Cork "paper" is a thin lengthway slice of cork obtained from cork board

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Cork "paper"

HANDBOOK of the EU concerted action on cork oak, FAIR I CT 95 0202 • Edited by Maria Carolina Varela

INIA - Estação Florestal Nacional

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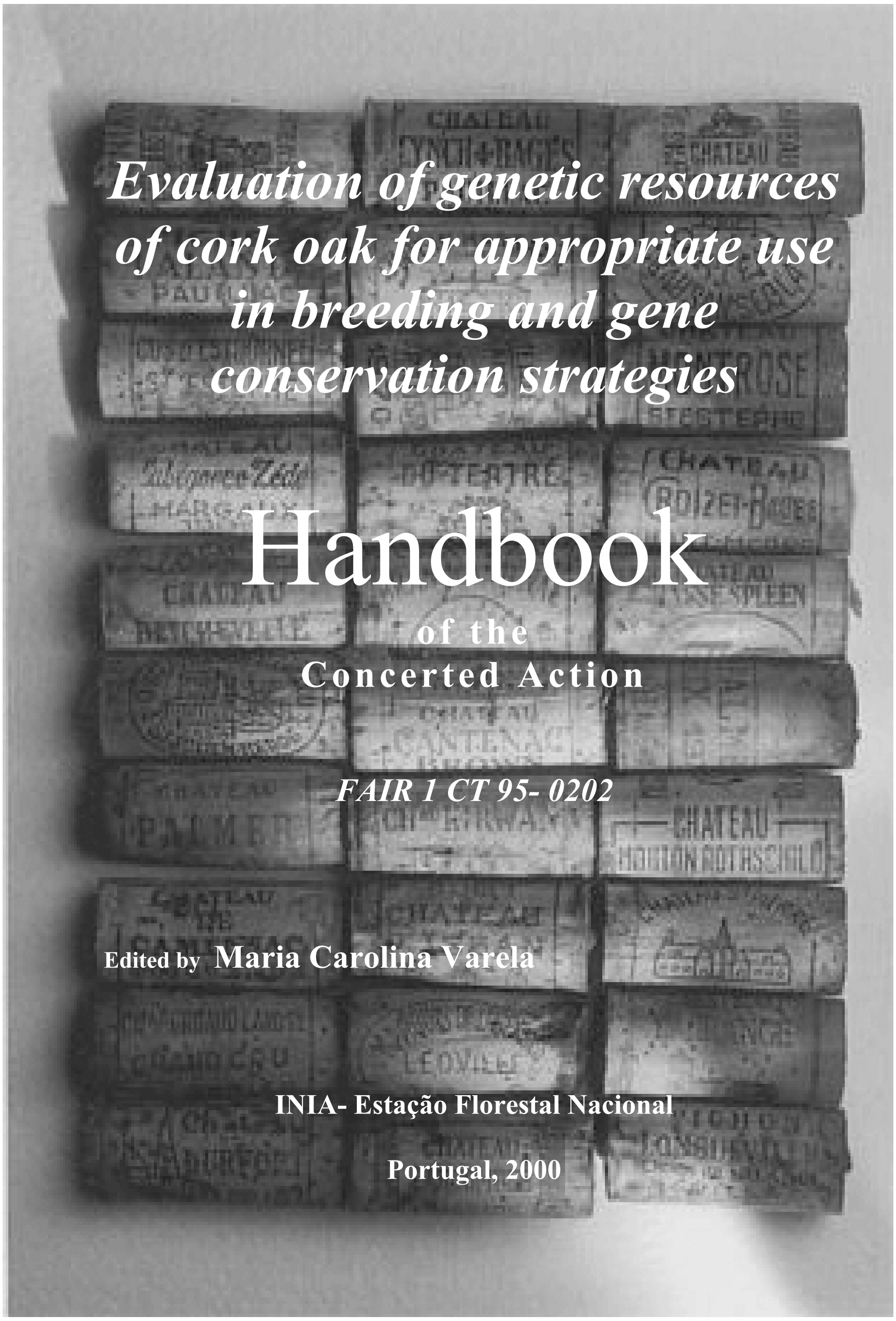

Evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies

Handbook

of the
Concerted Action

FAIR 1 CT 95- 0202

Edited by Maria Carolina Varela

INIA- Estação Florestal Nacional

Portugal, 2000

HANDBOOK

of the

Concerted Action

"European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies"

Reference ***- FAIR 1 CT 95- 0202***

1996-2000

Funded by **EC** FAIR Programme

Main objectives and tasks of the project

Targeted to the scientific and technical community anyhow interested on cork oak genetic improvement, indirectly useful for genetic research of other forest species, the HANDBOOK intends to summarise the main discussions and achievements of the European Union funded projects FAIR 1 CT 95 0202 and Micro Action B7/4100.

The implementation of the projects has been framed by the objectives and tasks hereafter transcribed from the contract:

Title-"European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies"

General objective of the project:

THE OBJECTIVE IS to promote the establishment of simultaneous provenance and progeny trials under standardise methodologies, representative from all area of distribution of cork oak, by means of a network involving 6 European countries.

THE SPECIFIC OBJECTIVES ARE:

- Selection of provenances and trees in Portugal, France, Spain and Italy under common report forms for passport data.
- Standardised production (in a nursery in Portugal) of plants. Delivering of the plants for the establishment field trials in 4 European countries.
- Exchange of germoplasm among participants for (national funded) complementary studies.
- Databases: Promotion of a data bank for future utilisation on research projects synthesised in a handbook focusing the genetics of cork oak.

Main tasks

Task 1

Selection, identification and characterisation of stands and mother trees; Common passport report form for each stand and for each tree. Seed collection.

Task 2

2. 1. - Exchange of germoplasm for complementary studies in field, laboratory or phytotron under national financing - N. The co-ordinator is in charge of delivering the germoplasm according the requests.

Task 3

Storage of acorns. Plants sowing and lifting for immediate deliver

Task 4

Data bank

Task 6 - Establishment of field trials

Not financed by the concerted action

Task 9 -Handbook

Task 11

Individual labelling of all plants to be delivered by the project to all countries for field trials establishment.

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France

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Michel Bariteau

IML- Institut Méditerraneenne du Liège:
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Germany

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- i) Project Praxis 2100/95
- ii) **IFADAP** *

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* IFADAP- Instituto de Financiamento e Apoio ao Desenvolvimento da Agricultura Portuguesa

Foreword

(M.C. Varela, EFN, Portugal*)*

Through France, Italy, Portugal and Spain, European Union reaches the leader position on the production, industrial processing and trading of cork. Entirely based on indoor technology and knowledge, emphasised by a lack of concurrence within the forestry scenario, cork enjoys an odd position in the EU deficit forestry economy.

If in any species genetic research is never a goal in itself, rather an intermediate tool for the support of an overall concerted economical sustainable management system, the various oddities of its economical product- Cork- enhance on it a specific dimension.

Being one of the few Mediterranean forest activities with large positive balance, cork oak overwhelms itself on indirect ecological and social values that hardly will go on existing if cork loses its actual economical value.

The HANBOOK of the concerted action FAIR 1 CT 95 0202 intends to summarise the discussions, methodologies, results and perspectives achieved by this European Union (EU) financed concerted action, complemented by the funding from the EU-DGIA/B Microaction B7 4100, both co-ordinated by Estação Florestal Nacional, Portugal.

Beyond the teams from the seven cork oak countries- Algeria, France, Italy, Morocco, Portugal, Spain and Tunisia- these EU projects have been enriched by the extensive experience on long living species from Germany and Sweden.

The implementation of the projects has also benefited from the co-operation of FAO/Silva Mediterranea network "Silviculture of *Quercus suber*" and from EUFORGEN *Quercus suber* network. The dialectic interaction among different backgrounds on technical and scientific expertise provided a level of genetic research ever before attained on cork oak.

A network of 17 trials based on common genetic entries that cover the entire area of cork oak (*Quercus suber* L.) is the most comprehensive and long lasting output of the projects, a unique collection of basic material for this species, where various research lines can find ground.

Cork oak, an odd species

Naturally restricted to the seven western Mediterranean countries - Algeria, France, Italy, Morocco, Portugal, Spain and Tunisia, (figure F1) - cork oak (*Quercus suber* L.) is the ONLY vegetal species able of renewable production of a cork with physic-chemical properties suited to feed an notorious industry- the cork stoppers for wine and spirits.

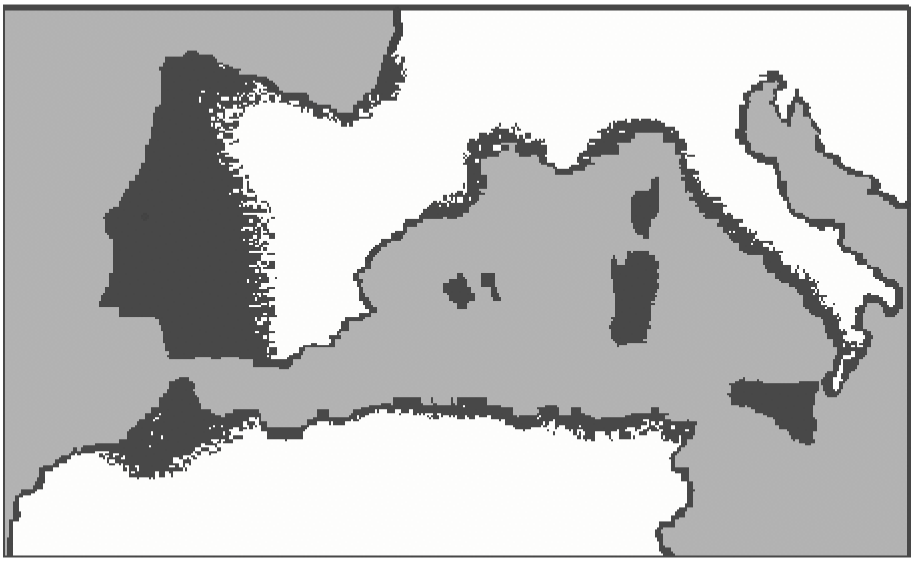

Figure F1- Cork oak natural range (Natividade JV, 1950)

Economical exploitation focused on a non-wood product while the use is concentrated on a consumer, the wine industry, induces a peculiar profile for cork oak at the forest scenario.

Using less 20% of the raw material but generating more than 80% of the economical income stoppers are the backbone of the entire cork oak chain.

Beyond the economical profile the species generates ecological and social benefits of major importance, especially for rural areas ongoing in human depressing phenomenon.

The overall sustainability of cork oak chain depends on cork continuity of being the elected material for stoppers on bottled wine and industrial innovation for the "non-stopper" cork.

Therefore, to cope with the growth on bottled wine market and assure the sustainability of the complex cork oak sector, the overall strategy for cork oak shall address simultaneous and concerted measures on 4 major axes:

- Silviculture and genetic improvement-Quality and quantity of cork production
- Industrial chain- Improvement of process, innovation and diversification
- Market actions for cork promotion
- International co-ordination under harmonised participation of all cork oak countries in close relation with wine sector

Implemented separately any of these actions may easily lead to poor use of financial and human investments.

The increase on the knowledge of the species and its economical scenario provided along the implementation of the projects was of great importance for other side actions.

The achievements of EUFORGEN** cork oak network are patent on publications providing a diffusion of results that goes beyond the project teams.

The creation of ***CORK MARK*** for cork defence deserves reference.

Available for some decades, cork-substituting materials are going through sophistication supported by aggressive marketing campaigns.

Under the scenario of outside threats to cork use the FAO/Silva Mediterranea network "Silviculture of *Quercus suber* L", internationally co-ordinated by Portugal, Estação Florestal Nacional, launched by 1998 the idea to create a trade mark for defence of cork products - the ***CORK MARK***, figure F2.

Figure F2 ***CORK MARK*** logotype

The creation of ***CORK MARK*** has been under the initiative and responsibility of "Silviculture of *Quercus suber*" network from FAO/Silva Mediterranea, co-ordinated by Portugal, Estação Florestal Nacional. The process has been participated by 12 countries, more than 60 public and private institutions, where wine sector participation is to be underlined.

CORK MARK is now a trade registered mark at European Union, Australia, United States of America, New Zealand and Switzerland.

** European Forest Genetic Resources Programme, EUFORGEN is a collaborative programme among European countries under the International Plant Genetic Resources Institute (IPGRI)

Genetic research as a part an overall strategy for cork oak

Gathering the scientific co-operation of North Africa cork oak countries through the financing coming from EU DGIA/B, the present project honours one of the few situations where teams of the 7 countries have worked together and synergistically.

The present project has given its contribution on the basic steps for the first issue, while opening perspectives for enhancement of the genetic research on the species.

Genetic research for increasing the surface and the use of better reproductive material are basic requirements at any strategy for the species.
A unique network of provenance and progeny trials never touched before for the species has been attained under this EU financed project.

Data basis overlapping and gaps on cork oak research

Overlapping and gaps on genetic research of cork oak drive a poor use of human and material means available for the needs on this subject. Therefore the project has pay attention to the implementation of a data basis for cork oak genetic research in order to provide guidance to the scientific community and responsible for research programs and funding.

A cork board
... old tree,
old times

Source: "Cortiça" IPF, Portugal

I- Introduction: Brief Synthesis of the Current Knowledge on Cork Oak

(R. Bellarosa, Univ. of Viterbo, DISAFRI, Italy*)*

Morphology

The cork oak belongs to the *Fagaceae* family and it is an evergreen oak whose arboreal individuals reach an average height of 15-20 meters, with the possibility of exceeding 25 metres. Branches constitute a wide and scarcely symmetrical crown which is widely expanded when the tree is isolated or it is within a sparse high stand and slender in shape when within dense or young populations. In sparse ones the plant almost always has a contorted, sinuous, rather stumpy trunk.

It is a long living species (200-250 years) and trees of considerable dimensions having a stem circumference above 4 metres can be found.

The initially greyish, smooth ritidome becomes of a spongy consistency and is furrowed by deep longitudinal fissures, which are light grey externally and reddish internally. Virgin cork average thickness is of 2.5-3 cm, between the ages of 40 and 60 years, reaching 5-6 cm by the age of about 100 years.

The extraordinary thickness of the bark is an adaptation of a "passive pyrophite" species (Naveh, 1974), that is to say of a species which, thanks to a specific means of resistance, survives fires with the consequent possibility of regenerating itself more easily thanks to the temporary lack of competition.

Leaves fall during the course of the second year. They are simple, alternate, leathery, ovato-lanceolate shaped with an ornate margin constituted by 4-7 pairs of acute teeth corresponding with the secondary nervations. When mature they are glossy, dark green on the upper surface and tomentous, white on the inner one, with a short petiole.

The inflorescence is by rule unisex. Yet hermaphrodite flowers can appear (Machado 1938, Varela & Valdiviesso, 1995). Male flowers, in lengthily pedunculated catkins, initially carmine reed in hue, are arranged at the extremity of the previous years' branch, at superior leaves' axilla. The female ones are united in erect spites carried at the top of the year's branch. Flowering occurs well into spring. When climatic conditions are particularly favourable there may be autumnal flowering also.

The fruit is an elongated oval acorn, protected half way by a briefly pedunculated cupula with grey tomentous free divergent scales. Fruiting begins when the plant is about 15 years old becoming abundant beginning from its thirtieth year and continuing well beyond 100 years of age. From empirical knowledge and ongoing flowering and fructifying studies (VARELA, 2000) it is known that mast years occur two to five times in a period of ten years, depending on the site and ecological conditions.

The fruit ripens between September and December in the annually maturing species whereas in the biennial biotypes the pollinated flowers winters; in these second biotypes, fertilisation occurs the following spring and fruit formation occurs in autumn.

The cork oak has a deep taproot, with robust lateral branching, which may reach a few metres in depth in sufficiently permeable soil.

Reproductive Cycles

The reproductive cycle of the cork oak and, more precisely, the lapse of time required for acorn maturation, is a bioecologic characteristic with noteworthy taxonomic implications though it does no seem to be associated with morphological traits, which in the past has created a series of difficulties in defining the systematic position of the species.

This is a very interesting aspect since cork oak does not have a fixed reproductive cycle but it enumerates biotypes with annual acorn maturation, biotypes with biennial maturation and biotypes having both types of maturation.

The annual maturation type is the more diffuse. CORTI (1955), the author who has more widely dealt with the subject, finds it as the exclusive type, or almost so, in Portugal, Provence and in Morocco, in the forest of Bab-Ahzar.

The biennial maturation type which was initially considered a *taxon* distinct from cork oak to the point of being named *Q. suber* ssp. (or variety, according to some authors) *occidentalis* Gay, does not correspond to an effective geographic delimitation, although it is prevalent at the very limits of the distribution area of the species. Subjects with fixed biennial maturation are exclusive to populations of the north Atlantic portion of the range of the species, that is of the French Landes, where biotype selection is presumably latitudinal, that is due to a shortening of the vegetative season because of delayed spring warmth and the more precocious arrival of autumn cold.

They reappear mixed with subjects having annual or combined maturation in the Italian cork oak range where a certain degree of summer drought seems to favour the biennial type, but the numerous local mitigation, due, for example, to groups of mountains which increase rainfall locally or to the presence of ground water which compensates for the lack of rainfalls, seem to allow for the coexistence of the different biotypes. Biennial specimens are also to be found on the Algerian mountains, in Spain, Portugal (DIAZ P, 2000) and in the vast forest of Maâmora in Morocco.

This latter is submitted to an Atlantic-Mediterranean climate, but is situated in the semiarid zones, at the extreme southwest of the range (Corti R, 1955). Biotypes with biennial maturation were found in Spain in the S. Joaquin de Helmos population which grows in a site submitted to long summer droughts, quite long, bitter winters and late frosts in the spring (ELENA - ROSSELLÓ et al., 1993).

Studies regarding the distribution of the different types of reproductive cycle within the range of the species led CORTI (1955) to the conclusion that biennial maturation is a trait revealing still current evolution with which the cork oak predisposes its reproductive processes to face conditions in which cold or drought determine the standstill in gametophyte development during the formative year and re-growth in the spring of the following year, allowing completion before the beginning of summer drought.

Perhaps though, Corti considerations are somewhat curtailing and cork oak can represent elective material for a more thorough study of the reproductive cycles, a sector, which is often carelessly investigated.

Geographic Distribution

The cork oak grows along the coastlines of European (Italy, France, Spain) and north African countries (Tunisia, Algeria and Morocco) bathed by the Western Mediterranean and on the islands of Sardinia, Corsica, Sicily and the Baleares where it can also be found in the interior. In the Atlantic region its maximal diffusion is in Portugal and along both the Spanish and French coasts. In Morocco it is concentrated in the Atlantic-Mediterranean region. The easternmost formations of the species belong to small woodlands nuclei situated along the eastern coast of Apulia (Italy).

Although the current species range has not undergone noteworthy variations respects to the recent past, the presence of the cork oak in the various countries has decreased considerably, above all, because of the strong anthropomorphic pressure which has left its mark particularly on the marginal populations often causing their complete disappearance.

Portugal is the European country presenting the maximum diffusion of the species which is to be found above all in the central-southern area where it has, nevertheless, undergone strong contractions both because of the diffusion of fast growing forest species and the development of urban areas.

In the rest of the country, the substitution of the species with other fast growing forest species and the assignment of the greater part of the cork oak land to agricultural activities and urban installations have strongly mitigated the cork oak while, in the north-eastern region of "Trás-os-Montes and Beira Interior", the particular type of orography limits its presence too (VARELA, 1997).

At present, the surface covered by cork oak stands appears settled on approximately 720,000 ha (VARELA, 2000).

In Spain, the cork oak occupies two well defined areas, one in the north-eastern zone of Catalonia and another in the western *Duero* basin, *Extremadura* and western *Andalucia*; instead it is rather rare in the continental area (GIL SÁNCHEZ, 1995).

The fragmentation of the range of the species is due both to paleobiogeographic factors and, above all, to the action of man who over the ages has conditioned not only the limits of its area but also the structure and dynamics of its populations. In the middle of the XIX century, a great number of trees died consequent to indiscriminate and uncontrolled extraction of cork which occurred especially in Valencia (GARCÍA-FAYOS, 1991), whilst 1,300,000 trees were felled in Cádiz for the extraction of tanning barks (CERÓN, 1879).

Actually the surface covered by cork oak is esteemed, according to the sources, around 365,000 – 478,000 ha (MONTERO, 1987) the majority of which due to new plantations initiated with the rise of the cork industry.

In France, cork oak grows in four separate geographic areas three of which, Corsica, Provence and Catalogna, are under the influence of the Mediterranean climate and the last, Landes region, grows along the Atlantic coast. From the beginning of the 20th century, the area occupied by cork oak has progressively regressed from 200,000 ha to less than 100,000 ha today of which only 43,000 ha are more or less extensively managed for cork production (LUMARET, 1995).

Notwithstanding the difficult situation faced by the species, during the last 30 years there was no significant progress concerning cork oak sylviculture and management. Only recently, the French regional authorities have taken measures to preserve cork oak ecosystems and improve cork quality.

At present, in Italy, cork oak covers an area more than 100,000 ha along the Tyrrhenian coast; in the Central Sicily; in Sardinia, the Italian region with the widest distribution of the species with its 60,676 ha; in Basilicata (Southern Italy), the most inland stand of the southern Apennines. Just as in other European countries, the surface covered by the species is rapidly and progressively reducing in time mainly due to human activities connected with grazing, farming, indiscriminate extraction of cork and numerous fires. Actually, the interest of the government authorities towards cork oak is increasing and projects for the recovery of the species are beginning.

Moroccan cork oak stands cover an area of 350,000 ha mostly located in the northwestern region, from the coastal plains to the central Rif and Middle Atlas. In the past, cork oak was spread on a more extensive surface than today and the major causes of degradation are similar for other countries.

In Algeria, cork oak presently covers about 468,000 ha respects to a certainly greater extension, which has undergone strong contractions over the centuries, but above all in the period between 1875 and 1897 because of the fires which destroyed thousands of hectares of forests.

At present the cork oak extends along the Mediterranean coast of Algeria in a band 450 km long, from Dellys (East of Algeris) to Calle (at the Tunisian border).

Finally, cork oak forests in Tunisia have developed along the Mediterranean coast covering 99,000 ha with pure and mixed stands that seem to be undergoing continuous degradation processes and their regeneration is becoming very difficult. The species is mainly concentrated in large stands in Nefza-Mogode and Khroumiria.

Ecology

The cork oak vegetation area corresponds to the "oceanic Mediterranean climate" characterised by high summer temperatures, mild winters, rather copious rainfall and not very marked summer drought which is anyway mitigated by high atmospheric humidity. Thus, on the basis of its ecological requirements the cork oak may be defined as a thermophilous, hygrophilous, tolerant to drought, heliophilous species. Winter cold is the factor which most of all limits species diffusion in the more continental interior zones.

The thermal values defining its distribution correspond to 13-14°C for annual mean temperature and 4-5°C for the coldest month mean temperature whereas the absolute minimum temperature tolerated is equal to –7, -8°C, according to some authors, as much as –10°C, according to others.

As far as rainfall is concerned, cork oak shows ample tolerance ranging from the 2000 mm of some north-western areas of Portugal, to the 1300 mm found in Sardinia, always associated with dry summers, to the 450-550 mm of the cork oak stands in Maâmora in Morocco.

The inferior limit tolerated by the species is 400 mm, but this condition is almost always accompanied by a high degree of atmospheric humidity. Rainfall distribution throughout the year is, on the other hand, of essential importance for cork oak affirmation in as much as aridity, if it is particularly high, can markedly influence species survival.

Temperature and rainfall values are strictly connected with the altimetric distribution of cork oak, which grows from 25 m *a.s.l.* in the localities of Tavira (Portugal) and Ostuni (Italy), to 200 m in the basins of Tagus and Sado, in Portugal, to the 1550 of Teniet el Had, in Algeria, to the 2,400 m in the Djebel Tirardine zone, in Morocco (Natividade, 1950).

In its natural habitat, cork oak prefers soils deriving from siliceous rocks or, which are in any case, decalcified, rather deep, sandy, generally lightly structured with a scanty presence of nitrogen, humus and more or less rich in potassium, with an acid or sub-acid reaction. But, over the centuries, strong anthropic pressure subtracted the best lands from the species assigning them to agricultural activities confining the cork oak to soils where drought and scarce fertility were hostile for other tree species.

Thus, in Portugal, cork oak is to be found on all types of soil so long as they are devoid of limestone and not too clayey. In Spain it can be found on sands, marles and tertiary lime-sandstone formations. In Italy, it appears on tertiary and quaternary sandy formations, on schists, granites and pyroclastites.

In Tunisia on superior Cretacean marls and on Pliocene sands. In Morocco on Pliocene and Quaternary sands. In Algeria on soils originating from numidic flysch, composed of alternate sandy and clayey slime layers. As a consequence of its autoecological characteristics, cork oak participates in the constitution of well defined phytocenoses at both compositive and structural levels. From the phytosociologic aspect, according to the CORINE (1991) classification, the species characterises the *Quercion suberis* and *Quercion fagineo-suberis* alliance and enters within the *Quercion ilicis*.

Cork oak stands cultivated for the production of cork may have multiple aspects according to the culture. One may see overgrazed arbored pastures with frequent asphodel; or, else, scattered trees may be found in a maquis of *Cistus monspeliensis* or *Phyllirea*, *Pistacia* and *Myrtus* or, else, in phyrophyte thickets of *Erica*. On the other hand, populations of cork oak submitted to agricultural-pastureland practices, which have led to the disappearance of shrub and grassy vegetation, are currently numerous.

This, associated with low arboreal density and the greater exposition of the soil to meteoric agents, has determined loss of the humus-rich superficial layers and the starting off of erosive phenomena with consequent increase in soil dryness and the initiation of cork oak stand degradation processes. When the cultivation is abandoned, these evolve, in an initial phase, in favour of the scrub species without being able to predict times and modes for natural regeneration of the cork oak (Bernetti, 1994).

Epiontology

Although very little fossil material is available to elucidate the origin of the Mediterranean sclerophyll forests (MAI, 1989), paleobotanical evidences suggest that *Quercus suber* probably appeared during the Miocene together with numerous other species belonging to genus *Quercus* (i.e. *Q. cerris*, *Q. aegilops*, *Q. trojana*, *Q. libani, Q. pubescens*, *Q. canariensis*) (PALAMAREV, 1989).

