



International Seminar:

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

Analysis of adaptive genetic variation EXAMPLES

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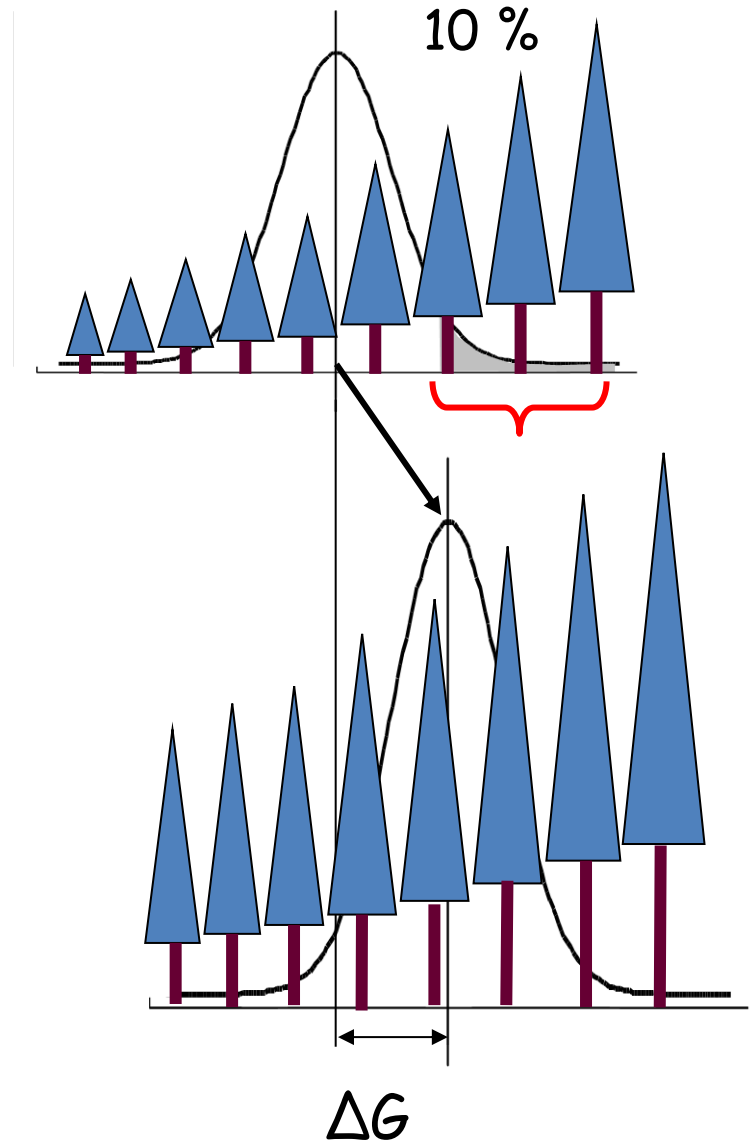
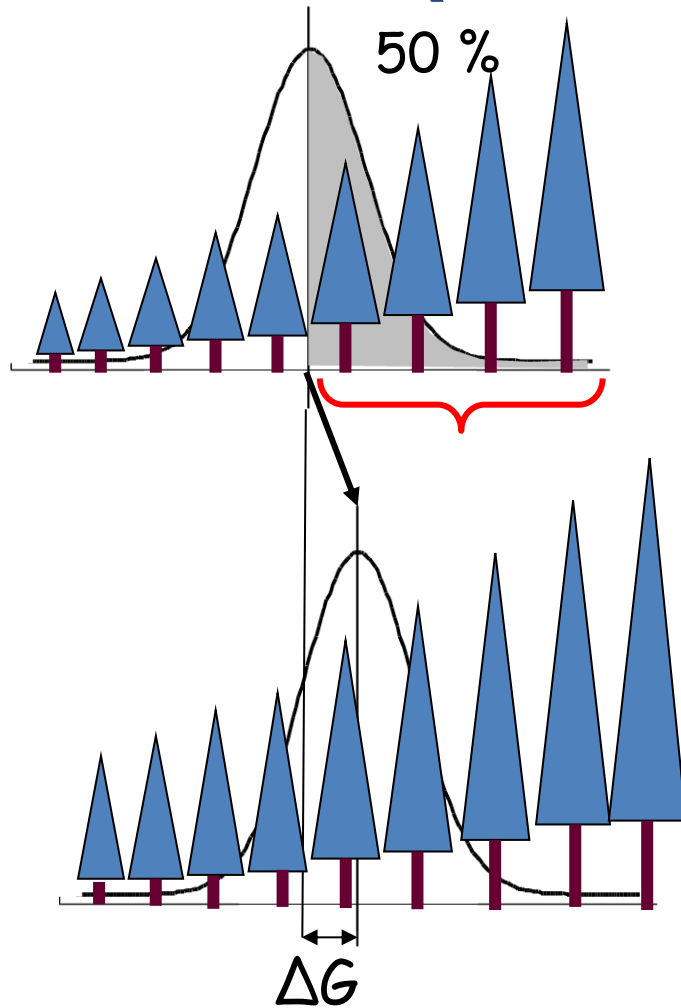
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Intl. Seminar 'Strengthening Agroforestry Programs in Higher Education for Food Security In Sub-Saharan Africa – SAPHE' Madrid, 27 Feb-03 Mar 2017



Selection (Natural or artificial)



2 mechanisms

δS

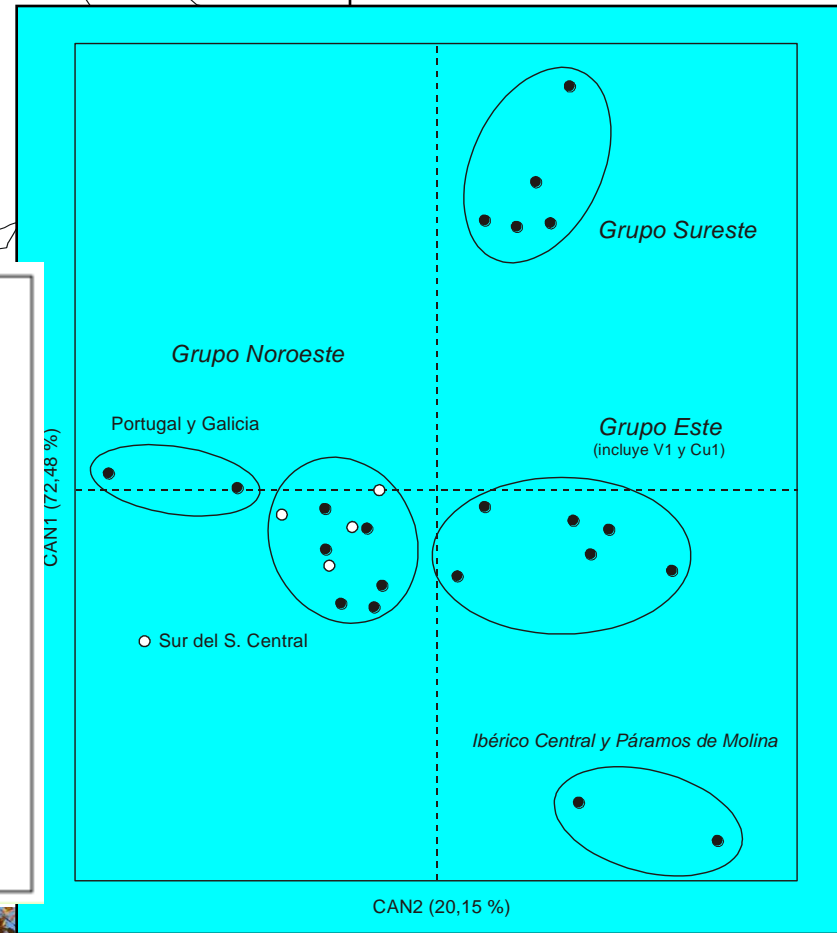
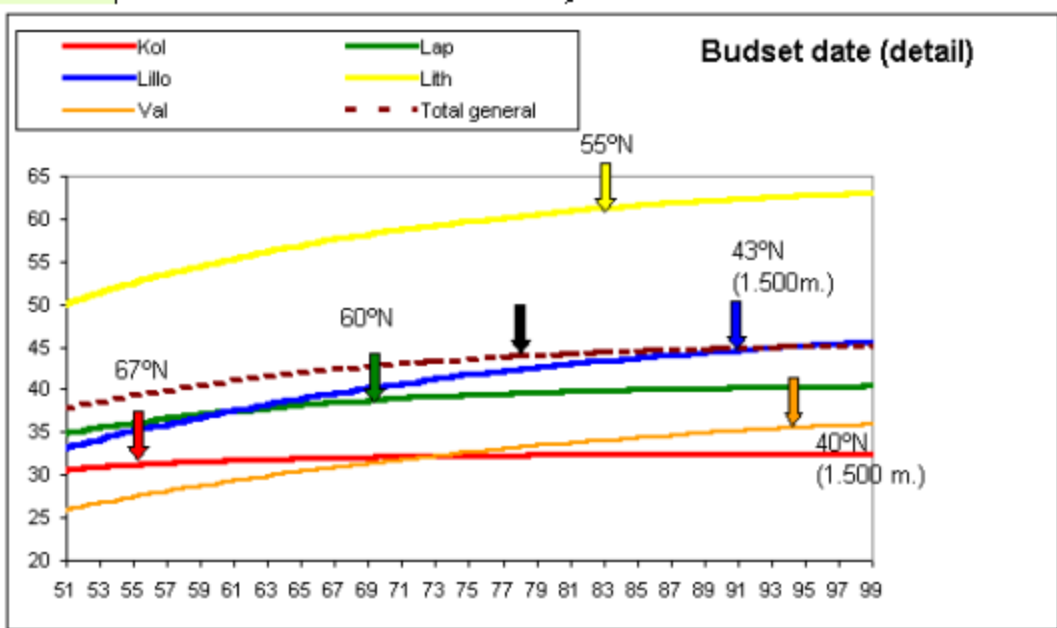
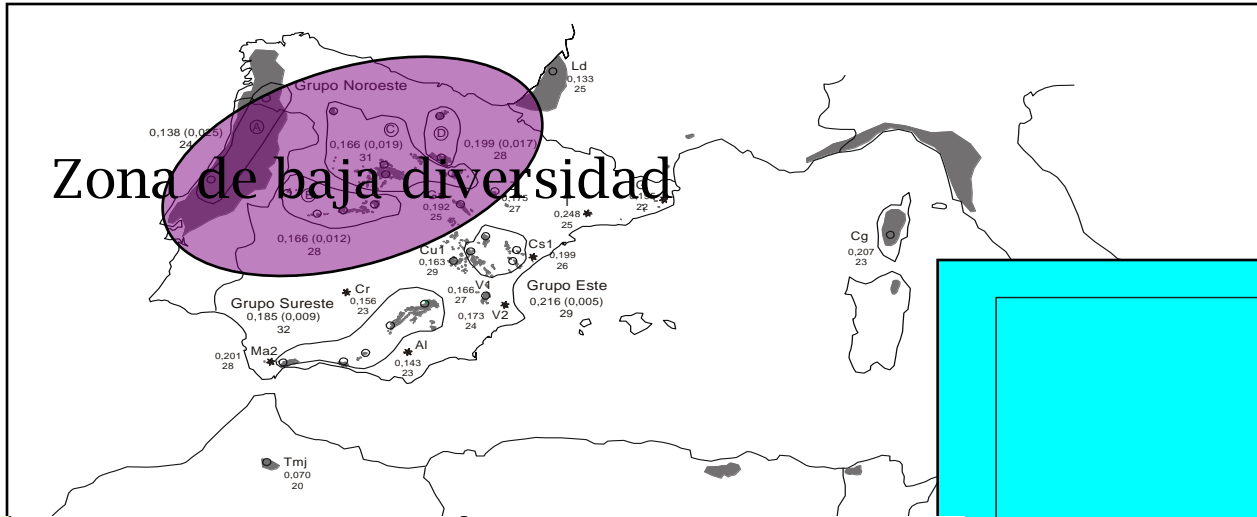
Phenotypic
Plasticity

