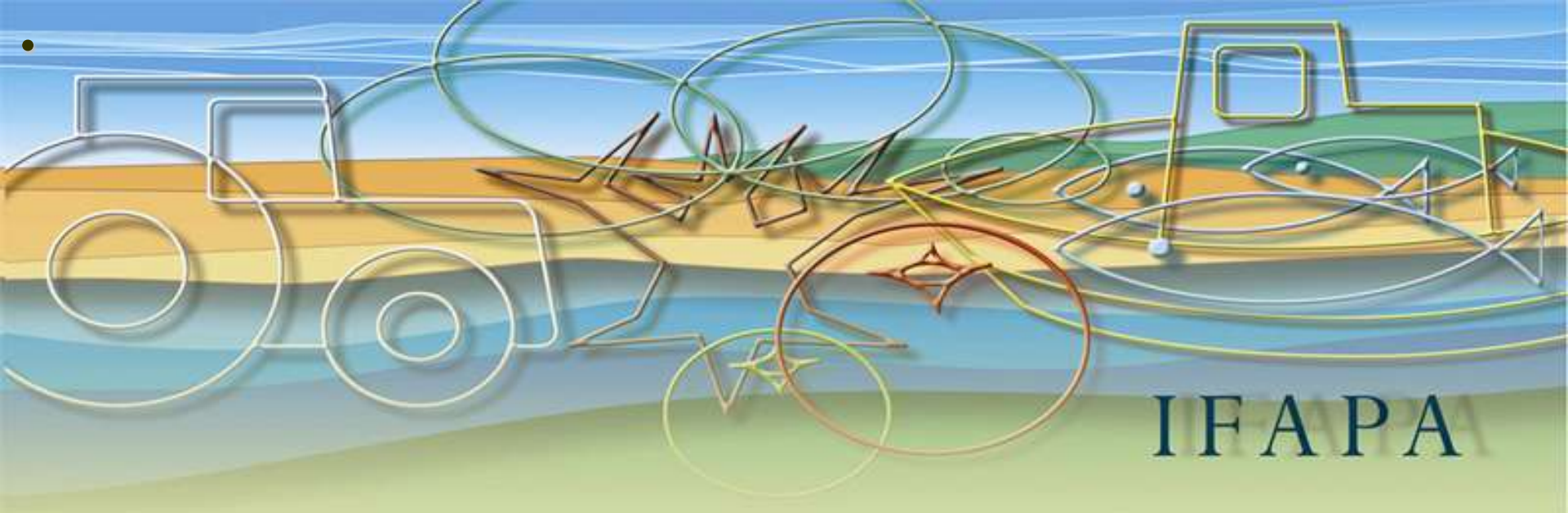


Olive biodiversity and sustanibility

Regional Awareness seminar: IOC-Ministry of Jihad-e-Agriculture

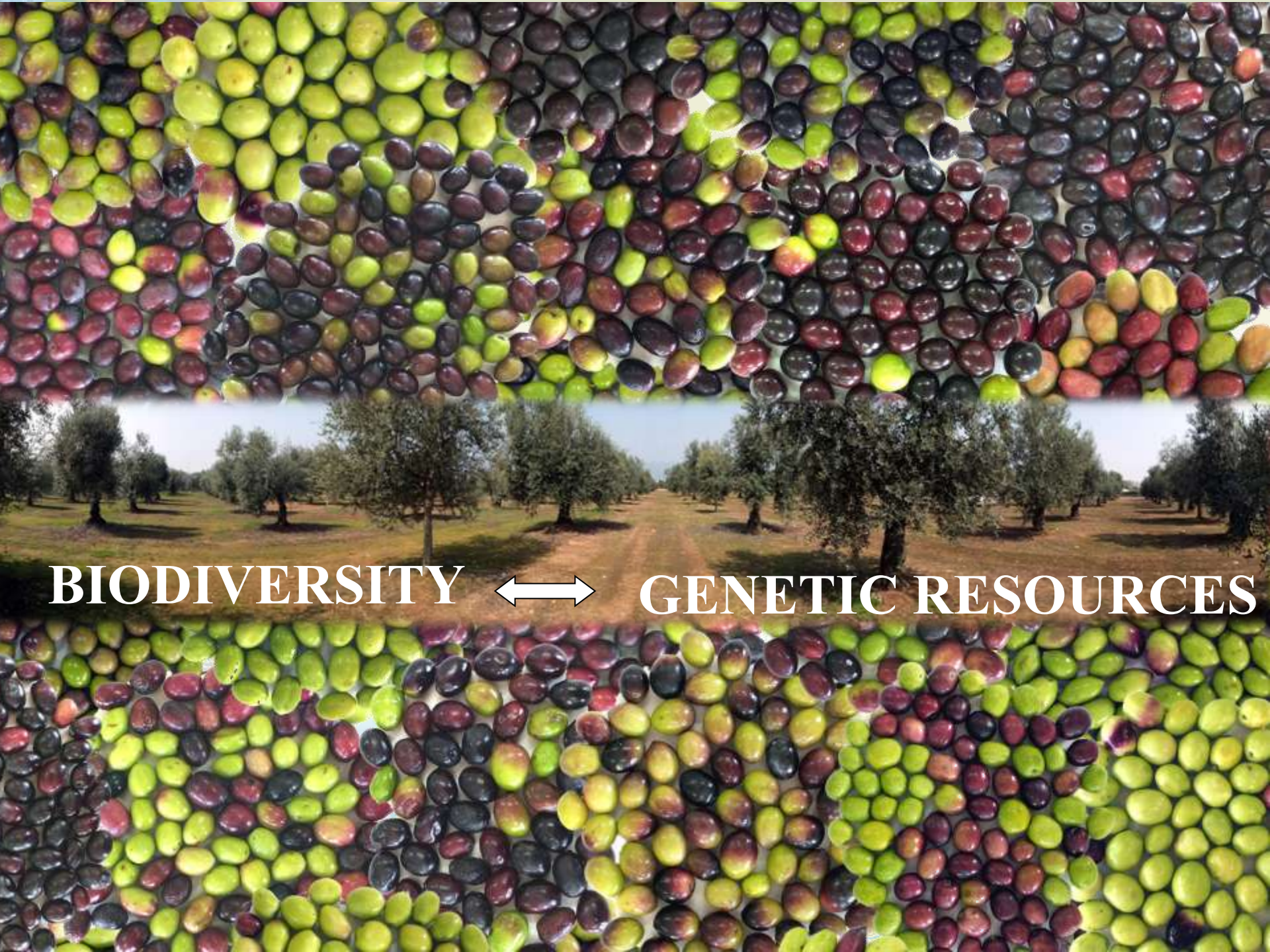
Angjelina Belaj

IFAPA. Centre "Alameda del Obispo"

Córdoba. Spain.

Tehran, 17 May 2016

JUNTA DE ANDALUCIA
Instituto de Investigación y Formación Agraria y Pesquera
CONSEJERÍA DE INNOVACIÓN, CIENCIA Y EMPRESA


BIODIVERSITY ⟷ GENETIC RESOURCES

GENETIC RESOURCES

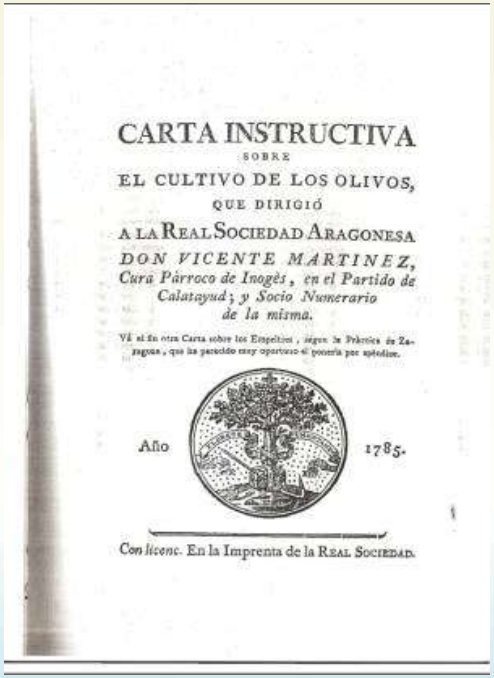
CULTIVATED OLIVE

WILD OLIVE POPULATIONS

RELATED SUBSPECIES

VARIETAL STRUCTURE IN OLIVE

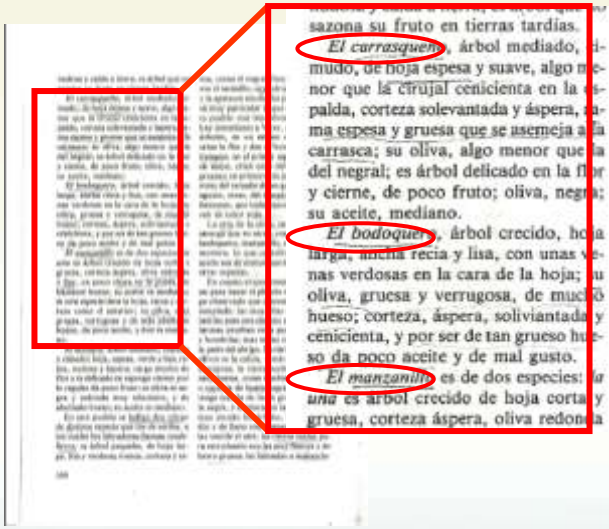
- **Very old cultivars**



CARTA INSTRUCTIVA
SOBRE
EL CULTIVO DE LOS OLIVOS,
QUE DIRIGIÓ
A LA REAL SOCIEDAD ARAGONESA
DON VICENTE MARTINEZ,
Cura Párroco de Inogés, en el Partido de Calatayud; y Socio Numerario de la misma.

Año 1785.