This hypothesis is also supported by the fact that only during the Late Miocene and Pliocene, a semiarid climatic zone was formed between 37° and 45°N latitude with more prominent sclerophyllous woody cenoses whose direct descendants nowadays constitute much of the woodland vegetation of the Mediterranean floristic area (PALAMAREV, 1989). Paleoecological data also support the hypothesis of the presence of cork oak in Southern Europe during the Tertiary period (CARVALHO, 1957).

According to SAUVAGE (1961), the Iberian Peninsula was probably the centre of the origin of Q. suber from which, at the end of the Miocene, the species colonised North Africa through the straits of Gibraltar.

This hypothesis, although very plausible, could be more probable if Iberian peninsula were seen as a second centre of origin for the diffusion of *Quercus suber* whilst the first should be located more exactly in the eastern countries such as those of the Colchis, where cork oak appears to have growing during the Miocene period as supported by PALAMAREV STUDIES (1989). Indeed, the oldest fossils of the ancestors of *Q. suber* (*Q. sosnowsky* group) were found in France, Poland, Rumania, Bulgaria, Turkey and Georgia.

The drastic variations in the climatic conditions during the next geological periods caused strong reduction in species diffusion and, during the Quaternary glaciations, cork oak could survive only in the refugial areas with favourable microclimatic conditions. Nowadays, isolated cork oak stands are still found as vestige of ancient populations notwithstanding the strong anthropic pressure, to which the species has been submitted during its life, thus revealing its ample capability to support climatic changes.

In fact, whenever anthropomorphic pressure has been reduced, cork oak has been able to colonise the freed area in a few decades probably thanks to its large genetic variation in adaptive traits and its reproductive ability which also allows it to cope with the rapidly changing environmental conditions although these are now occurring at a higher speed than in the past (DAVIS & ZABINSKI, 1992).

Taxonomy and biosystematics

Even though in the past the evergreen habitus and the diffuse porosity of the xylem has induced some authors to associate the cork oak with the evergreen oaks of the group *Schlerophyllodrys* Schwarz (*Q. ilex* and *Q. coccifera*), today, on the basis of more thorough considerations regarding the morphological characteristics, all the monographists of the genus *Quercus* agree in attributing *Q. suber* to the group *Cerris*, a cycle of oaks which, however, has not yet found precise taxonomic position due to its complexity.

Biosystematic investigations also based on the use of molecular markers such as storage proteins, the cpDNA and the rDNA genes confirm the position of the cork oak within the group *Cerris*.

Bellarosa *et al.* (1996) have analysed, by means of the total proteins, several *Quercus* species (*Q. robur, Q. pubescens, Q. frainetto, Q. trojana, Q. macrolepis, Q. cerris, Q. crenata, Q. suber, Q. ilex, Q. coccifera*) that were separated into three groups: *Q. robur + Q. pubescens + Q. frainetto ; Q. macrolepis + Q. trojana + Q. cerris + Q. crenata + Q. suber ; Q.*

ilex + *Q. coccifera*. This separation was in agreement with the one affected by Schwarz (1936-37) who, on the basis of the morphological characters, defined three subgenera: *Quercus*, *Cerris*, *Schlerophyllodrys* and also with the classification of Nixon (1993).

Inter-specific differences in genus *Quercus* were mainly detected by ribosomal DNA gene data and more precisely by restriction site analyses of the intergenic spacer (IGS).

According to Bellarosa *et al.* (1990), the intergenic spacer length variations found between the ribosomal DNA genes of six *Quercus* spp. were useful to separate them into two groups on the basis of: (1) the size of the longest gene; (2) the size of the other genes; (3) the number of the gene-types. The two groups were: *Q. coccifera* + *Q .ilex*, and *Q cerris* + *Q. trojana* + *Q. suber* + *Q .macrolepis*.

The taxonomic groups of subgenus Quercus constructed on the basis of the morphological traits agree also with those effected by Manos (1999) by means of chloroplast DNA (cpDNA) restriction sites analyses and the nucleotide sequences of the internal transcribed spacers (ITS) of the nuclear ribosomal DNA genes.

Combining data from the two types of molecular markers, a monophyletic group of section *Cerris* (*sensu* Camus) constituted by two subclades, *Ilex* and *Cerris*, was obtained. This group, which is at the basal placement of the 43 taxon combined tree, appears to be as a sister to a larger clade formed by members of the sections Protobalanus, *Quercus sensu stricto* and Lobate.

The two subclades, respectively constituted by *Q. ilex* + *Q. coccifera* + *Q. calliprinos* and *Q. phillyraeoides* + *Q. suber* + *Q. cerris* + *Q. acutissima*, were generally consistent with the provisional groups identified by Nixon (1993, e.g., *Ilex* and *Cerris*), the subsectional classification of section *Cerris* made by Camus (1936-1954), the pollen and leaf anatomy (Smit, 1973; Zhou *et al*., 1995) and the RFLP analysis of the intergenic spacer of rDNA (Bellarosa *et al.*, 1990). In the *Cerris* subclade *Q. suber* is located closed to *Q. cerris*.

This position has also been confirmed by ITS sequencing results obtained by Bellarosa et al. (in prep) with the following investigated species: *Q. ilex and Q. coccifera (*subg. *Schlerophyllodris); Q. macrolepis, Q. trojana, Q. cerris, Q. suber* and *Q. crenata* (subg. *Cerris*); *Q. robur, Q. petrea, Q. pubescens* and *Q. frainetto* (sub. *Quercus*).

All the species supposed to belong to the subg. *Cerris* are in the same clade separated from the other two referred to subg. *Schlerophyllodris* and subg. *Quercus*.

In contradiction with the above reported results are those obtained by Samuel et al. (1998) by means of the ITS sequencing that, as reported by the same authors, "diverge in an unexpected way from traditional groupings in respect to the SE European and deciduous *Q. cerris*, the type species of subg. (or sect.) *Cerris*". Therefore, Q. *cerris* is located between the groups of *Q. petraea* + *Q. robur* and *Q. ilex* + *Q. coccifera* in the same clade that comprises also *Q. virginiana*, a southern N American evergreen live oak, whereas *Q. suber* finds its position within another clade, distant to that of *Q. cerris*, and which comprises *Q. macrolepis*, *Q. acutissima* and *Q. rubra*.

Moreover, since *Q. suber* is positioned in the same clade of *Q. rubra* this suggests, always according to the authors, a narrow affinity between the Eurasian *Q. suber* group and the species-rich American subg. *Erythrobalanus* (= sect. *Lobatae*).

On the basis of these results, that are clamorously in conflict with the traditional concept of sect. or subg. *Cerris* as the same Authors assert, Samuel *et al*. support the hypothesis that genus *Quercus* should either be considered polyphyletic or else a genus without species.

According to Mayol and Rossellò's (2001) hypothesis, the contrasting phylogenetic histories obtained by Manos and Samuel teams should have been generated from the analysis of paralogous sequences by Samuel rather than from technical differences as supposed by Manos.

It is interesting to underline that, for cork oak, Samuel ITS nucleotide sequence of 486 bp is about 100 bp shorter respects to Manos and Bellarosa ITS.

Therefore, molecular systematists should use a special caution with the results obtained by means of molecular markers before drawing phylogenetic conclusions. A more precise understanding of the phylogenies and the existing relationships between *taxa* and populations should come out from the implementation of different data: ecological, morphological and molecular.

The above mentioned molecular markers have also been useful in recognising *Q. crenata* as a natural hybrid between *Q. suber* and *Q. cerris* (Bellarosa *et al*.,1993; Bellarosa *et al.*, 1996) as already defined by Camus (1936-54) and Pignatti (1982).

Another interesting hybrid is that which cork oak produces with holm oak when the two species grow together in the same stand. Elena-Rosselló *et al.* (1992) detected the hybrid in a mixed population of juvenile individuals using three diagnostic enzyme loci.

Although there is usually no overlap between the flowering period of the two species, during an exceptionally cold and wet year the flowering period of the holm oak may be delayed so that certain trees of the two species can flower at the same time and hybridisation can occur, fairly infrequent but not rare event.

Genetic Aspects

The first information on the genetic diversity within and among populations of cork oak was obtained with the use of molecular markers.

Bellarosa *et al.* (1996) applied the analyses of the storage proteins to seven Italian cork oak provenances [the island of Elba, La Rocca and Tuscania (Latium), Bultei and Pattada (Sardinia), Paticchi and Pignicella (Apulia)].

Even though the total protein profiles obtained were not quite able to differentiate between the provenances, Latium provenances showed a higher number of bands when compared with those of Apulia. Further confirmations of these differences were obtained by monodimensional electrophoresis of various protein fractions that were separated in different extraction buffers on the basis of solubility characteristics.

Also by means of the analysis of the intergenic spacer (IGS) length variations of rDNA genes, it was possible to distinguish the Apulian provenances group from those of the Sardinian and Tyrrhenian groups (Bellarosa 1995).

The genetic variation existing between some European and North African cork oak populations was showed by the analyses of the internal transcribed spacers (ITS) nucleotide sequences that revealed the existence of three well distinct groups: a first one constituted of Franco-Iberian populations, a second one comprising north African and Italian populations (Sicily and Sardinia islands included) and a third one constituted only of the Apulian population (Eastern Italy) (Bellarosa et al., in prep.).

These results are in a perfect agreement with those obtained by Toumi and Lumaret (1998) who investigated 40 populations, pure or in mixed stands with *Q. ilex* and/or *Q. coccifera*, sampled over the entire range of the species in the western Mediterranean basin, using 11 loci from seven enzyme systems.

Particularly relevant is the apparent genetic isolation that seems to characterize the Apulian sample, which is likely to confirm what was already pointed out from Bellarosa et al. (1996).

This scheme is able to subdivide the actual geographical area of presence of the cork oak in three genetic pools, the large Franco-Iberian and Afro-Italian and the small Apulian one.

The genetic differentiation of the Italian cork oak populations was also confirmed by the analyses of the internal transcribed spacers (ITS) nucleotide sequences (Bellarosa *et al.*, in prep.).

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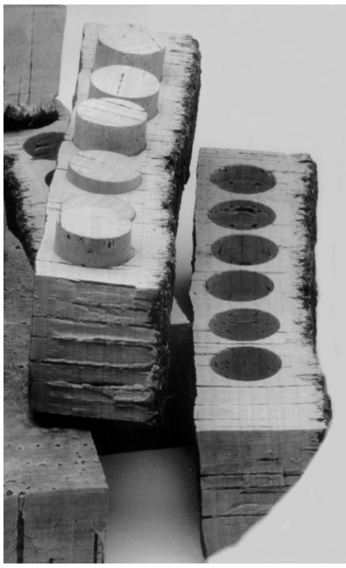
From the board to the stoppers



II- Objectives

(G. Eriksson, SLU, Sweden*)*

The general objective of the project European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation is:

To promote the establishment of simultaneous provenance and progeny trials under standardised methodologies. This was achieved by a representative selection of material from the entire area of distribution of cork oak. It was implemented by a network involving 6 European countries.

To enable breeding there is a need for knowledge of genetic variation, or more appropriate additive variance, of the traits of interest to improve. Similarly for gene conservation there is a demand to estimate additive variance of traits of adaptive value, that are traits of importance for continuous regeneration of natural cork oak stands. Additive variance is regarded as the fuel for breeding and evolution. Without additive variance of a trait there will be no evolution of that trait nor will it be possible to change the trait by breeding.

The existing differences among stands of different geographic origin are a consequence of the evolution during past generations. Disruptive natural selection causes among-stand differentiation. So does genetic drift but it is a process leading to random loss of genes. Pollen flow and acorn transport among populations is an opposing factor that eliminates differences among stands. Pollen flow and seed transport is usually designated as gene flow, which will be used below.

Since cork oak has a large distribution area with large variation in environmental conditions it is expected that disruptive natural selection (= adaptation) has caused large differentiation among populations in traits of adaptive significance such as ability to tolerate extended periods of drought, to cope with pests and diseases and varying temperature levels throughout the year. Cork oak, as a wind pollinated species, is expected to have a substantial gene flow. However, there is certainly few direct gene flow between a French stand of cork oak and any stand in North Africa. The gene flow is of importance to level stand genetic differences on a regional basis, but will not eradicate genetic differences among stands if the natural selection is very strong.

As is evident from chapter I there is no knowledge about available additive variance in cork oak. It is well known that genetic markers do not reflect the variation in adaptive traits. Generally a small variation in genetic markers means that there is a large variation in adaptive traits.

Therefore, to obtain information on how to sample cork oak stands for gene conservation there is a need to generate data on variation among stands for traits of importance for adaptation of cork oak. This is best done in traditional provenance trials. Each provenance trial will give information on the best seed source for the environmental conditions prevailing at this test area.

For future breeding it is of utmost importance to generate information on additive variance of traits included in the improvement programme. This might be done by establishment of progeny trials with families from individual trees in stands. Since we anticipate a large among-stand variation all stands are not of interest for breeding in a certain region.

Therefore, individual tree offspring from a few stands will suffice. The selection of stands for a particular region should be based on educated guesses about future environmental conditions in the area under testing. The progeny trials might fulfil a dual purpose since they also enable estimates of additive variance of traits of importance for the traits of adaptive significance in the wild.

In conclusion breeding and gene conservation of cork oak require data from provenance and progeny trials that have been established. The experimental design will be discussed in next chapter.

Mature cork oak stand

III- Methods

(M. Bariteau, INRA, France*)*

Specific objectives established for the project did not include the field tests establishment since supported actions are limited to selection of provenances and trees, standardised production of plants (in a nursery in Portugal), delivering of plants in each participating countries, promotion of 4 meetings and creation of a database focusing the research on *Quercus suber* research. Nevertheless, contractors had the commitment to establish field trials, following a standardised protocol allowing comparison of results in the future.

Specific methodologies concerning raising of plants will be described in Chapter V. A special attention will be paid in this Chapter to selection of provenances and trees as well as experimental designs for field trials. Few Mediterranean networks of the same type were achieved in the past and this handbook is a good mean to edit and share the concrete experience (*Pinus halepensis* network is another good example of a Mediterranean provenance network with standardised methodologies - project FAO/SCM/CRFM/4bis - protocol written by ECCHER in 1975).

Protocols were discussed and improved by the contractors during three meetings held in the frame of the Concerted Action:

1) Sassari, Sardinia, Italy, from 9 to 12 June 1996;
2) Almoraima, Spain from 20 to 22 February 1997;
3) Pegões, Portugal, from 20 to 21 July 1997.

Selection of provenances and trees

The number of seed lots to be included in the field trials, and the number of seed lots to be contributed from each of the participating countries, have been intensively discussed in Sassari.

The need for a balance between good representation of the entire ecogeographic range of cork oak and the size of field trials for sound statistical inference, as well as the costs involved, were considered. The number of stands (provenances) was discussed next. Countries made their own decision, having a good knowledge of their natural stands, to include one stand per provenance or to represent a certain number of them by more than one stand.

Based on the approved original project proposal and on the discussions during the meeting, it was agreed that:

- The main objective of the Concerted Action is to assess genetic variation at a provenance level in the species distribution area, to estimate within-provenance variation and G x E interaction, and to establish a basis for and to initiate tree improvement activities.

- Number of stands (provenances) in the international series should not exceed 40, in order to keep the trials manageable and effective while at the same time making a representative core collection of the species taking into account the whole range of it's variability. The number of stands (provenances) to be included from each country was discussed and the following scheme was suggested:

Table III.1 - Proposal for provenance distribution after the project first meeting Italy, Sardinia, 1996

	No. of provenances	Notes
Italy	5	2 from the continent + 2 from Sardinia + 1 from Sicily
Portugal	9	from the Regions of Provenance III, IV, V and VI
Spain	8	6 from main production regions and 2 from marginal populations
France	4	–
Morocco	6	–
Tunisia	2	–
Algeria	1	–
TOTAL	34	

The chosen number of provenances is necessarily moreover a base of work rather than a precise aspect of the protocol. Nevertheless, the final number of 34 was justified as follow:

1) Size of trials: The small size of blocks in Mediterranean field trials is a basic pre-requisite to control the huge levels of environmental variation, leading to a limitation of tested genotypes. Moreover, cork oak needs large spacing between trees at plantation. Big trials, with large blocks may easily lead impede accurate evaluation of genetic parameters, i.e. the experimental error shall be reduced as much as possible to allow the best possible appraisal of genetic components of variance.

2) Appraisal of genetic variability - 34 has also been considered as a good sample based on considerations focused on cork oak ecology, geographic distribution and genetic architecture.

Indeed, recent knowledge points that, as many other forest species, cork oak has more genetic variation within populations than among.

3) Human and material means - Number of provenances was also framed on these factors, the total cost of collections being limited.

Table III.2 - Number of trials to be established in each country

Country	Provenance Trials	Progeny Trials
Portugal	3	2
Spain	2	1
Italy	3	-
France	2	-
Morocco	1	1
Tunisia	2	1
Total	**13**	**5**

(The extensive characterisation of the trials - site and experimental design - is presented in Chapter VI).

- Number of mother trees:

at least 20 mother trees should be sampled per population

50-100 m (preferably 100 m) should be the distance between the mother trees

several age classes should be represented

average phenotypic performance of trees and availability of abundant seed crop will be two main criteria for selecting the trees in stands.

- Number of acorns/tree:

300-500 (at least 300 acorns should be sampled from each tree)

exception: one stand to be selected and sampled jointly by Portugal and Spain where 2000 acorns/tree have been agreed upon.

- Around 300 000 acorns will be sown in nursery. The number of seedlings at the end of the nursery phase is expected to be at least 102 000.

- Passport forms (descriptors): All seed lots must have a common passport label. Common passport forms for provenances and mother-trees were decided (see below)

- Seed lots must always be sent by Express mail, preferably by fast land transport to avoid the below-zero temperatures in cargo compartments in airplanes. Containers made of plastic should be avoided.

Seed storage was another important issue of the meeting in Sassari, to be agreed upon prior to the preparation of the field experiments. Seed storage in cork oak is generally considered a high-risk operation and it was therefore decided by the participants to do the experiments without conservation and to proceed with direct sowing. Several options were then discussed.

Owing to the irregular flowering and seed crops in the case of several provenances, the question of timing and integration of the seed collection, nursery production and trial establishment appeared as crucial. The hypothesis of field trials established in two years was considered, giving more chance for good fructifications in the different countries.

However, the interpretation of data obtained from the trials should have been more difficult and uncertain, because of the difference in age between trees. The forecast for the 1996 seed-collecting season looked promising.

The participants reported observations of unusually good flowering in all cork oak countries. It thus seemed possible to collect seeds from the majority of provenances in this year. So, it was agreed to collect as many stands (provenances) as possible during 1996.

Experimental design of field trials

Experimental design is the cornerstone of the project, and therefore particular attention was paid to discuss different options during the implementation process. Incorrect experimental design may strongly limit the results of any future research based on the field trials. The first step in any project dealing with such an experimental network is to assess the main objectives to be reached by experimentation.

Concerning *Q. suber*, three pertinent objectives have been distinguished:

- study of genetic variation among populations
- study of genetic variation both among and within populations
- study of genetic variation and breeding.

Taking these objectives into account, several proposals for the experimental design of the field trials were discussed

Two proposals of the experimental design were discussed. They are briefly summarised below. Proposal A is relevant whenever high priority is given to the progeny testing part (Objective 2), and Proposal B if the main objective is provenance testing (Objective 1).

Table III.3 - Proposal A (Simultaneous provenance/progeny trials)

PROPOSAL A	plot	block	Trial	observations
Genetic entries: 34 prov.	one m.t/plot 4 plants	all m.t./all prov. (20 m.t/prov.)	2 blocks (4x20x2=160 plants/prov.)	
n. of plants	initial=4 final=1	initial=2720 final=680	initial=5440 final=1360 (40/prov.)	2 thinnings
design	row plots (in line)	Randomized Complete Blocks (RCB)		8plants/mt (initial) and 2 pl/m.t (final)
acreage	initial=5 x 1.5 m final= 5 x 6 m	7.5X680x4=20400 m^2 = ***2.04 ha***	20400x2=40800 m^2 = ***4.08 ha***	

m.t = mother-tree
prov. = provenance

For classical statistical reasons, each open-pollinated progeny must be represented by at least 24 trees at the age of evaluation. The problem arises when there are many populations, each represented by a relatively large number of progenies. In the project there are as many as 34 populations and, for most of them, single-tree progenies are available. Even if all populations were not represented by all 20 progenies, a combined within- and among-population study would not be feasible for practical reasons.

The question then arises whether the number of progenies per tree at each site can be reduced (2 plants per mother-tree at final spacing in that case). That proposal is based on the idea to pool information obtained from all test sites for studying the variation within populations. This would be a problem in case of strong genotype x environment interaction. There is no available information on the G x E interaction for quantitative traits.

However, results of the studies of genetic information at isozyme loci show the classical pattern expected for wind-pollinated species, i.e. a limited genetic differentiation among populations. This in turn suggests high levels of geneflow among populations.

From an evolutionary point of view, there is a low probability for specific adaptations to particular habitats; the genetic variation of adaptive significance is probably clinal and not ecotypic. The G x E interaction can be expected to be of minor importance. Therefore, the proposal A should be followed for both objectives 1 and 2 (study of genetic variation within and among populations).

Table III.4 - Proposal B (Separated provenance and progeny trials). Provenance trials:

PROPOSAL B Provenance trials	**plot**	**block**	**trial**	**observations**
Genetic entries: 34 prov.	one m.t/plot 9 plants	One m.t./prov. All prov.	12 blocks (9x12=108 plants/prov.)	
n. of plants	initial=9 final=3	Initial=306 Final=102	initial=3672 final=1224 (36/prov.)	2 thinnings
design	row plots	Randomized Complete Blocks (RCB)		
acreage	initial=6 x 1.5 m final= 6 x 6 m	9 X 306=2754 m^2 = 0,275 ha	9x3672=33048 m^2 = 3.3 ha	

Progeny trials:

A non-schematic model for progeny trials was also mentioned based on the following assumptions:

- 610 mother trees is too large a number of genetic entries to be tested in cork oak distribution range. Usefulness of such a huge number of trees for evaluation of genetic parameters for further breeding is also questionable. Therefore, it has been proposed that countries interested in progeny trials would install a set of five provenances (100 mother trees) plus a chosen provenance, common to all progeny trials to be installed.

- Each trial would then be made up of 100+20* mother trees. Countries interested in family and individual selection (Objective 3) could even install two progeny trials (if there are sufficient plants), leading to 100+20* plus 100+20*. The choice of breeding populations will depend on the knowledge of climatic conditions at the sites and the information about stands where the material was collected. At each test site the populations chosen for Objective 3 should be planted separately. The focus is on selection of the best-performing trees within best families of a population.

Discussion

A key observation was made of particular importance to the entire philosophy of the project in that the results of this Concerted Action offer a rare opportunity in cork oak genetic research.

The participating countries have succeeded in developing a seed collection of 34 provenances traced on labeled seed lots of 20 mother trees and leading to a total of 610 genetic entries. Therefore, every effort shall be made to obtain the maximum amount of information from this unique collection.

This collection of basic material will give maximum benefit because it combines field trials, and related genetic research. Other fields may eventually benefit from the tracing of mother trees in the future. Therefore, it was proposed and accepted that all plants will be delivered for field trials, be labeled individually, and then located on the field maps.

There was an agreement regarding the huge variability of the Mediterranean environment. It is a particular type of climate where the coincidence of the dry season with the summer raises synergistic effects of drought stress, high temperatures and intense sun radiation.

Very high heterogeneity within sites results from such factors, amplified by soil heterogeneity. Therefore, the participants agreed that attention should be paid to controlling the environmental component of the trials, if genetic parameters are to be assessed accurately. The decision went to simultaneous trials (provenance and progeny tests) but under separated design.

Combined trials (proposal A) would mean an enormous number of genetic entries, therefore huge areas and huge block size. Both have been considered unsuitable for Mediterranean conditions.

Experimental designs accepted for field trials. As for provenance trials twos designs were accepted.

Table III.5.1 - Provenance tests - Design 1

	plot	**block**	**trial**	**observations**
Genetic entries: 34 provenance	4 plants	all m.t.	30 blocks	
design	square plot	RCB		
acreage	initial=3X3m final= 6mX6m	36X34=1224 m^2 = ***0,125 ha***	1224X30=36 720 m^2= ***3,7 ha***	
n. of plants	initial= 4 final=1	initial= 136 final=34	initial= 136X30=4080 final=34X30=1020	2 thinnings

Table III.5.2 - Provenance tests - design 2

	plot	block	trial	observations
Genetic entries 34 provenance	8 plants	all m.t.	15 blocks	
design	row plot	RCB		
acreage	initial -6X1,5m final- 6mX6m	72 m^{2}X34=2448 m^2 = ***0,25 ha***	2448X15=36 720 m^2= ***3,7 ha***	
n. of plants	initial= 8 final=2	Initial= 272 Final=68	initial= 136X30=4080 final=34X30=1020	2 thinnings

Concerning progeny tests, the proposal for progeny trial of 5 prov+1 common provenance was not feasible due to the insufficient number of plants in a considerable number of m.t. Progeny trials will have to be based on 3 or 4 populations making use of the all set of m.t. with enough plants by the end of the nursery phase.

Connection will be made through the common populations used on the progeny trial network (some of the populations will be used as « bridge population » between pair of sites). The experimental design is a complete block design with single tree plots, organised as a spit plot, in order to assume one single thinning

Table III. 6- Experimental design accepted for progeny tests

	plot		trial	observations
Genetic entries: 3 or 4 provenances	1 plant	all available m.t. of the chosen provenance	22 blocks	
design	single tree plot	Restricted complete randomisation		
acreage (for an average n. of 22 m.t.and 4 prov.)	initial=6X3m final= 6mX6m	18m^{2}X22mtxX4prov.≅ 1584 m^2 **= 0,16ha**	1584x22= 34848 m^2 **= 3,5 ha**	
n. of plants	initial= 2 final=1	initial= 176 final=88	initial=3872 final=1936	1 thinning

Cork oak acorns

IV- Collection of Material

(G. Catalan- INIA- CIFOR, Spain*)*

Since seed storage was considered to entail risks, it was decided that the material should be collected during the fall and winter of 1996 in all populations in which that was possible (according to methodologies presented in chapter III). During that season, taking advantage of the good harvest, the majority of countries were able to collect material in the initially proposed populations, reporting on the results during the meeting at La Amoraima (Cádiz, Spain, 20-22 February 1997).