Additive genetic
variance

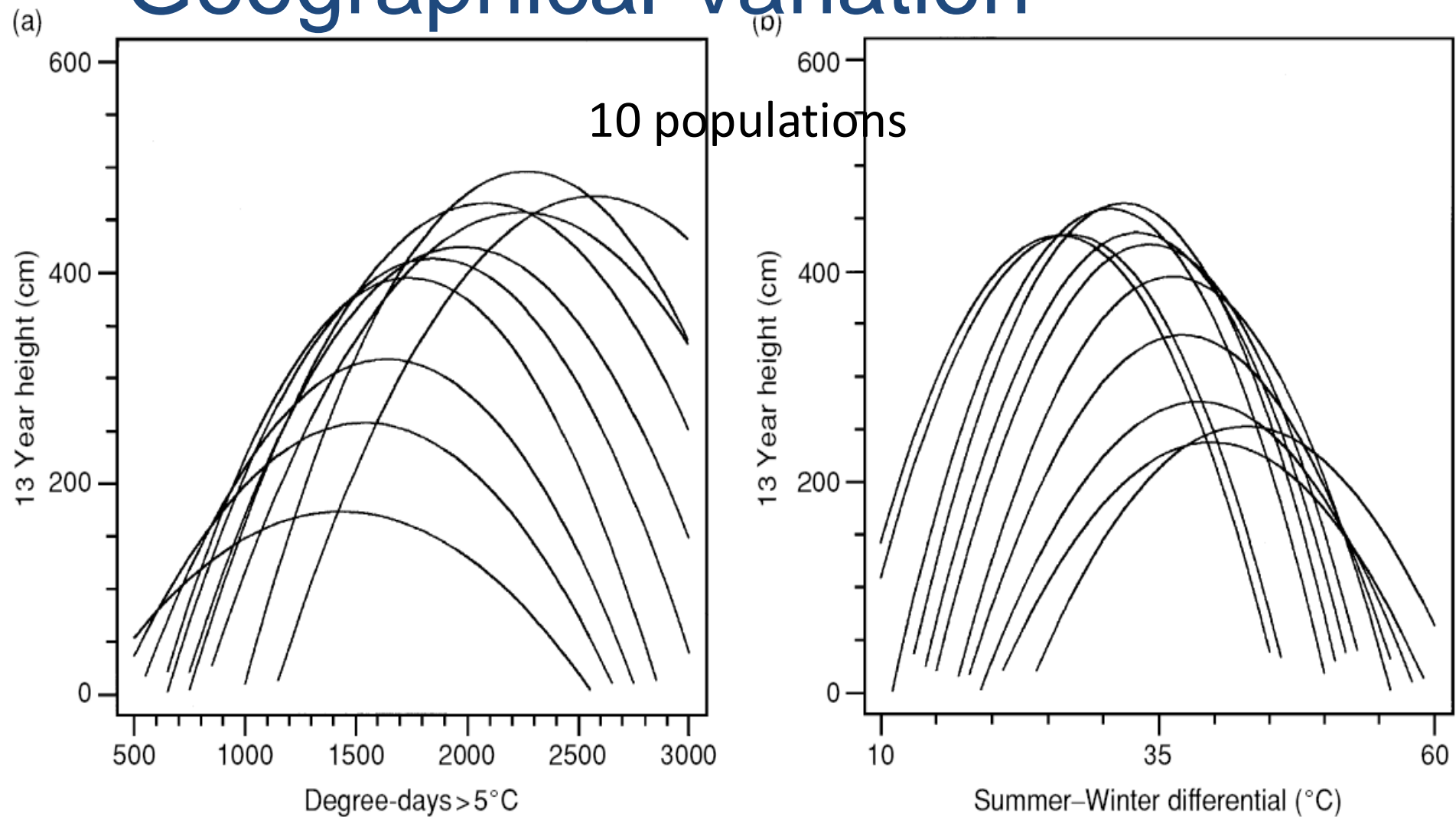
$$R = h^2 \delta S = \frac{\sigma_{\text{additive}}^2}{\sigma_{\text{phenotypic}}^2} \delta S$$



Variation Structure: Geographical



Geographical Variation

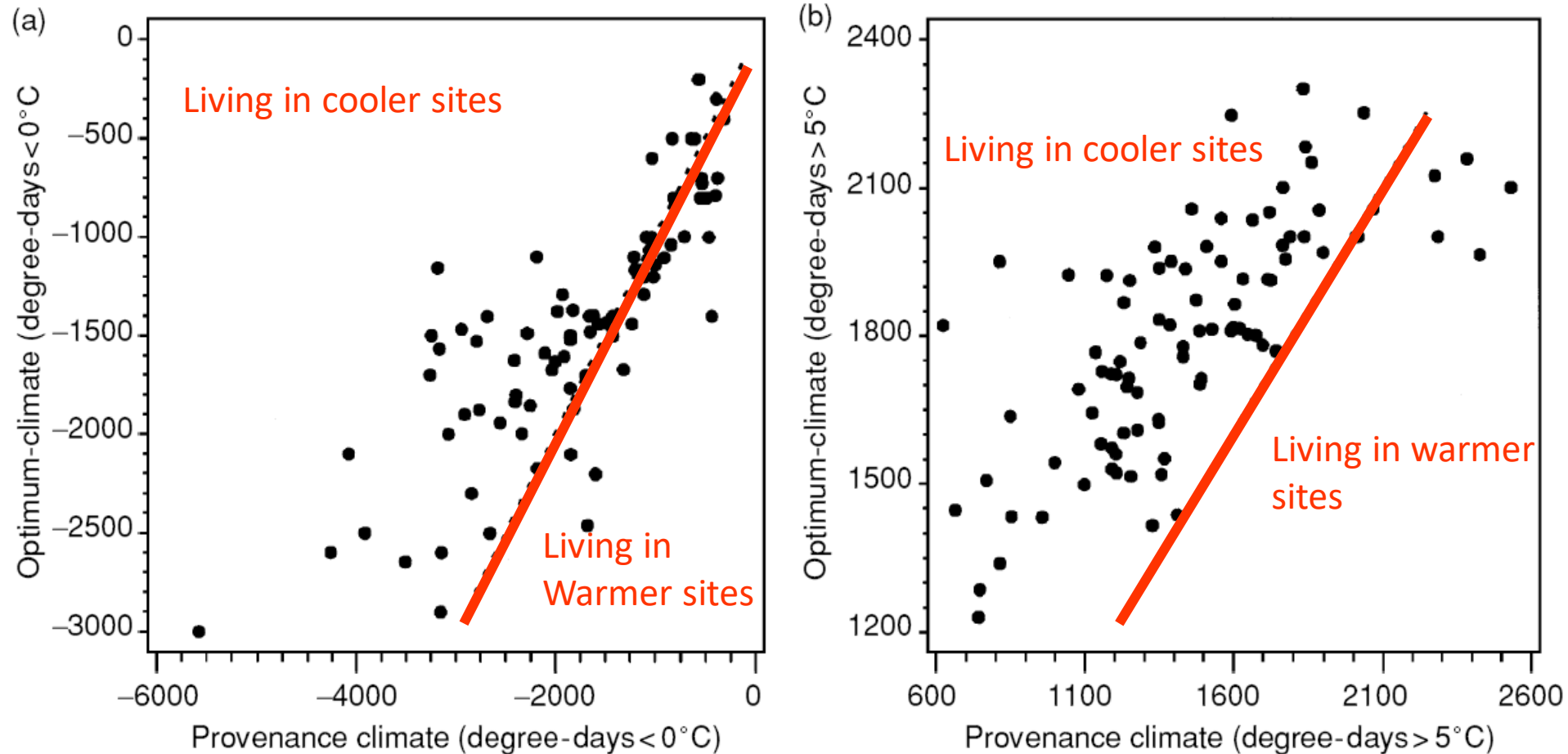


Rehfeldt, G.E., N.M. Tchebakova, Y.I. Parfenova, W.R. Wykoff, N.A. Kouzmina, and L.I. Milyutin. 2002. Intraspecific responses to climate in *Pinus sylvestris*. *Global Change Biology* 8: 1-18.



Climatic suboptimum!

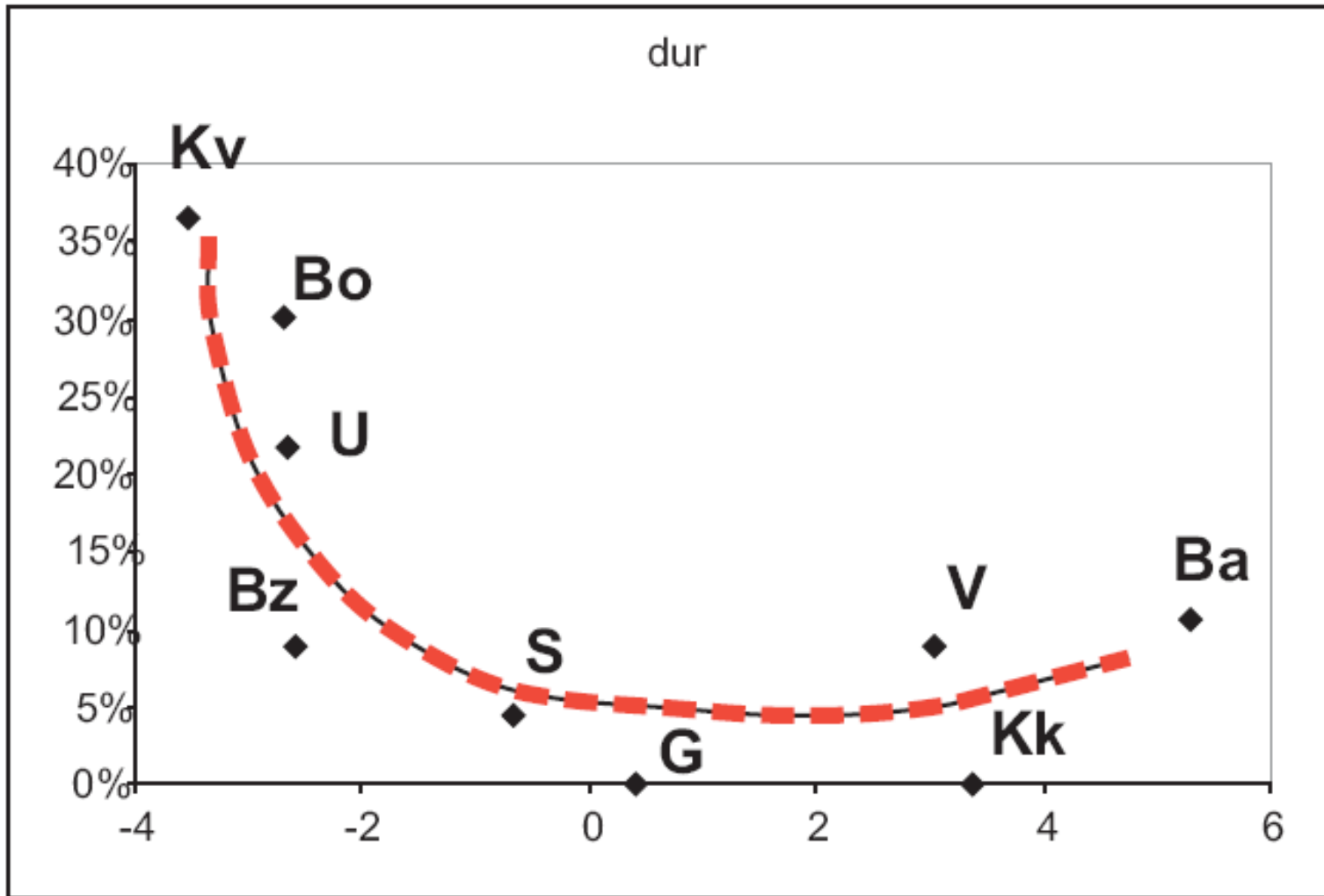
110 populations 47 sites



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.

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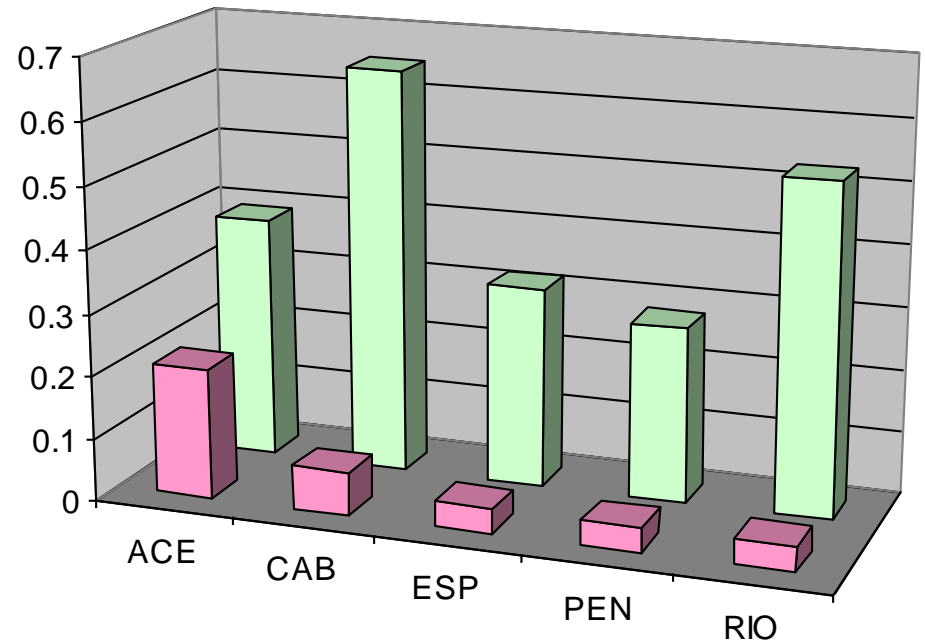