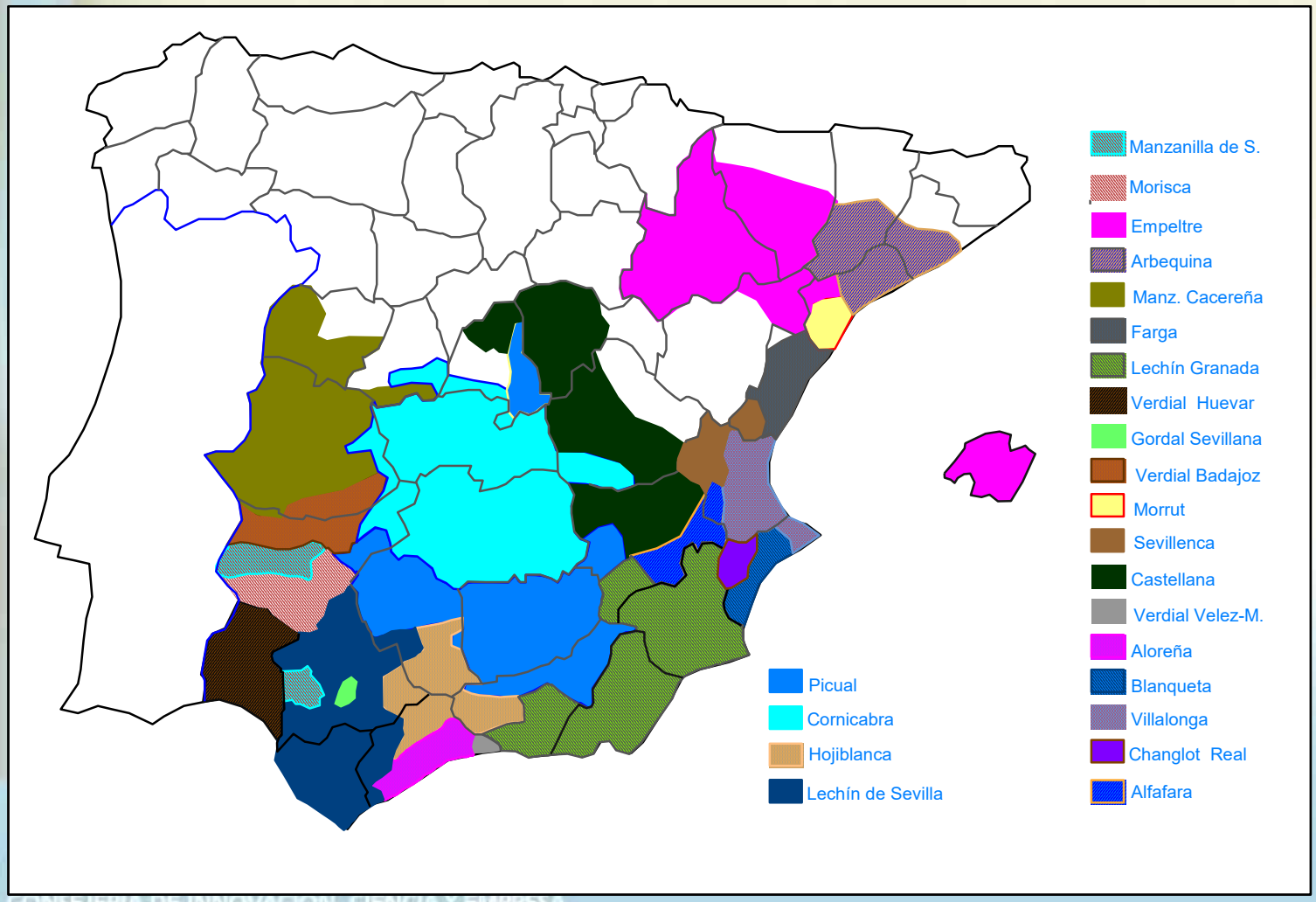
Con licenc. En la Imprenta de la REAL SOCIEDAD.



sazona su fruto en tierras tardías.
El carrasqueño, árbol mediado, ...mudo, de hoja espesa y suave, algo menor que la cirujal cenicienta en la ...palda, corteza solevantada y áspera, ...ma espesa y gruesa que se asemeja a la carrasca; su oliva, algo menor que la del negral; es árbol delicado en la flor y cierne, de poco fruto; oliva, negra; su aceite, mediano.
El bodoqueño, árbol crecido, hoja larga, ancha recia y lisa, con unas venas verdosas en la cara de la hoja; su oliva, gruesa y verrugosa, de mucho hueso; corteza, áspera, soliviantada y cenicienta, y por ser de tan grueso hueso da poco aceite y de mal gusto.
El manzanillo es de dos especies: *la una* es árbol crecido de hoja corta y gruesa, corteza áspera, oliva redonda

VARIETAL STRUCTURE IN OLIVE

- **Traditionally restricted location of cultivars**



VARIETAL STRUCTURE IN OLIVE

- **High number of cultivars**

1250 varieties

(3000 different names)

Bartolini et al. 2008; Olea database

>2000 varieties

(FAO 2010; Muzzalupo et al 2014)

GENERAL CRITERIA OF NAMING

- Homonyms

Main cultivars

'Toffahi', 'Belad', 'Majhol', 'Manzanilla', 'Verdial', 'Chemlal' 'Picholine

'Arbequina', 'Blanqueta', 'Picual'

'Aloreña', 'Castellana', 'Lechín de Granada', 'Manzanilla Cacereña', 'Manzanilla de Sevilla', , 'Morisca', 'Villalonga'

'Verdial de Badajoz', 'Verdial de Huévar', 'Verdial de Vélez-Málaga'

GENERAL CRITERIA OF NAMING

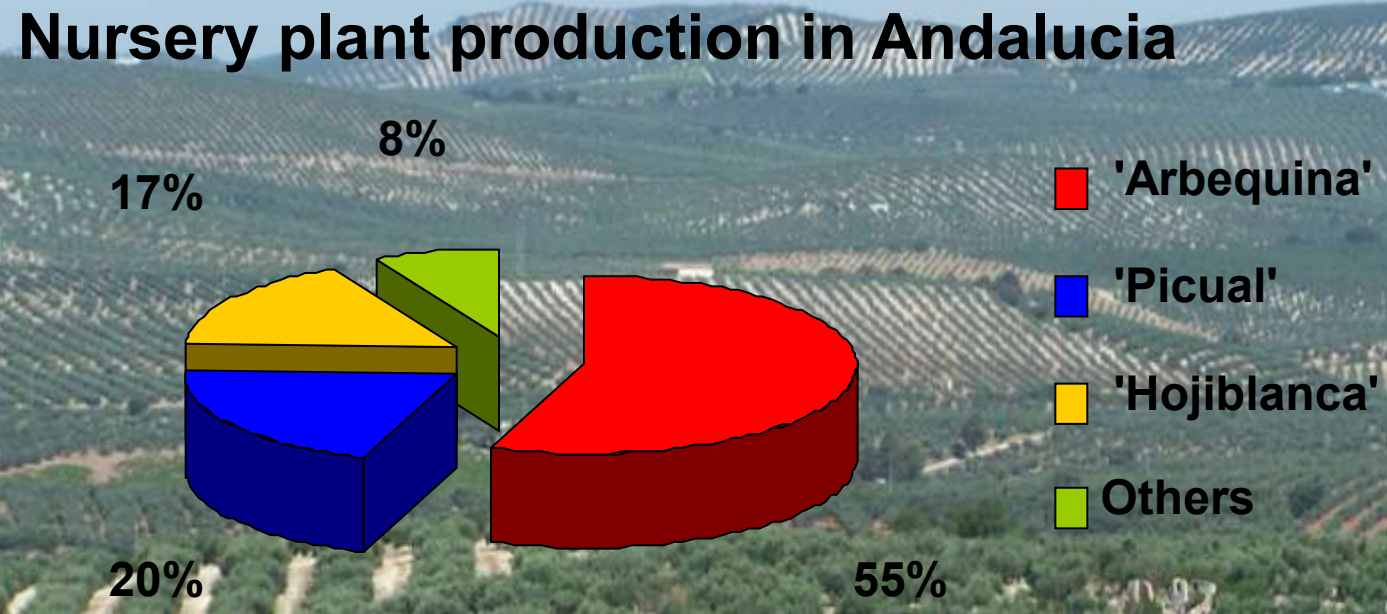
- **Synonyms**

SYNONYMS (Picual)	CRITERIA
Picúa	*fruit morphology*
Nevadillo	*leaf color*
De Aceite	*use*
Marteño, Lopereño, Andaluza	*localization*

Modern olive orchards: different planting systems

Modern olive orchards: Mechanical harvesting

NEW TRENDS: Distribution of olive varieties



Loss of genetic diversity of local cultivars

Genetic erosion risk

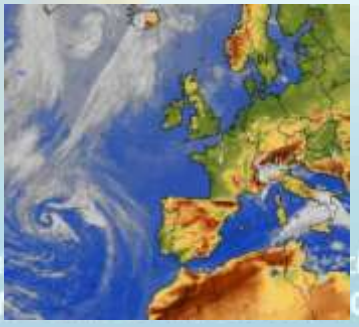
Useful diversity source against : Xylella fastidiosa

Diversity source: new and adiverse climate changes

High temeperatures and Scarce pluviometry

- **Cultivars from geographic areas with very law water availiability which confers them high resistence to drought.**

- **Genotypes with flowering and production capacities under very diverse environmental conditions (relatively high winter temperatures).**