In the case of the Portuguese cork oak stand at Romeo, the poor harvest prevented the collection of acorns per tree and that population was finally replaced by another (although it continues to be a part of the Portuguese experiments). The same occurred in two populations in marginal Spanish areas in which it was impossible to collect the necessary material and, thus, they were finally replaced by two other tree groups.

At all sites material was collected from over 20 mother trees, with the exception of four French populations. In one of them, only 11 progenies were included. In the other three it was not possible to distinguish the mother trees due to the fact that strong winds had caused the acorns to fall and, given the high density of the trees, it was impossible to determine from which tree they had fallen.

The location of each population within the area of distribution of the cork oak is reflected in Figure IV-1. The results of the harvest are summarised in Table IV-1 (in which codes have been assigned to each population).

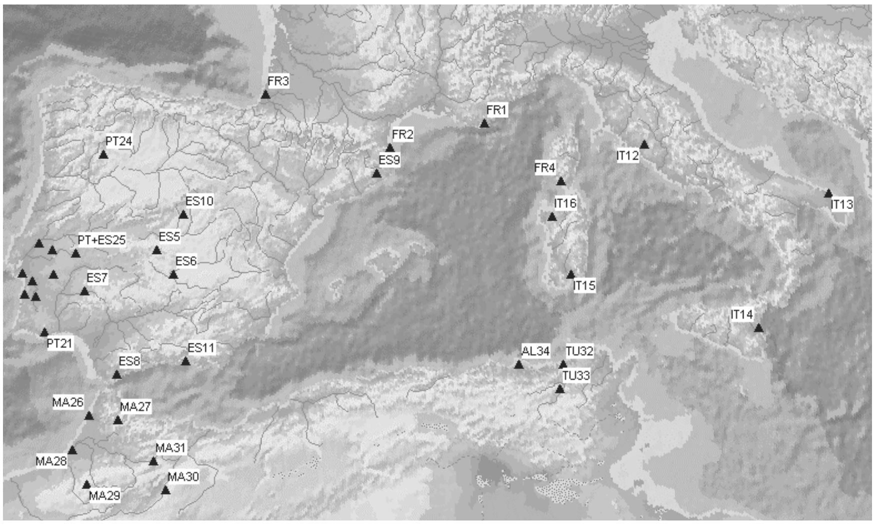


Figure IV-1 - Location of the provenances assayed

Table IV-1 a - Provenances

Nº	Code	Provenance	Nº	Code	Provenance
1	FR1	Les Maures	*18*	PT 18	Alcacer do Sal
2	FR2	Le Rimbaut	*19*	PT 19	Azeitão
3	FR3	Soustons	*20*	PT 20	Ponte de Sôr
4	FR4	Sartene	*21*	PT21	São Brás de Alportel
5	ES5	Cañamero	*22*	PT22	Azaruja
6	ES 6	Fuencaliente	*23*	PT23	Santiago do Cacém
7	ES 7	Jerez de los Caballeros	*24*	PT+ES25	Besteiros + Albuquerque
8	ES 8	La Almoraima	*25*	MA26	Boussafi
9	ES 9	Santa Coloma de Farnés	*26*	MA27	Ain Rami
10	ES 10	El Pardo	*27*	MA28	Maârnora; Canton A,B
11	ES lI	Haza de Lino	*28*	MA29	Ain Johra
12	IT 12	Tuscania	*29*	MA3O	Oulmés
13	IT 13	Brindisi	*30*	MA31	Bab Azhar
14	IT14	Catania	*31*	TU32	Mekna
15	IT 15	Cagliari	*32*	TU33	Fernana
16	1T16	Sassari	*33*	DZ34	Guerbès
17	PT 17	Chamusca			

Table IV-1 b - Provenances and number of mother trees by countries

(✳) This provenance would be use only in the Portuguese trials

Country	Code	Region of Provenance	Forest	Nearest Locality	Nº mother trees
France	FR 1	Var	Les Maures	Bomes Les Mimoses	11 (<300 seeds)
	FR 2	Pyrenées Orientales	Le Rimbaut	Le Rimbaut	One single seed lot
	FR 3	Landes	Soustons	Soustons	One single seed lot
	FR 4	Corse	Sartene	Sartene	One single seed lot
Spain	ES 5	Montes de Toledo	Cañamero	Cañamero	25
	ES 6	Sierra Morena Oriental	Fuencaliente	Fuencaliente	25
	ES 7	Sierra Morena Occidental	El Carbajo	Jerez de los Caballeros	25
	ES 8	Parque de los Alcornocales	La Almoraima	Castellar de la Frontera	25
	ES 9	Cataluña Litoral	Santa Coloma de Farnés	Santa Coloma de Farnés	25

	ES 10	Sierra de Guadarrama	El Pardo	Madrid	27
	ES 11	Alpujarras	Haza de Lino	Haza de Lino	25
Italy	IT 12	Lazio	Sughereta	Tuscania	26
	IT 13	Puglia	Lucci-S.Teresa	Ostuni	25
	IT 14	Sicilia	Zotte	Caltagirone	25
	IT 15	Sardegna (South)	Nuraghe Arcu de Mesu	Santadi	25
	IT 16	Sardegna (Nord)	Puttu addes de Subra	Villanova Monteleone	25
Portugal	PT 17	Vale do Tejo e Sado	Sociedade Agricola Igreja Velha	Chamusca	25
	PT 18	Vale do Tejo e Sado	Herdade da Palma	Alcácer do Sal	25
	PT 19	Vale do Tejo e Sado	Quinta da Serra	Azeitão	25
	PT 20	Vale do Tejo e Sado	Herdade de Vale Côvo	Ponte de Sôr	25
	PT 21	Sodoeste		San Brás de Alportel	25
	PT 22	Alentejo e Beira Baixa	Herdade do Paço de Camões	Azaruja	25
	PT 23	Sudoeste	Monte Branco	Santiago do Cacém	25
	PT 24	Trás-os-Montes e Beira Interior	Casa de Meneres	Romeo (✳)	One single seed lot
Portugal+Spain	PT+ES 25	Alentejo e Beira Baixa + Sierra de San Pedro	Valle de Mouro + La Tojera	Besteiros + Alburquerque	15 +15
Morocco	MA 26	Rif Atlántico	Boussafi	Larache	35
	MA 27	Rif Occidental	Aïn Rami	Chefchaouen	30
	MA 28	Maâmora	Canton A,B	Kenitra	20
	MA 29	Maâmora	Aïn Johra	Allal Bahraoui	38
	MA 30	Plateau Central	Oulmés	Oulmés	30
	MA 31	Rif Oriental	Bab Azhar	Taza	30
Tunisia	TU 32	Mekna	Tabarka	Aïn Sobh	25
	TU 33	Fernana	Fernana	Aïn el Baya	25
Algeria	DZ 34	Guerbès			25

provenances: 29 with identificated mother trees + 5 with one single seed lot, (including Les Maures); 610 identificated mother trees

The areas in which the seeds for the experiments were collected are natural cork oak forests distributed over the entire area in which the species grows in the western Mediterranean basin. The countries participating in the Concerted Action also agreed to compile basic data concerning origin (location, topography, climatology, edafology and the characteristics of the tree stands), by filling in standardised forms known as "Passport Data".

Box- IV 1 - Passport form to stands of *Quercus suber* L

PASSPORT FORM to STANDS OF *QUERCUS SUBER* L.												
Note: The various items do not claim detailing. However, countries are always free to go into further information.												
1- Region of provenance - _______________ 1.1- Reference of the stand - name; code, etc. --- 1.2 - Location on map 1: 25 000 or 1:50 000, etc. in annex--------------------												
2- Site Descriptors 2.1 Location - province, nearest locality, etc. ____ Longitude ________ Latitude_________ Altitude__________ .												
3- Environment descriptors 3.1 – Climate Nearest meteorological site - ____												
Temp.	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
rainfall												
3.2- Topography												
Plain	sunny slope			shadow slope			other					
3.3 – Soil												
a) Eruptive												
b) Sedimentary of silica type												
c) Sedimentary of limestone type												
d) Alluvium												
e) Clay												
f) Schist												
g) Metamorphic												
h) Other types												
4.1- Stand structure and composition												
Pure/mixed	If mixed, with what species											
4.2 - Density (Classification based on the average distance among trees): *Note: This proposal has in mind that for 7 countries where the species is submitted to different management, we need a pattern to frame the classifications of* "high", "medium" *and* "low".												
4.2.1 - till 25 m (high)	4.2.2 – about 25 m (medium)						4.2.3 - more than 25 m (low)					
5. Management												
5.1 - With natural regeneration	5.2-Without natural regeneration											

Box - IV 2 - Passport form to mother-trees (m.t.) selected within stands of *Quercus suber* L.

PASSPORT FORM to MOTHER TREES OF *QUERCUS SUBER* L		
1- Tree size		
1.1-Total height	Stem height	Stem perimeter

Notes for tree selection
Number of trees per stand **- 25 trees.**
Distance between trees: minimum ***- 50 m; 100 m*** whenever possible
Number of acorns per tree- **at least 400**

Box - IV 3- Label for the seed lots

1-COUNTRY
2- STAND IDENTIFICATION
3- NUMBER OF THE TREE
4- DATE OF COLLECTION

The southernmost population included in the test is Oulmés (33º46'N) in the Central Plateau of Morocco, while the northernmost is the site at Soustons (43°45'N) in the French Landes region. The easternmost site is Brindisi (17°40'E) near the Italian Adriatic coast, while the westernmost sample is one of the Portuguese provenances, Azeitão (9°02'W) near the shores of the Atlantic. Table IV-2 reflects the most relevant data concerning location for the 34 populations in which material for the experiments was collected: regions of provenance, province, closest cities, longitude and latitude.

Table IV-2 - Provenances by countries: code, longitude and latitude

Country	Code	Region of Provenance	Forest	Locality	Longitude	Latitude
France	FR 1	Var	Les Maures	Bomes Les Mimoses	6º15' a 6º45' E	43º 08' a 43º 25' N
	FR 2	Pyrenées Orientales	Le Rimbaut	Le Rimbaut	3º03' E	42º 30' N
	FR 3	Landes	Soustons	Soustons	1º20' W	43º 45' N
	FR 4	Corse	Sartene	Sartene	8º58' E	41º 37' N
Spain	ES 5	Montes de Toledo	Cañamero	Cañamero	5º21' a 5º25' W	39º 22' a 39º 25' N
	ES 6	S. Morena Oriental	Fuencaliente	Fuencaliente	4º16' a 4º22' W	38º 24' a 38º 33' N
	ES 7	S. Morena Occidental	El Carbajo	Jerez de los Caballeros	6º42' W	38º 13' N
	ES 8	Parque de los Alcornocales	La Almoraima	Castellar de la Frontera	5º22' W	36º 16' N
	ES 9	Cataluña Litoral	Sta. Coloma	Sta Coloma de Farnes	2º32' a 2º38'E	41º 51' a 41º 53' N
	ES 10	Sierra de Guadarrama	El Pardo	Madrid	3º45' W	40º 31' N
	ES 11	Alpujarras	Haza de Lino	Haza de Lino	3º18' W	36º 50' N
Italy	IT 12	Lazio	Sughereta	Tuscania	11º57' E	42º 25' N

	IT 13	Puglia	Lucci-S.Teresa	Brindisi	17º40' E	40º 34' N
	IT 14	Sicilia	Zotte	Catania	14º30' E	37º 07' N
	IT 15	Sardegna	Nuraghe Arcu de Mesu	Cagliari	8º51' E	39º 05' N
	IT 16	Sardegna	Puttu addes de Subra	Sassari	8º34' E	40º 27' N
Portugal	PT 17	Vale do Tejo e Sado	Soc. Agricola Igreja Velha	Chamusca	8º26' W	39º 23' N
	PT 18	Vale do Tejo e Sado	Herdade da Palma	Alcacer do Sal	8º35' W	38º 29' N
	PT 19	Vale do Tejo e Sado	Quinta da Serra	Azeitâo	9º2' W	38º 30' N
	PT 20	Vale do Tejo e Sado	Herdade de Vale Côvo	Ponte do Sôr	8º10' W	39º 03' N
	PT 21	Sudoeste		S. Bras de Alportel	Nucl.1:7º56' W Nucl.2:7º52' W	37º 2' N
	PT 22	Alentejo e Beira Baixa	Herdade Paço de Camões	Azaruja	7º 48' W	38º 45' N
	PT 23	Sudoeste	Monte Branco	Santiago do Cacém	8º42' W	38º 01' N
Portugal + Spain	PT + ES 25	Alentejo e Beira Baixa + Sierra de San Pedro	Vale do Mouro + La Tojera	Besteiros + Alburquerque	7º13' W 7º24' W	39º 12' N 39º 21' N
Morocco	MA 26	Rif Atlántico	Boussafi	Larache	6º03' W	35º 11' N
	MA 27	Rif Occidental	Aïn Rami	Chefchaouen	5º16' W	35º 07' N
	MA 28	Maâmora	Canton A, B	Kenitra	6º35' W	34º 05' N
	MA 29	Maâmora	Aïn Johra	Allal Bahraoui	6º20' W	34º 07' N
	MA 30	Plateau Central	Oulmés	Oulmés	4º06' W	33º 46' N
	MA 31	Rif Oriental	Bab Azhar	Taza	4º15' W	34º 12' N
Tunisia	TU 32	Mekna	Tabarka	Aïn Sobh	8º51' E	36º 57' N
	TU 33	Fernana	Fernana	Aïn el Baya	8º32' E	36º 35' N
Algeria	DZ 34	Guerbès				

The stands, where the collection took place are located at altitudes that vary from practically sea level (Mekna: 12 m, Maures: 15 m), to above 1100 m (Oulmés: 1115 m, Bab Azhar: 1130 m), the highest being the 1300 m altitude of Haza de Lino in Las Alpujarras in Spain.

Almost flat and sunny slope topographies predominate; only the oak stand at Fuencaliente being located on a shady slope. Soil substrates are quite varied, but tree masses growing in siliceous sediments, clays and schist are the most abundant. The aforementioned characteristics have been summarised in Table IV-3.

Table IV-3 - Topography and soil

Country	Provenance	Code	Altitude	Topography	Soil
France	Var	FR 1	15–155	Plain or sunny slope	Schist and clay
	Pyrenées Orientales	FR 2	200	Sunny slope	Schist
	Landes	FR 3	20	Plain	Sedimentary of silica type
	Corse	FR 4	50	Plain	Alluvium
Spain	Montes de Toledo	ES 5	600–800	Sunny slope	Quartzyte
	Sierra Morena Oriental	ES 6	700-900	Shadow slope	Sedimentary of silica type
	Sierra Morena Occidental	ES 7	400-500	Sunny slope	Sedimentary of silica type
	Parque de los Alcornocales	ES 8	20-120	Sunny slope	Sedimentary of silica type
	Cataluña Litoral	ES 9	200-500	Sunny slope	Sedimentary of silica type
	Sierra de Guadarrama	ES 10	680-740	Plain	Sedimentary of silica type
	Alpujarras	ES 11	1300	Sunny slope	Schist
Italy	Lazio	IT 12	160	Plain	Eruptive
	Puglia	IT 13	45	Plain	Sedimentary of limestone type
	Sicilia	IT 14	250	Plain	Terre rosse
	Sardegna	IT 15	200	Sunny slope	Granite
	Sardegna	IT 16	300	Plain	Eruptive: trachite
Portugal	Vale do Tejo e Sado	PT 17	75	Sunny slope	
	Vale do Tejo e Sado	PT 18	30	Plain	
	Vale do Tejo e Sado	PT 19	120	Plain	
	Vale do Tejo e Sado	PT 20	70	Plain	Sedimentary of silica type
	Sudoeste	PT 21	440-485	Sunny slope	
	Alentejo e Beira Baixa	PT 22	360	Plain	
	Sudoeste	PT 23	140	Plain	
Portugal Spain	Alentejo e Beira Baixa + Sierra de San Pedro	PT + ES 25	450-515	Plain or sunny slope	Sedimentary of silica type
Morocco	Rif Atlántico	MA 26	150	Plain	Clay
	Rif Occidental	MA 27	300	Sunny slope	Sedimentary of silica type
	Maâmora	MA 28	160	Plain	Clay
	Maâmora	MA 29	150	Plain	Clay
	Plateau Central	MA 30	1115	Sunny slope	Schist
	Rif Oriental	MA 31	1130	Sunny slope	Schist
Tunisia	Mekna	TU 32	12	Plain	Sedimentary of silica type
	Fernana	TU 33	270	Plain	Sedimentary of silica type
Algeria	Guerbès	MZ 34			

In the collection zones some of the characteristics of the cork oak stands were also noted. The majority of the Italian and Spanish and two of the French populations (Le Rimbaut and Soustons) are mixed masses, where cork oak is found alongside other species of the Q*uercus* genus (*Q. ilex* ssp. *ilex* in Italy and in the Spanish population at S. Coloma de Farnés, *Q. ilex* ssp. *ballota* in the rest of the Spanish provenances and in Azaruja (Portugal), *Q. faginea, Q. pyrenaica, Q. canariensis, Q. coccifera, Q. humillis and*

Q. morisi), and in a few rare cases among *Pinus pinaster*, *Castanea sativa* or introduced species such as *Pinus radiata* and *Eucalyptus viminalis*.

The Moroccan, Tunisian, and almost all of the Portuguese populations are pure masses of cork oak, as are the populations of Les Maures, Sartene, Haza de Lino and Sughereta.

The density of the cork oak forest varies, having a lower than average density in Morocco and Tunisia, a higher than average density in Italy and Spain, and being quite diverse in the populations of Portugal and France, with some high-density masses and others of low-density.

The majority of the cork oak forest show evidence of natural regeneration, but this does not occur in several of the cork oak stands in Morocco (Boussafi, Maâmora, Aïn Rami and Oulmés), in two in Spain (La Almoraima and Jerez de los Caballeros), in three in France (Les Maures, Le Rimbaut and Sartene) and in Portugal at Santiago do Cacém. The preceding data has been compiled in Table IV-4.

The Passport Data also includes the average rainfall and temperatures recorded at the weather stations closest to each collecting area. These data are shown in Table IV-5. The total annual rainfall is lowest in the Sicilian population (Catania: 448 mm), while the maximum was registered in the Tunisian cork oak forest of Fernana (1610 mm). As for temperatures, the highest annual temperature corresponds to Mekna (17.9ºC.), while the lowest average temperature was recorded at Maures (11.9ºC.).

Table IV-4 - Stand structure, composition and management

Country	Provenance	Code	Stand Composition	Density	Natural Recruitment
France	Var	FR 1	Pure	Medium	No
	Pyrenées Orientales	FR 2	Mixed	High	No
	Landes	FR 3	Mixed with *Pinus pinaster*	Low	Yes
	Corse	FR 4	Pure	High	No
Spain	Montes de Toledo	ES 5	Mixed with *Quercus ilex* ssp ballota and *Q. faginea*	High	Yes
	Sierra Morena Oriental	ES 6	Mixed with *Quercus ilex* ssp. ballota, *Q. faginea* and *Q. pyrenaica*	High	Yes
	Sierra Morena Occidental	ES 7	Mixed with *Quercus ilex* ssp. ballota	High	No
	Parque de los Alcornocales	ES 8	Mixed with *Quercus canariensis*	High	No
	Cataluña Litoral	ES 9	Mixed with *Q. ilex* ssp. ballota, *Q. humilis*, *Castanea sativa* and *Pinus radiata*	High	Yes
	Sierra de Guadarrama	ES 10	Mixed with *Quercus ilex* ssp. ballota	High	No
	Alpujarras	ES 11	Pure	High	Yes
Italy	Lazio	IT 12	Pure	Medium	Yes
	Puglia	IT 13	Mixed with *Quercus ilex* ssp. ilex and *Q. morisi*	High	Yes

	Sicilia	IT 14	Mixed with *Pinus halepensis* and *Eucalyptus viminalis*	High	Yes
	Sardegna	IT 15	Mixed with Quercus ilex ssp. ilex	Medium	Yes
	Sardegna	IT 16	Mixed with some trees of *Quercus humilis*	Medium	Yes
Portugal	Vale do Tejo e Sado	PT 17	Pure	Low	
	Vale do Tejo e Sado	PT 18	Pure	Low	Yes
	Vale do Tejo e Sado	PT 19	Pure	Low	Yes
	Vale do Tejo e Sado	PT 20	Pure	Low	Yes
	Sudoeste	PT 21	Pure	High	Yes
	Alentejo e Beira Baixa	PT 22	Mixed with *Quercus ilex* ssp. ballota	High	Yes
	Sudoeste	PT 23	Pure	High	No
Spain + Portugal	Alentejo e Beira Baixa + Sierra de San Pedro	PT + ES 25	Mixed with *Q. ilex* ssp. ballota (Spain) and *Pinus pinaster* (Portugal)	Medium-high	Yes
Morocco	Rif Atlántico	MA 26	Pure	Low	No
	Rif Occidental	MA 27	Pure	Medium	Yes
	Maâmora	MA 28	Pure	Medium	No
	Maâmora	MA 29	Pure	Medium	No
	Plateau Central	MA 30	Pure	Medium	No
	Rif Oriental	MA 31	Pure	Medium	Yes
Tunisia	Mekna	TU 32	Pure	Low	Yes
	Fernana	TU 33	Pure	Low	Yes
Algeria	Guerbès	MZ 34			

<u>Density classification based on the average distance among trees:</u>

> 25 m $\Rightarrow$ low density

≈ 25 m $\Rightarrow$ medium density

< 25 m $\Rightarrow$ high density

Table IV-5 - Temperature and rainfall

Provenance (Climatic site, alt.m)	**Code**	**T(ºC) P(mm)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Tot** / $\bar{X}$
Var (Bormes.INRA, 80m)	FR 1	T	7,1	7,5	9,5	11,3	14,9	18,9	21,9	21,9	18,8	14,7	10,3	7,9	11,9
		P	140	105	84	93	65	62	13	36	70	156	102	103	963
Pyrenées Orientales	FR 2	T	8,2	9,2	11,4	13,3	17,1	20,6	24,4	24,4	21,0	16,6	12,1	9,9	15,7
		P	61	84	75	68	78	48	14	35	61	173	197	64	958
Landes	FR 3	T	5,5	7,5	8,0	10,5	13,5	17,0	19,5	19,0	17,2	14,5	8,5	6,5	12,3
		P	100	80	60	60	60	50	40	50	80	90	100	100	870
Corse (Sartene)	FR 4	T	7,2	3,6	3,2	12,4	13,7	18,6	24,1	23,6	18,4	16,7	14,7	10,7	13,9
		P	119	25	19	81	54	7	28	20	65	81	123	69	691
Montes de Toledo (Cañamero, 589m)	ES 5	T	7,1	8,2	10,7	13,6	16,7	21,4	25,2	24,5	21,3	16,2	10,7	6,9	15,2
		P	177	141	118	103	67	38	9	7	59	94	140	114	1063
Sierra Morena Oriental	ES 6	T	4,4	6,8	9,8	13,5	14,6	21,3	24,7	22,4	21,1	16,1	10,8	5,7	14,3

(Fuencaliente, 696m)		P	86	87	81	75	64	31	6	6	31	73	73	106	719
Sierra Morena Occidental	ES 7	T	8,1	9,3	11,6	14,0	17,4	21,7	24,8	25,2	22,2	17,5	12,0	8,6	16,0
(Jerez de los Caballeros, 492m)		P	83	86	90	49	45	24	4	6	29	67	87	96	666
Parque de los Alcornocales	ES 8	T	11,4	11,5	12,7	14,5	17,2	20,4	23,7	23,3	20,8	17,5	14,4	12,0	16,6
(Castellar de la Frontera, 60m)		P	150	157	109	70	42	12	2	4	23	110	125	189	993
Cataluña litoral	ES 9	T	7,9	8,6	11,1	13,4	16,1	20,6	23,6	23,1	20,1	16,0	11,9	7,5	15,0
(Castanayet, 260)		P	48	72	74	84	99	55	29	56	81	86	63	54	802
Sierra de Guadarrama	ES 10	T	5,4	6,9	9,8	12,4	15,8	20,4	24,0	23,6	19,8	14,3	8,9	5,8	13,9
(Madrid-Retiro, 667m)		P	44	41	45	47	42	29	11	12	32	52	53	49	455
Alpujarras	ES 11	T	6,3	7,3	8,5	10,3	13,8	17,1	21,5	21,9	18,9	13,7	9,6	7,0	13,0
(Soportújar, 1400m)		P	100	91	105	72	41	20	3	3	22	84	74	123	742
Lazio	IT 12	T	6,5	7,6	9,7	12,2	16,1	20,0	23,1	23,2	20,3	15,8	11,3	7,8	14,5
(Tuscania, 165m)		P	83	88	77	62	99	44	42	39	81	105	117	100	937
Puglia	IT 13	T	9,1	9,6	11,3	14,1	18	22	24,5	24,6	22	18,1	14,3	11	16,6
(Brindisi, 45m)		P	74	61	53	45	28	15	13	21	35	65	90	88	588
Sicilia	IT 14	T	11,2	11,1	12,6	13,9	19,2	23,4	26,2	25,6	22,9	19,5	15,1	11,9	17,7
(Vittoria, 168m)		P	39	47	39	28	18	1	1	7	51	44	88	85	448
Sardegna	IT 15	T	9,5	9,6	11,6	14,2	17,2	22,7	25,9	25,8	23,2	18,5	14,3	11,1	17,0
(Iglesias-Pantaleo, 193m)		P	122	104	88	58	51	16	3	10	47	110	125	149	883
Sardegna	IT 17	T	6,6	6,8	9,2	12,0	15,3	20,0	22,9	23,1	20,1	15,4	11,2	8,1	14,2
(Villanova Monteleone, 567m)		P	126	112	90	76	64	23	6	14	60	116	115	108	910
Vale do Tejo e Sado	PT 17	T	9,1	10,2	11,8	13,9	16,9	19,9	22,8	22,9	21,0	17,1	12,0	9,2	15,6
(Tancos-Base aérea, 83m)		P	118	127	77	70	58	34	5	7	42	93	09	89	829
Vale do Tejo e Sado	PT 18	T	10,3	11,2	12,8	14,7	17,6	20,6	22,9	23,0	21,3	17,8	13,4	10,5	16,3
Alcácer do Sal, 31m)		P	85	80	77	44	34	19	4	3	20	53	70	88	577
Vale do Tejo e Sado	PT 19	T	9,4	10,0	11,3	12,8	15,2	17,6	19,6	19,7	18,7	16,0	12,0	9,7	14,3
(Sesimbra, Maça, 120m)		P	102	91	94	49	33	12	3	4	23	73	96	101	681
Vale do Tejo e Sado	PT 20	T	9,6	10,1	12,4	14,4	17,7	20,6	22,9	23,2	21,4	17,7	12,8	9,8	16
(Montargil-Barragen, 75m)		P	110	102	87	56	43	34	5	4	30	72	78	89	710
Sudoeste	PT 21	T	10,0	10,6	11,8	13,8	16,9	20,2	23,2	23,2	20,9	17,2	12,8	10,3	15,9
(S. Bras de Alportel, 240m)		P	148	130	119	59	38	22	1	4	21	91	109	132	874
Alentejo e Beira Baixa	PT 22	T	9,3	9,9	11,5	13,6	16,6	19,9	22,8	23,0	21,1	17,1	12,4	9,7	15,6
Evora, 309m)		P	94	85	83	49	39	27	6	3	25	67	79	7	564
Sudoeste	PT 23	T	10,4	10,8	12,3	14,1	16,5	18,9	20,7	21,2	20,2	17,8	13,5	10,9	15,6
(Santiago do Cacém, 228m)		P	126	97	100	46	44	17	2	3	20	71	103	107	736

