



**Soil Fertility and Crop Nutrition Management in  
Mediterranean Organic Agriculture**  
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# **SPATIAL DISTRIBUTION OF SOIL ORGANIC MATTER CONTENT AND ORGANIC MATTER MINERALIZATION IN AN OLIVE ORCHARD**

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# INTRODUCTION

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- ✘ Crop production:
  - + Genotype
  - + Soil fertility
  - + Water availability
  - + ...



Photo: [www.pixdaus.com](http://www.pixdaus.com)

Soil fertility has to be preserved in order to assure highest yields and therefore better income

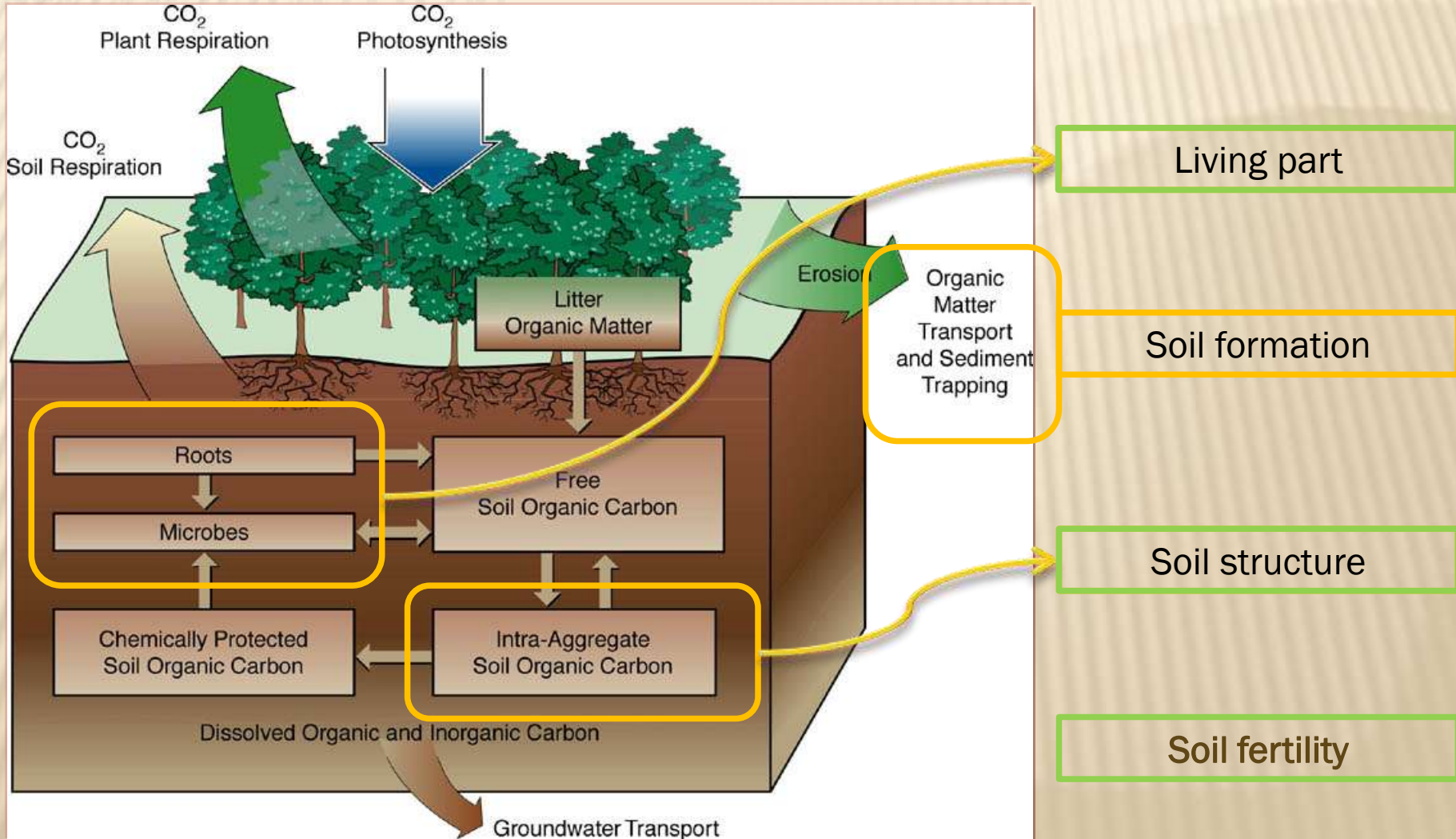
# INTRODUCTION

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## × Soil fertility

- + The quality of a soil that enables it to provide essential chemical elements in quantities and proportions for the growth of specified plants;  
[Brady and Weil, 1999 - The Nature and Properties of Soils;](#)
- + A measure of the ability of soil to provide plants with sufficient amount of nutrients and water, and a suitable medium for root development to assure proper plant growth and maturity;  
[eusoils.jrc.ec.europa.eu/ESDB\\_Archive/glossary/Soil\\_Terms.html](#)
- + Soil quality which allows to provide of nutrients in proper quantities and in balanced way for the growth of plants when other growth factors such as light, humidity, temperature and physical conditions of the soil are favorable;  
[river.unu.edu/glossary.html](#)
- + The amount of organic matter or humus present in the soil;  
<https://www.uwsp.edu/natres/nres743/Glossary.htm>
- + The productive part of the soil, containing nutrients, water and organic matter;  
[tilz.tearfund.org/Publications/PILLARS/Agroforestry/PILLARS+Agroforestry+glossary.htm](#)