MANAGEMENT OF GENETIC RESOURCES

Knowledge and conservation of genetic resources

Ex situ conservation: GERMPLASM BANKS

CULTIVATED OLIVE

100 olive collections
54 countries

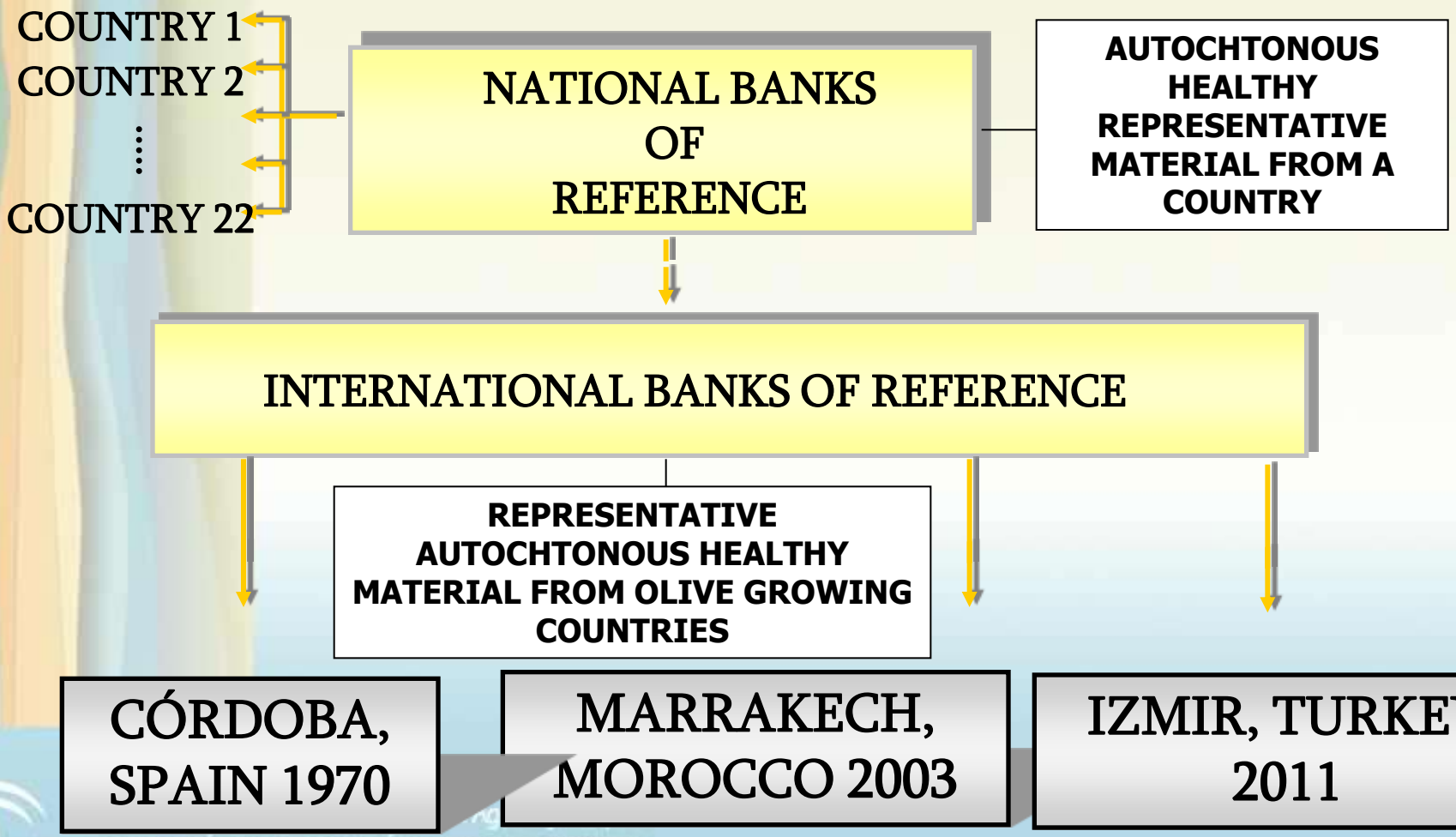
1250 Cultivars

(3000 different names)

Bartolini et al. 2008

Network of Germplasm Banks IOC-FAO (1996)

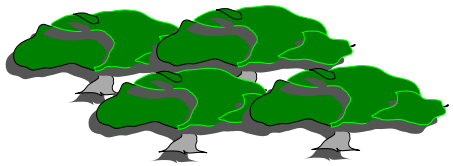
RESGEN CT/ 96-97 PROJECT (UE-IOC)



GERMPLASM BANKS

OBJECTIVES

- **To preserve in collection all plant material considered to be different on regional, national or world levels**
- **To study the variability of the species through systematic agronomical evaluation**
- **To document genotypes**



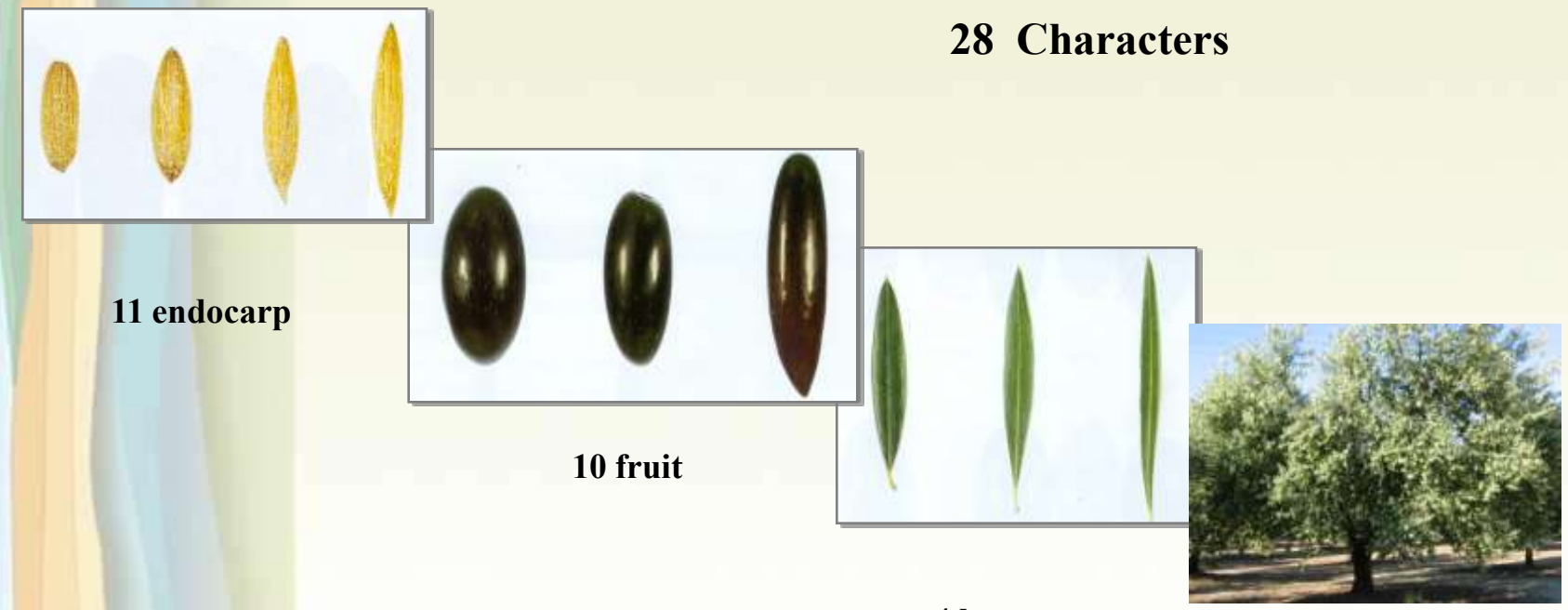
Selection

COMPARATIVE TRIALS

(VARIETIES OR PLANT STOCKS)

GENETIC BREEDING

Establishment and use of a common morphological schedule



28 Characters

11 endocarp

10 fruit

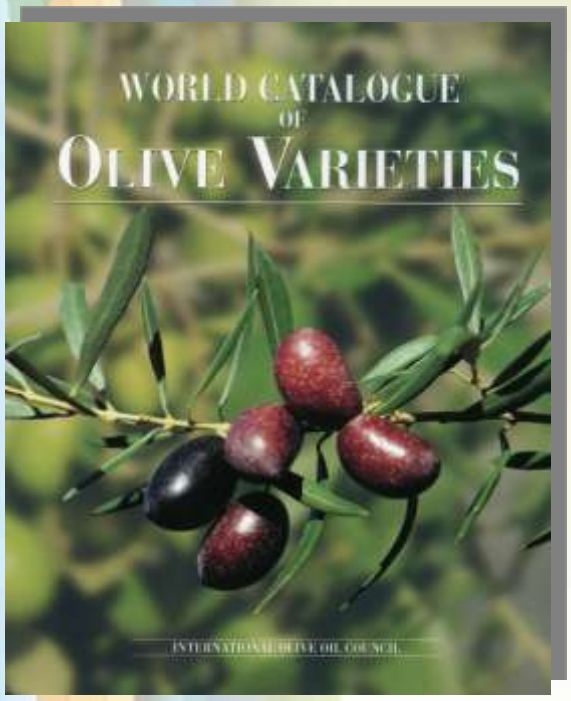
4 leaves

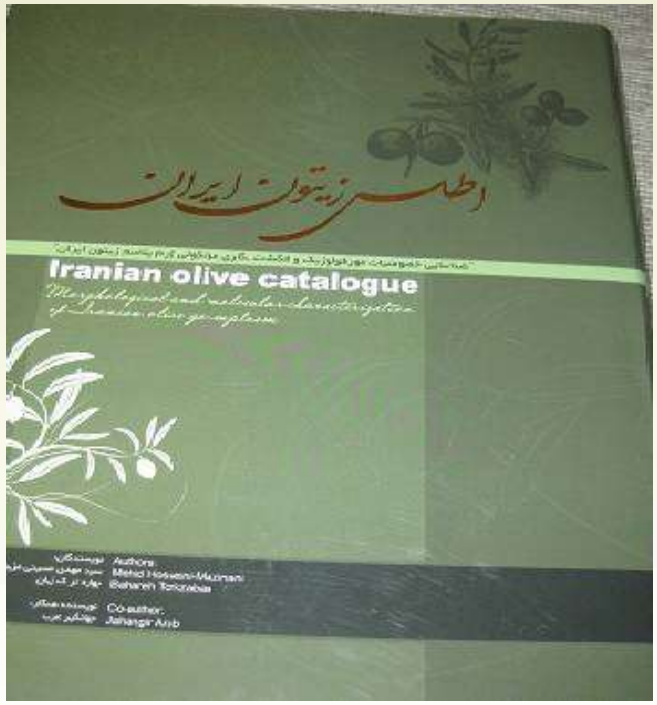
3 tree

EU-IOC Resgen results 2011: 1100 accessions recovered and characterised

(www.internationalolive oil,org/ resgen/index.html)

Establishment and use of a common morphological schedule





IOC (2000)

139 cultivars

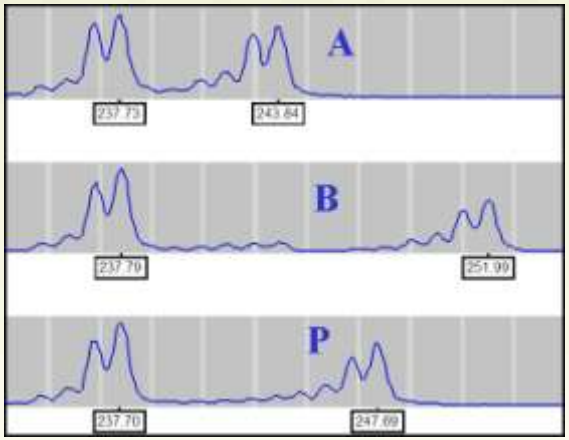
23 Countries

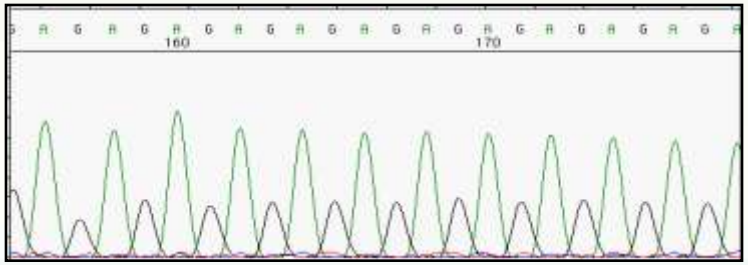
Endocarp and fruit traits more discriminative and stable: authentication