Alentejo + Sierra de San Pedro	PT + ES 25	T	7,8	9,0	11,0	13,4	16,1	20,6	24,5	24,4	21,3	16,5	11,6	8,0	15,4
Alburquerque, 500m + Portalegre, 597m)		P	118	102	101	62	51	29	6	7	35	79	93	95	778
Rif Atlantique	MA 26	T	--	--	--	--	--	--	--	--	--	--	--	--	--
(Larache)		P	109	77	89	54	34	7	0	1	13	60	99	140	574
Rif Occidental	MA 27	T	--	--	--	--	--	--	--	--	--	--	--	--	--
(Bab Taza)		P	239	248	202	128	76	24	1	1	21	111	165	266	1280
Maâmora	MA 28	T	--	--	--	--	--	--	--	--	--	--	--	--	--
(Rabat)		P	82	69	67	58	19	8	0	1	7	36	84	105	536
Maâmora	MA 29	T	--	--	--	--	--	--	--	--	--	--	--	--	--
(Tiflet)		P	88	64	64	42	31	2	1	0	8	27	58	94	479
Pateau Central	MA 30	T	--	--	--	--	--	--	--	--	--	--	--	--	--
(Oulmes)		P	84	100	88	86	25	15	5	0	25	45	110	90	673
Rif Oriental	MA 31	T	--	--	--	--	--	--	--	--	--	--	--	--	--
(Bab Azhar)		P	110	196	121	111	73	20	6	3	20	68	104	138	970
Mekna	TU 32	T	11,1	11,4	13,4	15,2	18,7	22,5	24,9	25,6	23,9	19,8	15,6	12,3	17,9
(Tabarka)		P	141	118	97	69	36	12	4	11	50	117	135	158	948
Fernana	TU 33	T	6,6	7,2	9,8	12,3	15,9	20,2	23,7	24,8	21,8	16,9	11,9	7,9	14,9
(Aïn Draham)		P	261	196	174	137	78	28	7	14	67	153	202	293	1610

Four of the participating countries (Tunisia, Italy, Spain and Portugal) provided measurements of the mother trees (total height, stem height and diameter) that are reflected in Table IV-6. An analysis of that data shows that the trees with the highest total height are found in the Spanish population of La Almoraima, measuring an average of 12.29 m, while those of Sicilia and S. Brás with an average height of 7 m and 6.30 respectively, are the shortest. The tallest (19 m) and the shortest (3.36 M) cork oaks were found at Santa Coloma.

The second variable measured was stem height, yielding average figures per population that ranged from 1.83 m at Ferana and 3.79 at Santa Coloma. The tree at Santa Coloma that registered the maximum total height also had the tallest stem (16 m). The opposite occurred at Brindisi, where seed was gathered from a cork oak whose first branch measured only a half meter from the ground.

The diameter of the Italian, Tunisian, Spanish and Portuguese trees range from 31.19 cm (Fernana) to 63.04 cm (Villuercas). The tree with the longest perimeter was found at Las Villuercas (149.61 cm), while the shortest was at Azaruja (10,21 cm). Establishing diametrical classes in 10 cm increments, graphs were drawn to show the distribution of age classes in the 14 populations for which these data wear made available (Figure IV-2).

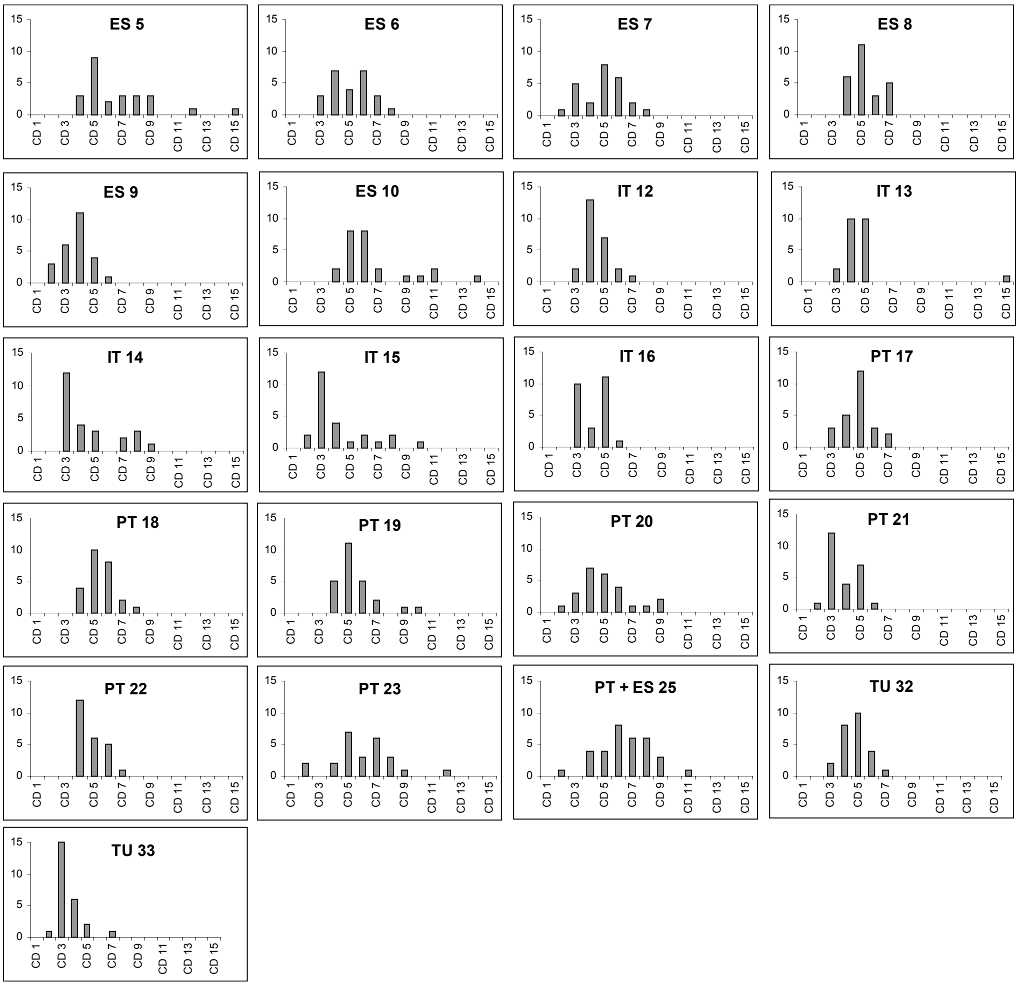


Figure IV-2 - Diameter distribution of mother trees in Spanish, Italian, Portuguese and Tunisian provenances

General view of the plants in nursery

V-Nursery, Raising and Labelling of the Material

(M. Carolina Varela, Teresa Branco, Isabel Reforço Barros, EFN,
M. Helena Almeida, M. Regina Chambel, ISA, Portugal*)*

Reception of acorns lots

To assure harmony on seedlings, project's proponents agreed that plant production should take place in one nursery in Portugal.

This procedure took benefit from the experience on a similar EU project the concerted action on *Fagus sylvatica* co-ordinated by Institut fur Forest Genetics, Germany.

Plant raising in each country nursery according to the foreseen number of trials would eliminate the costs of plant deliver. Yet raise of plants in various nursery rarely achieves the need level of harmonisation, in spite of common protocol is previously agreed. Factors of contingency along plant raising become higher as the number of nurseries involved increase, compromising future comparability of data among trials

Nursery climate and quality of water are not feasible of conformity. Random events such as temporary break down of watering system would enhance the systematic differences among the various nurseries. Vigour differences could easily happen along the different nurseries.

Following the partners decision of plant raising in one single nursery, the co-ordinator choose the private nursery of Santo Izidro considering its goods standards and previous experience on oaks, namely *Q. ilex*, *Q. suber* and *Q. robur*.

All seed lots have been sent to the co-ordinator institution, EFN in Portugal, under common basic items.

a) European Countries

Since European Union is a single trading region, phytossanitary certificates are not needed for seed and plants transfers among member countries. Phytossanitary certificates where only required for the acorns coming from North Africa countries.

Beyond any legal requirements, health standards of trees and acorns has been obviously a pre-requisite for selection of trees and on acorn collection.

Since cork oak acorns are recalcitrant seeds attention was given to the packing material for transporting. Preference has been given to materials that allow respiration of the seeds, i.e., paper boxes, net bags or sacks of vegetable fibre tissue Plastic bags has been strongly unadvised.

Sowing methodology

Each lot of acorns was kept in its respective transporting container identified with two labels, one placed inside and another outside. Labels indicated the provenance and the number of the mother tree (see chapter IV - COLLECTION OF MATERIAL, BOX IV. 1 BOX IV. 2).

France

Seeds were sent to Portugal by mail. They were collected at the airport and then transported by car to the nursery, where they were kept in sacks in the cool chamber until sowing, i.e. some few weeks.

The acorns showed good vegetative state.

Italy

The logistic of transportation was identical to the French scheme. The acorns presented a good vegetative state also.

Portugal

In Portugal the seeds were transported from the stands of collection to the nursery directly by car. Good vegetative conditions of acorns were also verified.

Spain

Acorns collected in the Spanish stands were transported by car by the Spanish partner to a previously agreed place in the Portuguese border where they were collected by the Portuguese co-ordinator.

b) North African Countries

Unlike transit between European countries, the transportation from North African countries to Portugal required special documentation. Phytossanitary certificates and "proforma invoices" were needed.

Since this Concerted Action is a European project, under the FAIR programme, the participation of countries outside Europe was not possible. The acquisition of acorns from North African countries was made possible by means of purchase.

Morocco

The seeds from Morocco were sent by plane, in sacks made of a tissue of vegetable fibre.

Seeds were retained in the airport during the weekend without any specific storage conditions, i.e. under the normal seasonal temperatures in Portugal, +5ºC - +15ºC and air moisture.

The seeds were transported by car from the airport to the nursery.

Some seeds showed already an onset of root apex, which is very common in cork oak.

Tunisia

Seeds were sent by express mail. Due to customs problems they were retained during one week in the airport. During this period they were not under any special storage conditions, however this did not seem to affect the germination ability of these acorns.

The customs difficulties were related with lacking of some documents. To avoid these situations of "uncontrolled storage conditions" that may diminish seed quality, one advises to get sound information on the documentation requirements.

Some seeds, although few, showed already onset of root apex.

Algeria

Acorns from Algeria were sent to Portugal by plane. At the arrival they showed good vegetative conditions.

Storage

Acorns were gathered at S[to] Isidro Nursery, located in Pegões, Portugal, where the production of the seedlings has been previously accorded. Engª Isabel Almeida, the nursery forest expert in charge of plant production, performed the supervision of the plant raising process.

As justified in chapter III, the project team agreed that acorns should not undergo on long time storage. Yet to cope with the lapse of time from arrival till sowing – a few weeks- the acorns have been temporally stored in a cool chamber under temperature from +3-+5 ºC (provided by the nursery without extra charge) well-aired and away from rodents.

The lapse of time has been due to the pace of sowing required to assure strict identification of each seed lot, along all the process since arrival of acorns till delivery of plants, for trials establishment.

Moreover, for plant delivery it was a basic requirement to place acorns from each provenance and respective mother trees seed lots together in the nursery area (set aside for the plants of the project).

Sacks where placed into special containers that leave in between them a space about 10cm that allows air circulation. Moistening of acorns was also verified and the sacks were revolved frequently

Suggested by the French partner, Dr. Bariteau (INRA, France), Dr. Falconnet (CEMAGREF – Aix-en-Provence) has been in Portugal from 6-9 February 1997 to provide guidance on the task of plant raising. Dr. Falconnet is a recognised expert with sound and diversified experience in plant production, namely cork oak.

According to his opinion the nursery provided adequate technical means to mass production of cork oak seedlings.

Sowing

Sowing occurred along January and February 1997.

Sowing process has been done following country and respective provenance, pursuing the following phases:

Immersion in water during 24-28 hours- labelling of water containers. The water was added with fungicide TIADORA (tirame 80%) in the proportion of 150gr/100 l water.

Sowing in trays of 38 individual containers of 400 cm^3-labelling

Transporting of trays for the definite zone in the nursery, after completely sowing of the specific seed lot. Mapping of the nursery location of each seed lot.

The containers were identified with yellow plastic labels exhibiting <u>country</u>, <u>provenance</u>, <u>mother tree</u> (m.t.) and <u>sowing date</u>.

The number of persons involved on the sowing process has been assessed, revelling that rigour and speed have a compromise.

In order to achieve 200 plants per mother tree, the number of seedlings needed to satisfy the experimental design, 300 acorns at minimum were sowed, having into account the average germination rate for the species. Regarding the lots where individualisation was not possible, about 3800 acorns were sowed (100 containers for each provenance).

Floating acorns were not used whenever the amount on the lot allowed. Yet all were used, even those floating, on the lots where the number of acorns was close to the limit. According to nursery experience, these acorns often proved to be in good conditions to germinate.

After all seeds were sowed and all containers placed in the nursery area a map has been done, indicating the position and number of containers for each seed lot.

Along the nursery phase map has been systematically used to confirm container labels any time plants have been picked up

The aspect of plants in nursery is patent at Figure V.1, where photographs from the provenance- Italy-Cagliari, Morocco, France- Le Rimbaut, Spain- Fuencaliente, are used as example.

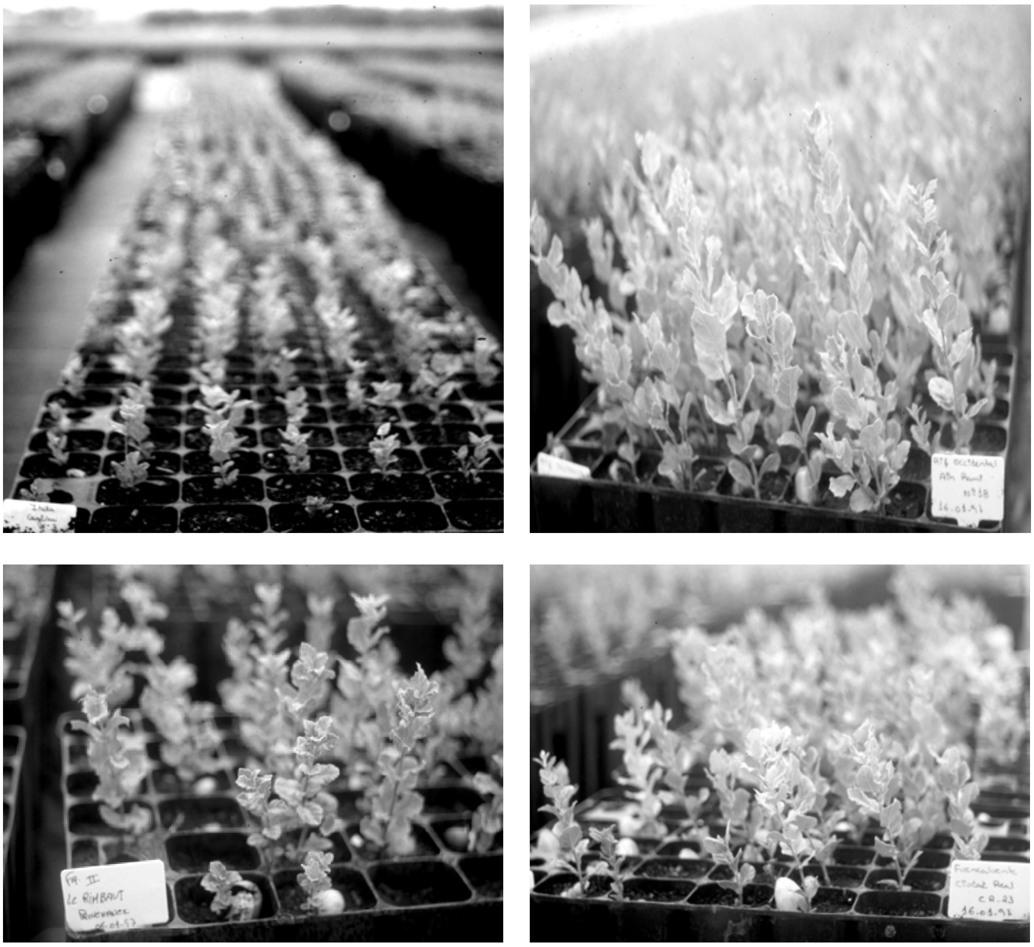


Figure V-1 - Aspect of the plants 9 months after sowing. Provenance- Italy-Cagliari, Morocco, France- Le Rimbaut, Spain- Fuencaliente are used as example**.**

Following Dr. Falconnet advice the methodologies adopted for the production of the cork oak seedlings are now described.

Containers

The containers used were Forest-Pot F/P 400 whose capacity is 400 cm^3.

This volumetry is the most indicated for lifting cork oak plants, for it assures a good development of the root system while giving a balanced size that enhances survival changes after plantation.

These containers have alveolus with interior longitudinal furrows to impede the curling of the root system.

Characteristics:

Model	Perimeter	Height	Superior surface of the alveolus	Nº alveolus	Capacity	Density
F/P 400	430X300	190	60X48.5 (29 cm^2)	38	400 cm^3	280alv/m^2

Substrate

The substrate used was a composed of crushed pine bark.

Table V-1 - Physical properties of the substrate

Properties	
Natural humidity (%)	64
Humidity referred to dry weigh at 105ºC (%)	178
Natural apparent density (g/cc)	0.39
Dry apparent density (g/cc)	0.14
Dry porosity, from dry apparent density (%)	92.4
pH - H_2O	4.5 - 5.5
Total organic matter (%)	94
Organic matter easily oxidable (%)	60 - 80

This substrate is a competitor for phosphates

Protection

To prevent attacks from birds a net was placed to cover the whole area where the containers were placed.

Fertilisation

Nutrient level should be monitored through conductivity levels, which should stay within the limits of 250-400.

Fertilisation was done at sowing with Osmocote 10+11+18+Mg+Micronutrients. The fertiliser was mixed with the substrate and applied at the proportion of 1,5 Kg/m^3.

Three applications of fertiliser 13+40+13+B+Cu+Fe+Mn+Zn (commercial name Hakaphos® violeta) were made once a week in order to invigorate the root system.

Phytossanitary treatments

Beyond the procedure of sinking the seeds in water with fungicide TIDORA (80% Tirame) for 24-48 hours, the same product was applied after sowing on the net covering the containers. Watering was made afterwards. The product was applied at the proportion of 300g/100 l water/500 m^2.

Watering

Water was provided from a deep spring.
Maintenance of moisture level at a pF of about 1.5 as an average of the maximum limits of 1-2.7 is a basic requirement to assure good architecture on the root system, while preventing lixiviation of nutrients. Irregularities on watering leading to dry periods leads to inverse root growth and curling.

Seedlings were slightly watered various times, which provides better physiologic conditions than a once-a-day heavy watering, which easily induces run-off of nutrients.

Observation of a sample of alveolus chosen randomly, was used for empirical assessment of watering needs.

Labelling and delivering of plants for trials establishment

The labelling process has been a crucial task in this project. Plants to be sent for the establishment of field trials were individually labelled so that maximum genetic information is available for future evaluation of the field trials. It allows mother trees to be traced throughout the duration of the trials.

The huge number of plants, a total of about 250 000, as well as the number of genetic entities involved (34 provenances with 20-25 mother tree each) required a precise control of this task.

To make it simple and clear, the information related on each individual was condensed into a code. However this was done having in mind that concision could not lead to omission of relevant information. In this perspective each label contains the indication of the country (two capital letters); of the provenance (codes for provenance were attributed by each country and the ones used are the same as in the passport forms). The number of mother tree was also included. In parenthesis the name of the nearest locality and of the region of provenance.

The example below shows how codes were applied.

ES	**2- A**	**m.t. 20**	**(La Tojera)**	**-Sierra de SAN PEDRO)**
Country Code	Provenance Code	NO of the mother tree	Nearest Locality	Name of the region of Provenance

Special paper labels long lasting, water resistant and suited for computer printing were used.

The number of labels needed was calculated having in account the number of trials and the number of plants for each trial according to the experimental designs.

In the nursery, the plants were disposed in containers of 38 alveolus identified during the sowing process with rigid labels, for each country, provenance and mother tree.

For the individual labelling of plants it was needed 6 persons per day, working in two/three groups for a precisely control the operation.

Each group was in charge of all plants from one provenance at a time, taking four weeks of intense labour to accomplish this task.

After all plants needed for the trials were labelled it was initiated the preparation of the plant lots for delivery.

Each lot was prepared according to each country request in what concerns number of plants per provenance and mother tree to satisfy the ED for their provenance and progeny trials. However to cover eventual mortality during transportation or after planting an extra number of plants was sent.

Plants were procured on the different seed lots spread on the nursery and gathered on lots that were put in plastic boxes of 400 cm^3.

For this task there were 8 persons working by day.

Plants from the mother trees from one provenance were grouped in one lot of 3-4 boxes. In each box a plastic sheet separated plants from the same mother tree from the other mother trees' plants. Each of these groups was identified by paper labels add-on to the box exterior.

The lot of plants to be delivered to each one of the countries was carefully organised in palettes.

Sending

The plant transportation took place between Dec 1997 and February 1998. It was made by two means:

Plane - To the North African countries (Morocco and Tunisia)

Truck - To the European countries (Spain, France and Italy, Portugal).

During transportation the following conditions should be respected:

Temperature - +8º C

Humidity - 70% a 80%

Plants should not be in the darkness for periods superior to 4 days

The best season to make the transport is October/November

The synchronisation from plant deliver and reception in local was assured before delivering. Whenever immediate plantation has not been possible plants were send only after information from reception Institutions of having the necessary conditions mainly for watering and shading..

Transportation companies were previously informed of the total number of plants, volume and weight, and of the fact the cargo was of living plants, therefore perishable, and to be delivered in good physiologic conditions for planting.

Legal documents to accompany the plants included:

Box V. 1 - Phytosanitary certificates - emitted by the competent institution

- Proforma invoices - emitted by the institution responsible by the delivery of the plants. It should contain the following information

DATE			SENDER:
NO of Volumes	Weigh	Price	DESTINATION
-----volumes = m^3 containing ---------- boxes and --------- plants	-------- Kgs		

The present invoice sums up: .... Merchandise Without Lucrative Value.
Signed by the Director of Estação Florestal Nacional

<u>Donation certificates</u> - emitted by the institution responsible by the delivery (Estação Florestal Nacional) of the plants. This document facilitates the custom's procedures by stating the material as a donation between the ministries of the involved countries. This information was also presented in the Proforma invoice.

Following the agreed experimental design 8 plants from each m.t. were needed

The process of delivering was very time consuming since there was the need to pick 9 plants from each m.t. within each provenance to send for provenance trials. The provenances for progeny trials (see chapter III) had to be a compromise between the country request and the availability of plants. Rigours counting from the plants were done several times.

Nursery observations

At nursery stage uniformity of environmental components reach a high level that allows phenotypic characteristics to be taken as an appraisal of genetic differences. At Figures V.2 and V.3 consistence differences among provenances are patent.

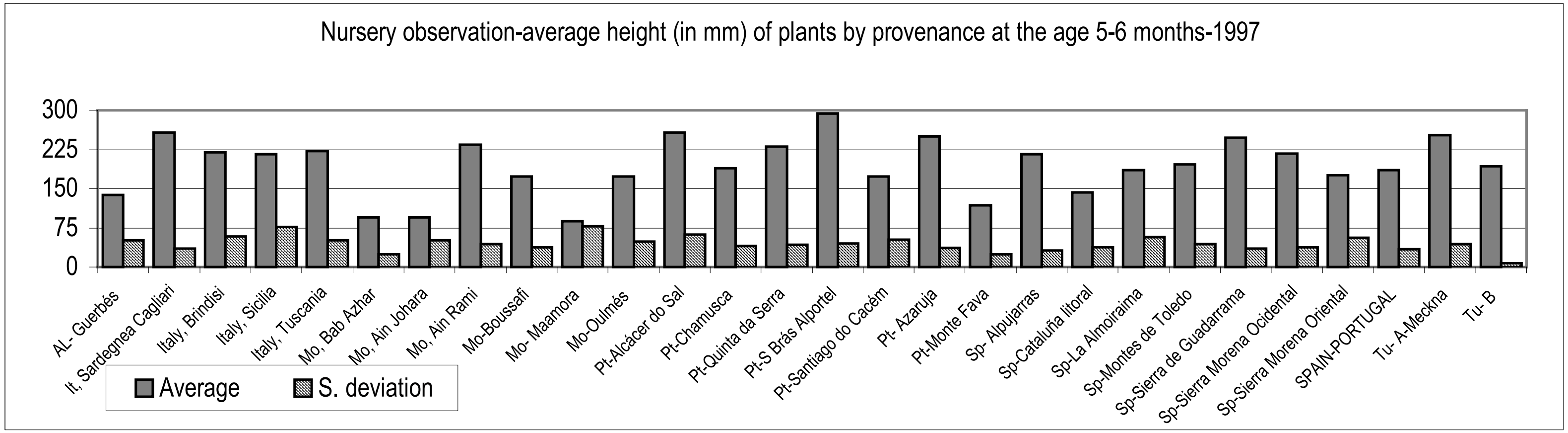


Figure V-2 - -Height of seedlings 5-6 months after sowing.