- + A general descriptive term giving an indication of the quality of a soil;  
[www.mainlandminerals.co.nz/glossary-information.html](#)
- + ...

# INTRODUCTION



# INTRODUCTION

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- ✘ Among the objectives of organic farming
  - + Soil fertility preservation
  - + A living soil with active flora
  - + Crop production sustainability
- ✘ Conserving Organic Matter cycle (organic fertilization)

# INTRODUCTION

- ✘ In rainfed olive orchards of central Tunisia spontaneous plants are systemically avoided in order to limit competition for water,
- ✘ Lack of manure application,
- ✘ Fruits, leaves, wood... totally exported out of the orchard



Photo: H. Bentaher



☹ soil fertility degradation.

# INTRODUCTION

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- ✘ Olive organic production: organic fertilization
  - + soil organic matter content distribution is considered spatially uniform ?
  - + organic matter mineralization is the same everywhere ?
  - + Important variations may exist !
  - ☹ organic fertilization may be far to meet soil fertility sustainability requirements for the whole orchard

# INTRODUCTION

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- ✘ Precision organic farming:
  - + Detection of spatial variation of organic matter content/mineralization,
  - + Apply fertilizers according to initial content and mineralization rate variations,
  - ☺ Fertilization meet requirements of the whole orchard

# OBJECTIVES

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1. To draw soil organic matter content spatial variability,
2. To assess spatial variability of soil organic matter mineralization
3. To propose organic fertilization solutions based on previous findings