Spain (Barranco et al., 2005); Algeria (Mendil and Sebai, 2006); Albania (Ismaili et al., 2012); Greece (Kostelenos, 2011); France (Moutier et al., 2004); Italy (Perri et al., 2003; Muzzalupo et al., 2010); Tunisia (Trigui et al., 2002; 2006), Hosseini-Mazinani et al 2013) etc

GENETIC MARKERS

- **BIOCHEMICAL MARKERS (isozymes)**
- **DNA MARKERS**





-No environmental influence

-Good coverage of the genome

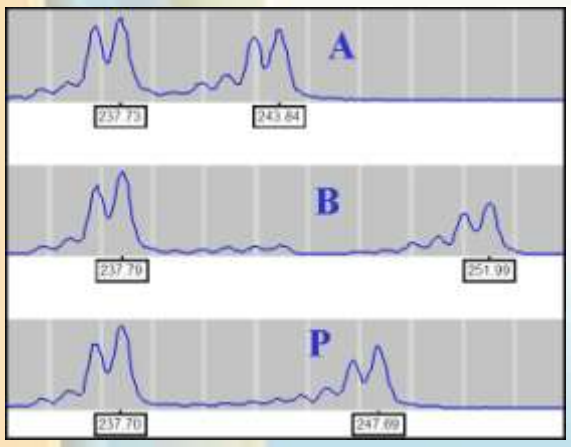
-Evaluation in early phases of plant growth

-Complementary tools/morphology

CHARACTERIZATION OF OLIVE GERMPLASM

ARBEQUINA

BLANQUETA



DNA Markers use:

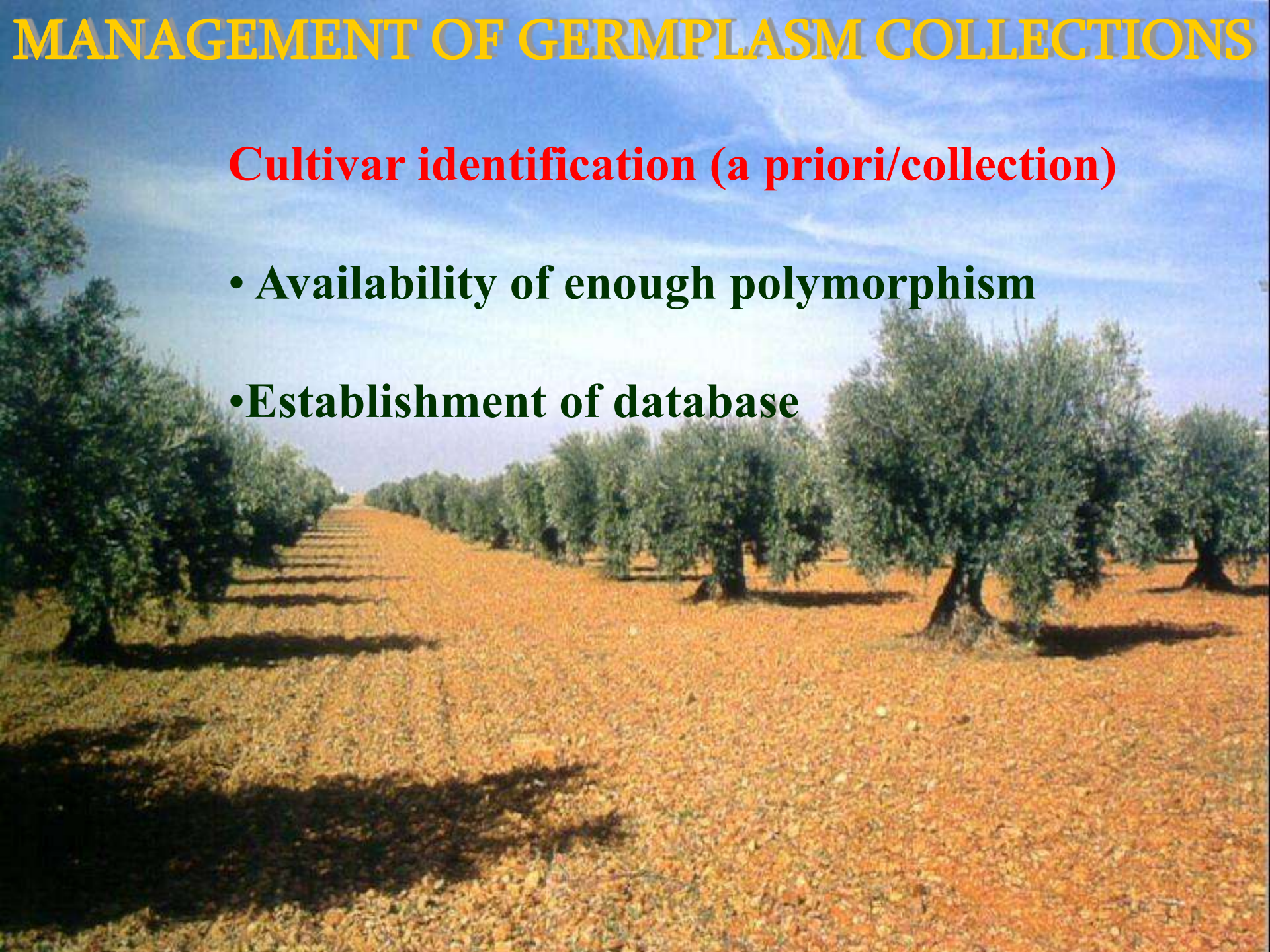
Management of germplasm collections

Cultivar Identification

Genetic variability and relationships

(Sarri et al., 2006; Noormohammadi et al. 2007; 2014; Alba et al., 2009; Erre et al.2010; Fendri et al., 2010; Belaj et al. 2012; Chalak et al., 2012; Linos et al., 2014; Trujillo et al., 2014; Brake et al, 2014; Beghé et al. 2015; Lasoviç et al. 2016)

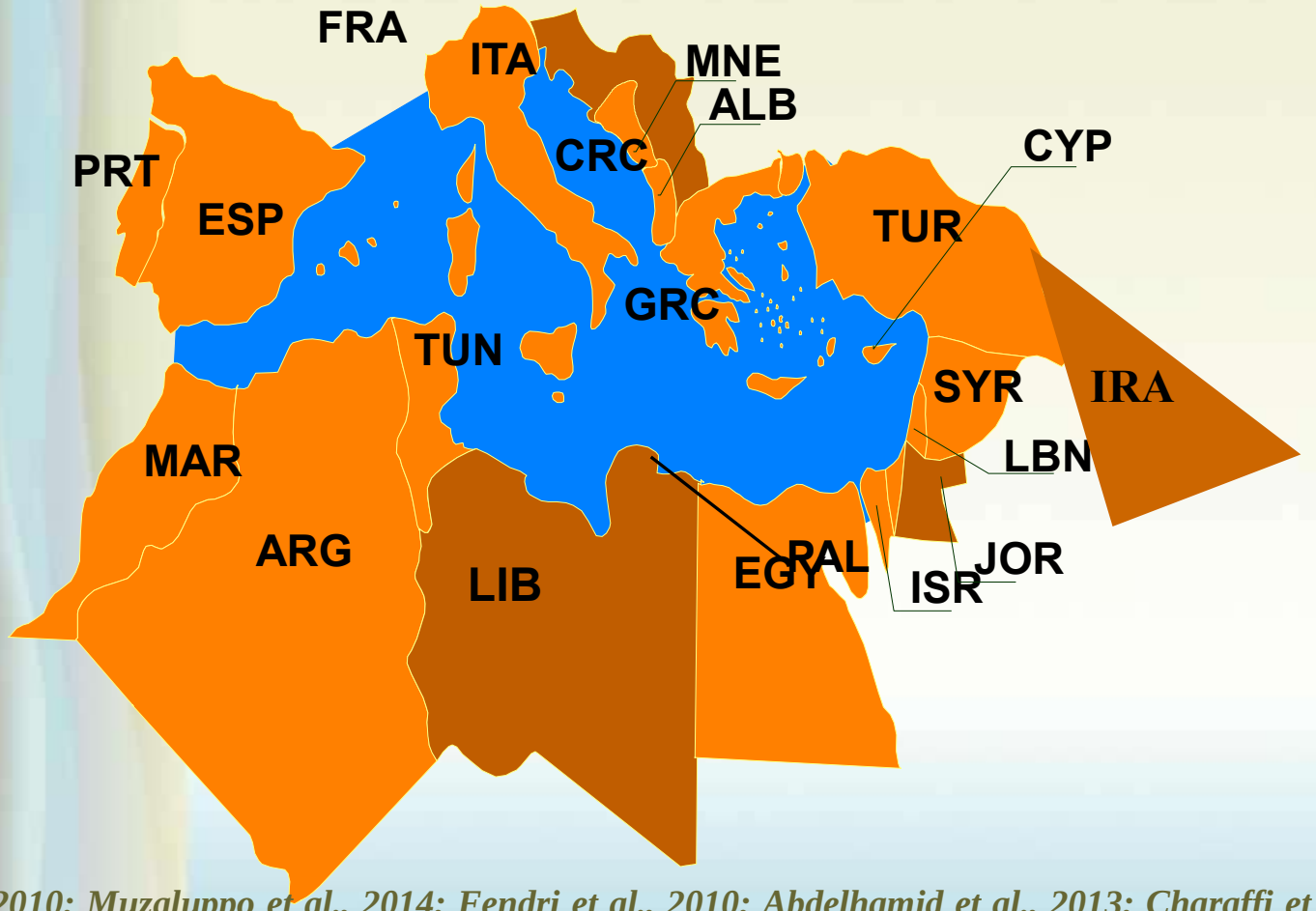
MANAGEMENT OF GERMPLASM COLLECTIONS



Cultivar identification (a priori/collection)

- **Availability of enough polymorphism**
- **Establishment of database**

Cultivar identification of national and international collections



(Soleri et al. 2010; Muzaluppo et al., 2014; Fendri et al., 2010; Abdelhamid et al., 2013; Charaffi et al., 2008; Basheer-Salimia et al., 2009; Dag et al., 2012; Dominguez et al., 2012; Linos et al., 2014; Haouane et al., 2011; Brake et al., 2014; Mousavi et al., 2014; Noormohammadi et al., 2007; 2014; Chalak et al., 2012; Kaya et al., 2013; Atienza et al., 2013; Sadeeg S.A. 2014; Trujillo et al., 2014; Abdessemed et al, 2015; Beghé et al. 2015; Lasoviç et al. 2016)