Responsible person for data: R. Chambel and MH Almeida, ISA, Portugal

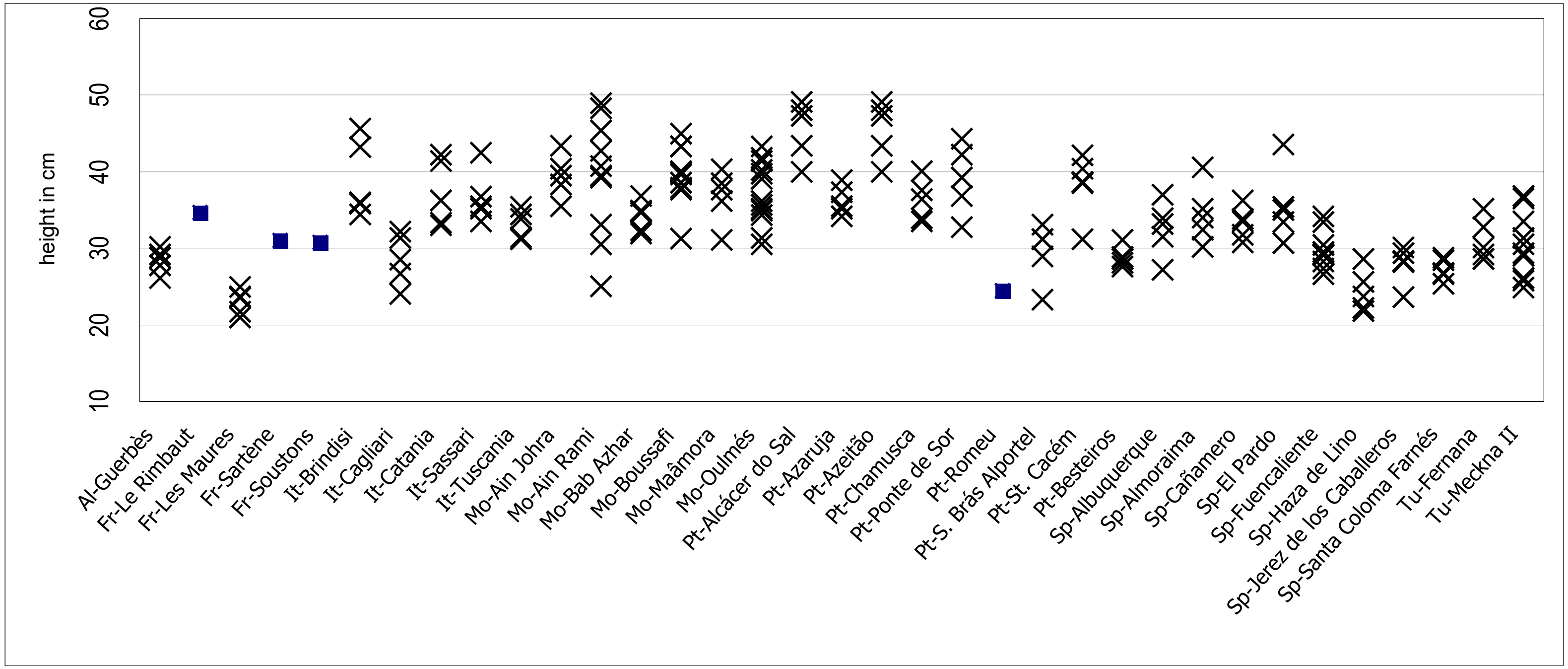


Figure V-3 -Nursery measurements - Height in the nursery-measurements by Dec- Jan 1998, 10-12 months post-sowing

(Legend) Each point is the average for a half-sib family (x-marks; 15 measurements) or a seed lot (squares; 30 measurements). Responsible persons for data- Paulo de Oliveira, Univ of Évora; Elsa Coelho

Young
plantation
of cork oak

VI- Field Trials

(H. Sbay, CNRF, Morocco*)*

The establishment of the cork oak trials was made in each country by national funding. Each of the participating countries decided, based on its research lines for *Quercus suber*, the type and number of trials to be established.

In this chapter it will be presented the description of each trial focusing the characterisation of the site and the experimental design used.

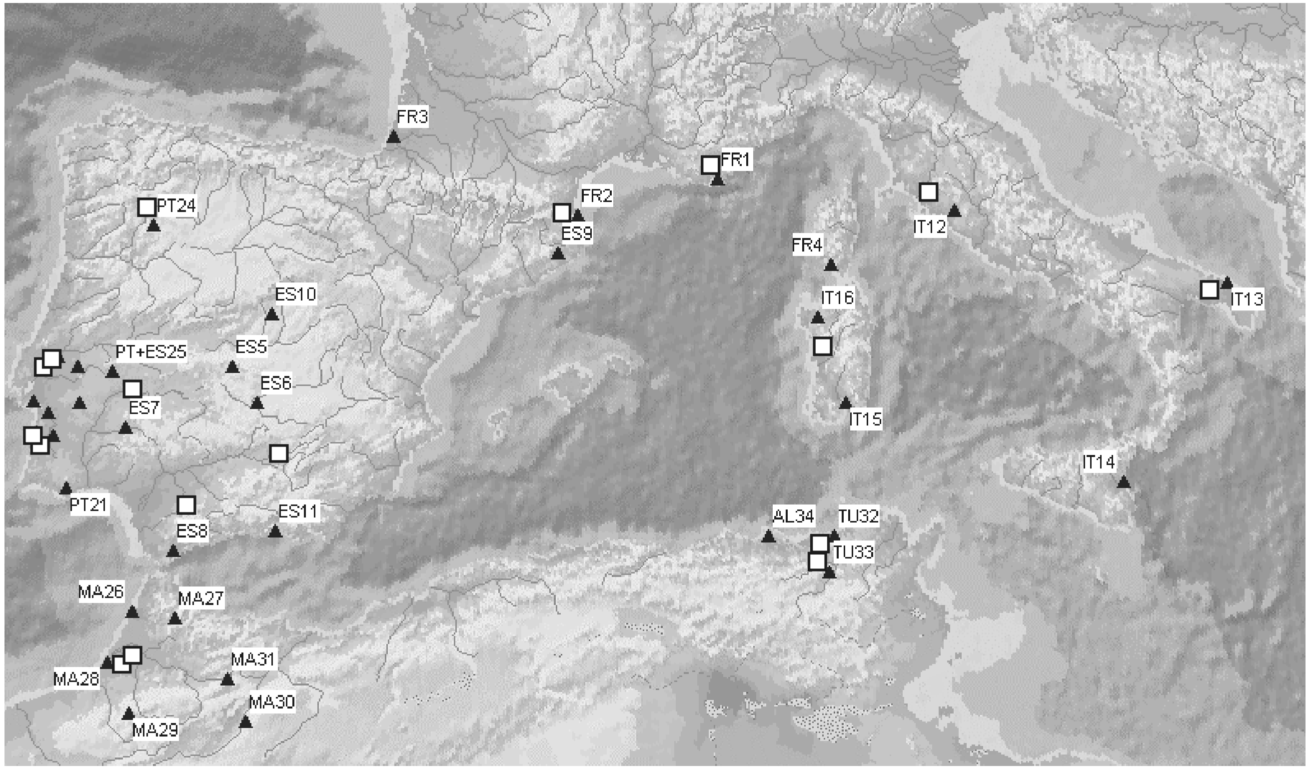


Figure VI.1 - Approximate location of provenances and trials (▲ - provenances; □ - trials)

For further details please see table IV.2 and the tables of the current chapter

FRANCE

France has established two provenance trials, one in Maures and other in Pyrenées Orientales.

Provenance Trial in Maures

Location: Maures, Bormes-les-Mimosas **Community:**
Council: **Forêt domaniale des Maures** **District**:
Region of Provenance:

Table VI.1a - Brief description of the site Maures, Bormes-les-Mimosas, France

Exposition	all
Longitude	6°22'E
Latitude	43°11'N
Altitude	300 m
Medium Slope	10%
Climate	Nearest Meteorological site of reference: Bormes les Ruscas (alt: 93 m) (1974-1993) P total: 975 mm P summer: 84 mm T annual average: 13,6 ºC T average min of the coldest month: 1,6º C T average max. of the hottest month: 29 º C Coefficient d'Emberger 130-140 3 dry months
Soil type	Gneiss migmatiques and amphibolitiques
Porosity	Low
Soil deepness	45-60 cm
Texture	Sandy -limoneuse
Soil preparation	Mechanical clearing and subooling Nov. 1997
Fertilisation	--
Former use	*Pinus pinaster*
Date of establishment	January 8-9 1998 for 29 provenances and February 1998 for the fourth French provenances

Species:

Common name- chêne liège **Latin name**- *Quercus suber* L.

Table VI.1 b- Experimental Design of the Provenance Trial in Maures, France

Number and list of provenance	35 provenances (7 Spanish, 5 Italian, 9 Portuguese, 4 French, 2 Tunisian, 6 Moroccan, 1 Algerian and 1 Portuguese-Spanish)
Type of experimental design	Complete Randomized Blocks (**RCB**)
Number of blocks	18
Number of plots	
Number of plants per plot	4
Number of plants per block:	132
Number of plants per provenance	72
Total number of plants	2376
Tree shelters	60cm height
Cartography	Michelin map n°245
Acreage	Spacing: 3,5 m x 2,5 m Block size: 8,75 m² x 33 plots = 288,75 m² Total acreage without border: 288,75 x 18 blocks = Total acreage with border: about

Provenance trial in Languedoc-Roussillon

Location: Languedoc-Roussillon
Community: Pyrénée-Orientale
Council:
District:
Region of Provenance:

Table VI. 2 a- Brief description of the site Languedoc-Roussillon, France

Exposition	South-west
Longitude	2°55' E
Latitude	42°53' N
Altitude	20 m
Medium Slope	5%
Climate	Nearest Meteorological site of reference: Canet en Roussillon (1961-1997) P total: 631mm P summer: 182.4 mm T annual average: 15 ^{0}C T average min of the coldest month: -10º C T average max. of the hottest month: 19.5 º C Coefficient d'Emberger - 3 dry months
Soil type	Colluvions anciennes
Porosity	10-15%
Soil deepness	80-100 cm
Texture	Sandy -silt
Soil preparation	Vineyard clearing up
Fertilization	--
Former use	Vineyard
Date of establishment	May 1998

Species:

Common name- chêne liege **Latin name**- *Quercus suber* L.

Table VI. 2 b- Experimental Design for provenance trial in Languedoc-Roussillon, France

Number and list of provenance	34 provenances (7 Spanish, 5 Italian, 9 Portuguese, 4 French, 2 Tunisian, 6 Moroccan, 1 Algerian
Type of experimental design	Complete Randomized Blocks (**RCB**)
Number of blocks	
Number of plots	
Number of plants per plot	
Number of plants per block:	
Number of plants per provenance	Complete Randomized design.
Total number of plants	
Tree shelters	Against rabbik (Nov. 1998)
Cartography	IGN map n°2548 0T
Acreage	Spacing: 4 m x 2,5 m Block size: - Total acreage without border: - Total acreage with border:

ITALY

Three provenances trials have been established in Italy, two in the continental country and one in Sardinia island.

```
Design of blocks for provenance trials:

X1 --- 3m ---X1 ---3m--X2---3m--- X2
 |           |          |          |
 3m          3m         3m         3m
 |           |          |          |
 X1---3m--- X1  ---3m—X2 ---3m--- X2
```

Figure VI.2 - Design of blocks for provenance trials in Italy

Provenance trial in Roccarespampani

Location: Roccarespampani
Community: Viterbo
Council:Lazio
District:
Region of provenance: central Italy

Table VI.4 a - Brief description of site conditions in Roccarespampani, central Italy

Exposition	All
Longitude	11°55'E
Latitude	42°67'N
Altitude	160 m
Medium Slope	0-1%
Climate	Nearest Meteorological site of reference: Tuscania (alt: 165 m)
	P total: mm 868,7 P summer: mm 108,7
	T annual average: 14,8 ^{0}C
	T average min of the coldest month: 2,4° C
	T average max. of the hottest month: 31° C
	Coefficient d'Emberger: 90,9
	3 months dry in Summer
Soil type	Cromic luvisols
Porosity	Medium/low
Soil deepness	80-100 cm
Texture	Sandy/clay
Soil preparation	The area was ripped with a ripper with 1 tooth.
Fertilisation	No

Former use	Uncultivated meadow
Date of establishment	1st week of March 1998

Species:
Common name- Sughera **Latin name**- *Quercus suber* L.

Table VI.4 b- Experimental design for provenance trial in Roccarespampani

Number and list of provenance	30 provenances (7 Spanish, 5 Italian, 7 Portuguese, 2 French, 2 Tunisian, 5 Moroccan, 1 Algerian and 1 Portuguese-Spanish)
Type of experimental design	Complete Randomized Blocks (**RCB**)
Number of blocks	30
Number of plots	30
Number of plants per plot	4
Number of plants per block:	120 (except for MOIV-2, 63 plants, and PTIV-01, 72 plants)
Number of plants per provenance	4
Total number of plants	3495
Tree shelters	Wire-cloth
Cartography	(Istituto Geog. De Agostini map.N° 74)
Acreage	Spacing: 3 m x 3 m Block size: $9m^2$ x 4 30 plots = 0,108 ha Total acreage without border: 0,108 ha x 30 blocks= 3,24 ha Total acreage with border: about ha 4,5

Provenance trial in Restinco

Location: Restinco **Community**: Brindisi
Council: Puglia **District**:
Region of provenance: south Italy

Table VI.5 a- Brief description of site conditions in Restinco, south Italy

Exposition	all
Longitude	17°60'
Latitude	40°34'
Altitude	45m
Medium Slope	

Climate	Nearest Meteorological site of reference: Brindisi (alt: 45 m) P total: mm 589,2 P summer: 49.1 mm T annual average: 16,8 ^{0}C T average min of the coldest month: 6° C T average max. of the hottest month: 28,7° C Coefficient d'Emberger: 74,8 3 months dry in Summer
Soil type	Terra rossa
Porosity	high
Soil deepness	80-100 cm
Texture	sandy/limoneus
Soil preparation	Rippering, ploughing and harrowing
Fertilisation	No
Former use	horticulture
Date of establishment	1st week of May 1998

Species:

Common name- Sughera **Latin name**- *Quercus suber* L.

Table VI.5b - Experimental Design for provenance trial in Restinco

Number and list of provenance	33 provenances (7 Spanish, 5 Italian, 7 Portuguese, 4 French, 2 Tunisian, 6 Moroccan, 1 Algerian and 1 Portuguese-Spanish)
Type of experimental design	Complete Randomized Blocks (**RCB**)
Number of blocks	30
Number of plots	33
Number of plants per plot	4
Number of plants per block:	132 (except for PT IV01, 86 plants; PT VI01, 89; FRI,28; FRIV, 19)
Number of plants per provenance	4
Total number of plants	3848
Tree shelters	Wire-cloth
Cartography	(Istituto Geog. De Agostini map N°102)
Acreage	Spacing: 3 m x 3 m Block size: 9m^2 x 4 x 33 plots = 0.1188 ha Total acreage without border: 0.1118 ha x 33 blocks = 3.564 ha Total acreage with border: about ha 6

Provenance trial in Pramanda

Location: Complesso forestale Grighini, Loc. Pramanda **Community**: Oristano
Council: Sardegna **District**: Siamanna
Region of provenance: island

Table VI.6a - Brief description of site conditions in Pramanda, Sardegna, Italy

Exposition	all
Longitude	8°48’53”
Latitude	39°55’35”
Altitude	410-440 m
Medium Slope	0-1%
Climate	Nearest Meteorological site of reference: Allai (alt: m) 50 P total: mm 672 P summer: mm 28 T annual average: ^{0}C 18.6 T average min of the coldest month: ° C 4,7°C T average max. of the hottest month: ° C 32,4°C Coefficient d'Emberger: 83,2 4 months dry in Summer
Soil type	Lithic xerorthents
Porosity	high
Soil deepness	80-100 cm
Texture	Sandy/ limoneus
Soil preparation	Rippering, ploughing and harrowing
Fertilisation	No
Former use	Cistus sp., young cork oaks
Date of establishment	4st week of March 1999

Species:
Common name- Sughera **Latin name**- *Quercus suber* L.

Table VI.6b - Experimental Design for provenance trial in Pramanda, Italy

Number and list of provenance	27 provenances (6 Spanish, 5 Italian, 6 Portuguese, 2 French, 2 Tunisian, 4 Moroccan, 1 Algerian, 1 Portuguese-Spanish)
Type of experimental design	Complete Randomized Blocks (**RCB**)
Number of blocks	25 (note: in this trial there weren’t enough plants for all 30 blocks)

Number of plots	27
Number of plants per plot	4
Number of plants per block:	108
Number of plants per provenance	4
Total number of plants	2700
Tree shelters	Wire-cloth
Cartography	(Istituto Geog. De Agostini map. N°147)
Acreage	Spacing: 3 m x 3 m Block size: 9m² x 4 x 27 plots = 0,0972 ha Total acreage without border: 0,0972 ha x 25 blocks = 2.430 ha Total acreage with border: about ha 3.5

PORTUGAL

Three provenance trials and two progeny trials have been established in Portugal. These trials share a common design, which is presented bellow.

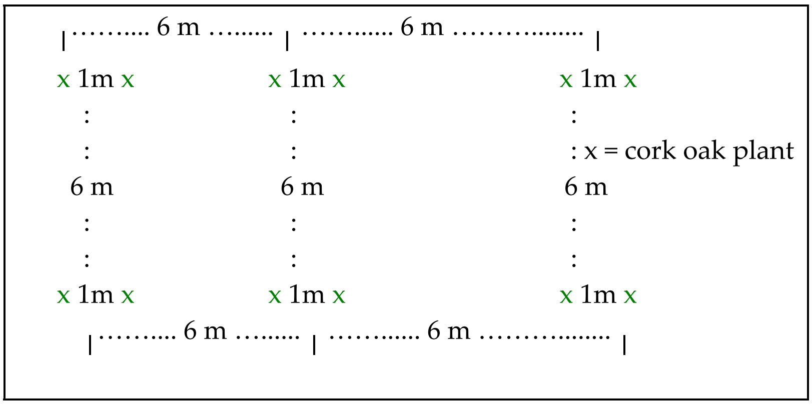


Figure VI-3 - Design of blocks for Portuguese provenance and progeny trials

Provenance trial in Quinta da Nogueira

Location: Quinta da Nogueira
Community: Mogadouro
Council: Mogadouro
District: Bragança
Region of provenance: I - Noroeste Português

Table VI. 7 a- Brief description of the site in Quinta da Nogueira, Portugal

Exposition	Northeast
Longitude	6º40'W
Latitude	41º20'N
Altitude	784 m
Medium Slope	10%

Climate	Nearest Meteorological site of reference: Miranda do Douro (alt: 639 m) (Data:1951-1980) Ptotal: 554.7 mm P summer: 60.3 mm T annual average: 12.0 ºC T average min of the coldest month: 0,7º C T average max. of the hottest month: 28,6 º C Coefficient d'Emberger - 68.94 4 months dry in Summer
Soil type	sandy/clay
Porosity	medium
Soil deepness	30 cm
Texture	medium
Soil preparation	40% of the area it was ripped with a ripper with 1 tooth and one mobilisation on subsoil and on 60% of the steep zone a ripping with a ripper with 3 teeth was made. The arming of soil it was made in trench and hillock.
Fertilisation	P: K (0:2:2), 10-15 gr. per plant
Former use	cereal
Date of establishment	1st week of May 1998

Species:

Common name- Sobreiro **Latin name**- *Quercus suber* L.

Table VI.7 b- Experimental Design for provenance trial in Quinta da Nogueira, Portugal

Number and list of provenance	34 provenances (7 Spanish, 5 Italian, 9 Portuguese, 3 French, 2 Tunisian, 6 Moroccan, 1 Algerian and 1 Portuguese-Spanish)
Type of experimental design	Complete Randomized Blocks (**RCB**)
Number of blocks	30
Number of plants per block:	136
Number of plants per provenance per block	4, planted in 2 pairs of the same progeny, randomly distributed across the block
Total number of plants	4080 (note: in this trial there was not enough plant of França IV, the corresponding positions were planted using commercial plants to maintain total acreage of the trial)
Tree shelters	60cm height
Cartography	Military map nº107 (1/25 000)
Acreage	Spacing: 6 m x 6 m Block size: 36 m² x 70 plots = 0,25 ha Total acreage without border: 0,25 ha x 30 blocks = 7,56 ha Total acreage with border: 11,51 ha (a border line was planted in the exterior limits of the trial

Provenance trial of Mata das Virtudes

Location: Mata das Virtudes
Community - Aveiras de Baixo
Council - Azambuja
District - Santarém
Region of Provenance: IV Vale do Tejo e Sado

Table VI.8 a - Brief description of the site of Mata das Virtudes, Portugal

Climate	all
Longitude	8º 59′ W
Latitude	39º 05′ N
Altitude	25 m to 47,5 m
Medium Slope	<5%
Climate	Nearest Meteorological site: OTA/Base Aérea (Data: 1951 to 1980) Annual rainfall: 587,3 mm Summer rainfall: 31,6 mm T annual average 16,1º C T average min of the coldest month: 5,9º C T average max. of the honest month: 28,4 º C Emberger coefficient: 89.9 4 dry summer months
Soil type	solonchancks gleizados
Porosity	high
Soil deepness	40 cm
Texture	sandy
Soil preparation	Continuos harrowing with heavy harrow. Felling of all young trees. Burning of old stumps.
Fertilisation	Osmocote (10-15 gr. per plant).
Former soil use	*Cistus* sp., *Halimium* sp., *Erica* sp. e *Ulex* sp. and sparced young cork oaks and pine trees.

Species:

Common name: Sobreiro **Latin name:** *Quercus suber* L.

Table VI.9 b - Experimental Design of provenance trial in Mata das Virtudes, Portugal

Number and list of provenances	35 provenances (7 Spanish, 5 Italian, 9 Portuguese, 4 French, 2 Tunisian, 6 Moroccan, 1 Algerian and 1 Portuguese-Spanish)
Experimental design:	Randomized Complete Blocks (RCB).
Number of blocks	30
Number of plants per	4 (planted in 2 pairs of the same progeny, randomly

provenance/block	distributed across the block.)
Number of plants per block	140
Total number of plants in the trial	4200
Tree shelters	60 cm height
Cartography	Military map nº 377
Acreage	Spacing: 6 m x 6 m Block size: 0,2520 ha Total acreage: (not including border lines): 7,56 ha (a border line was planted in the exterior limits of the trial)

Provenance trial of Monte da Fava

Location: Monte Fava
Community: Ermidas do Sado
Council: Santiago do Cacém
District: Beja

Region of Provenance: IV – Valeys of Tejo and Sado

Table VI 10 a. - Brief description of the site Monte da Fava, Portugal

Exposition	all
Longitude	8° 7′ W
Latitude	38° 00′ N
Altitude	79 m
Medium Slope	< 5%
Climate	Nearest Meteorological site: Alvalade do Sado (alt: 61m) (Data: 1951-1980) P total: 556,6 mm P summer: 19,4 mm T annual average: 15,8 ºC T average min of the coldest month: 4,3º C T average max. of the hottest month:31,3 º C Coefficient d'Emberger - 69,8 3 months dry in Summer
Soil type	sandy
Porosity	medium
Soil deepness	40 cm
Texture	medium
Soil preparation	ripping
Fertilisation:	P : K (0:2:2), 10-15 gr. Per plant
Former use of the area:	natural grazing ground
Date of establishment: Provenance trial	3rd week of March 1998

Species:
Common name- Sobreiro **Latin name**- *Quercus suber* L.

Table VI. 10 b-Experimental Design for province trial in Monte da Fava, Portugal

Number and list of provenance	35 provenances (7 Spanish, 5 Italian, 9 Portuguese, 4 French, 2 Tunisian, 6 Moroccan, 1 Algerian and 1 Portuguese-Spanish
Type of experimental design	Randomized Complete Blocks (**RCB**)
Number of blocks	30
Number of plants per block	140
Number of plants/provenance/ block	4, planted in 2 pairs of the same progeny randomly distributed across the block
Total number of plants	4200
Tree shelters	60 cm height
Cartography	Military map nº518 (1/25 000)
Acreage	Spacing: 6 m x 6 m Block size: 36 m^2 x 70 plots = 0,25 ha Total acreage without border: 0,25 ha x 30 blocks = 7,56 ha Total acreage with border: about 11 ha

Progeny trial of Monte da Fava

Location: Monte Fava **Community**: Ermidas do Sado
Council: Santiago do Cacém **District:** Beja

Region of Provenance: IV – Valeys of Tejo and Sado

Table VI 10 c- Experimental Design for progeny trial at Monte da Fava, Portugal

Number and list of provenances	4 provenances : Pqe. Alcornocales (Spain) - Mte. Fava (Portugal)- Qta. da Serra (Portugal) – Catânia (Italy) Each provenance is represented by 22 progenies
Type of experimental design	Split Plot
Number of blocks	22
Number of plots	4 whole plots per block corresponding to the 4 populations, each including 22 subplots corresponding to the progenies
Number of plants per progeny per block	2, planted in 1 pair of the same progeny randomly distributed on the whole plots
Number of plants per provenance per block	44
Number of plants per block	176
Total number of plants per	44

progeny	
Total number of plants	3872
Tree shelters	60 cm height
Cartography	Military map (1/25 000) nº 518
Acreage	Spacing: 6 m x 6 m Block size: 36 m² x 88 plots =0,32 ha Total acreage without border: 0,32 ha x 22 blocks = 7,04 ha Total acreage with border: 12 ha

Progeny trial in Caniceira

Location: Herdade da Caniceira
Community: Abrantes and Constância
Council:
District: Santarém

Region of Provenance: IV – Valeys of Tejo and Sado

Table VI 11 a - Brief description of the site Herdade da Caniceira, Portugal

Exposition	all
Longitude	8º 25′ W
Latitude	39º 24′ N
Altitude	95 m
Medium Slope	< 5%
Climate	Nearest Meteorological Site: Tancos/Base aérea (Range of data used: 1959 to 1980) P total: 828 mm P summer: 52.9 mm T annual average: 15.6 º C T average min of the coldest month: 4.2 º C T average max. of the hottest month: 30.2 º C Coefficient d'Emberger - 109.66 4 months dry in Summer
Soil type	sandy/clay
Porosity	medium
Soil deepness	medium
Texture	medium
Soil preparation	Ripping (0.6 m deep) and harrowing with heavy harrow.
Fertilisation:	Osmocote 11:22:9 + 6 Mg (10-15 grams per plant).
Former use of the area:	Pastures and cereals.