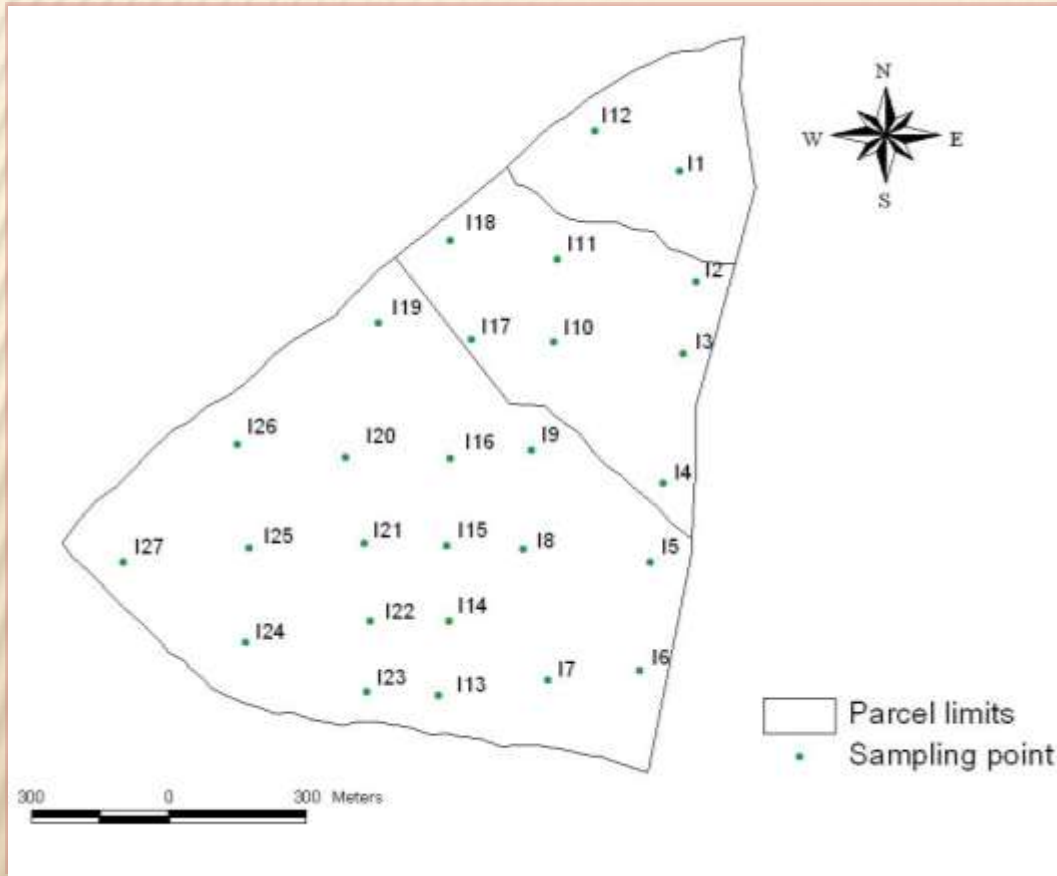
# METHODOLOGY



- ✘ Study area: a topographical sequence: 134 ha.
- ✘ Sfax region – Center of Tunisia - 34.37 N 10.16 E
- ✘ Arid climate average rainfall 200 mm/year
- ✘ 200x200 m grid pattern was established; each intersection point (node) represented a sampling point (Tot. No. = 27)

# METHODOLOGY

- The topographical sequence : 134 ha.



- ✗ Soil characteristics: organic matter.
- ✗ Horizon: 1m depth.
- ✗ Sampling period 2005 - 2008
- ✗ Statistical analysis : ANOVA, classical descriptors,
- ✗ Interpolation ranges according to standard deviations and thresholds

# METHODOLOGY

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- ✘ Two ESRI GIS softwares have been used:
  - + ARC/INFO : data base creation and mapping
  - + ARC/VIEW : modelling and interpolation
- ✘ Semivariogram models were fitted by the *least square* procedure (VARIOWIN- software - Springer Verlag, New York, USA.)