Cultivar identification of national and international collections

- **Errors due to generic naming of cultivars**

Homonyms: **Manzanilla, Lechín, Gordal, Picual, Toffahi, bardhë, Bjelica.**

Synonyms: **‘Cakir’- ‘Valanolia’; ‘Cañivano Blanco’- ‘ Picholin Marrocaine’‘Manzanilla de Sevilla’- ‘Redondil’**

- **Prospecting redundancies**
- **Plant propagation errors or msilabelling (donor or receptor collection)**
- **Possible somatic mutations (intracultivar diversity)**

GENETIC DIVERISTY

High molecular varibility

- regional level
- country level
- Mediterranean level
- within group variability

High genetic diversity

- country level

>200 genotypes propected/studied

Around 100 cultivars (Many Local ones)

High genetic diversity

Differentiation with the world olive cultivars

(Noormohammadi et al. 2007; 2014; Mazinani et al., 2013; Mousavi et al. 2014 etc)

GENETIC RELATIONSHIPS

- **Clustering according to geographical origin**

  Besnard *et al*. 2001[a]; Belaj *et al*. 2002;2003; 2004, Angiolillo *et al*. 2006; Sarri et al., 2006; Linos et al., 2014

- **Clustering according to fruit size**

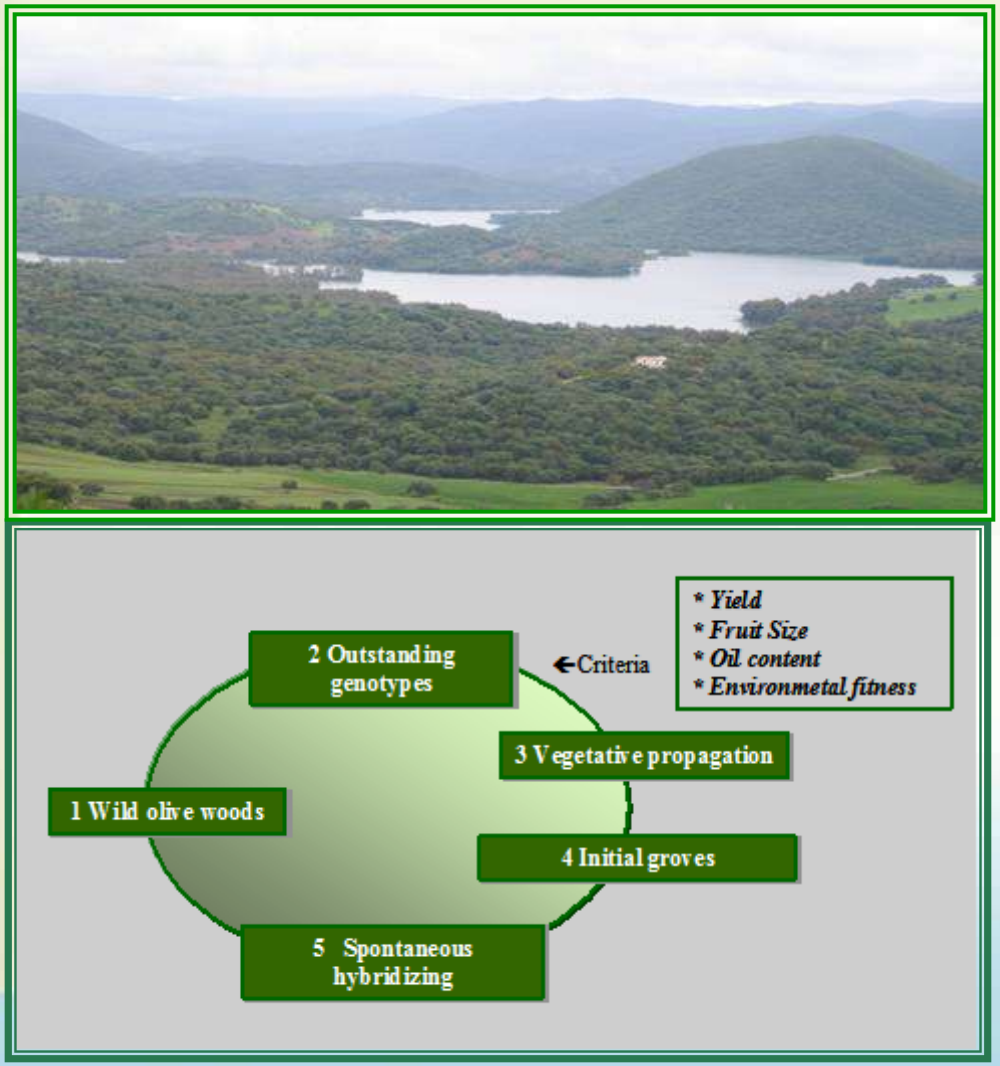
  Hagidimitriou *et al*. 2005; Grati-Kamoun *et al*. 2006; Nikoloudakis *et al*. 2003; Montemurro *et al*. 2005

- **Multilocal selection of olive cultivars**

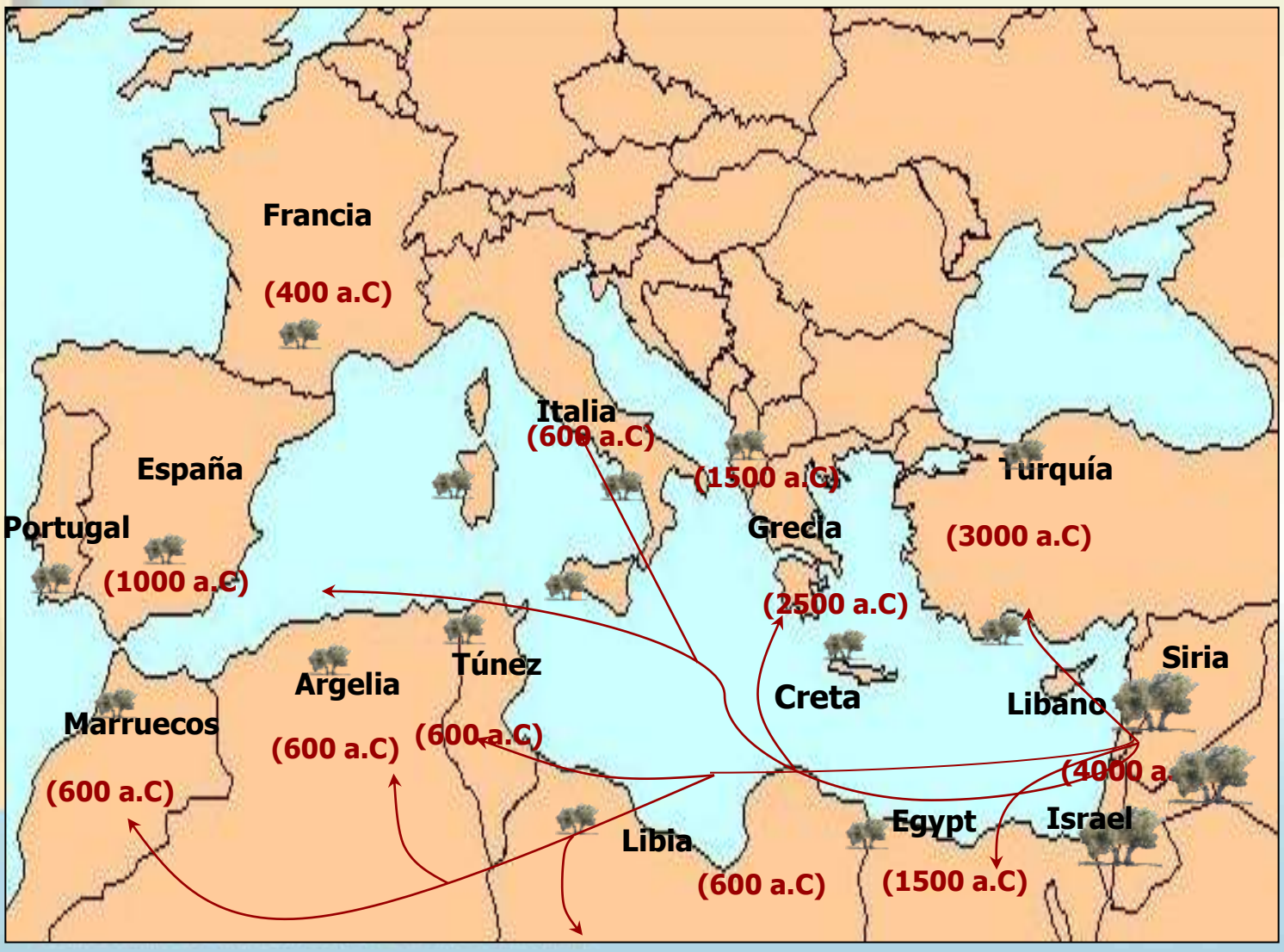
  influence of human migrations

  crosses betwen local and foreing germplasm

Local selection of cultivars



East to West diffussion of olive cultivars/Local selection West



PHENOTYPING EVALUATIONS

- **At the collection level:**
- **Evaluatio of many cultivars (the same environment)**
- **A general view on agronomic diversity**

- **Still limited information**
- **Delay collection/cultivar evaluation**
- **Many years of trait evaluations**
- **Common evaluation schedule**

Vigor

Production

Phenology

Pomology

Olive oil quality

Rooting Ability

Biotic & Abiotic Resistance

Del Rio et al., 2005; Trenatcoste et al., 2011; Cantini et al., 1999; Trapero et al., 2013

Banco de Germoplasma Mundial de Olivo

I.F.A.P.A.
Centro "Alameda del Obispo"
Córdoba (Spain)

Fruit related traits

WEIGHT

‘Gordal Sevillana’

‘Real Sevillana’

‘Ocal’

‘Morisca’

‘Hojiblanca’

‘Picudo’

FRUIT/STONE

‘M. del Piquito’

‘M. Cacereña’

‘M. De Sevilla’

‘Gordal Sevillana’

‘Changlot Real’