Date of establishment:	February 1999
Progeny trial	

Table VI 11 b - Experimental Design for the progeny trial at Herdade da Caniceira, Portugal

Number and list of provenances	5 provenances: Alcácer do Sal (PT18), Ponte de Sôr (PT20), S. Brás de Alportel (PT21), Azaruja (PT22), Besteiros + Albuquerque (PT+ES25). Each provenance is represented by 22 progenies
Type of experimental design	Split Plot
Number of blocks	20
Number of plots	5 whole plots per block, corresponding to the 5 populations, each including 22 subplots corresponding to the 22 progenies.
Number of plants per progeny per block	2, planted in 1 pair of the same progeny, randomly distributed on the whole plots
Number of plants per provenance per block	44
Number of plants per block	220
Total number of plants per progeny	40
Total number of plants	4400
Tree shelters	
Cartography	Military map nº 343 (1/25 000)
Acreage	Spacing: 6 m x 6 m Block size: 0.3960 ha Total acreage without border: 7.92 ha (a border line was planted in the exterior limits of the trial) Total acreage with border:

MOROCCO

One provenance trial and one progeny trial have been established in Morocco. Both trials are located in the same site. The design adopted for each is schematised below.

```
provenance trial
X1 --- 3m ---X1 ---3m--X2---3m---  X2
 |           |          |          |
 3m          3m         3m         3m
 |           |          |          |
 X1---3m--- X1  ---3m—X2 ---3m--- X2

progeny trial
X1 --- 3m ---X1 ---3m--X2---3m---  X2
 |           |          |          |
 |           |          |          |
 6m          6m         6m         6m
 |           |          |          |
 |           |          |          |
 X3---3m--- X3  ---3m—X4---3m--- X4
```

Figure VI 4:- Design of blocks for provenance and progeny trials

Provenance trial in Mamora forest

Localization: Mamora forest AII5
Community: Sidi Taybi
Council: Kenitra
District: Kenitra

Region of provenance: I – Mamora III 1

Table VI 12 a. - Brief description of site of in Mamora forest, Morocco

Exposition	All
Longitude	6° 36′ W
Latitude	34° 13′ N
Altitude	50 – 55 m
Medium	3 – 5 %
Slope	
Climate	Nearest Meteorological site of reference: Kénitra (alt: 40 m)
	P total: 600 mm
	T average min of the coldest month: 7,6º C
	T average max. of the hottest month: 32º C
	3 months dry in Summer
Soil type	sandy/clay
Porosity	Medium
Soil deepness	1 - 1,50 m
Texture	Medium

Soil preparation	20% of the area was ripped with a ripper and total area was ploughed two times.
Planted before with	*Acacia mollissima* and *Pinus pinaster*
Date of establishment	Marsh 1998

Species:
Common name- Fernane **Latin name**- *Quercus suber* L.

Table VI.12 b. - Experimental Design provenance trial in Mamora forest, Morocco

Number and list of provenance	30 provenances (7 Spanish, 5 Italian, 7 Portuguese, 2 French, 2 Tunisian, 5 Moroccan, 1 Algerian and 1 Portuguese-Spanish)
Type of experimental design	Row-Column Design could be used as Randomized Complete Blocks (**RCB**)
Number of blocks	30
Number of plots	30
Number of plants per plot	4
Number of plants per block:	120
Number of plants per provenance	4
Total number of plants	3600
Tree shelters	60cm height
Cartography	
Acreage	Spacing: 3 m x 3 m Block size: 9 m² x 4 x 30 plots = 0,108 ha Total acreage without border: 0,108 ha x 30 blocks = 3,24 ha Total acreage with border: about 3.625 ha

Progeny Trial in Mamora forest

Table VI. 12 c- Experimental Design of progeny trial in Mamora forest, Morocco

Number and list of provenance	4 provenances : Bousafi – Chamusca – Mekna – Canamero
Type of experimental design	Row-Column Design could be used as Randomized Complete Blocks (**RCB**)
Number of blocks	23
Number of plots	88
Number of plants per plot	2
Number of plants per	44

provenance	
Number of plants per block	176
Number of plants per progeny	2
Total number of plants	4048
Tree shelters	60 cm height
Cartography	
Acreage	Spacing: 3 m x 6 m Block size: 18 m^2 x 88 plots x 2 plants = 0,3168 ha Total acreage without border: 0,3168 ha x 23 blocks = 7, 29 ha Total acreage with border: about 8.28 ha

One provenance and one progeny trial have been established in Morocco.

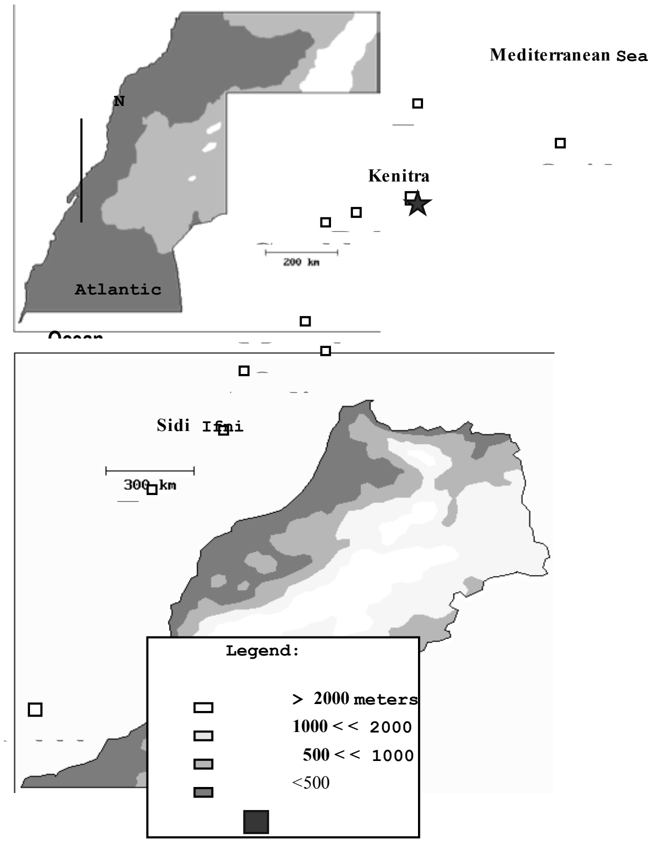


Figure VI-5- Location of cork oak (*Quercus suber* L.) provenance and progeny trials established in Morocco after the concerted action FAIR 1 CT 95 0202 / MicroAction B7 4100.

SPAIN

Spain hosts two provenance trials and one progeny trial

Provenance trial in Monfragüe

Location: Monfrague
Community: Caceres (Extremadura)
Council: Serradilla
District:

Region of Provenance: North Caceres - Salamanca

Table VI.13 a. - Brief description of the site North Caceres - Salamanca, Spain

Exposition	NW
Longitude	6° 02' W
Latitude	39° 51' N
Altitude	360 m
Medium Slope	14%
Climate	Nearest meteorological site of reference: Serradilla P total: 759 mm P summer: 13,9 mm T annual average: 16.9 °C T average min of the coldest month: 3.8° C T average max. of the hottest month: 35.5° C Coefficient d'Emberger 3.46 months dry in summer
Soil type	haplic alisol (FAO); acid fersialitic red soil (Clasificación Básica Forestal Española)
Porosity	medium
Soil deepness	>125 cm (before rock bed)
Texture	sandy
Soil preparation	elimination of eucalyptus and terraces, shrub cleaning and manual hole-opening.
Fertilisation:	
Former use of the area:	Eucalyptus
Date of establishment:	February 13th to 20th, 1998

Species:
Common name: alcornoque **Latin name**: *Quercus suber* L.

Table VI.13 b - Experimental Design for provenance trial at North Caceres - Salamanca, Spain

Number and list of provenance	32 provenances (7 Spanish; 5 Italian; 7 Portuguese; 3 French; 2 Tunisian; 6 Moroccan and 1 Algerian)
Type of experimental design	Randomized Complete Blocks (**RCB**)
Number of blocks	30
Number of plots	32
Number of plants per plot	4
Number of plants per block	128
Number of plants per provenance	120
Total number of plants	3840
Tree shelters	
Cartography	ING nº623 (1:50.000): Malpartida de Plasencia
Acreage	Spacing: 3m x 3m Block size: 9m² x 128 = 0.1152 ha Total acreage without border: 0,1152 ha x 30 blocks=3.45 ha Total acreage with border: about 3.8 ha

Provenance trial in La Almoraima

Location: La Almoraima **Community**: Cadiz (Andalucia)
Council: Castellar de la Frontera **District:**
Region of Provenance: Parque de los Alcornocales - Serranía de Ronda

Table VI 14 a - Brief description of the site La Almoraima, Spain

Exposition	W
Longitude	5º 31' W
Latitude	36º 21' N
Altitude	50 m
Medium Slope	0-9%
Climate	Nearest meteorological site of reference: Castellar de la Frontera P total: 813 mm P summer: 2.1 mm T annual average: 17.4 ºC T average min of the coldest month: 6.9º C

	T average max. of the hottest month: 33.8º C Coefficient d'Emberger 4.34 months dry in summer
Soil type	cromic luvisol (FAO);acid fersialitic red soil (Clasificación Básica Forestal Española)
Porosity	low
Soil deepness	>125 cm (before rock bed)
Texture	clayey
Soil preparation	mechanic plough and manual hole-opening (in 20 blocks); ripping with a separation ot 3 x 3 m (in 10 blocks)
Fertilisation:	
Former use of the area:	old extensive cultivation, grazing land with cork oak and wild olive trees.
Date of establishment:	March 14th to 18th, 1998

Species:
Common name: alcornoque **Latin name**: *Quercus suber* L.

Table VI.14 b - Experimental Design of the provenance trial in La Almoraima, Spain

Number and list of provenance	30 provenances (7 Spanish; 5 Italian; 7 Portuguese; 2 French; 2 Tunisian; 5 Moroccan and 1
Type of experimental design	Randomized Complete Blocks (**RCB**)
Number of blocks	30
Number of plants per block	120
Number of plants/provenance	120
Total number of plants	3600
Tree shelters	
Cartography	ING nº1071 (1:50.000): Jimena de la Frontera
Acreage	Spacing: 3m x 3m Block size: 9m² x 120 = 0.1080 ha Total acreage without border: 0,1080 ha x 30 blocks = 3.24 ha Total acreage with border: about 3.6 ha

Progeny trial in Selladores

Localization: Selladores **Community**: Jaen (Andalucia)
Council: Bairros de la Encina **District**:

Region of provenance: Sierra Morena Oriental

Table VI.15 a - Brief description of the site Selladores, Spain

Exposition	E-SE
Longitude	3° 51' W
Latitude	38° 21' N
Altitude	850 m
Medium Slope	4-13%
Climate	Nearest meteorological site of reference: El Centenillo P total: 651.5 mm P summer:11.1 mm T annual average: 14.8 °C T average min of the coldest month: 2.2° C T average max. of the hottest month: 32.8° C 3.63 months dry in Summer
Soil type	eutric cambisol (FAO); acid fersialitic red soil (Clasificación Básica Forestal Española)
Porosity	Medium
Soil deepness	>125 cm (before rock bed)
Texture	Sandy
Soil preparation	elimination of scrubs and ripping with a separation of 3 x 3 m.
Fertilisation	
Former use	grazing land with dispersed *Quercus suber*, *Q. ilex* and *Q. faginea* trees; western zone was occupied by scrubs of *Cistus* sp, *Erica* sp, *Phillyrea* sp
Date of establishment	March 8th to 12th, 1998

Species:
Common name: alcornoque **Latin name**: *Quercus suber* L.

Table VI 15 b- Experimental Design for the progeny trial in Selladores, Spain

Number and list of provenance	66 progenies (22 from La Almoraima, Spain, 22 from Alcácer do Sal, Portugal and 22 from Aïn Rami, Morocco)
Type of experimental design	Incomplete Randomized Blocks
Number of blocks	23
Number of plots	variable
Number of plants per plot	2
Number of plants per block	variable
Number of plants per progeny	variable
Total number of plants	2506
Tree shelters	
Cartography	ING nº861 (1:50.000): Solana del Pino
Acreage	Spacing: 6m (E to W) x 3m (N to S: plants in the same plot) Block size: variable Total acreage with border: about 6 ha

Tunisia

In Tunisia it was established two provenance trials and one progeny trial. The design used for the trials is as follows:

```
Provenance trial
X1 --------- 3m ---------X2
  |                      |
  3m                     3m
  |                      |
 X3---------3m---------- X4

 Progeny trial
X1 -------- 3m ----------X2
  |                      |
  |                      |
 3m                      3m
  |                      |
  |                      |
 X3---------3m---------- X4
```

Figure VI-4 - Design of blocks for provenance and progeny trials

Provenance trial in Tebaba

Location: Tebaba
Council: Beja
Community: Nefza
District

Table VI. 16 a- Brief description of the site Tebaba, Tunisia

Exposition	South
Longitude	8°52' E
Latitude	36°58' N
Altitude	250m
Medium	12%
Slope	
Climate	humid with mild winter
Soil type	Marly/clay
Porosity	
Soil deepness	50 to 80 cm.
Texture	medium

Soil preparation	Cleaning, ripping and tilling
Fertilization	without fertilization
Former use	
Date of establishment	3rd and 4th week of December 1997

Species:
Common name: chêne liège **Latin name**: *Quercus suber* L.
Table VI. 16 b.- Experimental Design for the provenance trial in Tebaba, Tunisia

Number and list of provenance	26 provenances (2 Tunisian, 5 Italian, 5 Portuguese, 1 Algerian, 7 Spanish, 5 Moroccan and 1 Portuguese-Spanish)
Type of experimental design	Completely randomized block (RCB)
Number of blocks	30
Number of plots	78
Number of plants per plot	1
Number of plants per block:	78
Number of plants per provenance	3
Total number of plants	2340
Tree shelters	
Cartography	
Acreage	area by plant 3x3 = 9 m^2 block size 9m^2 x 78 plots=632m^2 632 m^2 x 30 blocks = 1896 m^2 without border

Provenance trial in Hanya

Location: Hanya **Community:** Sejnene
Council: Beja **District**

Table VI. 17 a - Brief description of the site Hanya, Tunisia

Exposition	South
Longitude	9°7' E
Latitude	37°9' N
Altitude	150m
Medium Slope	8%
Climate	humid with hot winter
Soil type	pseudo-gley
Porosity -	
Soil deepness	80 cm.

Texture	medium
Soil preparation,	Cleaning
Fertilisation	without fertilization
Former use	
Date of establishment	end of February-beginning of March 1998

Table VI.17 a -Experimental Design for the provenance trial in Hanya, Tunisia

Number and list of provenance	20 provenances: (2 Tunisian, 5 Italian, 4 Portuguese, 1 Algerian, 3 Spanish, 4 Moroccan and 1 Portuguese-Spanish)
Type of experimental design	Completely Randomized Blocks (**RCB**)
Number of blocks	25
Number of plots	60
Number of plants per plot	1
Number of plants per provenance	3
Number of plants per block	60
Total number of plants	1500
Tree shelters	
Cartography	
Acreage	Spacing: 3 m x 3 m Block size: 9 m^2 x 60 plants = 540 m^2 Total acreage without border: 25 blocks x 540 m^2 = 1, 35 ha Total acreage with border: about --- ha

Progeny Trial in Tebaba

Location: Tebaba **Community:**Nefza
Council: Beja **District**

Table VI.18 a - Brief description of the site Tebaba, Beja, Tunisia

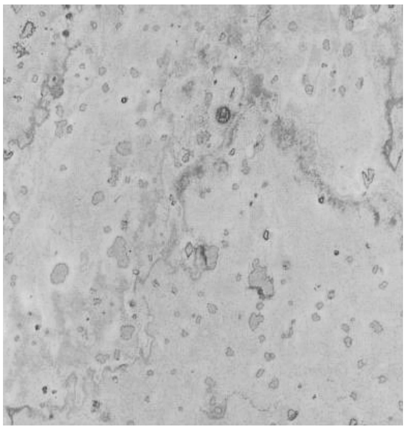
Exposition	South
Longitude	8°52' E
Latitude	36°58' N
Altitude	150m
Medium Slope	8%
Climate	humid with mild winter

Soil type	pseudo-gley
Porosity	
Soil deepness.	80 cm
Texture	medium
Soil preparation	Cleaning, ripping and tilling
Fertilization	without fertilization
Former use	
Date of establishment	December 4th 1998

Table VI. 18 b. - Experimental Design of the progeny trial in Tebaba, Tunisia

Number and list of provenance	4 provenances : (1 Tunisian, 1 Portuguese, 1 Spanish and 1 Moroccan)
Type of experimental design	Completely Randomized Blocks (**RCB**)
Number of blocks	22
Number of plots	60
Number of plants per plot	1
Number of plants per provenance	20
Number of plants per progeny	1
Total number of plants	1760
Tree shelters	
Cartography	
Acreage	Spacing: 3 m x 3 m Block size: 9 m^2 x 60 plants = 540 m^2 Total acreage without border: 22 blocks x 540 m^2 = 1, 188 ha Total acreage with border: about --- ha

Cork "paper"



Chapter VII - *Quercus suber* Genetics Database

(T. Branco, M C Varela -EFN, Portugal*)*

Scope for the creation of the *Quercus suber* Genetics Database

The Concerted Action "European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies" - Ref. FAIR 1 CT 95-0202 provided an excellent means of starting a database on *Quercus suber* genetics research, through the possibility of wider exchange of data and contacts between partners.

Cork oak (*Quercus suber* L.) is one of the most particular species of the Mediterranean Basin, playing assignable ecological and socio-economical rule, especially in Portugal. Therefore, it has been since long time the focus of interest of research, regardless its characteristics which make particularly difficult the implementation of breeding strategies:

This fact fully justifies the creation of a database on *Quercus suber* genetics research. Providing information on what has been accomplished before reduces the risk of duplicated efforts, allowing the investment of funds and expertise towards innovation. This is especially relevant when considering the difficulties faced while attempting cork oak breeding.

Also, gathering and making disposable for the scientific community indication of other experts, of what they are doing and where and their results, promotes scientific exchange and creates the opportunity to implement integrated efforts between different partners.

Subjects of the Database

The database main aims are:

1. To centralise information on cork oak genetics/improvement
    1.1. Information on both institutions and researchers
    1.2. Publications and meetings
    1.3. Projects and field trials
2. To provide clues on the blanks and overlaps in cork oak genetics/improvement research with special reference to four main areas within this theme: Molecular genetics; Field studies; Vegetative propagation and Reproduction studies.

To accomplish this the database stores the following subjects:

1. Countries
    1.1 Country name
    1.2 Area occupied by the species in absolute values and as percentage of the world area occupied by the species
    1.3 Type of management most common for cork oak stands
    1.4 Existence or not of genetic conservation populations
2. Institutions
    2.1 Name
    2.2 Address and contacts
    2.3 Interest Field: investigation, education, commercial...
    2.4 Status: public, private, associative...
3. Scientists
    3.1 Name
    3.2 Title
    3.3 Institution
    3.4 Involvement with *Quercus suber* genetics
    3.5 Research area
4. Publications
    4.1 Original and English title
    4.2 Authors
    4.3 Language
    4.4 Source
    4.5 Main subjects covered: molecular genetics, field studies, vegetative propagation and reproduction studies
5. Projects
    5.1 Title
    5.2 Objectives

5.3 Participants
5.4 Co-ordination
5.5 Project results (Reference of final and meeting reports; field trials established; publications)
5.6 Main subjects covered: molecular genetics, field studies, vegetative propagation and reproduction studies

6. Meetings
    6.1 Type: Congress, workshop, seminary...
    6.2 Title
    6.3 Date and place
    6.4 Organising institution
    6.5 Main points of the agenda (when applicable)
    6.6 Availability of reports and proceedings
7. Field trials
    7.1 Title
    7.2 Objectives
    7.3 Managing institution
    7.4 Location (including latitude, longitude and altitude)
8. Graphics

The graphics included in this database are meant to answer objective 2. which is to provide clues on the blanks and overlaps in four main areas within cork oak genetics/improvement research. They are accessed from form Projects and from form Publications. In the first case, one intends to present a quick perception of the number of projects covering each of the main areas defined: molecular genetics, field studies, vegetative propagation and reproduction studies. Similarly, in the form Publications the graphic shows the number of publications devoted to each of the mentioned themes.

Database structure

Prior to the implementation of the database it is essential to establish its conceptual model. The conceptualisation must be clearly differentiated from implementation, in fact they have distinct objectives and restraints. While conceptualisation intends to represent a certain reality and it is mainly directed by the definition of the entities within that reality, implementation is mainly restricted by technical factors.

Rigorous definition of what are the entities in our problem is difficult and carries a certain degree of subjectivity. Different people can differently interpret same realities. Also defining which entities' characteristics are relevant can be problematic, especially because confusion between what can be considered as an individual entity or as an attribute of one identity is usual.

Furthermore, the relationships between different entities should be established judiciously in order to establish a model as simple and concise as possible while keeping completeness.

In this process one cannot overcome the determination of relationships' cardinality, this is, each element of an entity correspond to how many elements in a related entity.

Identification of which attributes of an entity are key attributes is another necessary step in the conceptualisation of the database, this means to determine which attribute univocally identifies each element of the entity. Key attributes are unique for each entity.

All these aspects must be taken into account in order to create a database allowing expedite data inputs, well structured visualisation of the information and the possibility of performing all the queries of interest in the frame of the database subject.

Once the conceptual model was established the database was implemented.

The software used was Access 7.0 for Windows 95. This system was chosen for its compatibility with other Windows applications and data bank systems; flexibility and easiness of use.

Each table in the database represents an entity, its attributes are fields in the respective table. Attributes defined as key attributes were set as table's primary keys. Relationships between entities were implemented as relationships between tables.

In the implementation process it was respected the conditions of integrity: both existential and referential.

The relational structure designed for this database allows saving storage space in the disk, faster speed when working with data and avoids data duplication, making inputs and consultations of data easier and more precise.

Tables in the database correspond to the 7 subjects mentioned above. Each of the fields in these tables corresponds to the respective sub-points.

Consultations

In order to allow a friendlier and more organised viewing of the information, it was created forms. They contain the information constant on the tables but permit easier inputs of the data and more attractive viewing.

Each of these forms is accessed from a main switchboard by clicking the respective button.

The relational model designed for this database allows crossing information between different forms. With the help of macros and queries pre-defined by the database designer it is possible to access information in other forms or in forms based on queries, which combine data from different forms simultaneously.

An example of this is the accession of a project's results in terms of publications, field trials established and meetings performed. By clicking one of these options from the form Projects it will be retrieved the publications (or field trials or meetings, depending on the option chosen) reporting the results obtained during the project's implementation.

Similarly, in form Scientists, one can get the full address and contacts of the institution each expert belongs to by double-clicking the field Institution Code, which stores just the code for the institution. This code is the same as in table Institutions, where it is a primary key.

As mentioned before, this database include graphics meant to provide clues on the blanks and overlaps in cork oak genetics/improvement research. They are accessed from form Projects and from form Publications.

On the graphic from Projects it can be displayed the project number (a reference number attributed by the database and which is the primary key) the title and objectives of the projects counted in each of the categories: molecular genetics, field studies, vegetative propagation and reproduction studies. This information is displayed by clicking the respective label on the graphic.

The same way, in graphic Publications one can view the titles of the publications aggregated in each category.

A note on this subject must be here added. When analysing these graphics one must keep in mind the two following aspects:

- the same project or publication may cover more than one of the categories specified. Therefore it is counted in all the categories it covers. The total number of projects cannot be calculated as the sum of the number of projects in each category
- the panorama expressed by these graphics refers mainly to the contents of the database. If this expresses more or less accurately the broader reality of cork oak genetics research that depends on how more or less representative is the sample constant in the database. But this representativeness is difficult to evaluate, one can only be sure that the larger the number of references in the database the closer its content will be to reality.

These are just some of the examples how information can be crossed "automatically" in this database by means of pre-defined macros and queries. However, skilled users with further knowledge of Access features may build their own queries to respond to their specific needs. The scheme of relationships between tables will allow them these further searches.

Administration

The *Quercus suber* Genetics database is centralised in Estação Florestal Nacional (EFN), in Lisbon.

EFN is the responsible institution for its maintenance and management. Periodical updates will be undertaken, questionnaires will be diffused from EFN to all institutions that are potential providers of data.

The database is available to anyone interested in the subject. One shall sent his/her request, the file will be delivered by floppy disk in a zipped file format or by electronic mail. One can also get the database from the internet site of EFN, where it is available for downloading.