Phenotypic Plasticity

Height growth

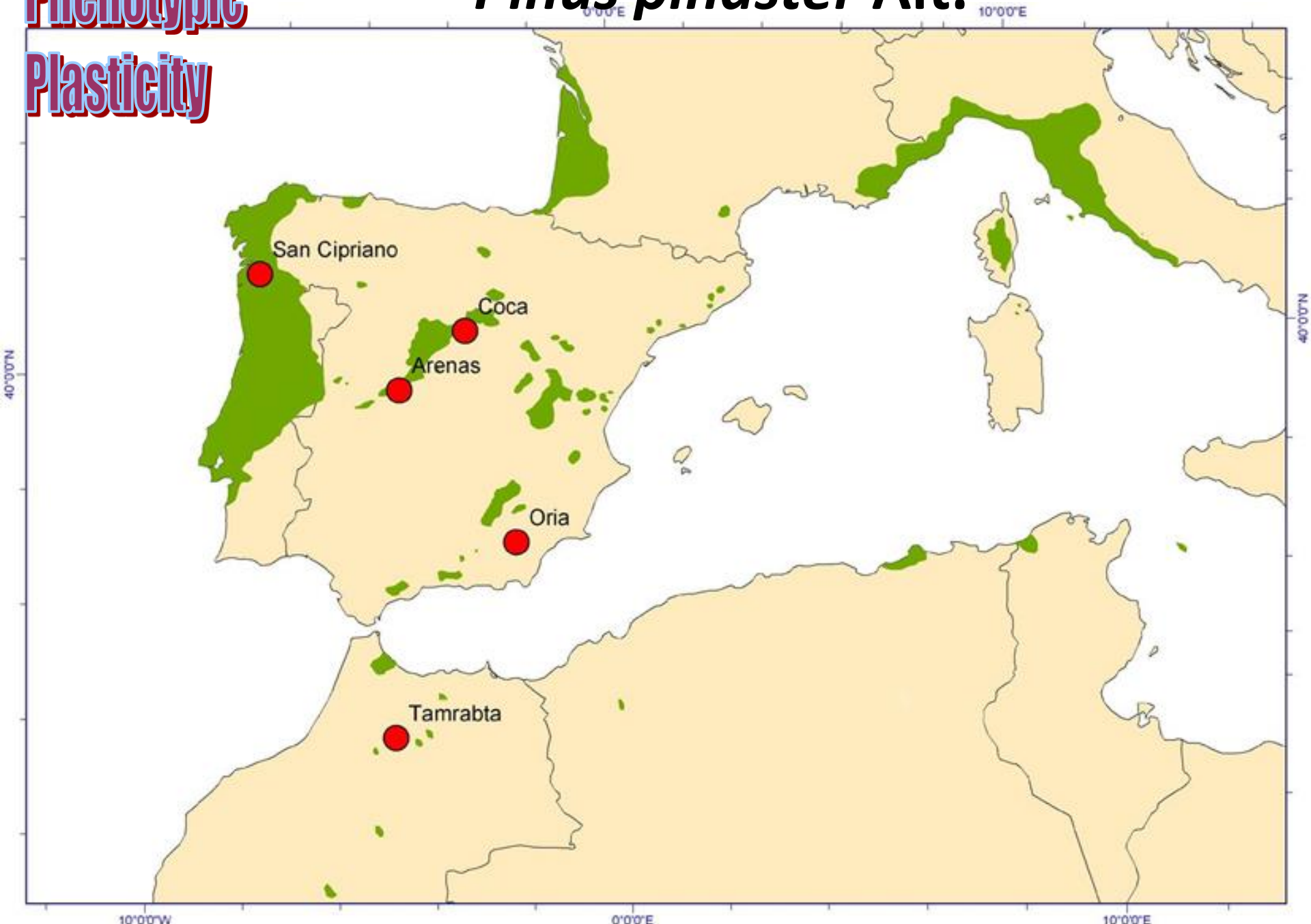
Pinus pinaster, 32 y.o. provenance trial



Phenotypic

Plasticity

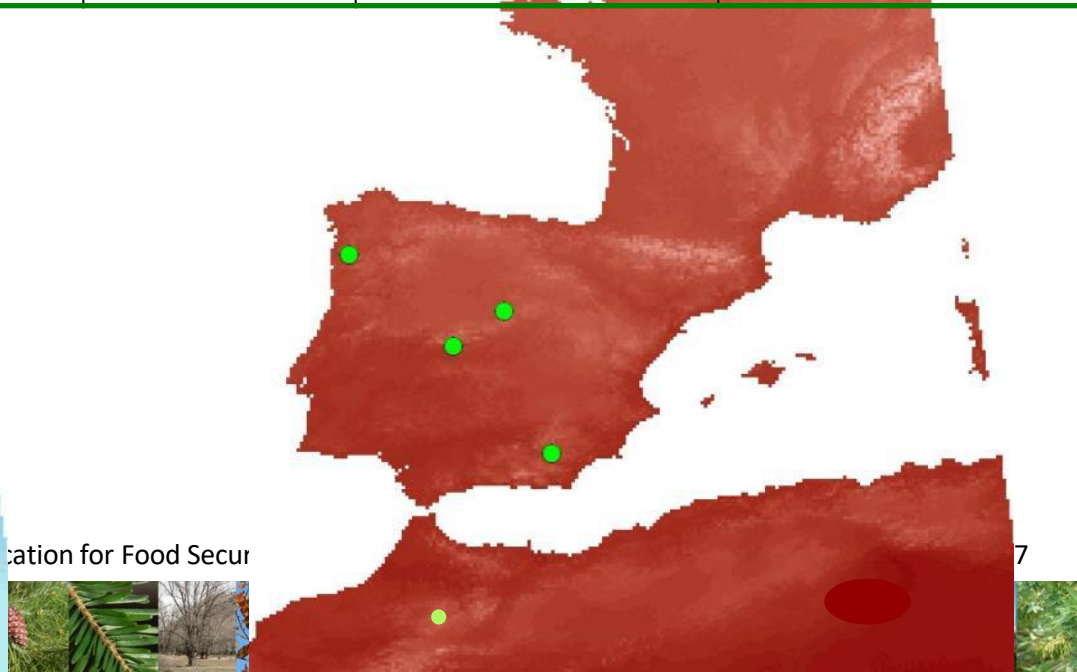
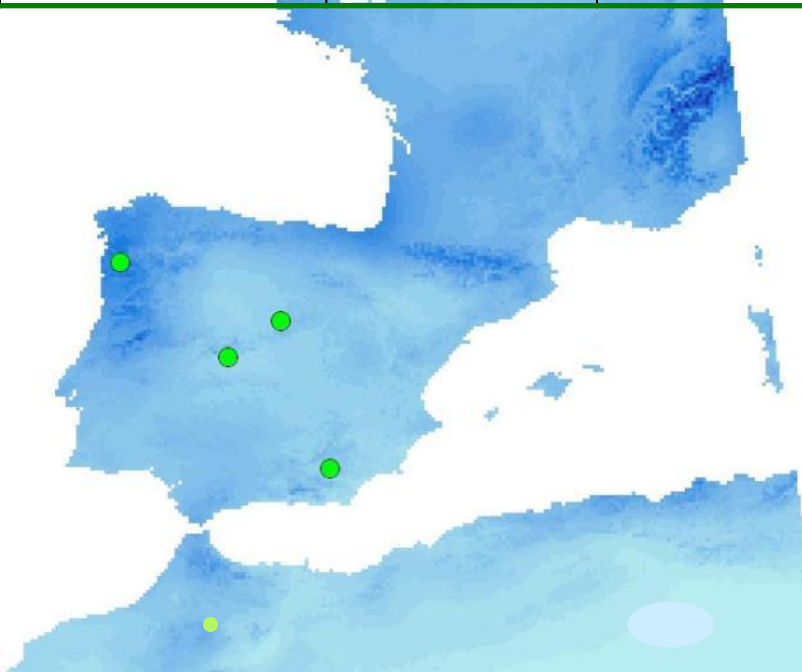
Pinus pinaster Ait.