# METHODOLOGY

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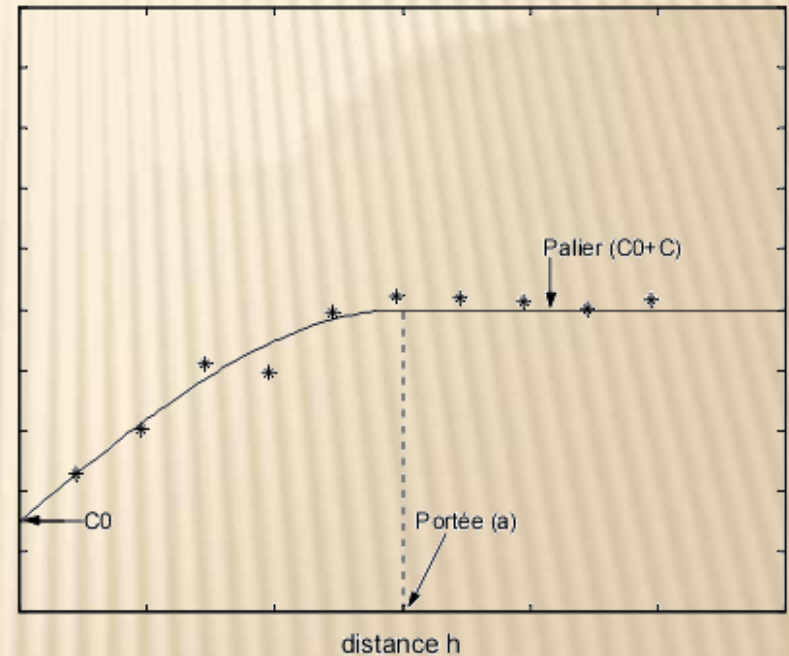
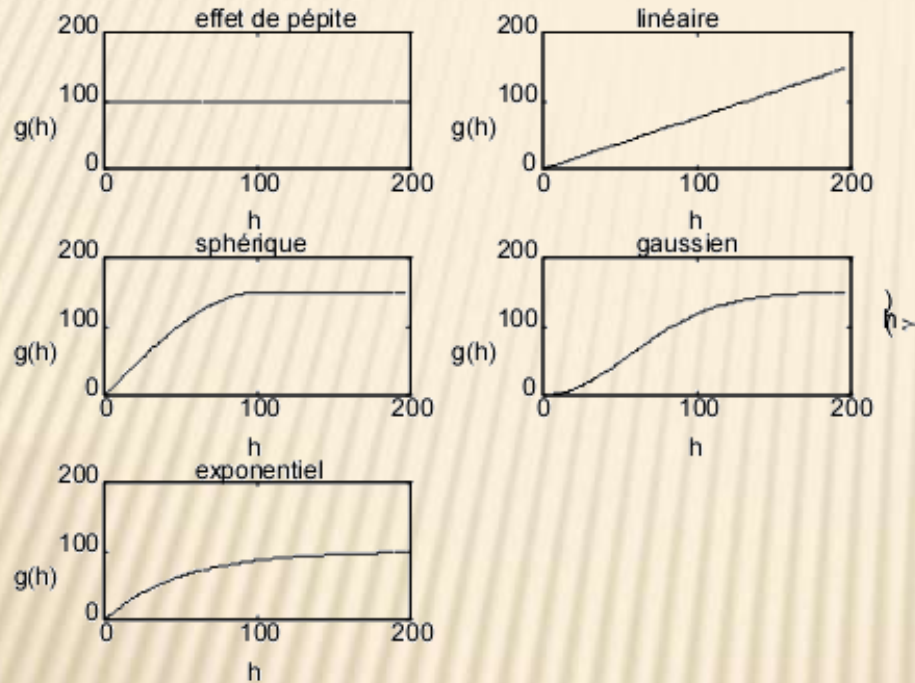
- ✘ Geostatistical analysis : Kriging interpolation procedure that generates an estimated surface from a scattered set of points with  $z$  values.
- ✘ Semivariogram calculated for each parameter by the equation:

(Lopez-Granados et al, 2004, Webster and Oliver, 2001).

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [z(x_i + h) - z(x_i)]^2$$

- ✘ where  $\gamma(h)$  is the experimental semivariogram value at distance interval  $h$ ;  $N(h)$  the number of sample value pairs within the distance interval  $h$ ;  $z(x_i)$ ,  $z(x_i + h)$  sample values at two points separated by the distance interval  $h$ .

# METHODOLOGY



5 semivariogram models were fitted to experimental data in order to detect the best one,

# RESULTS, DESCRIPTIVE STATISTICS

	Min.	Max.	Mean	SD	CV (%)	Skewness
O.M. (%)	0.14	0.59	0.39	0.11	28	0.02

- Organic matter follow a normal distribution
- High variation within the orchard
- Medium CV detected for O.M.

