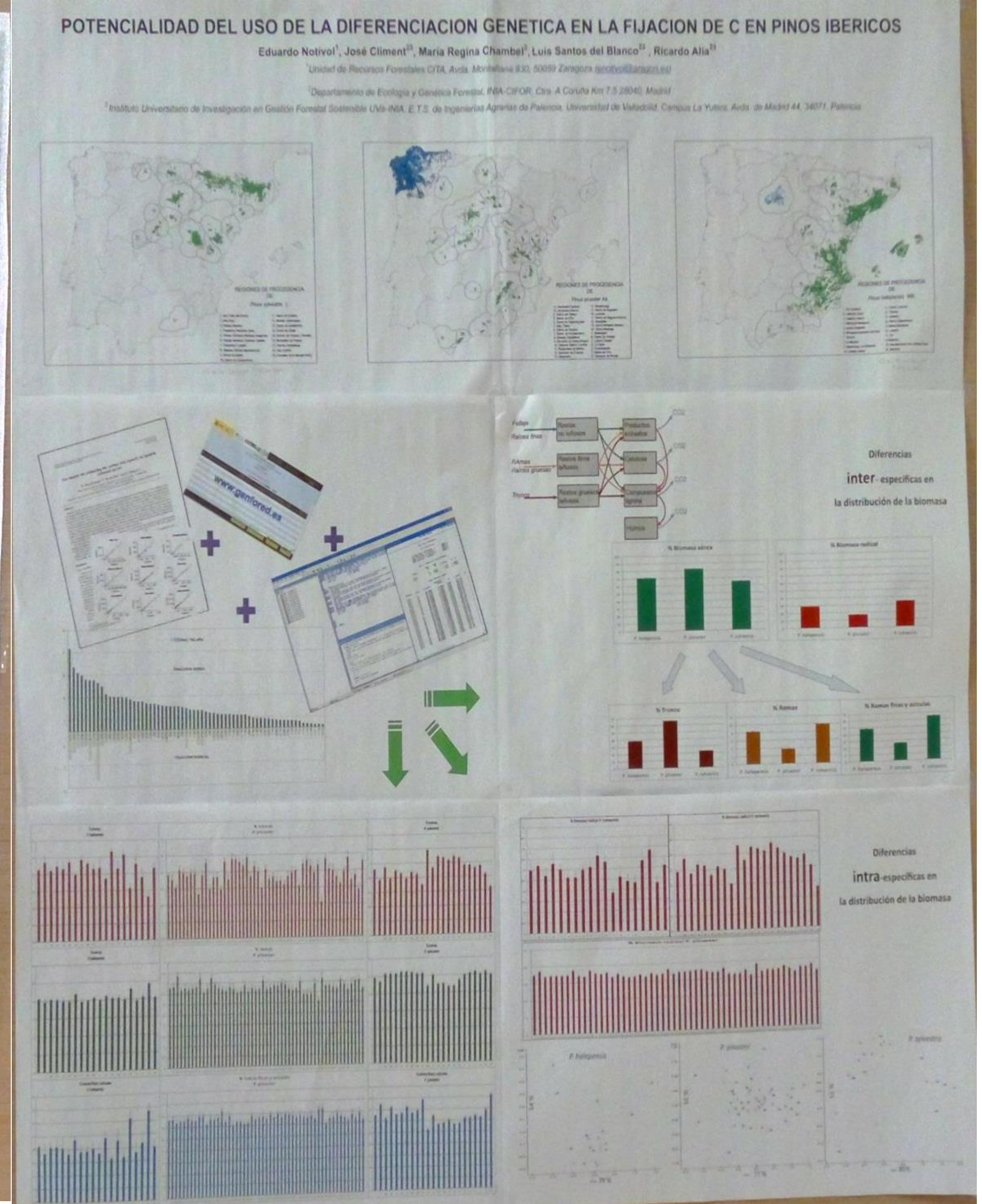
Coef. genetic additive variance

9 *Pinus sylvestris* populations (natural distribution area)







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