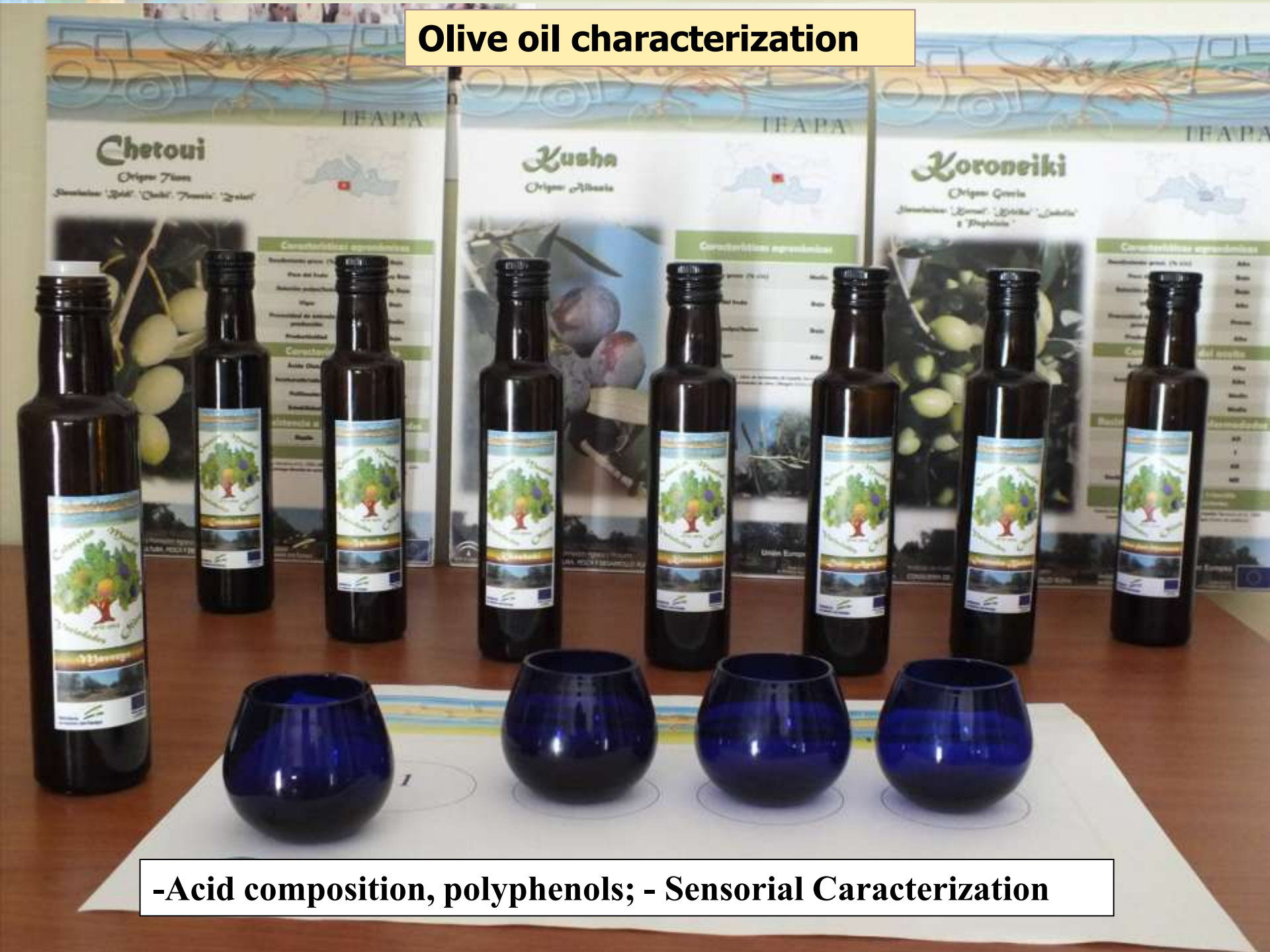
‘Hojiblanca’

% Olive oil d.m

‘Chalkidiki’ , ‘Coratina’

‘Bolvino’, ‘Morrut’, ‘Zaity’

Olive oil characterization



-Acid composition, polyphenols; - Sensorial Caracterization

Evaluation under Controlled conditions

TOLERANCIA A VERTICILOSIS

Non Defolianted (V4) or Defoliated (V117)

-<u>resistent or less susceptibles</u>: ‘Frantoio’, ‘Empeltre’, ‘Changlot Real’, ‘Grosal de Albocafer’, ‘Kato Drys’, ‘Manzanilla Picua’ , ‘Sevillana de Abla’ etc

- Controlled and Field conditions

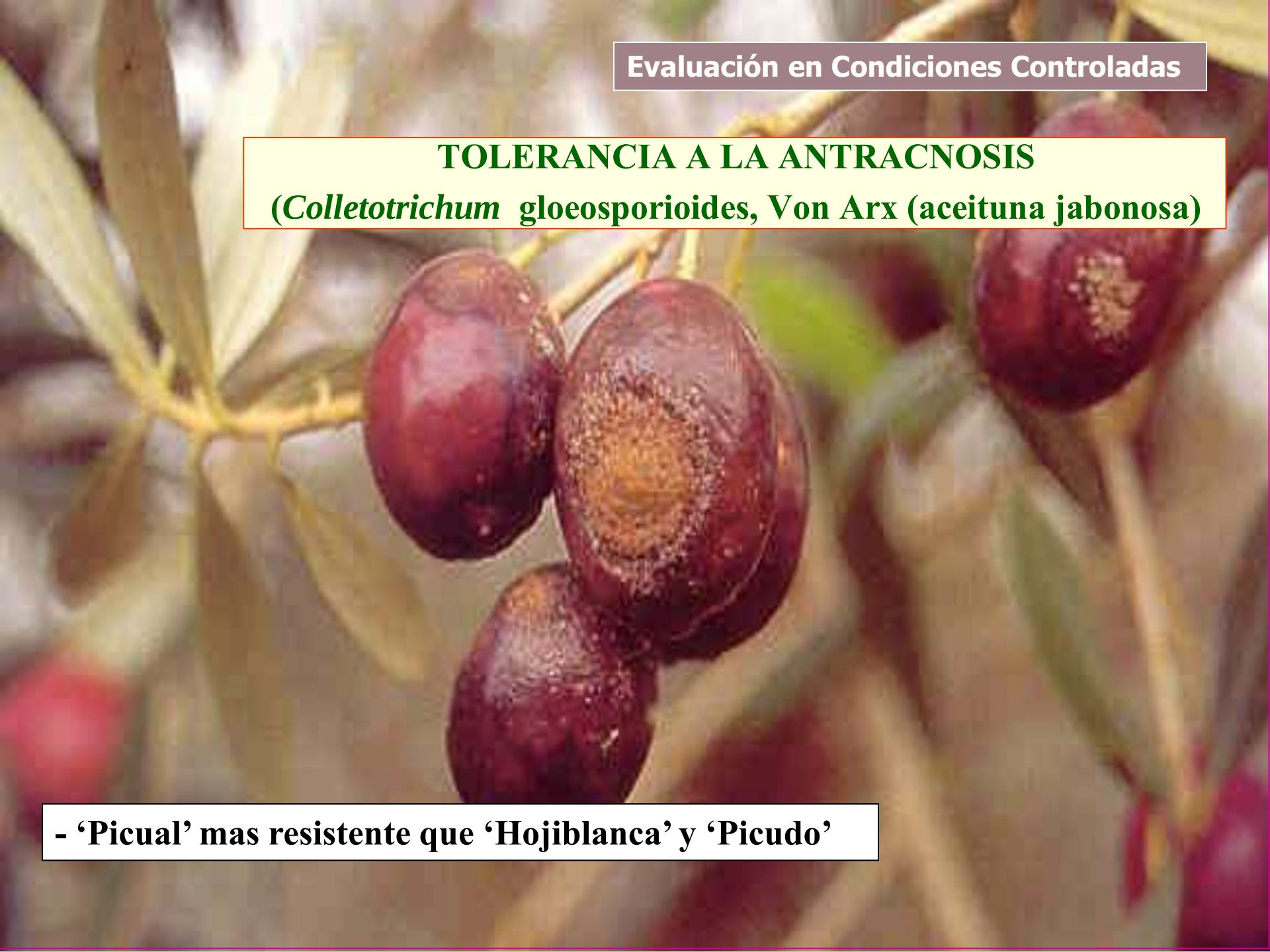
Evaluación en Condiciones Controladas

TOLERANCIA A REPILO
Spilocaea oleaginea (Cast.)

- <u>48 resistent</u>: ‘Arbosana’, ‘Frantoio’, ‘Galega Vulgar’, Lechín de Sevilla’

TOLERANCIA A LA ANTRACNOSIS

(*Colletotrichum* gloeosporioides, Von Arx (aceituna jabonosa)



- ‘Picual’ mas resistente que ‘Hojiblanca’ y ‘Picudo’

Evaluación en Condiciones Controladas

TOLERANCIA A CLOROSIS FÉRRICA

Variedades evaluadas

- **34, BGM- IFAPA**
- **7 tolerantes: ‘Nevadillo Negro de Jaén’, ‘Pajarero’, ‘Manzanilla de Sevilla’, ‘Blanqueta’, ‘Carolea’, ‘Acebuchera’, ‘Morisca’**

Evaluación en Condiciones Controladas

TOLERANCIA AL FRIO

Variedades evaluadas

- **37, BGM-IFAPA**
- **10 tolerantes: ‘Mollar de Cieza’, ‘Farga’, ‘Lucio’, ‘Gordal S.,‘Arbequina’**

PHENOTYPING EVALUATIONS

- **At the collection level:**

- **Identification of local and allochthonous cultivars with outstanding agronomic performance/the same environment conditions**

- **Molecular+agronomic diversity: selection of parents for breeding**

- **Few replications/genotypes**

- **Envioronmentally dependent agronomic traits**

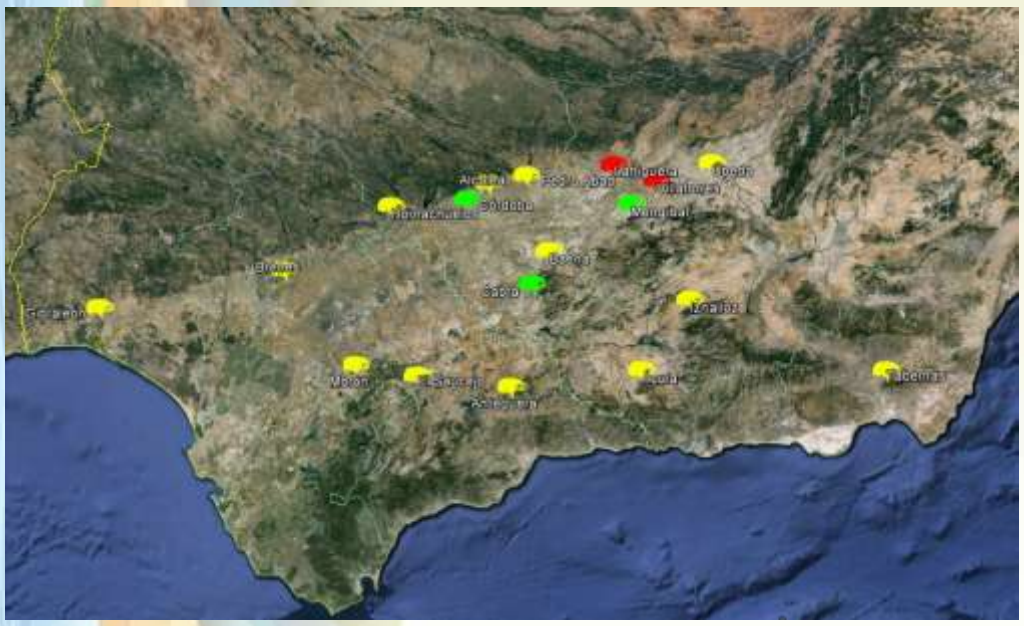
PHENOTYPING EVALUATIONS

Need of Field Comparative trials

- Different agro-climatic conditions
- Many replications per genotype
- Diversification of olive orchards : local/foreign cultivars
- Very useful information for the farmers
- Contribute to a better use of olive genetic resources
- Not extensively used/scarced published results