# RESULTS, GEOSTATISTICAL ANALYSIS

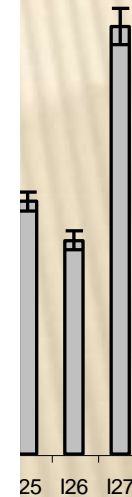
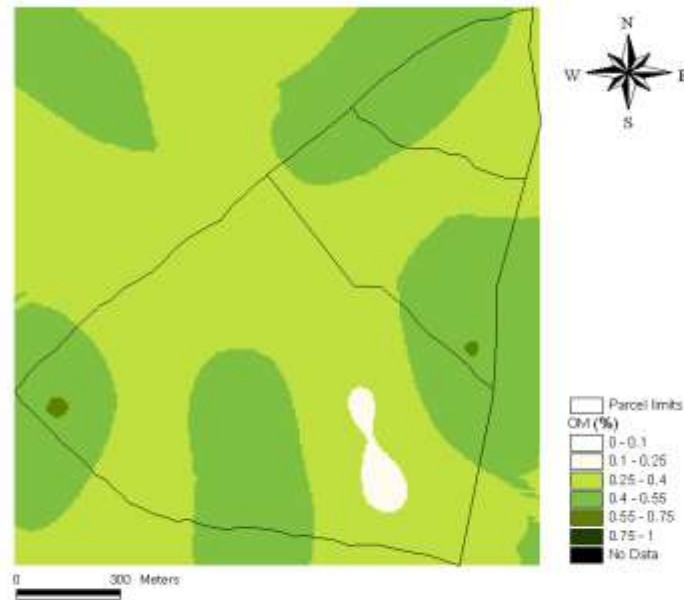
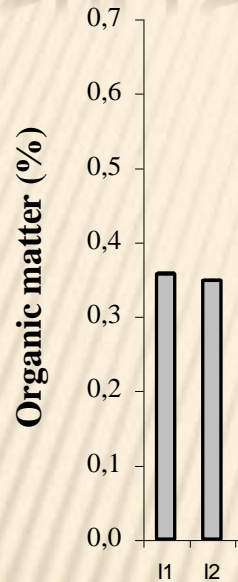
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Parameter	Nugget Semivariance Ratio <sup>a</sup> (%)	Sill	Dependence level (%)	Range (m)	Spatial distribution model <sup>b</sup>	MSE <sup>c</sup>
O.M.	0.0014	0.0039	15.1	411.88	S, spherical	0.000026

a: Percentage of the sill due to the nugget; b: Spatial distribution (S, strong spatial dependence; M, moderate spatial dependence; Pure nugget: no spatial dependence), and spatial distribution model; c: MSE: mean squared error expressed as percentage of the sample variance.

- O.M. was strongly distributed in patches
- O.M. followed spherical spatial distribution model
- Range values was 411.88 m

# RESULTS



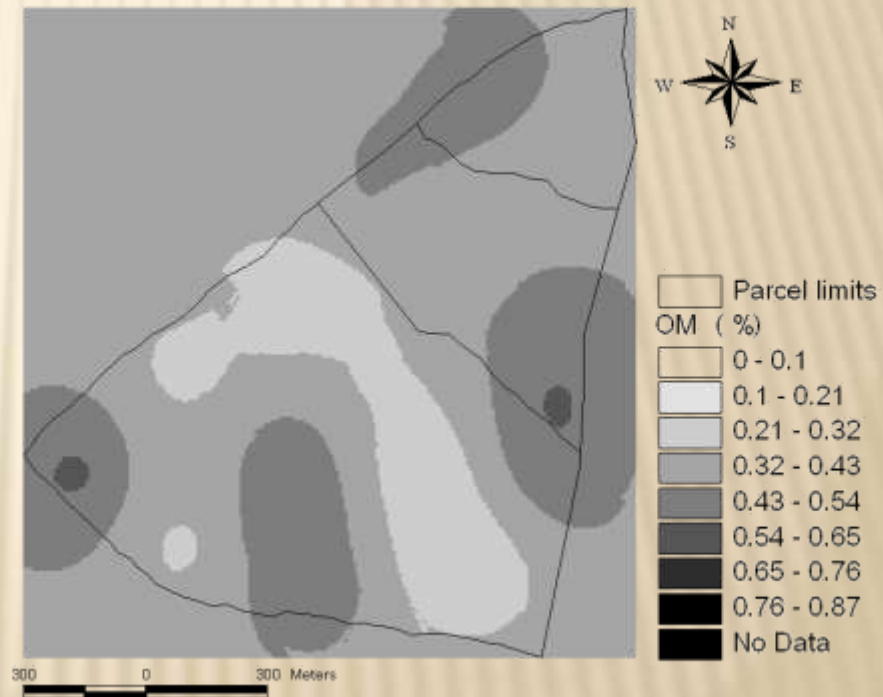
- Very low organic matter content (0.14 to 0.59 %) threshold = 1.5%
- Important spatial variation in the orchard
- ✗ Gradients appear O.M spatial distribution
- ✗ a strong influence among neighbouring values of O.M. was detected, even at great distance (>400 m.)