Spain climate



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

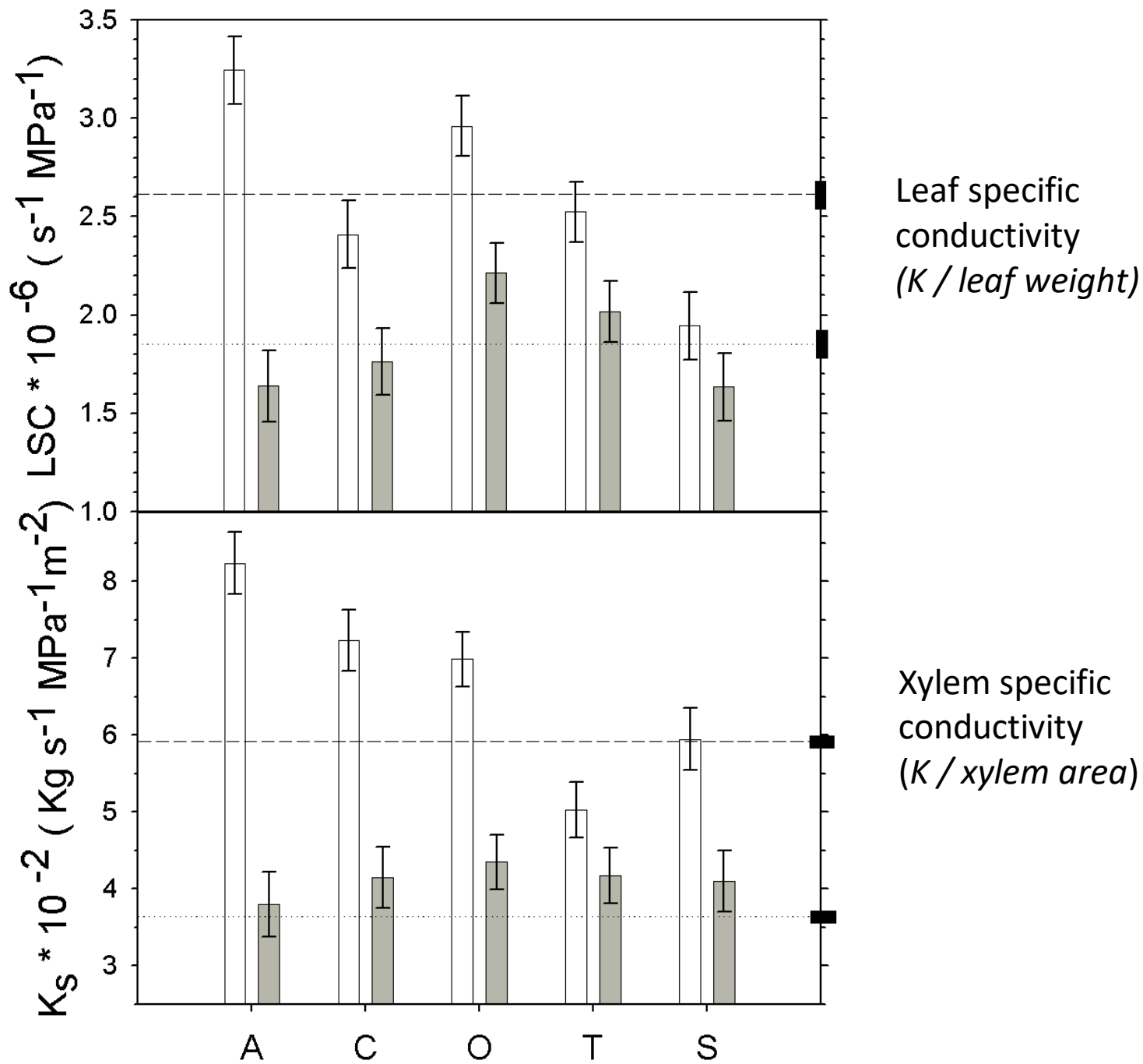
Anova summary

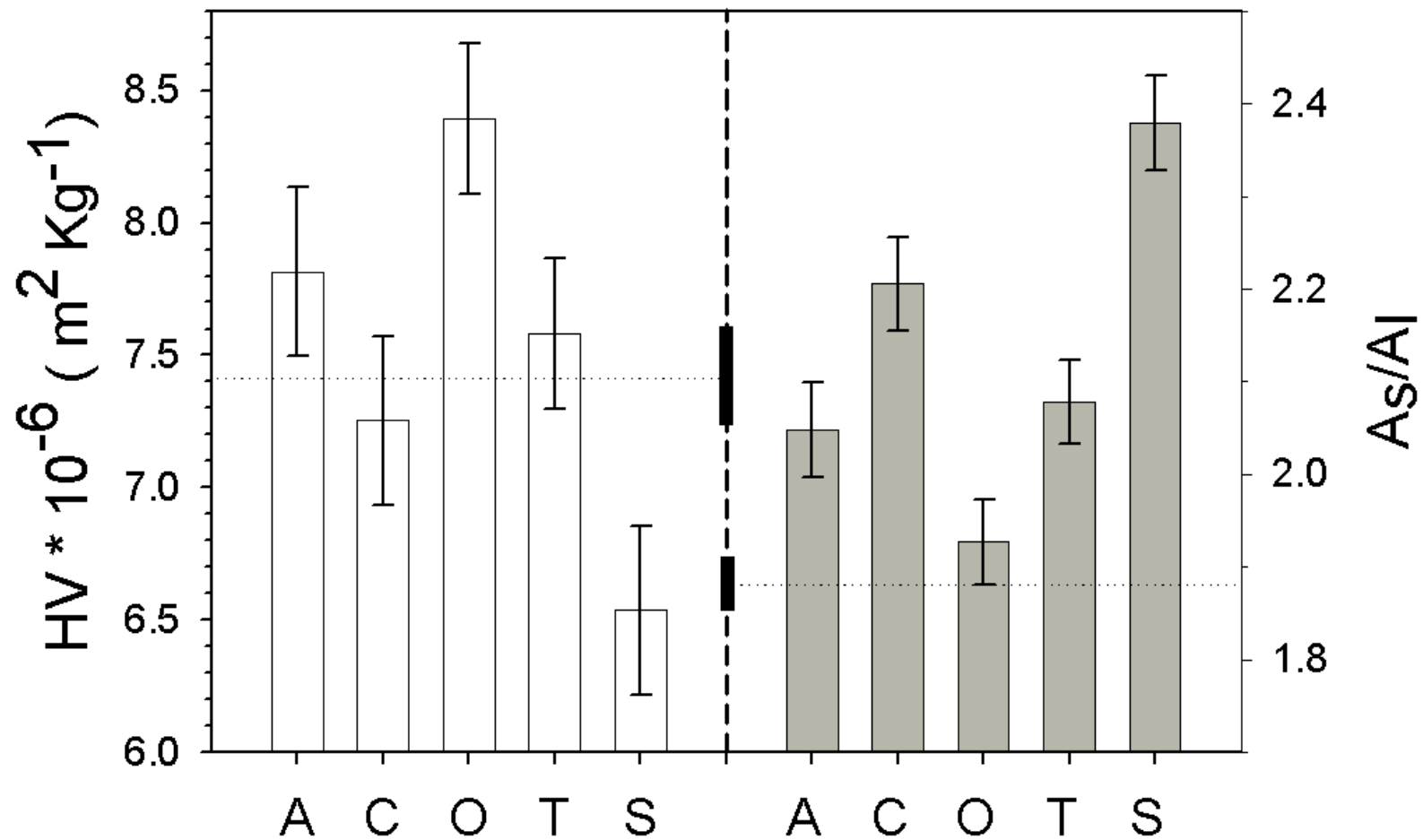
	Conductivity				13	H	D	Allocation							Rooting S				
S	***	***			**										***	***	***	***	***
P	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
PxS	***	***		***	***											*		**	
F	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
FxS	***	**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