Main diffusion of results

- ***Congreso sobre Forestacion en las Dehesas***
  Junta de Extremadura, Mérida, Spain 20- 22 May 1999
  Varela, MC. ,"*Selecção e melhoramento genético em sobreiro (Quercus suber L.)*"

- ***Reunião de trabalho sobre Replobacion Forestal y sobre Mejora Genética Forestal*** Sociedad Española de Ciencias Forestales, Lourizán, January 1999
  Varela, MC. ,"*Rede Internacional de Testes de Proveniências e de Descendências em Sobreiro (Quercus suberl)*"

- ***Seventh Congress of the European Society for Evolutionary Biology***
  Barcelona, Spain, 23-28 August 1999
  In this congress one poster was presented based on the progenies collected under the project. Presentation explicitly mentioned the project.
  Oliveira P; Coelho E; R. Barros I, Varela MC & Meierrose C., "*Biometric survey of cork oak families representative of the whole species natural range*."

  Diffusion of the project activities were also made through the following publications:
  - *"Strengthening the conservation and use of cork oak genetic resources"* in IPGRI newsletter for Europe, NO 16 September 1999
  - Varela, MC - "*A cada clima o seu sobreiro*" in Revista INIA nº 1 9/21/99.53 pp.42-2000
  - The EUFORGEN *Quercus suber* Network and the research projects for the evaluation of genetic variability of cork oak- in Borelli S & Mediterranean Oaks Network, Report of the first meeting , 12-14 2000, Antalya Turkey IPGRI, Rome

Cork boards

Chapter VIII- The importance of cork oak to North Africa countries

(M. Larbi Kouhja, Abdelhamid Kahldi, Ali Khouaja, INGREF, Tunisia*)*

Cork oak grows in North Africa in Algeria, Morocco and Tunisia. The stands of the southern arc of the Mediterranean Basin show specific characteristics different from those of the northern part of the Mediterranean. Differences may be summarised in three major points:

- The social role of cork oak forests - income on grazing, firewood, edible mushrooms and even acorns that are essential for survival of rural populations
- Hard ecological conditions, with special reference for climatic irregularities on rainfall, where considerable drought pheromones may occur
- Increase of economical value of cork, specially in the years of 1999, 2000 and 2001, after a long period of stagnancy

Cork oak stands do not show a homogeneous pattern, rather significant contrasts.

High density stands claiming thinning are found in some areas. Other sites are going into a degradation stage of shrubs domination due to incendies.

Natural regeneration is generally poor, so is productivity on cork.

Natural areas of cork oak are consequently decreasing while solutions are not easy to find. Research is an essential field to overcome the ongoing problems of cork oak in North Africa countries. Though the social and economical importance of cork oak quite few researchers are currently concentrating their work on the species.

Great efforts have been done on management of stands and cork harvesting techniques being the results satisfactory.

Cork oak characteristics and differentiating factors

In North Africa cork oak covers the largest area of Mediterranean basin, after Portugal, under a wide range of ecological conditions:

- On altitude it grows from see level to 2000 m
- The optimal average temperature varies from +12ºC to +18 ºC but the species grows at +45 ºC.
- The limits for rainfall are between 400mm and 2000mm per year.
- In a broad sense the different ecotypes may be summarised in two different varieties where some phenotipical differences may be underline:
- One refereed as growing in Tunisia and Algeria
- The atlantic growing in the setentrional part of Morocco

The *atlantic* type is characterised by a slender crown, large and sweet acorns and finally by a short period on fall of leaves. Transient morph types are found depending on the geographical location. When growing near Tunisia and Algeria the east Morocco type approaches the numidian form, while it gets closer to that of Andalusia and Portugal when it grows at the Rif and near Tangiers.

Hybridisation

Cork oak can introgress with other Mediterranean oaks, *Quercus affares* and *Quercus ilex*.

The ecological conditions strong affect the cork oak behaviour. In extreme conditions, semi-arid and very cold humid climates, natural regeneration is almost absent. On optimal conditions it shows better resistance to aggressive practices and degradation processes.

Actual situation of the cork oak

Cork oak is endemic to North Africa. It has been recognised at fossil state.

The total area of *Quercus suber* has been estimated about 900 000 ha:

Algeria- 450 000 ha (Yessad SA, 2000)
Morocco-350 000 ha (Benzyane, 1996)
Tunisia-104 000ha (Abid &Semi K, 1996)

The largest area in Algeria is in the region of Kabyllie while the remaining is found in stands of few thousands or few hundreds of hectares close to Algiers, Oran and Tlemcen.

In Morocco cork oak grows mainly close the Atlantic ocean (Gharb of the Rif) while discontinuous, small areas are seen when moving inland and eastward, seaside to Taza. The most important forest of cork oak in Morocco is Maamora. The species still grows at Chaouia of Zaers and Oulmès plains.

In Tunisia cork oak are mainly located at the north of the Medjerdah in the Kroumiri.

In all these countries cork oak the occurrence of cork oak dates from the prehistorically times. Yet a decreasing on the area is evident. Ecologists and forests experts disagree at the causes. Ecologists put accent on climate changes while forests are in favour add the destructive impacts coming from human activity, heavy grazing, fires, harvesting of acorns, clearing for agriculture.

In fact the human pressures involve some climate disturbance by creating dryer microclimates and soil erosion. Harshning of growing conditions are turning the trees more sensitive to insects and fungi attacks, natural regeneration is weakening in vigour and quantity. Increasing summer drought along last years is also contributing for turning the forest management more difficult.

Socio-economic aspects

In North Africa the economic impact of the cork oak forests and their side products have strong effect on rural population. The cork oak forests produce about 40 000 tons of cork, which represents 15% of the world production. The majority is exported as raw material, a small part is processed in local industries.

Human settlements living closer to cork oak stands benefit from side products such as fire wood, fodder, essential oils, aromatic plants, edible mushrooms and acorns when they happen to be sweet.

Research

Along the past years some few research projects have been done specially in regeneration and stand management. First results going back to the 1960s can be applied into practice for the establishment of new stands of cork oak.

In the last few years research projects have been focused on restrict objectives Research projects are being oriented to:

- Monitoring the health state of stands by permanent observations- The goal is to identify the primary pests (*Lymantria dispar*) and set up a program for their evolution in time and space. The other objective is to identify the die out of these species
- The improvement of the artificial regeneration techniques through production of seedlings in nursery, acorn harvesting and conservation and improvement of seedlings quality by means of mycorrization
- Management of stands under the objective to promote natural regeneration and assisted natural regeneration

- Stand management for recovering of degraded stands after various factors, with special reference for fire
- Genetic improvement under the objective of selection of seed sources, local versus transferred seed sources
- Improvement of cork harvesting techniques, rotation period, impact of height of stripping on the physiological balance of the trees

In North Africa financial return may take over regeneration and biological factors. The forest manager and the researcher shall co-operate to set strategies and future work plans to optimize the forest management under the following objectives:

- Against pest, diseases
- Technical guidelines for restoration of cork oak stands
- Improvement of regeneration techniques
- Establishment of management policies
- Actions and fires

The overall scenario for cork oak forest in North Africa shall be regarded in a positive way in close relation with the peculiarities of the socio-economic situation. All actions taken at cork oak forests must have in mind the hard conditions on climate and human living standards. All these conditions interact in increasing the jeopardy from fires, the lack of natural regeneration and the intensive use of forest resources by herds.

To assure the perenity of these forests and all the economic, ecological, social values the reestablishment of an ecological equilibrium is critical.

Stoppers are the most valuable product from cork oak

Chapter IX – Perspectives: Assessment of the trials; implications of the project for practical conservation and use of cork oak genetic resources

(M Carolina Varela, EFN Portugal*; H. Muhs, G. Wuelisch*, BFH-Germany*)*

A network of field trials based on common genetic entries coming out of the entire area of cork oak (*Quercus suber* L.) under the dialectic interaction of different backgrounds on technical and scientific expertise is the most comprehensive and long lasting output of the European Union financed concerted action FAIR 1 CT 95 0202, co-ordinated by Estação Florestal Nacional, Portugal.

The 17 trials established in France, Italy, Morocco, Portugal, Spain and Tunisia on the winter of 1997/98 (details on chapter VI) hold a unique collection of material where a diversity of convergent research lines of time gradual results may be ground and enhanced if international co-operation is reached.

Long life, long juvenile period, complex reproductive behaviour and late assessment of cork quality make genetic improvement of cork oak a task of tardy results.

Since afforestation actions can not wait till all scientific answers are available, educated use of results provide along trials' life allows for indication on choice and use of reproductive material.

While provenance trials provide appraisal of among population genetic variation, progeny trials are the tool for evaluation of within population variability. The knowledge of the degree of the two components is fundamental to draw perspectives on advanced improvement and/or gene conservation programmes.

Provenance trials

In simultaneity with industrial research and appropriated cork defence and promotion, adaptive profile and cork quality are essential tools for sustainable economical forest management of cork oak.

Due to growing procurement of cork impelled by increase consume of bottled wine and impulse for new afforestation and set aside of farm land coming from EU or national supports for slow growing forest species, several thousands of hectares of cork oak are established in European Union and North Africa cork oak countries every year.

In a clear reverse upon previous epochs where natural regeneration or seed collection on vicinity was the dominant patterns, sowing or planting is now a common practice that is enlarging seed procurement into a broad scale.

On this scenario of intensification on procurement and movements of reproductive material official institutions, private nurseries and owners face lack of information to ground their decisions.

Transfers of reproductive material have long be done in forestry activity, revealing situations where exotic material had either overcome or perform under the local one, showing that success is a matter of mere contingency when not supported on results from provenance trials.

Inappropriateness of seed source may reveal itself several years ahead leading to failures of serious economical consequences as has been the case of Pinus pinaster and Eucalyptus sp. upon the winter cold wave in France during 1985 (Roman-Amat, 1991).

Relentless dependent on immensity on space and baring intrinsic moderate economical turnover upon short term agriculture crops, forestry populations long term productivity has to rely, above all, at genetic variability rather than on environmental control.

Provenance trials are the most qualified tool for the evaluation of the adaptability of population from long living species. Under the actual degree of knowledge on cork quality evaluation conclusive results from the field tests are not obtainable before the age of 40, when the second cork stripping takes place. Though early results may be used in practical guidance.

The degree of genetic control on cork quality is a key issue for planning long term economical management of cork oak and the strategy upon genetic improvement. A high degree of genetic control points a dominant role for genetic selection, while a poor degree focus for efforts on upgrading of silvicultural practices.

The population structure of cork oak is being addressed through various genetic markers studies. In a recent paper Jimenez 2000, found a migration rate of 7 individuals per generation which reveals high levels of gene flow. Yet the available results from trials show clear differences on provenance behaviour which might be due to an overcoming effect from strong natural selection upon population differentiation coming from the migration effect.

Provenance trials are expected to provide information on among population variation upon aspects such as:

-adaptation to local climate, specially winter temperatures and summer drought. Cork oak spreads naturally from wide limits on rainfall (2500 mm to 450mm), summer drought (1 to 5 months < 30mm) and winter temperatures from mild to negative temperatures. Under these wide limits populations may have evolved adaptation leading to chocks when transferred to contrasting sites.

-soil type

Apart from hydromorphic or active calcareous soils cork oak is able to colonise a broad variety of soils. Yet the species spreads on rich and deep soils as well as on sandy soils usually characterised by poor water retention. Tolerance to drought may have evolved differently leading chokes on vigour when moving provenance material.

-genotype X environment interaction

Decisions on the use of alien reproductive material should wait the appraisal of the level of genotype X environment interaction. Under high GXE interaction provenance chocks can drive considerable failures while low GXE interaction allows to focus afforestation material on the basis of behaviour on economical characteristics independent of the local of the seed source. Therefore under the actual state of knowledge and having into consideration that provenances reveals differences on vigour and survival, the use of local material shall be recommended whenever artificial regeneration is to be used for cork oak.

Short term results

Though preliminary, trials are already revealing differences on performances on the various provenances as patent on figures IX.1, IX.2, IX.3, IX.4, IX.5, IX.6, IX 7, IX.8, IX.9, IX.10, IX. 11, IX.12, IX.13, IX.14, IX.15, IX.16. The codes at the figures are an abbreviation of those used in other project related publications. Correspondence is patent at table IX.1

Provenance label at the graphics the follows the alphabetic order after the English code for the country.

Table IX. 1- Codes for provenances used at the project reports and EUFORGEN publications. Correspondence with the abbreviation codes used at the Handbook graphics

Country codes after the country Portuguese name)		***Region of provenance***	***Forest***	***Nearest Locality***	*Codes used at the graphics*
France	FR 1	Var	Les Maures	Bormes les Mimosas	Fr-Les Maures
	FR 2	Pyrenees Orientales	Le Rimbaut	Collioure	Fr-Le Rimbault
	FR 3	Landes	Soustons	Soustons	Fr-Soustons
	FR 4	Corse	Sartene	Sartene	Fr-Sartene
Spain	ES 5	Montes de Toledo	Cañamero	Cañamero	Sp-Canamero
	ES 6	Sierra Morena Oriental	Fuencaliente	Fuencaliente	Sp-Fuencaliente
	ES 7	Sierra Morena Occidental	El Carbajo	Jerez de los Caballeros	Sp-Jerez Caballeros
	ES 8	Parque De Los Alcornocales	La Almoraima	Castellar de la Frontera	Sp-Almoraima
	ES 9	Cataluña Litoral	Santa Coloma de Farnèes	Santa Coloma de Farnes	Sp-S. C. Franées
	ES 10	Sierra de Guadarrama	El Pardo	Madrid	Sp-El Pardo
	ES 11	Alpujarras	Haza de Lino	Haza de Lino	Sp-Haza de Lino
Italy	IT 12	Lazio	Sughereta	Tuscania	It-Tuscania

	IT 13	Puglia	Lucci-S.Teresa	Brindisi	It-Brindisi
	IT 14	Sicilia	Zotte	Catania	It-Catania
	IT 15	Sardegna	Nuraghe Arcu de Mesu	Cagliari	It-Cagliari
	IT 16	Sardegna	Puttu addes de Subra	Sassari	It-Sassari
Portugal	PT 17	Vale do Tejo e Sado	Sociedade Agrícola Igreja Velha	Chamusca	Pt-Chamusca
	PT 18	Vale do Tejo e Sado	Herdade da Palma	Alcacer do Sal	PT- Alcácer Sal
	PT 19	Vale do Tejo e Sado	Quinta da Serra	Azeitão	Pt-Azeitão
	PT 20	Vale do Tejo e Sado	Herdade de Vale Côvo	Ponte de Sôr	Pt-Ponte Sor
	PT 21	Sudoeste		S. Brás de Alportel	Pt-S B.Alportel
	PT 22	Alentejo E Beira Baixa	Herdade do Paço de Camões	Azaruja	Pt-Azaruja
	PT 23	Sudoeste	Monte Branco	Santiago do Cacém	Pt-S. Cacém
	PT 24	Trás-Os-Montes E Beira Interior	Casa de Meneres	Romeo	Pt-Romeu
	PT ##	Sudoeste	Monte Fava	Santiago do Cacém	Pt-Mte. Fava
Portugal+ Spain	PT+ES 25	Alentejo e Beira Baixa+Sierra de S. Pedro	Vale de Mouro + La Tojera	Besteiros+Albuquerqu	Sp- Pt
Morocco	MA 26	Rif Atlantique I.1	Boussafi	Larache	Mo-Boussafi
	MA 27	Rif Occidental I.2	Aïn Rami	Chefchaouen	Mo-Ain Rami
	MA 28	Maâmora III.1	Canton A,B	Kenitra	Mo-Maamora
	MA 29	Maâmora III.1	Aïn Johra	Allal Bahraoui	Mo-Ain Johra
	MA 30	Plateau Central III.2	Oulmes	Oulmès	Mo-Oulmés
	MA 31	Rif Oriental	Bab Azhar	Taza	Mo-Bab Azhar
Tunisia	TU 32	Mekna	Tabarka	Aïn Sobh	Tu-Fernana
	TU 33	Fernana	Fernana	Aïn El Baya	Tu-Mekna
Algeria	AL.34	Guerbés			Al- Guerbès

France

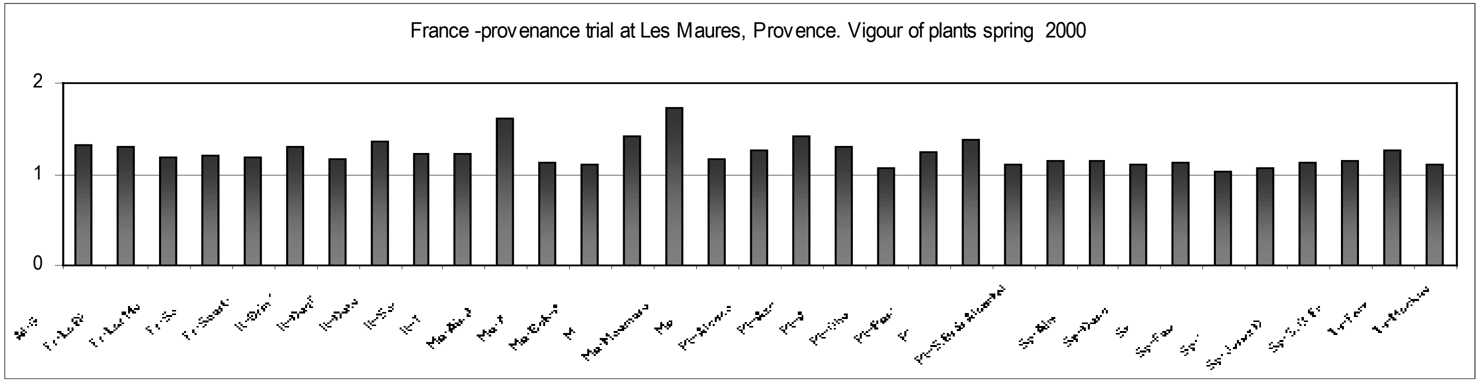


Figure IX.1- Vigour of plants by provenance (vigour classes: see text) at provenance trial in Les Maures, Provence, France. Responsible person for data- JM Courdier, ONF

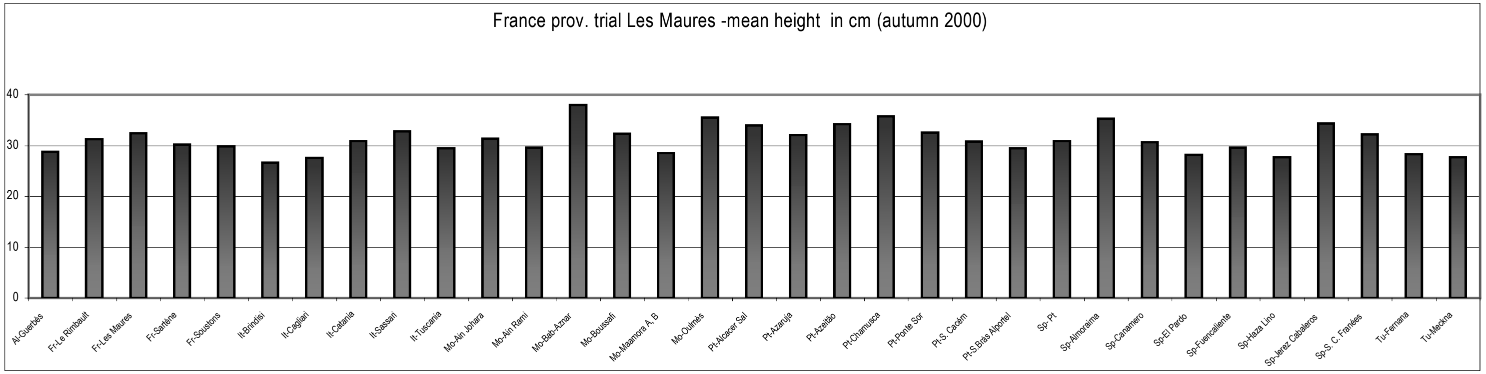
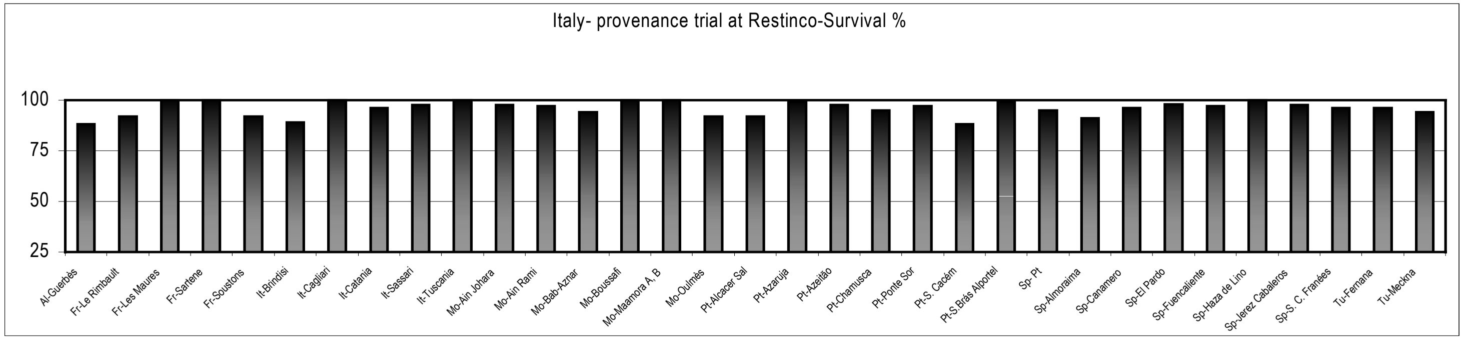


Figure IX.2- Mean height (in cm) of plants at provenance trial in Les Maures, Provence, France. Responsible person for data-JM Courdier, **ONF**

Italy



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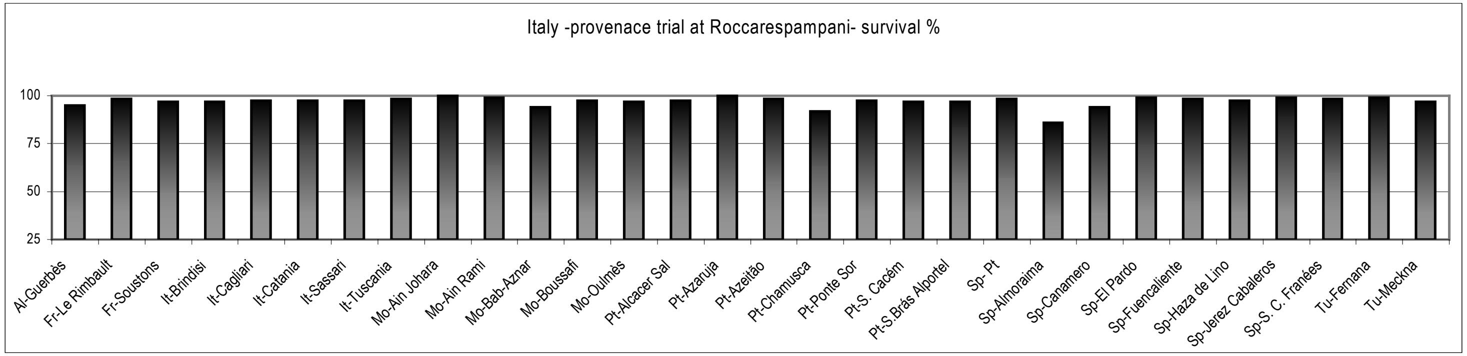

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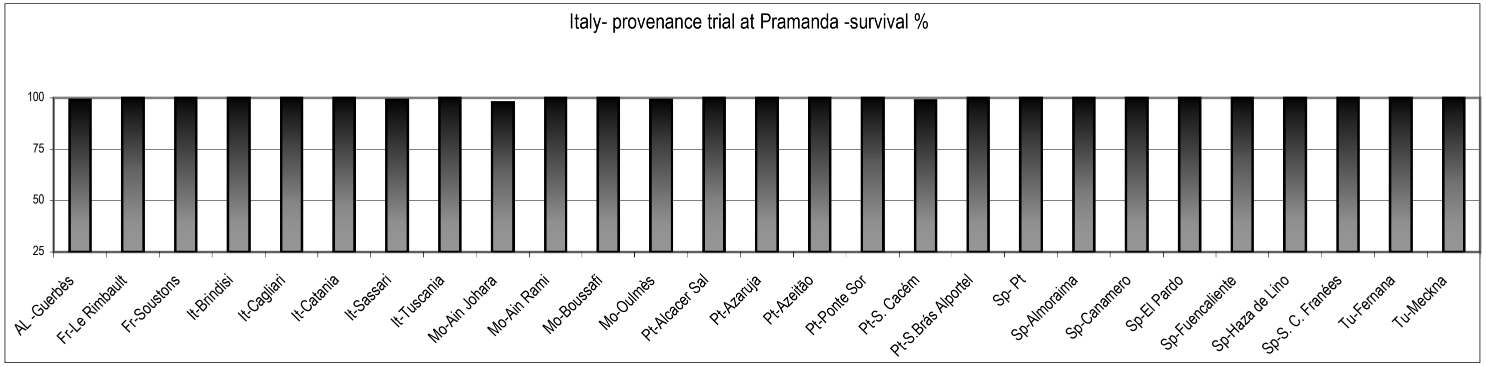

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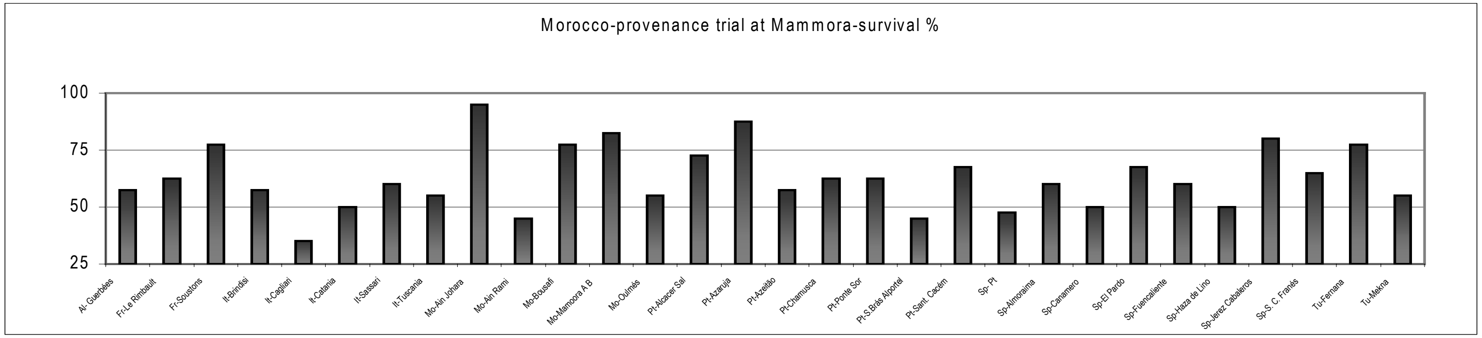