The most efficient way to determine the best suited cultivars/area

Diversify varietal offer



- Farmers properties
- IFAPA Centres
- Verticilosis trials

- **Comparative trials of olive oil cultivars**
- **Comparative trials of Verticilium Resistance**
- **Comparative trials of table olive cultivars**

Olive Germplasm Collections

- **High number of varieties maintained**
- **High genetic and phenotypic diversity**
- **Useful information for olive orchards diversification**
- **Ideal base for olive breeding**

The need of new olive cultivars

Olive growing in a new era: New diversity

OLIVE BREEDING

REASONS

- Most cultivated varieties are centennial
- Not adapted to the new olive growing systems
- Quality characteristics are far from optimum

DIFFICULTIES

- Long juvenile period (10-15 years)
- Lack of knowledge about inheritance of the main agronomic traits

14 breeding programs/Different objectives

Objectives

High productivity

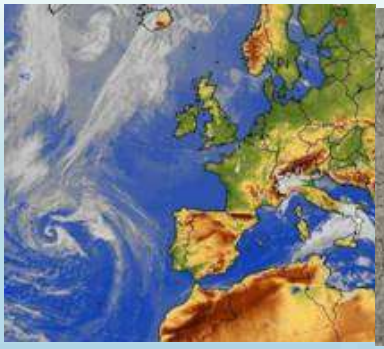
Olive oil quality

Suitability to different orchard systems

Reducing of labor cost (harvesting)

Resistance to pest and diseases

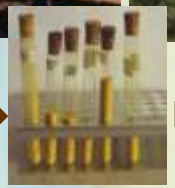
Adjustment to different and extreme environmental conditions



Olive breeding program protocol

male

female



polen

Seedlings

2000 genotypes 1 replicate
(5 years)

Intermediate evaluation

200 genotypes 4 replicates
(7 years)

Comparative trials

20 genotipos 16 repeticiones
(8 years)

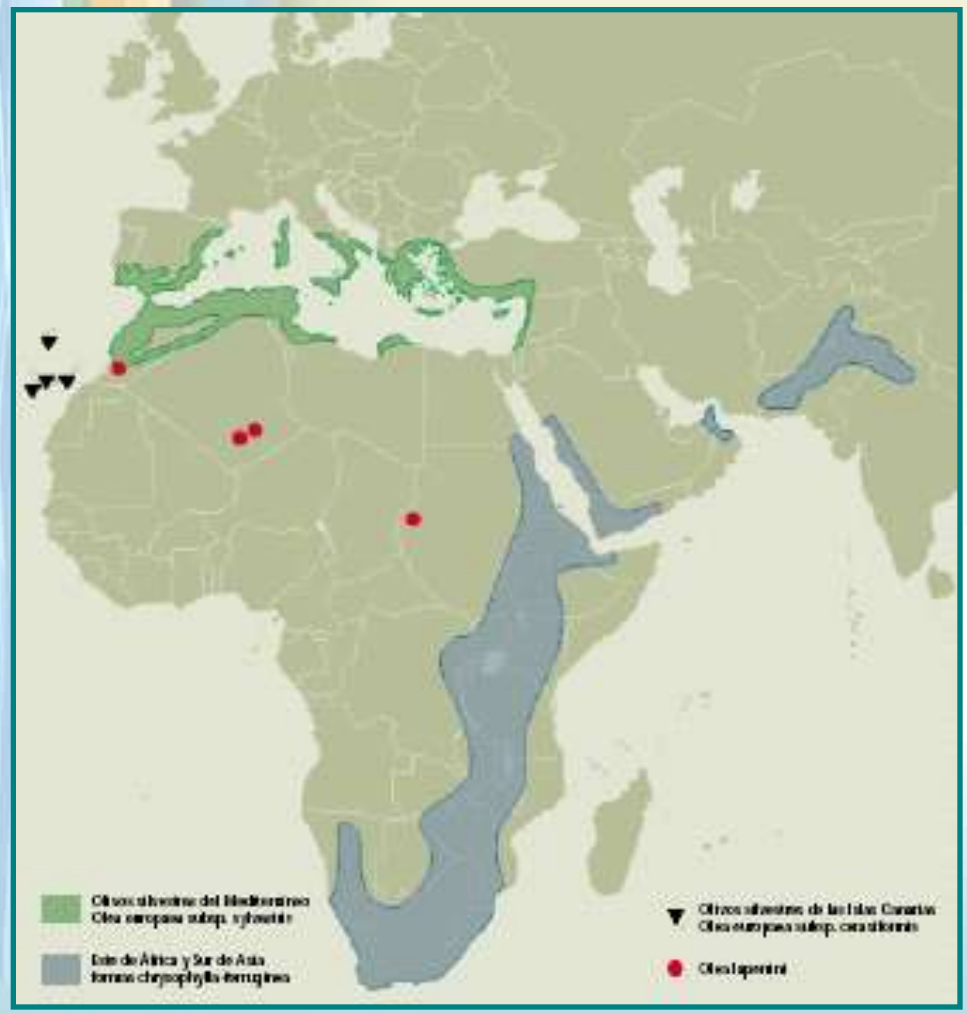
More than 20 cultivars with relevant commercial use

All of them come from crosses between cultivars

HIGH AVALIABLE DIVERSITY/LOW USE

2006-2014: Interesting wild olive genotypes

Wild olives *(Olea europaea* subsp. *europaea* var. *sylvestris)*



Wild/cultivated

2*n*=2*x*=46

Interfertile

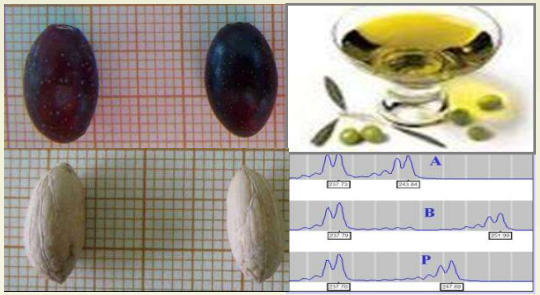
Wind pollination

Seed dispersion

New source of variability

DIVERSITY OF HABITATS, SHAPES AND DIMENSIONS

- ***In situ*** **evaluation of wild olives**



Morphological and agronomical evaluation

(Mulas et al. 2004; Hannachi et al., 2009; Belaj et al. 2011)

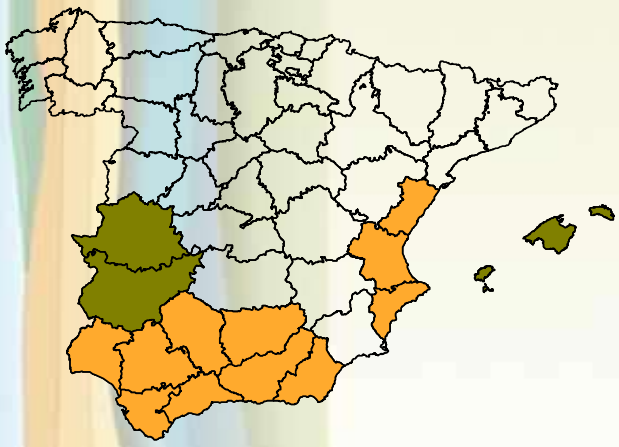
Genetic diversity and genetic relationships

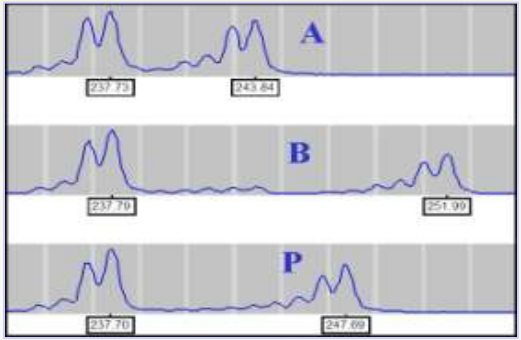
(Lumaret al., 2004; Besnard et al. 2008; 2014; Hannachi et al. 2008: Belaj et al. 2007; 2010)

Information on the history of olive domestication

(Breton et al., 2006; Besnard et al. 2008; 2014[a], b; Belaj et al., 2010)

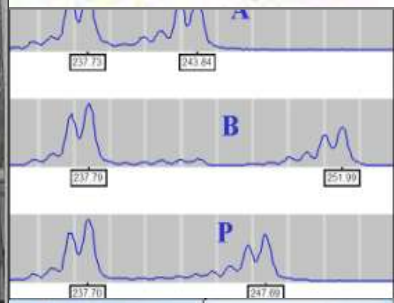
- **The establishment of a collection of wild olives in the field (IFAPA, Córdoba)**
- ***Ex situ* Molecular and phenotypic characterization of wild olives**

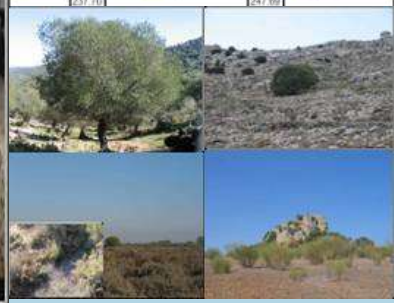




Wild olives and genetic diversity

- High genetic diversity of wild olive population
- Differentiation between wild and cultivated olives
- Presence of genuine wild olive forest in Mediterranean bassin
- Useful source of resistence to biotic and abiotic stress
- Use as parents in breeding crosses or as rootstoks





Olive genetic resources: related subspecies

Olea cerasiformis

Olea guanchica

Olea guanchica

Olea maroccana

Olea cuspidata

Ancient olive trees: Cultivated and wilds

Ancient olive trees

-Historical, cultural, landscape, and economical value

-Vulnerability and expoliation risks

-New sources of genetic diversity maintened *in situ/on farm*

-Local unknown ancient cultivars and landraces (Andalusia: 90% unknown local cultivars)

Rich genetic patrimony:

Protection (fisical, legal, education)

Combination of in situ(on farm) and ex situ conservation

Agronomical evaluation

Olive ancient trees

North Eastern Spain: The power of farmers 'union

Territorio de Senia: 2000km^2

(Catalonia, Valencia and Aragon)

4,526 ancient olive trees

Olive oil comercialisation

In olive we do have a rich genetic patrimony

-Traditional Cultivars (main and local)

- New cultivars from breeding

-Wild olive populations/related subspecies

- Ancient trees

But what about olive cultivation sustainability?