Wood Anatomy

	L	W
F	***	**

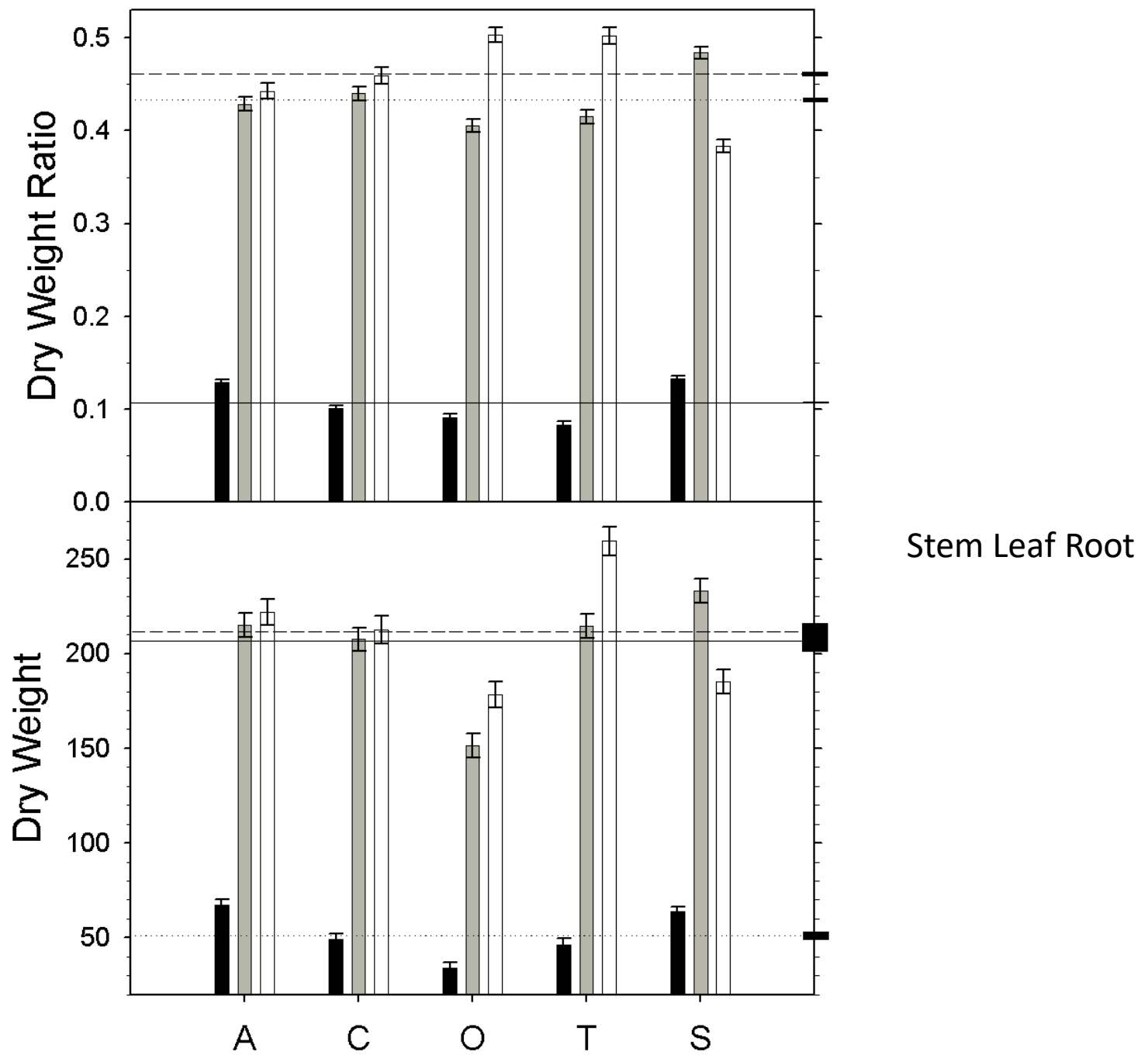




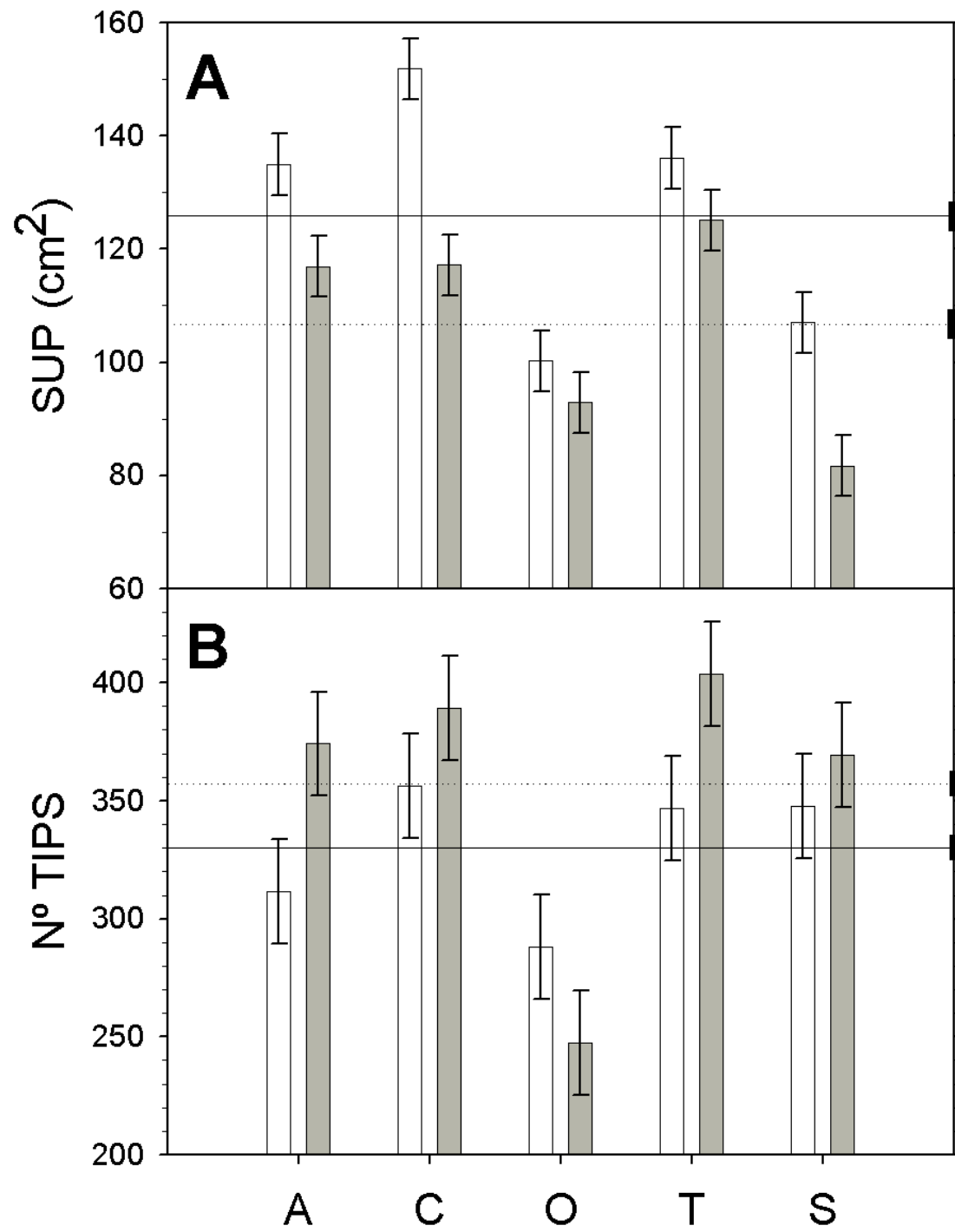


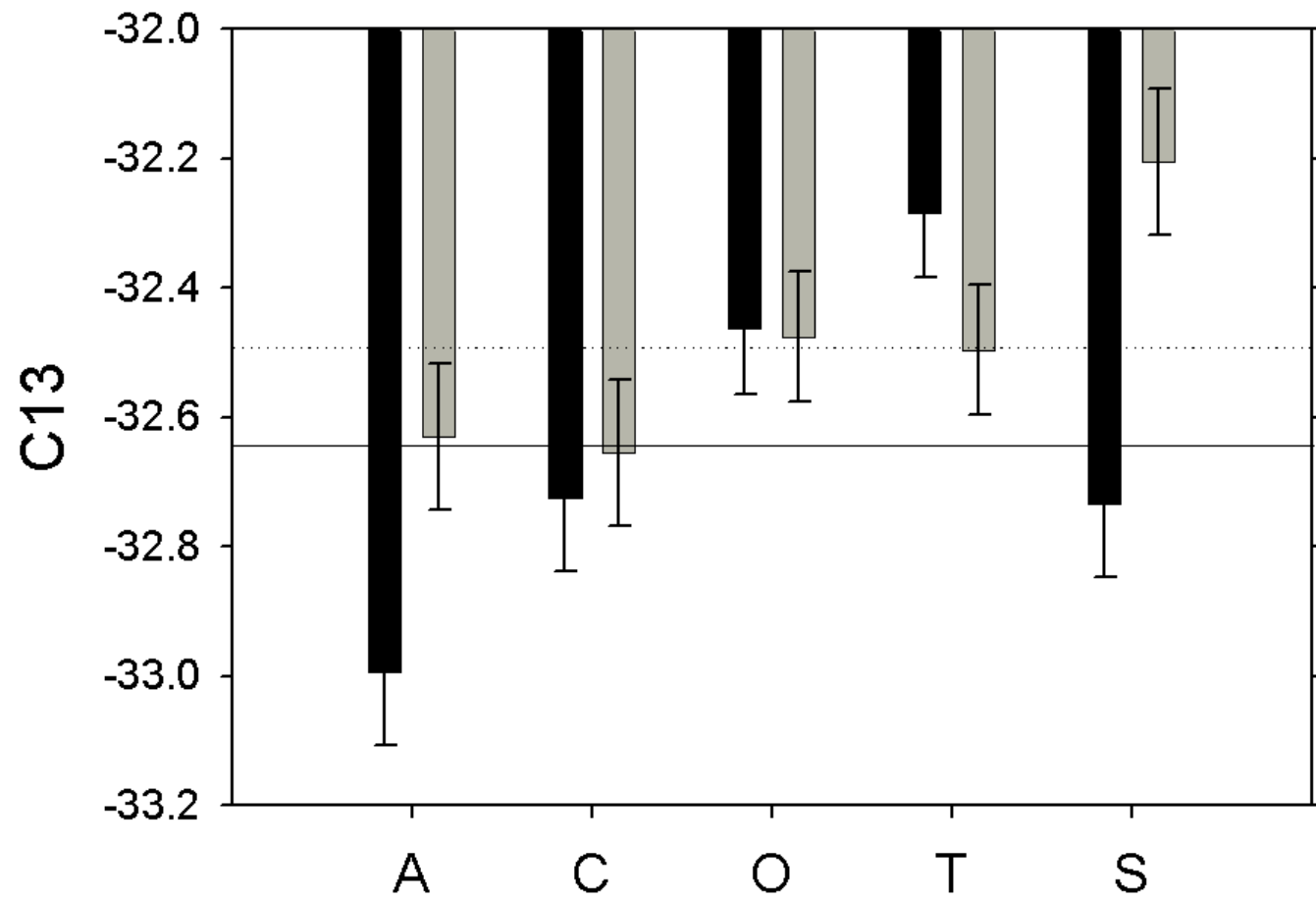
Cross xylem area / leaf weight

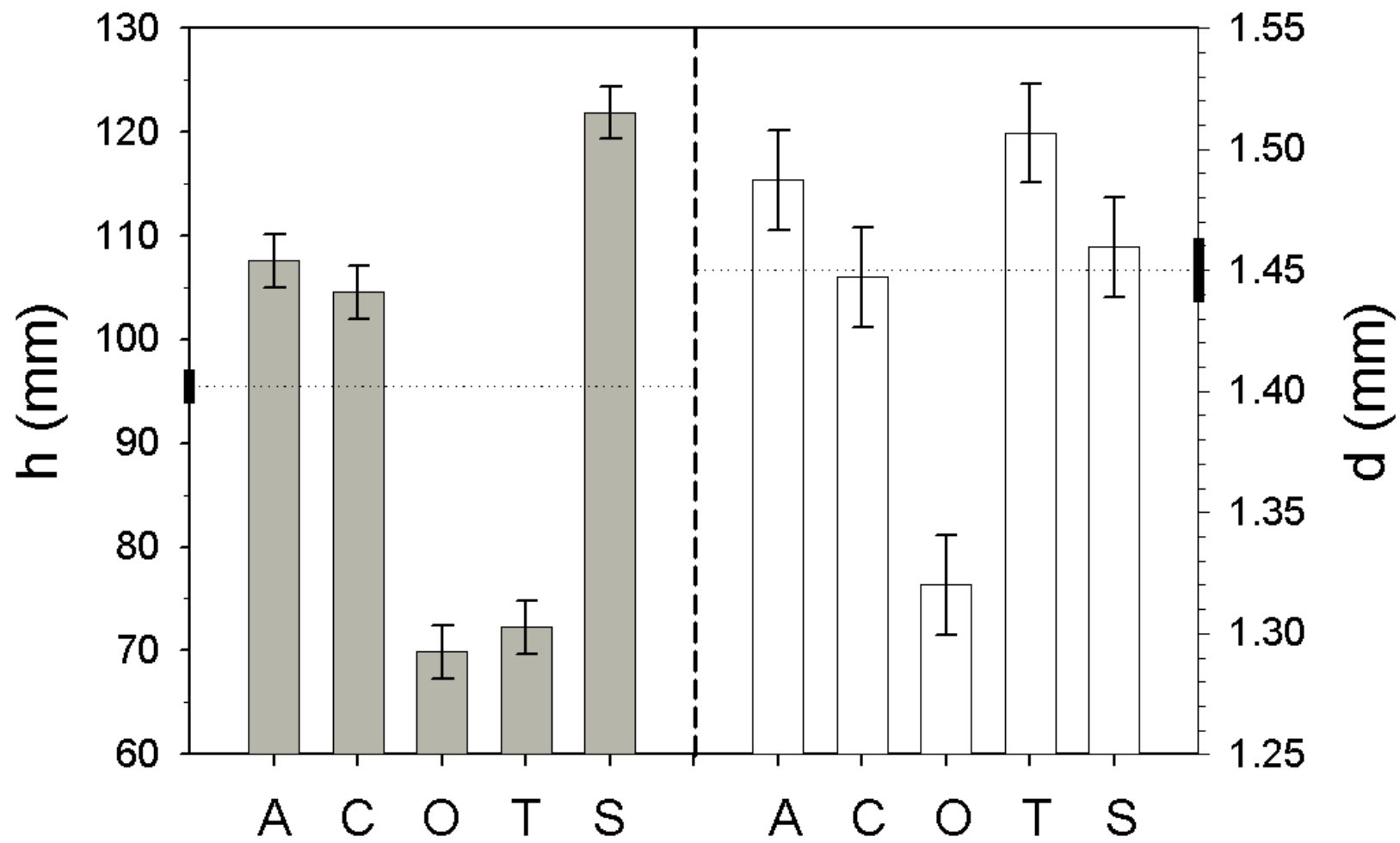
Leaf area / xylem area



Rooting system

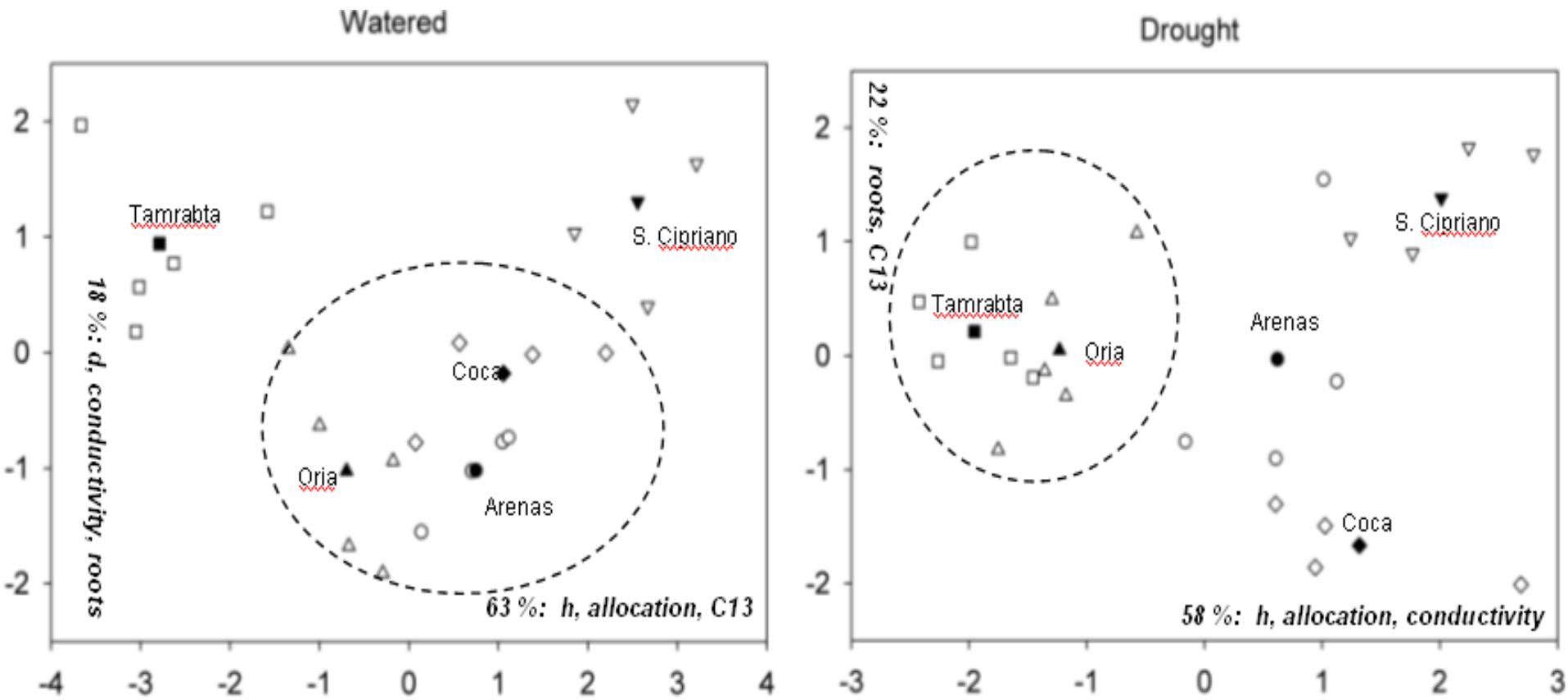






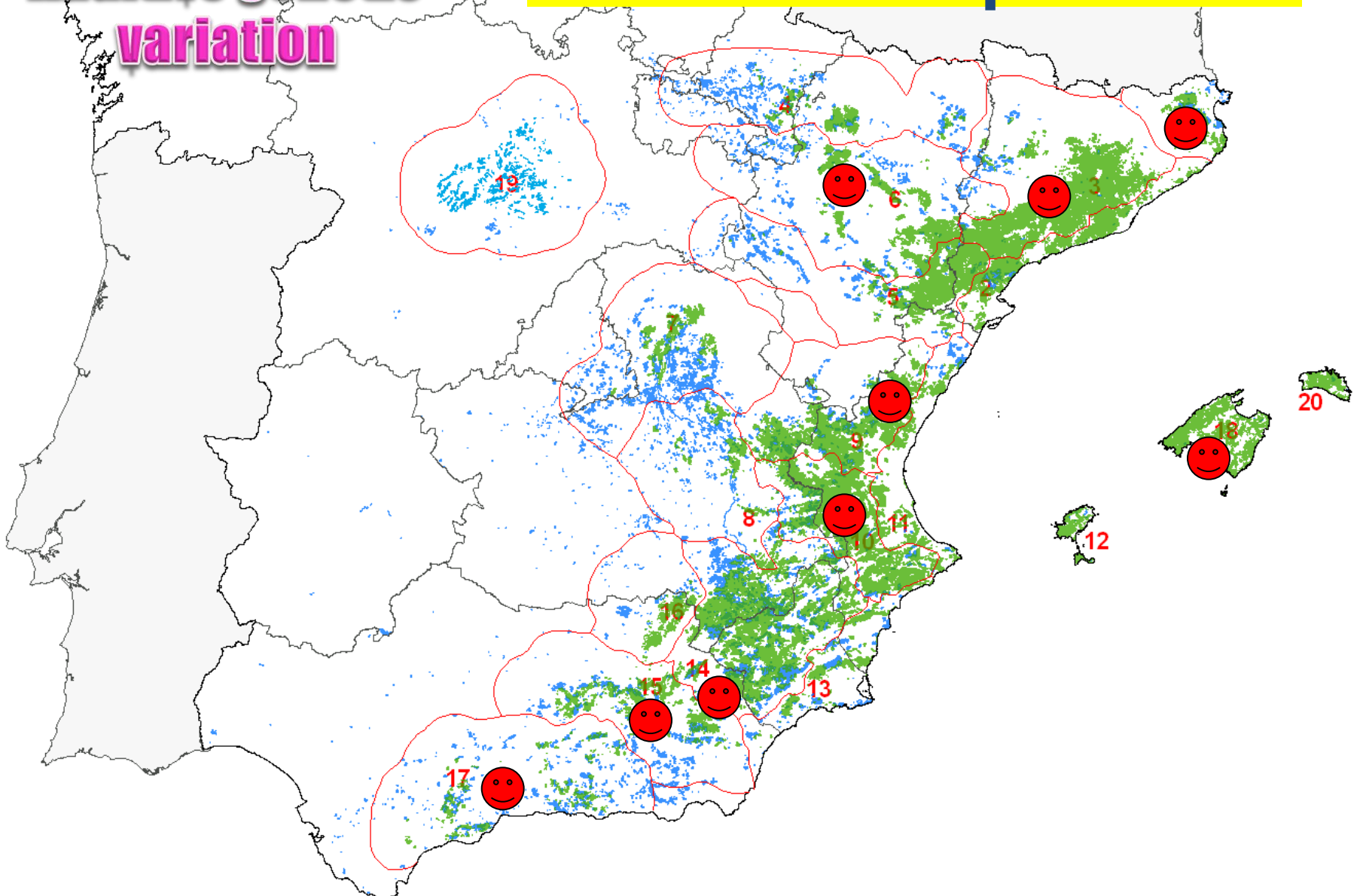
Plasticity for drought (physiology, morphology, WUE)

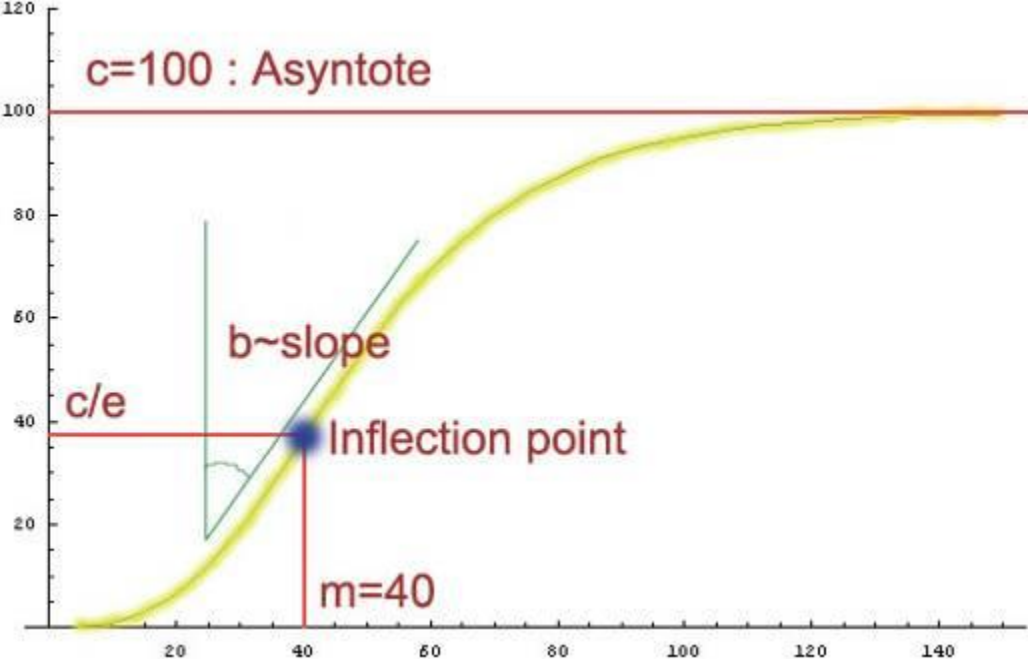
Pinus pinaster, Provenance/Progeny trial under controlled environment