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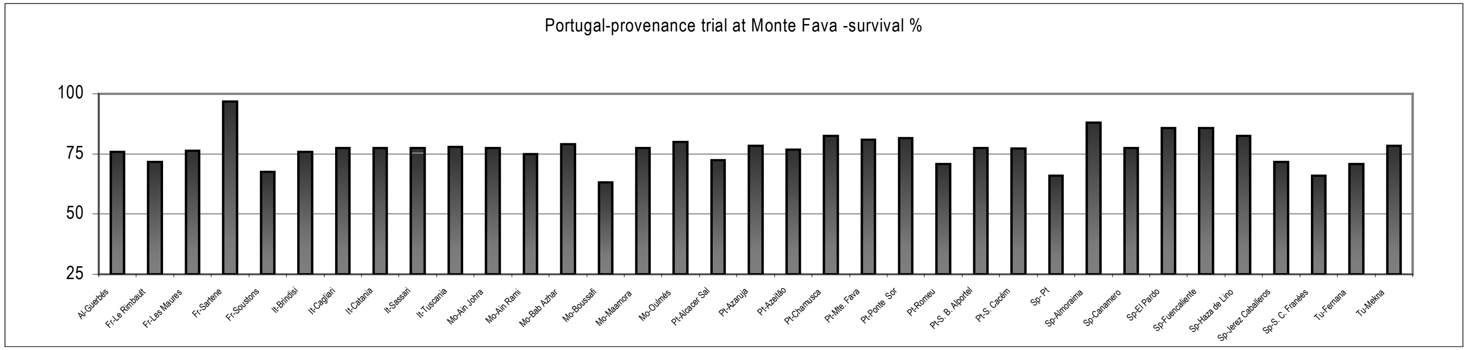

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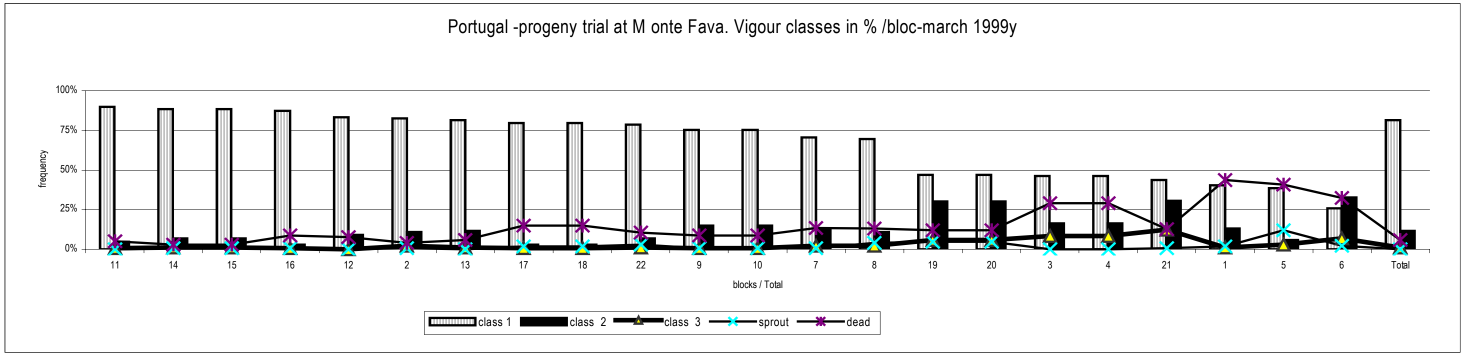

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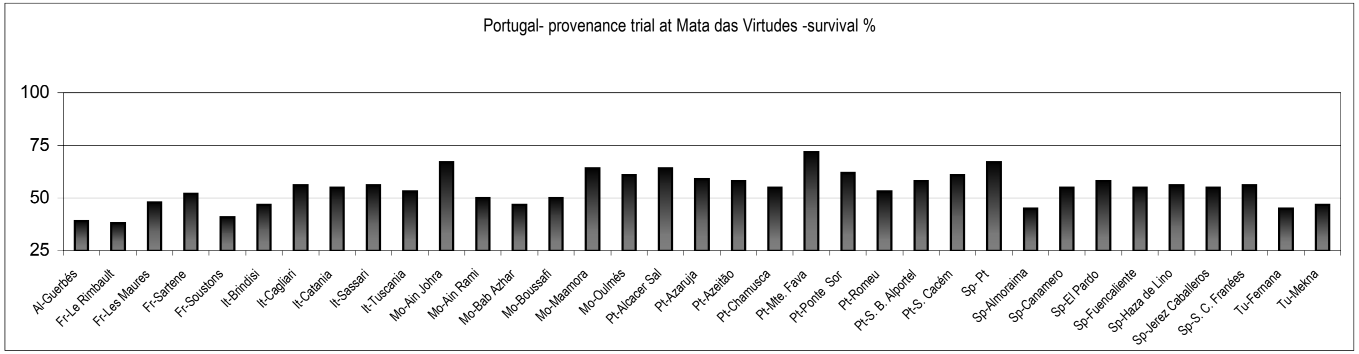

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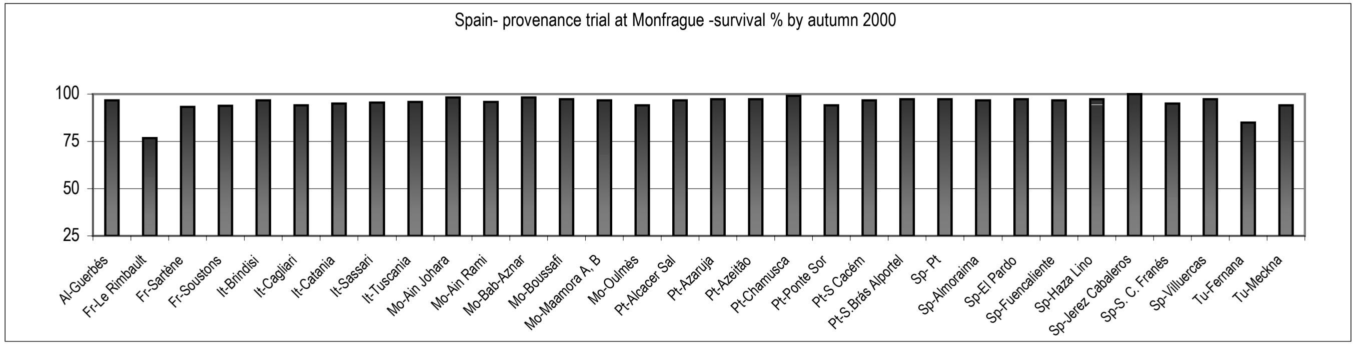

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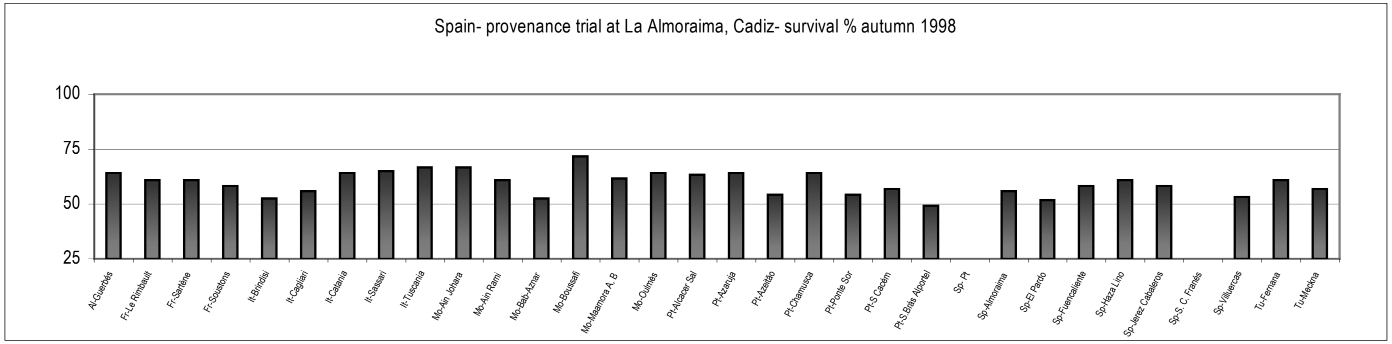

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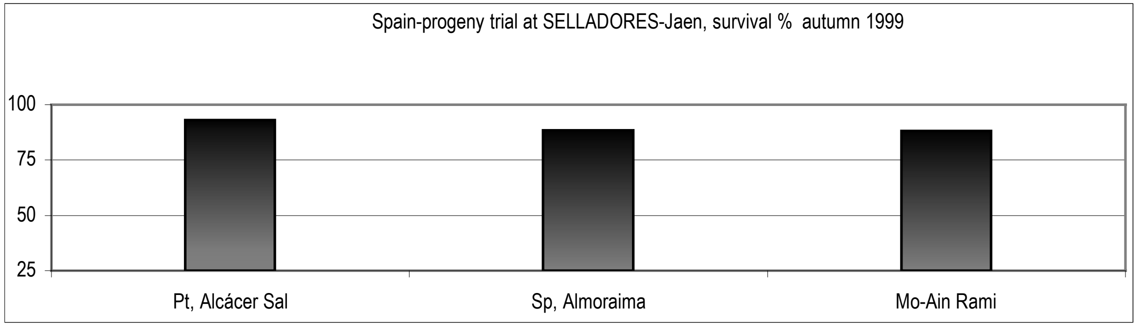

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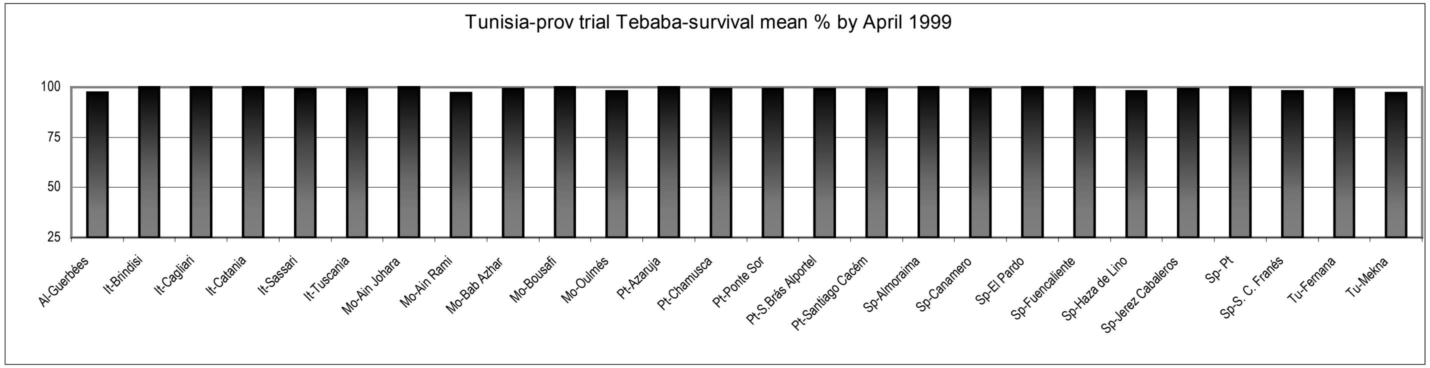

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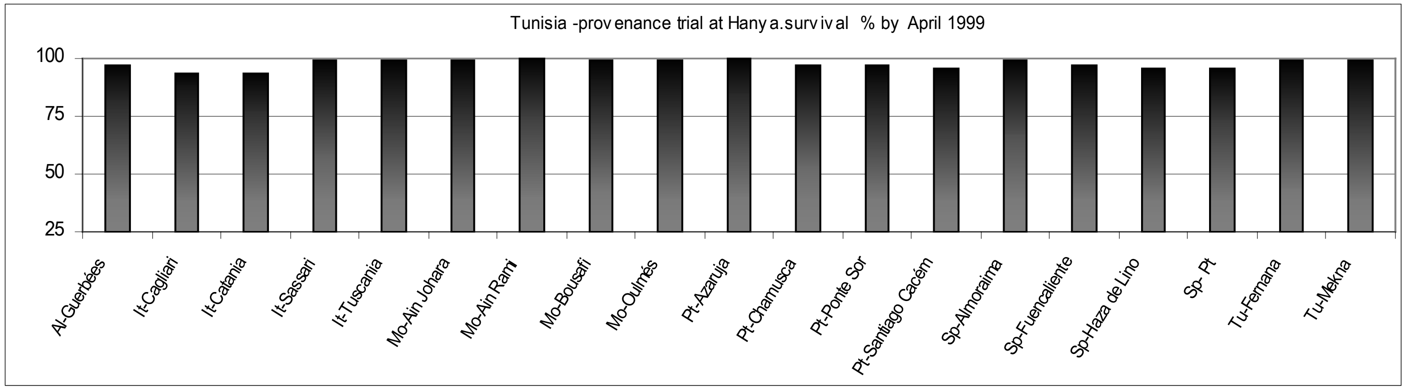

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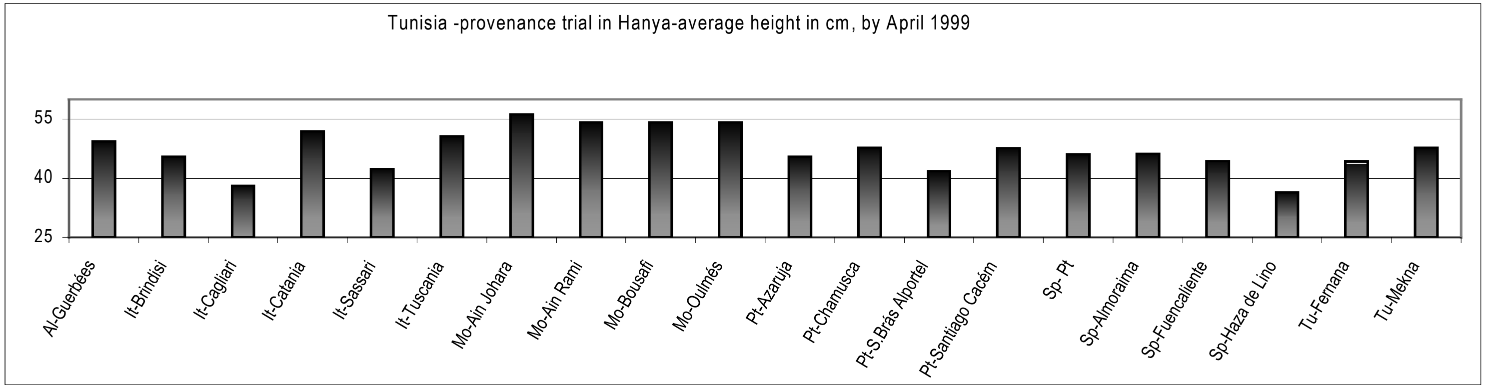

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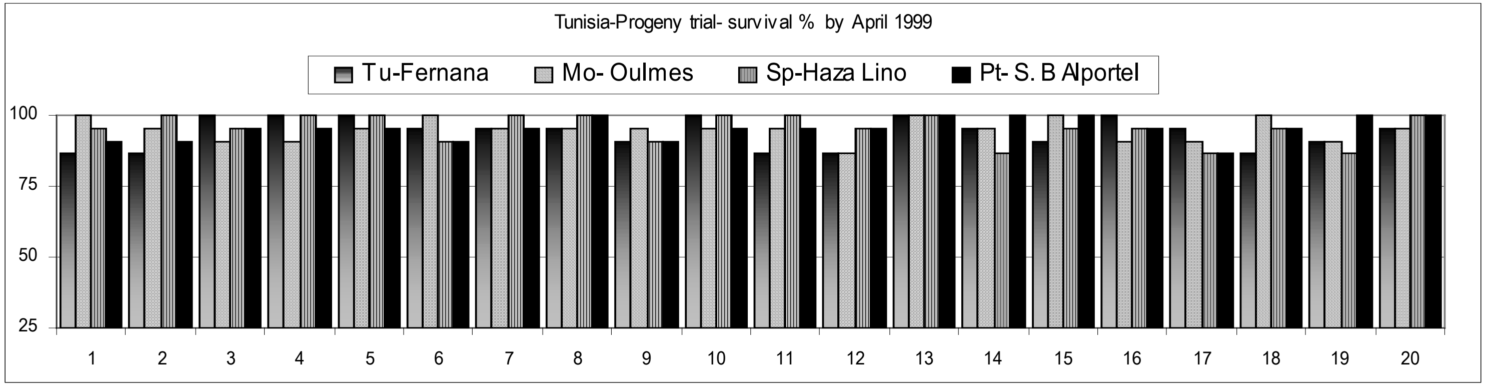

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By age 10, a part of the climatic variation is expected to take place, insights may be drowned from the trials allowing for intermediate practical recommendations. Provenances of high rate of mortality along the various blocks shall be appointed as unsuited for afforestation on similar edapho climatic conditions of the trial site. Decisions upon provenance of intermediate behaviour shall be postpone.

Adaptive traits

Surviving and vigour are characteristics that usually exhibit sharp differences at early stages.

If good initial performance may not be taken as a grant for seed sources' decision since good behaviour may be followed by deceiving traits, even death (Zobel & Talbert, 1984) poor performance allows already to point practical guidelines. Low profile provenance shall be dissuaded for use on sites of similar edapho climatic conditions of the trials, at least till confirmation through further trials.

Already showing up differences among the various provenances (Varela, 2000), more solid results are expected by age between 5 - 10, an early evaluation considering the species life span is over 150 years.

Cork quality

Phenotypic signs of cork quality are also assessable at young ages, by visual observation of external aspect of cork.

Long practice shows that trees exhibiting clear colour and wide open cork longitudinal growing fissures hold good possibilities of interesting cork quality, while brownish, narrowed overtures are unlikely of good quality. Coincident with the age of the first shaping pruning, these aspects may be observed by age of 8-10.

Long term results

Side by side with the second and third cork stripping, that takes place by age of 40-50 (according to site conditions and individual tree growing), ecological adaptation of the various provenance is expected to be concluded by the same period, considering 40 years a time length where occurrence of major weather fluctuations are probabilistically included.

An interactive processing of data coming from the trials on the various countries will certainly drive synergistic results.

Complementary studies

Unsuited on themselves to substitute field trials on the appraisal of genetic parameters of population and individuals, studies on genetic markers, eco-physiology, histology and other domains are of great importance to enhance the characterisation of provenance and progenies.

When appropriately linked with the results coming from provenance and progeny long term tests, may even reveal characteristics that allow for early appraisal of adaptation and genetic value of the genetic material decreasing the time lag for assessment.

Reproductive behaviour of cork oak is also a research line for complementary information on the strategy for the species genetic improvement.

Both aspects are currently being addressed under various research activities. (Jimenez 2000; Diaz, 2000; Varela, 2000). Long juvenile period and strong irregularities on population and individual tree (Varela & Eriksson 1995) make of planning and control of seed supply on cork oak a difficult task.

As it happens in other oaks seed supply may be a constraint on advanced genetic improvement programmes (Zobel & Talbert, 1984). Therefore studies on the reproductive biology and behaviour of cork oak are also need.

A clear knowledge of the consequences of the introgression *Quercus suber* /*Quercus ilex* on cork quality is also required to base decisions on mixed versus pure stands for seed collection.

Isolation of seed orchards eventually established will also claim knowledge of the introgression process.

Along the 4 decades still need to decisive results, new and more precise tools for understanding genetic functioning of population are expected. Efforts to keep updated research making use of updated complementary studies shall be supported and stimulated on national and EU funding programmes.

Progeny trials

The main objective of the progeny trials established after the concerted action FAIR 1 CT 95 0202 and the EU Microaction B7 4100 for North Africa countries is to assess the degree of genetic control of cork production and quality.

In order to enhance the information from the field trials progeny trials are established under a split-plot single-tree experimental design, of 88 open-pollinated progenies coming from 4 provenances from the set of 34 included at the provenance trials. The 4 provenance were choose by each country on educated guess of potential interesting characteristics as drought or cold tolerance, cork quality, etc..

The issue of global change, specially the probability of periods of extreme warmth and reduction of growing-season soil moisture levels due to greater evapotranspiration (Wigley, 1992) on cork oak range background country choice on the provenance for the progeny trials.

In order to get appraisal of unbiased heritability values progeny trials were based on a random sample of trees rather than in selection of plus trees. Therefore mother-trees were chosen among the dominant strata on the basis of fruit ability and healthy state. Trees of notorious bad cork quality were not included. In order to mitigate parental probability trees to be included on the progeny trials were required to be from 50-100m apart.

Genetic improvement or intensification of management will be privileged according the results of the progeny trials according the level of heritability.

Short term results

The longevity and the fact of being half-sib drive poor expectation for early ages results at progeny level.

Though preliminary, trials are already revealing differences as patent on figures IX.8, IX.12 and IX.16.

The phenotypic aspect of cork growing used on practice for early evaluation and thinning still lacks scientific base. Studies on the phelogene, the tissue responsible for cork production shall be complemented by histology observation and gene markers on progenies in order to turn early selection more sound long term results.

The half-sib progeny tests allow for appraisal of narrow sense heritability. Although conclusive will not be available before age of 40.

Hosting 88 half -sib progenies the progeny trials provided by this concerted action are insufficient for individual genetic selection.

Yet since the 88 progenies come from four provenance commons to the provenance trials synergistic results may be expected.

Genetic variability concentrated on population level

Claiming high efforts individual tree selection and establishment of seed orchards shall be postponed until results from trials are available.

If studies reveal the genetic variability to be concentrated at the population level individual tree selection and seed orchards may be an investment of poor return, since as referred before seed supply may be a constraint.

Therefore provenance studies and adequate seed stands selection shall be the most profitable tool for genetic improvement of the species.

Genetic variability concentrated on individual level

Under these conditions of genetic variability individual tree selection and seed orchards shall an important methodology for genetic improvement of cork oak.

Genetic variability and management of cork oak for simultaneous simple breeding and conservation of genetic resources

The theoretical and practical knowledge of cork oak genetic variability acquired along the project implementation together with the with the co-operative work developed by EUFORGEN cork oak network allow to address some guidelines for management of cork oak for simultaneous simple breeding and conservation of genetic resources.

Methods to guarantee natural regeneration under multi purpose management

- natural regeneration - in-situ MPBS model

In considerable part of cork oak stands natural regeneration is used and desirable as the main methodology. A simple breeding and conservation of cork genetic resources while taking care of associated species has also been addressed (Figure 2).

To combine the various objectives the area submitted to natural regeneration shall be divided into plots closed from grazing and other activities liable to destroy the seedlings along a period enough to include 3 mast years. In order to keep genetic variability the area $\mathbf{A_N}$ shall contain a number of adult fruit trees to assure Ne>=50. Having into consideration the reproductive profile of cork oak (Varela, 1994; Varela, 2000) the closing time shall be from 15-20 years and the plot shall include about 250 adult trees, which means 4- 6 ha for Portuguese average conditions for cork oak forests.

Along the regeneration process management shall be focused on thinning and shape pruning practices as well as on shrub control to minimise fire control risks. By age of 15 trees are usually able to stand for cattle pressures.

Furthermore the process is environmentally positive since there is no soil movements which is a practice usually of negative consequences for Mediterranean soils, specially the poor and shallow ones where cork oak stands usually grow. Yet closing means a temporary lost of income therefore the process should be supported by European Union or national programmes as it happens for artificial regeneration.

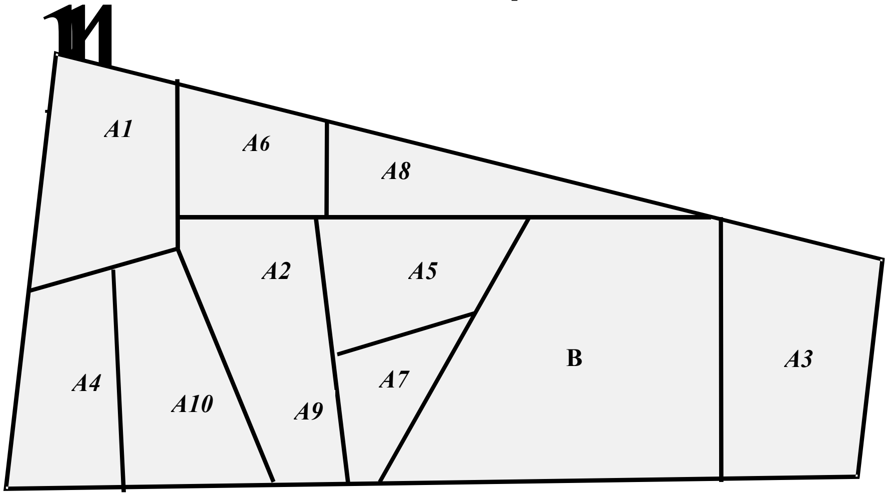

Figure IX. 17 - Model for combining simple breeding and conservation of cork genetic resources while taking care of associated species, under natural regeneration of multiuse exploitation of cork oak.

A- area to be closed to grazing and/or agriculture during 15/20 years. In order to include Ne=50 for cork average conditions the minimum area is 5 ha. **B**- nature reserve for associated species, or area for other uses

<u>Conservation of genetic resources in face of global climate changes</u>

The role of cork oak on many Mediterranean ecosystems drives attention on conservation of genetic resources of cork oak in face of climatic changes on region.

Emphasis was given to the need for adaptation in face of uncertain climate changes while taking care of genetic variability to cope with the actual human needs on goods and eventual alteration on markets demands on forest products.

- small marginal populations

Marginal populations growing on extreme environmental conditions may carry peculiar adaptation useful as gene resource for overall species evolution. Marginal populations of effective size =50 will be included on an *in situ* network. For populations of Ne =50 there is the need to promote increase of effective size. Supply of local seedlings or seeds to forest owners free of charge is a low-cost alternative for conservation of genetic resources from small marginal populations.

Information from the genetic trials is important to basis decision on extra seed or plants suply whenever there will be the need to assist the natural regeneration process.

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