Current situation of the olive orchards

Patrimony:

10 to 11 million ha
≈1 000 million olive trees

Distribution:

Land of mountains, hills, plains, cold climates, semi-arid and arid zones, desert.

Characteristics of the growing systems

Growing system	Density (trees/ha)	Productivity (kg/ha)
Marginal	<80	≤1 000
Traditional	80-150	1 500-3 000
Intensive	200-450	5 000-7 000
		(irrigated 8 000-12 000)
High density	**1 500-2 500**	**8 000-12 000**

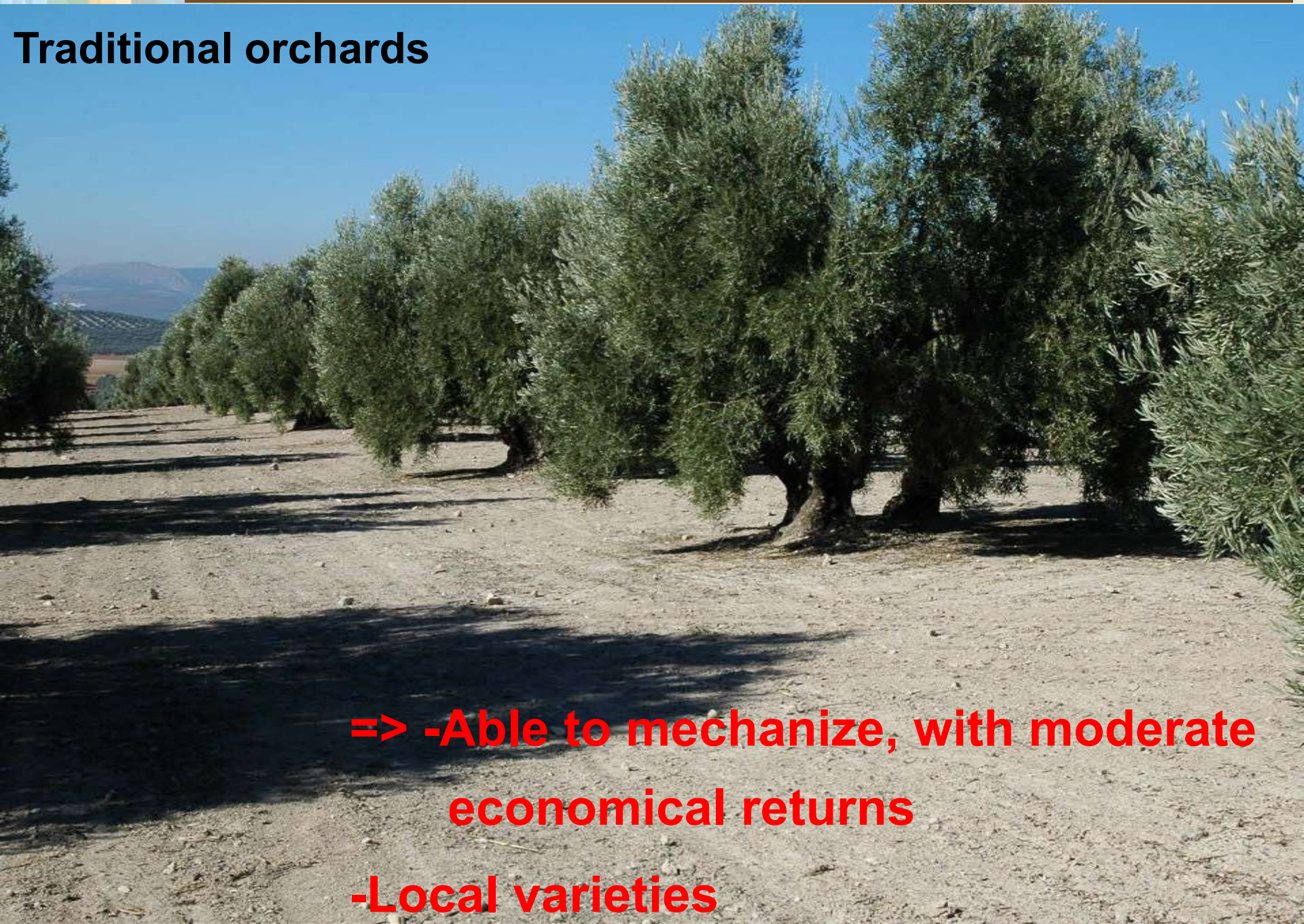
Marginal orchards

=> -Low inputs, no mechanization and very low profitability.

-Local varieties

Marginal orchards

Traditional orchards



=> -Able to mechanize, with moderate economical returns

-Local varieties

Traditional orchards

Intensive Orchards

=> -Training with single trunks for mechanical harvesting

-Usually irrigated, with continuous pruning

-Tendency to reduce the number of varieties

-The most common planting system in modern orchards

204 trees/ha (7x7m)

Intensive Orchards

357 trees/ha (7x4m) → 178 trees/ha (7x8m)

Intensive Orchards

570 trees/ha (7x2.5m) → 285 trees/ha (7x5m)

High density orchards

2 000 trees/ha (3.75x1.35m)

High density orchards

=>-Hedgerow planting, drip irrigated

-Low cost of harvest and early bearing

-High investment cost and short life

-Few varieties adapted and difficult tree size control

1 250 trees/ha (4x2m)

Key factors determining the evolution of the growing systems

Sustainability of cultural practices

New harvesting solutions

Pest and diseases management

New varieties

•Sustainability of cultural practices

Good practices of pruning (form and maintain the trees)

Soil managenment to reduce its erosion: use of cover crop

Irrigation: Strong response of olive tree yield but need to define water requeirements as precisely as possible

Fertilisation: Leaf-nutrient analysis provides an indication of tree nutritional status and for determining fertilization requirements

PRUNING

- **Maintain an adequate leaf-wood ratio.**
- **Respect the natural trend of the variety**
- **Carry out rejuvenation pruning when necessary**
- **Recycling of pruners in specialization courses**

New harvesting solutions

Need of adaptation of the tree to mechanical harvesting

Development of mechanical pruning to achieve integral mechanization and cost reduction

Increase efficiency and reduce fruit damage in mechanical harvesting of table olives

Need to release new varieties adapted to mchanical harvesting

Nursery plant identification and certification

Spain

2002-2005: 1086 samples

Molecular markers

10% of identification errors

Australia: Identification of mother plants

(Rehman A et al., 2012; Trujillo et al., in press)

Conclusions

- **Need of a better knowledge, management and exploitation of cultivated , wild olive genetic resources and ancient trees.**
- **Need of accurate genotyping and phenotyping of germplasm collections and establishment of comparative trials with national and foreign cultivars**
- **Reduce of the gap between the huge genetic patrimony available in olive and its use.**
- **Olive breeding programs need to be promoted and developed in olive growing countries.**
- **Need to use sustainable cultural practices to better respond to the clear tendency of intensification of olive growing**
- **Need of Collaboration at all levels**

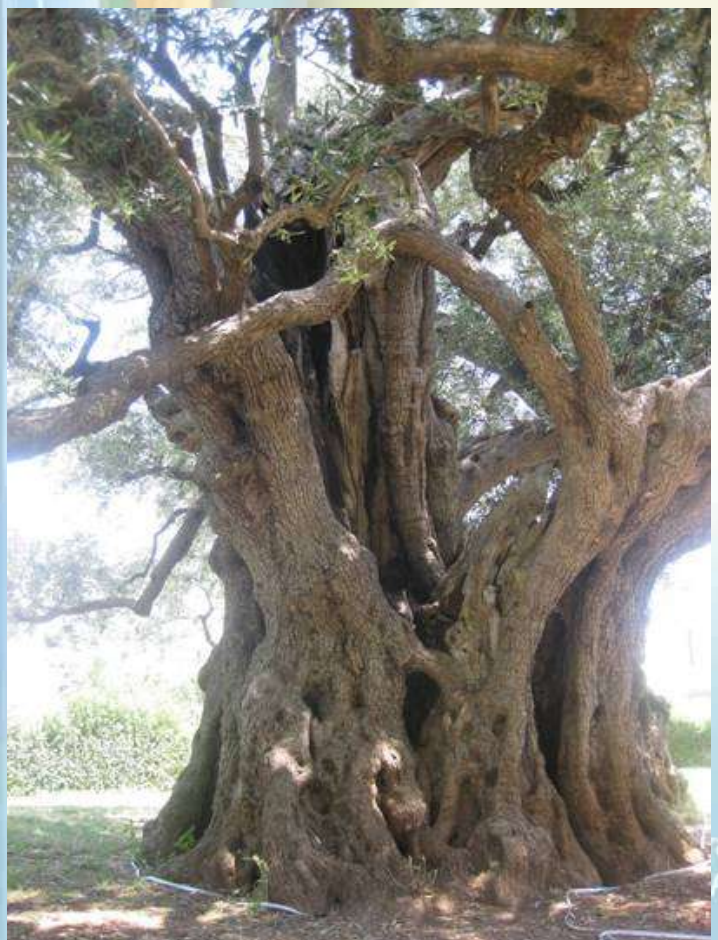

Sustainable use of olive genetic
diversity for the future

ACKNOWLEDGMENTS

To all the generations of Mediterranean area and beyond areas for the great genetic olive diversity, selected and maintained through the long history of olive cultivation

ACKNOWLEGMENTS

The International Olive Council and the Iranian Ministry of Agriculture e Jihad



To: Ms. Azizi & Mr. Arab

Dr. Hoseini-Mazinani

IFAPA & UCO colleagues

THANK YOU FOR YOUR ATTENTION

angjelina.belaj@juntadeandalucia.es