Additive genetic variation

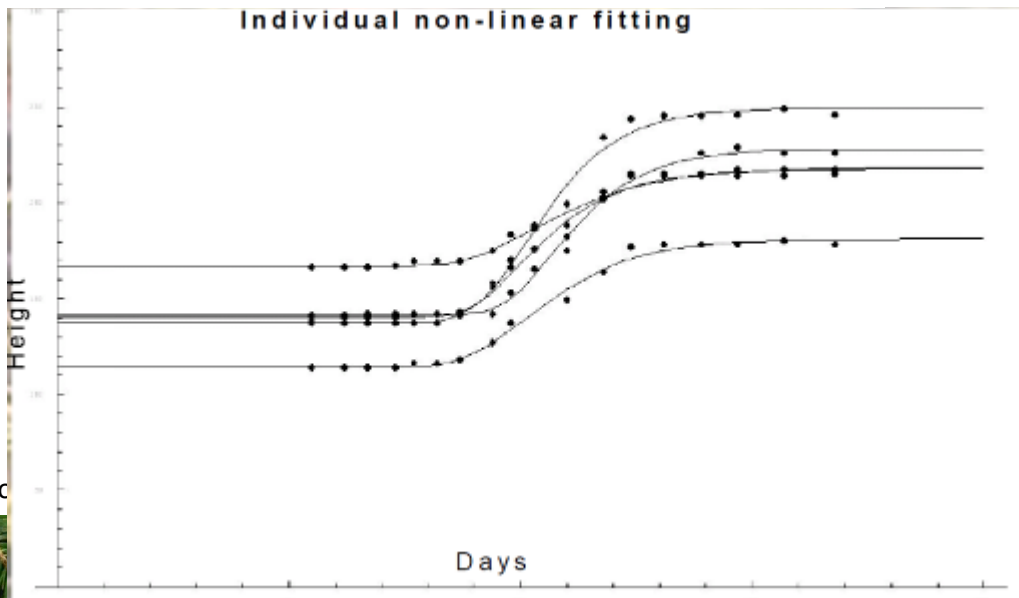
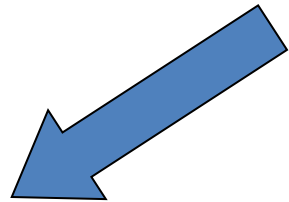
Pinus halepensis





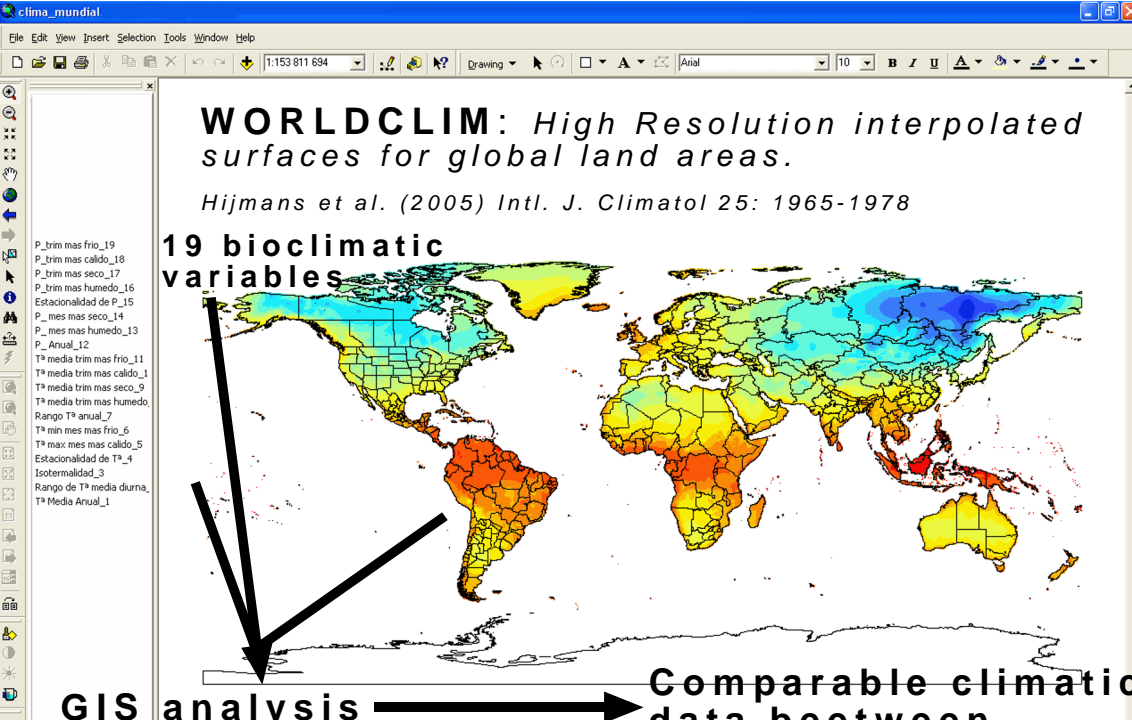
Gompertz model: $H = h + c e^{-e^{-b(-m+t)}}$

**c, b, m,
t10, t90 & dur**



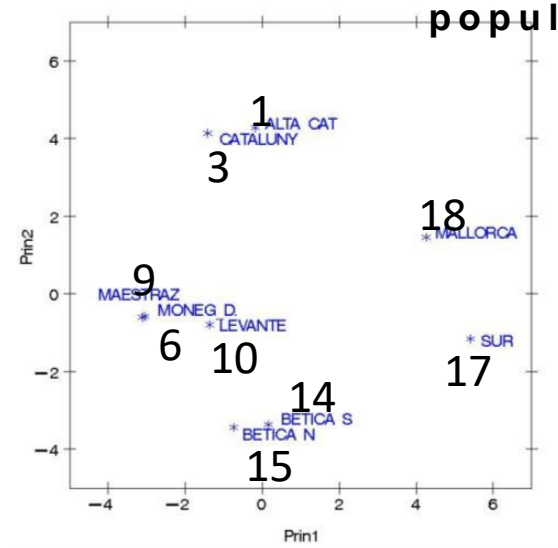
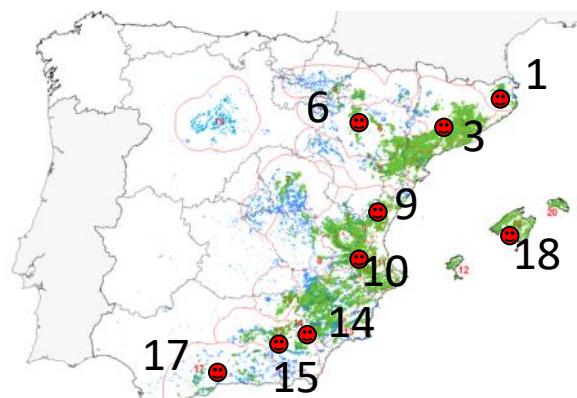
Spain climate





GIS

ESRI Grids
Spatial Analyst
Neighbourhood statistics
25 Km radius



- 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



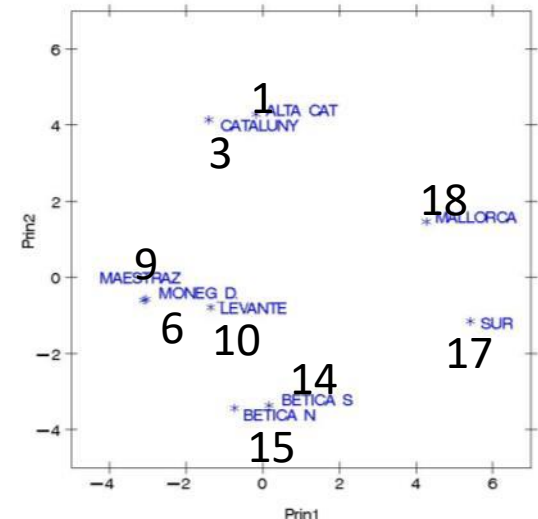
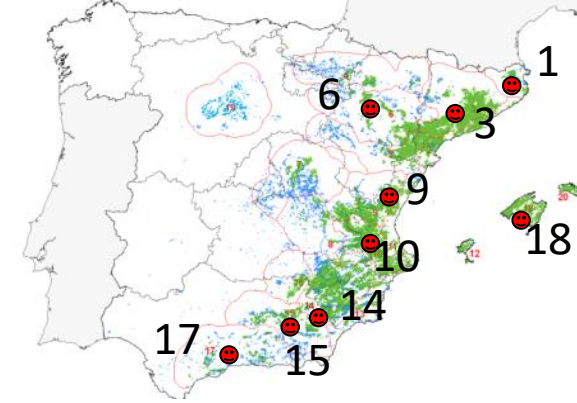
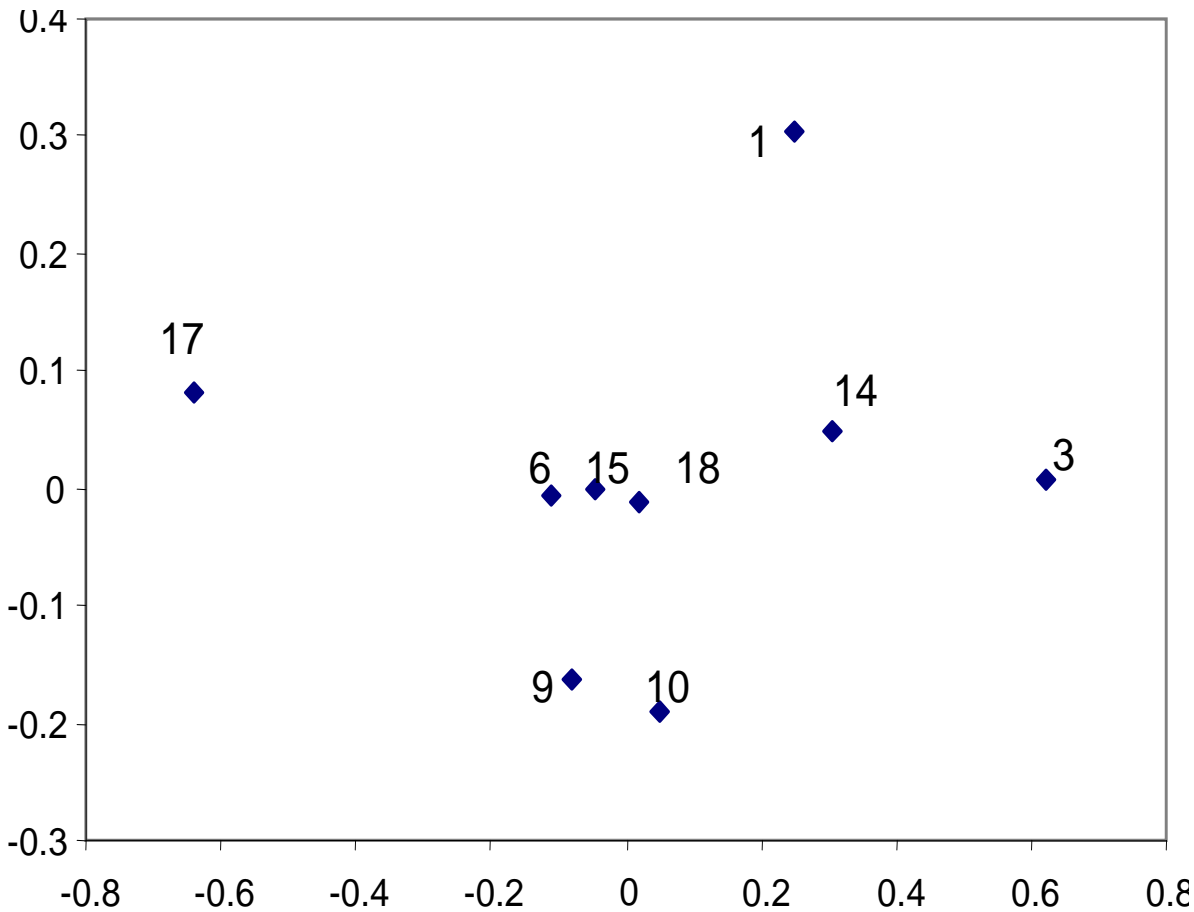
Results

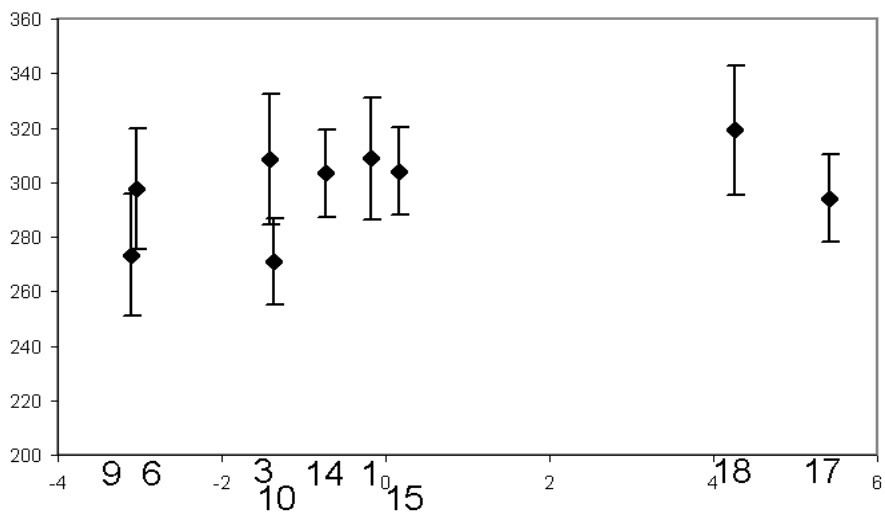
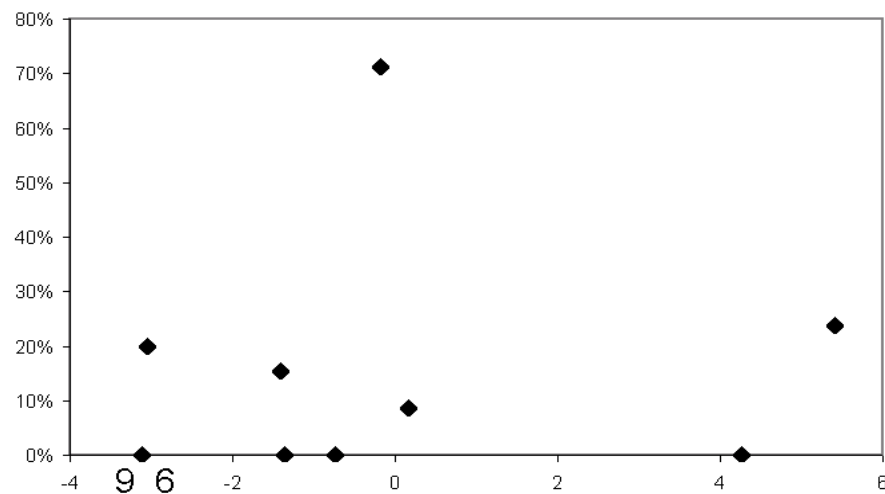
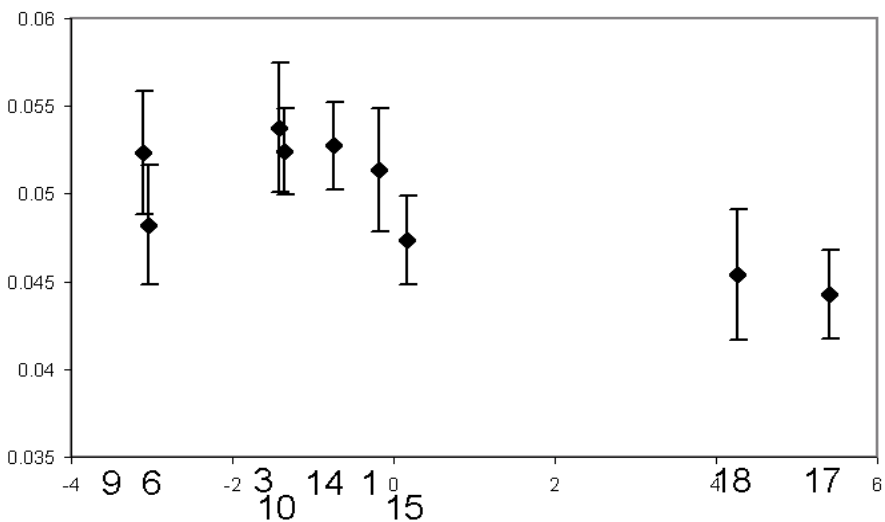
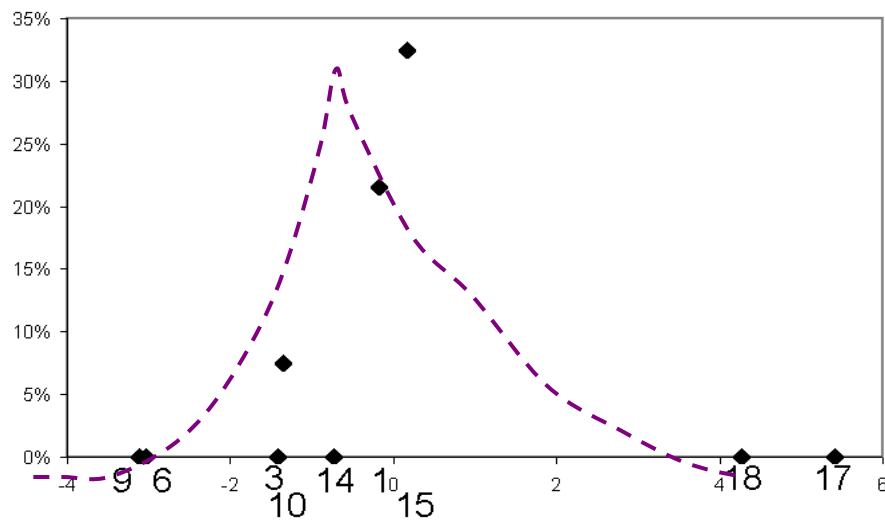
- Very accurately fitting (error<3%)
- Population effect significant for **t10, t90 & dur**
- But not for **c, b, m**
- PCA 1&2 absorbed 90% variation, but not clear grouping of populations (not very different?)
- CVa: Additive coefficient of variance as adaptive potential index



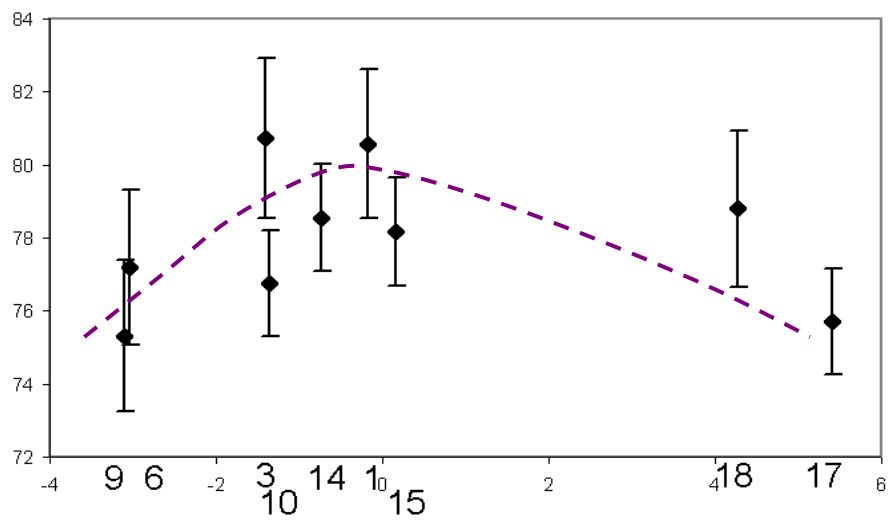
Multivariate analysis: Geographical grouping?

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

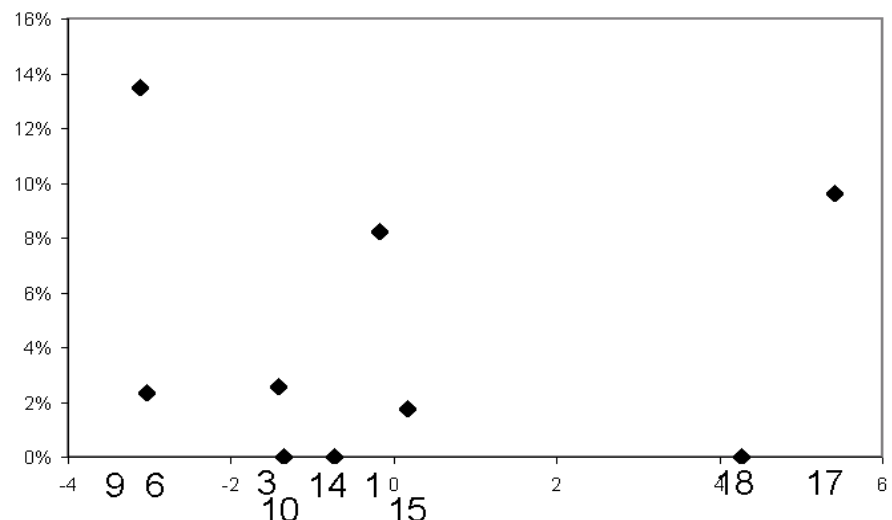


c**c****b****b**

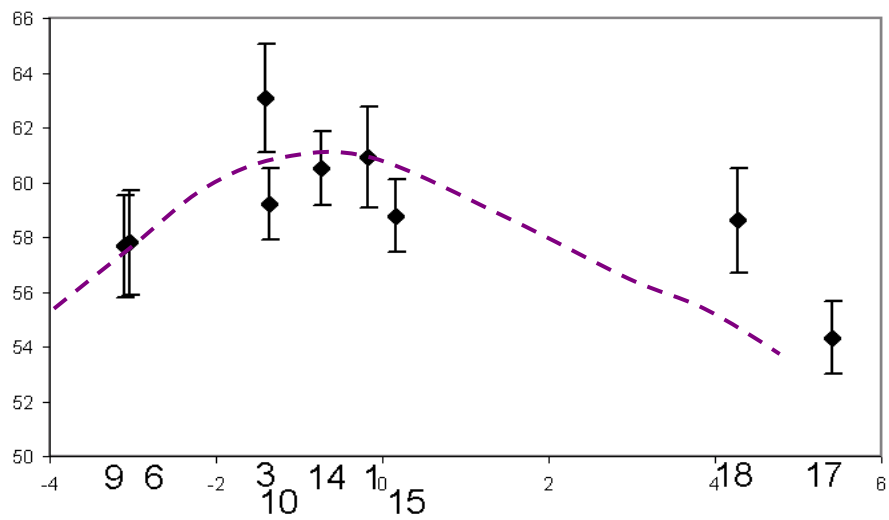
m



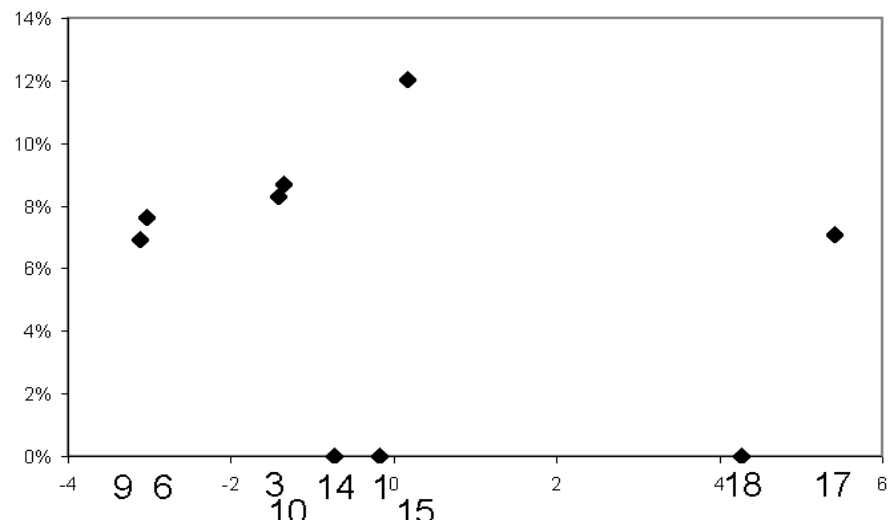
m



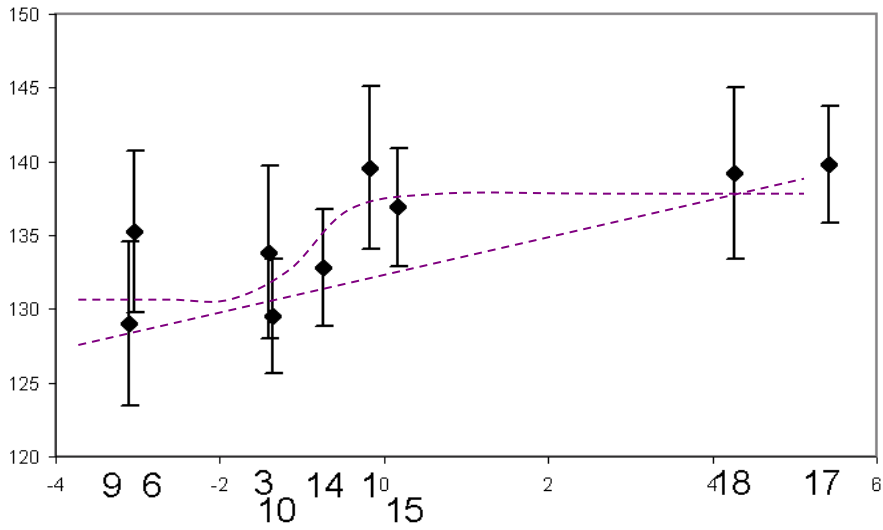
t10



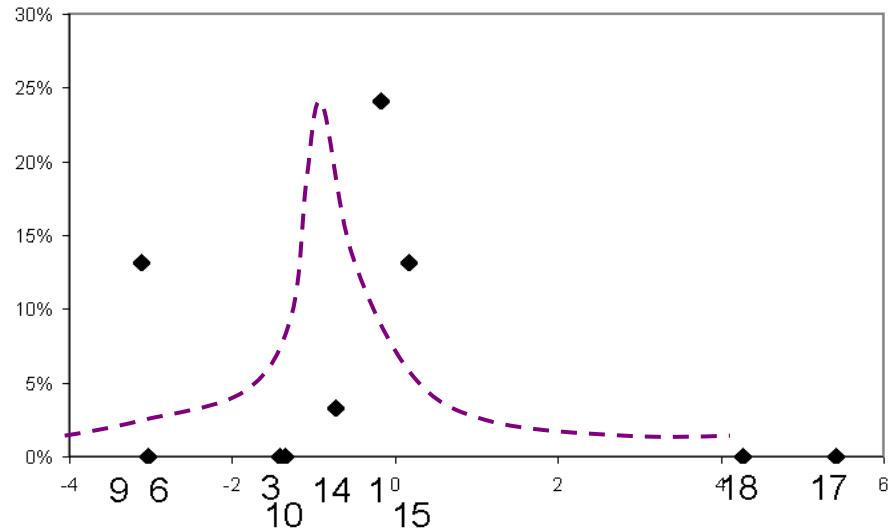
t10



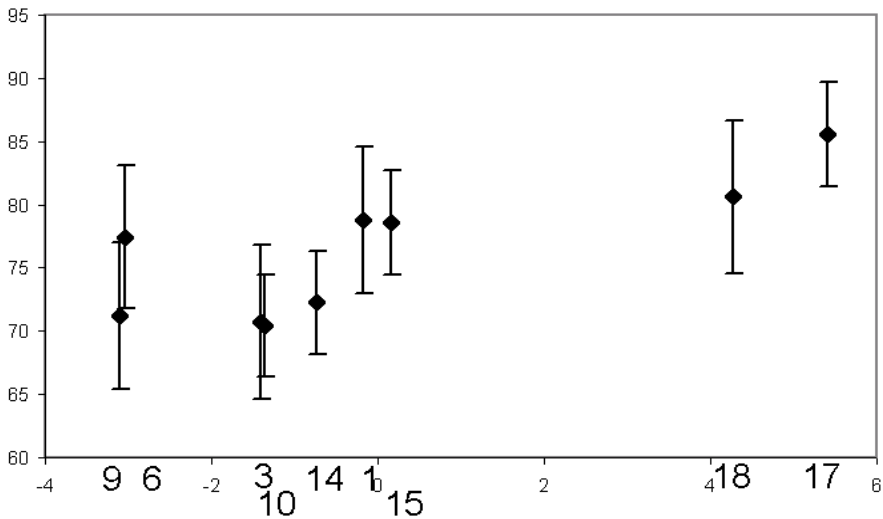
t90



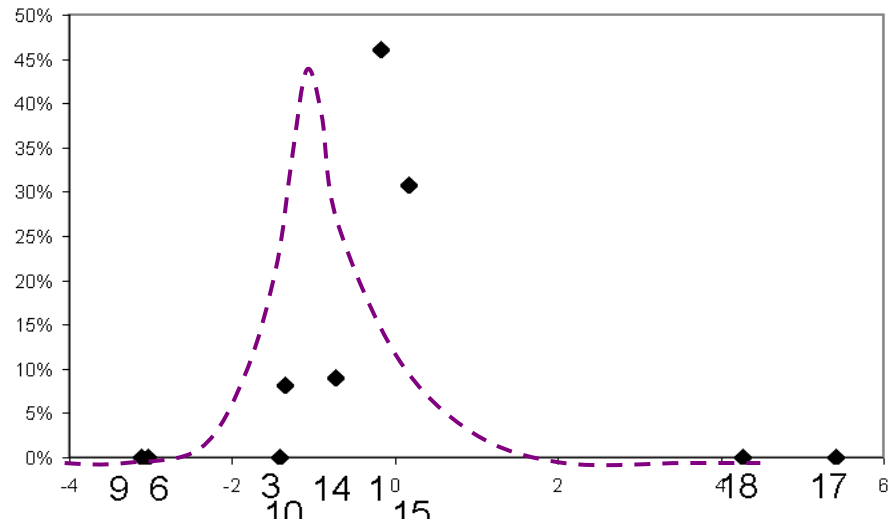
t90



dur

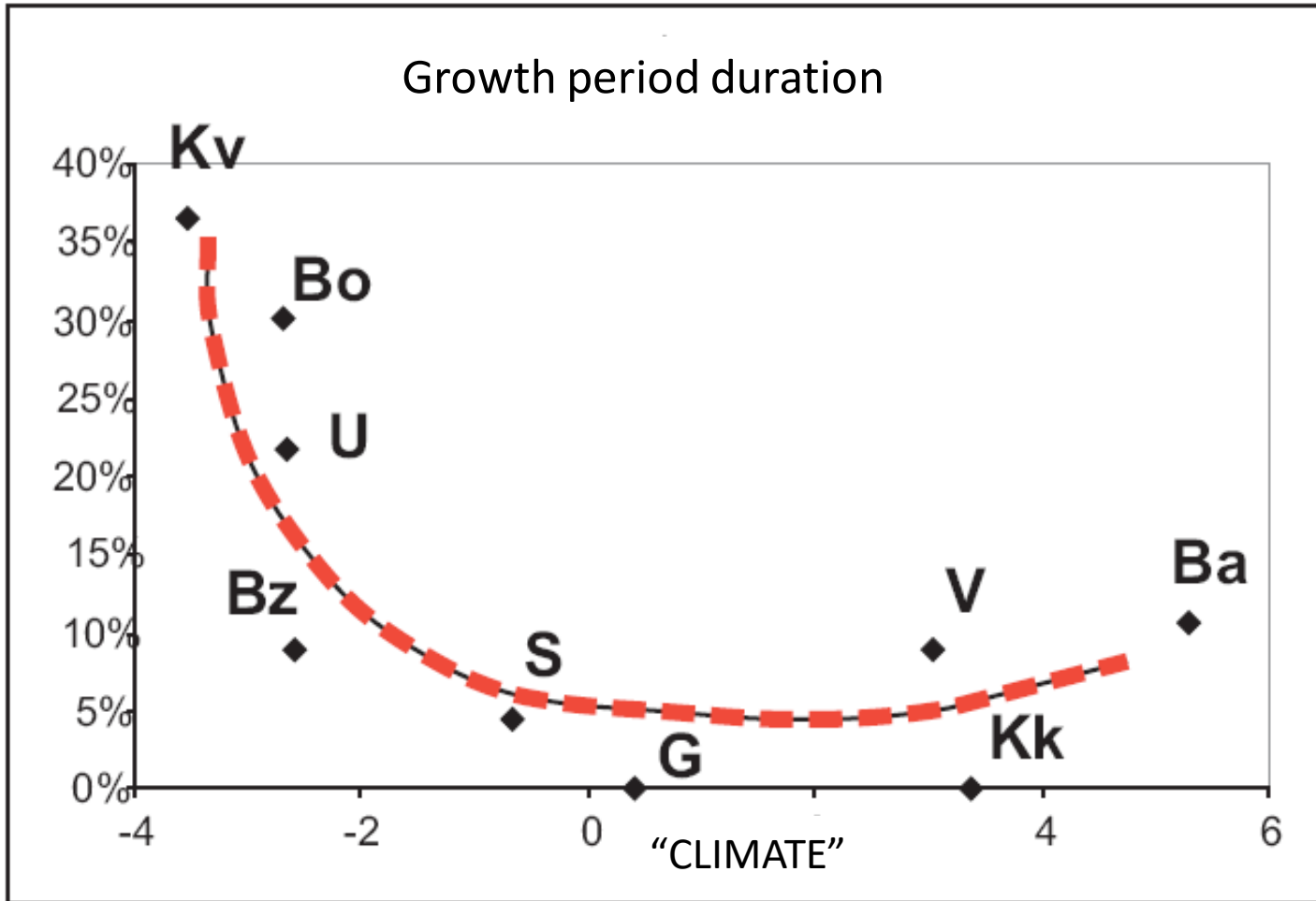


dur



Coef. genetic additive variance

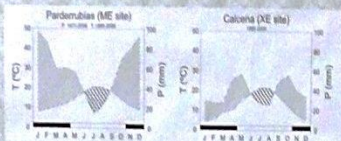
9 *Pinus sylvestris* populations (natural distribution area)



Variation in biochemical stress indicators among *Pinus pinaster* genotypes

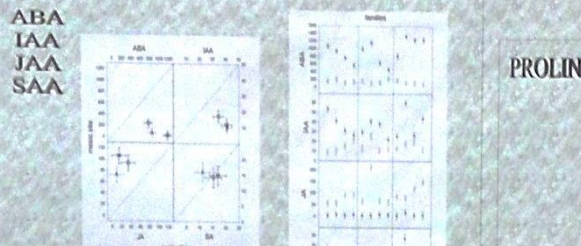


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Government of Aragón, 50059 Zaragoza, Spain, lcorcuera@aragon.es



Genotype	Origin	Year	Site	ABA (ng/g)	IAA (ng/g)	JAA (ng/g)	SAA (ng/g)	PROLINE (mg/g)
Arnavia	Spain	2007	ME	1.2	0.8	0.5	0.3	15
Oriz	Spain	2007	ME	1.5	1.0	0.6	0.4	18
Miseric	Spain	2007	ME	1.8	1.2	0.7	0.5	22
Arnavia	Spain	2007	XE	1.0	0.7	0.4	0.2	12
Oriz	Spain	2007	XE	1.3	0.9	0.5	0.3	16
Miseric	Spain	2007	XE	1.6	1.1	0.6	0.4	20

INTRODUCTION
Pines and phytohormones (abscisic acid, ABA; jasmonic acid, JA; indoleacetic acid, IAA; salicylic acid, SA) participate in plants in response to biotic and abiotic stress. The positive effect of these compounds play a key role in plant adaptation to adverse environmental conditions, inducing an increased resistance to stress factors of different origin.
The aim of the study was to evaluate the phenotypic diversity and phylogenetic relation of these metabolites in *Pinus pinaster* and to determine the best indicators for family and population discrimination.



Genotype	ME (Pardenubias)				XE (Calonsá)				
	Arnavia	Oriz	Miseric	Arnavia	Oriz	Miseric	Arnavia	Oriz	Miseric
ABA	1.2	1.5	1.8	1.0	1.3	1.6	0.8	1.1	1.4
IAA	0.8	1.0	1.2	0.7	0.9	1.1	0.5	0.7	0.9
JAA	0.5	0.6	0.7	0.4	0.5	0.6	0.3	0.4	0.5
SAA	0.3	0.4	0.5	0.2	0.3	0.4	0.1	0.2	0.3
PROLINE	15	18	22	12	16	20	10	14	18

Genotype	ME (Pardenubias)				XE (Calonsá)				
	Arnavia	Oriz	Miseric	Arnavia	Oriz	Miseric	Arnavia	Oriz	Miseric
ABA	1.2	1.5	1.8	1.0	1.3	1.6	0.8	1.1	1.4
IAA	0.8	1.0	1.2	0.7	0.9	1.1	0.5	0.7	0.9
JAA	0.5	0.6	0.7	0.4	0.5	0.6	0.3	0.4	0.5
SAA	0.3	0.4	0.5	0.2	0.3	0.4	0.1	0.2	0.3
PROLINE	15	18	22	12	16	20	10	14	18

CONCLUSIONS
The environmental effect was remarkable as the ME had a highly significant effect on ABA, IAA, JA and PROLINE (Table IA, IIA). As expected, the production of metabolites (ABA, IAA and PROLINE) increased in the xeric site (below the diagonal line, Fig. 3) and (JA), excepting for JA, which showed higher accumulation in the mesic site (above the diagonal line, Fig. 3), probably related to plant protection from pests and pathogens in humid sites, and SA, which ABA, JA and PROLINE displayed a G x E interaction (Table IA, IIA).
POPULATION EFFECTS
ABA and PROLINE discriminated among populations in the xeric site, where the French population, Miseric, presented the higher concentration (Table IB, IIB). JA discriminated among populations in both sites, but population differences were small (Table IB, IIC, Fig. 3).
FAMILY EFFECTS
All the stress indicators showed significant family variation in both sites (Table IB, IIC, IIB, IIC).
The plasticity of PROLINE, ABA, IAA and JA and its genetic variation at the population and family level would be useful for the selection of resistant genotypes in the framework of global warming.

POTENCIALIDAD DEL USO DE LA DIFERENCIACION GENETICA EN LA FIJACION DE C EN PINOS IBERICOS

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