# RESULTS, O.M. CONTENT EVOLUTION

2005

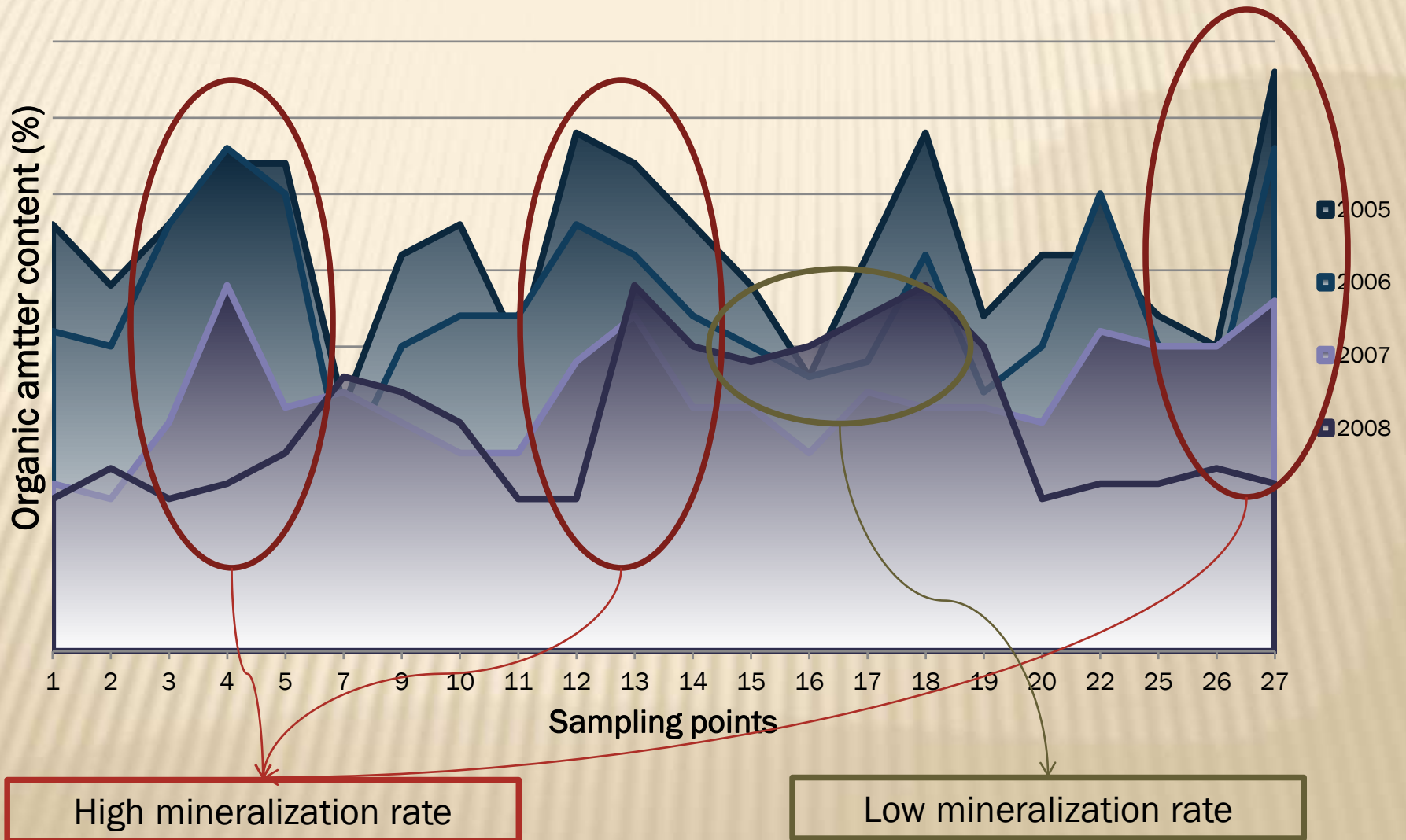


2007

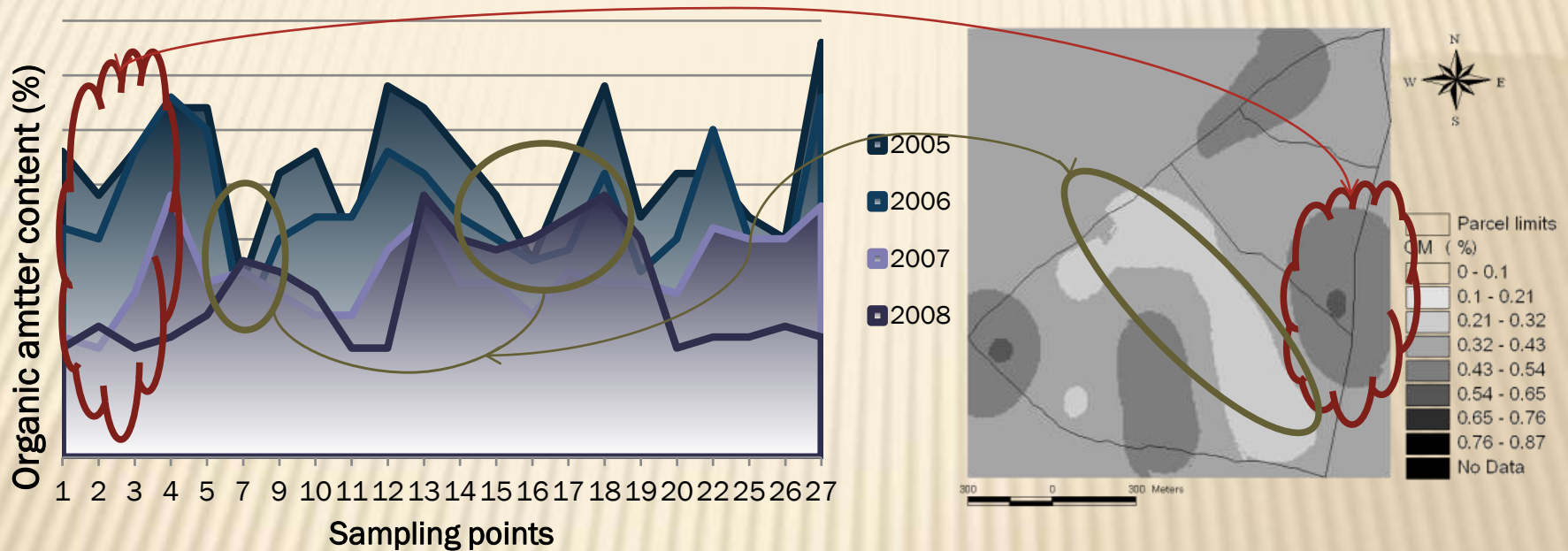


☹ Extension of the very poor area

# RESULTS, O.M. MINERALIZATION



# RESULTS, ORGANIC AMENDEMENTS NEEDS



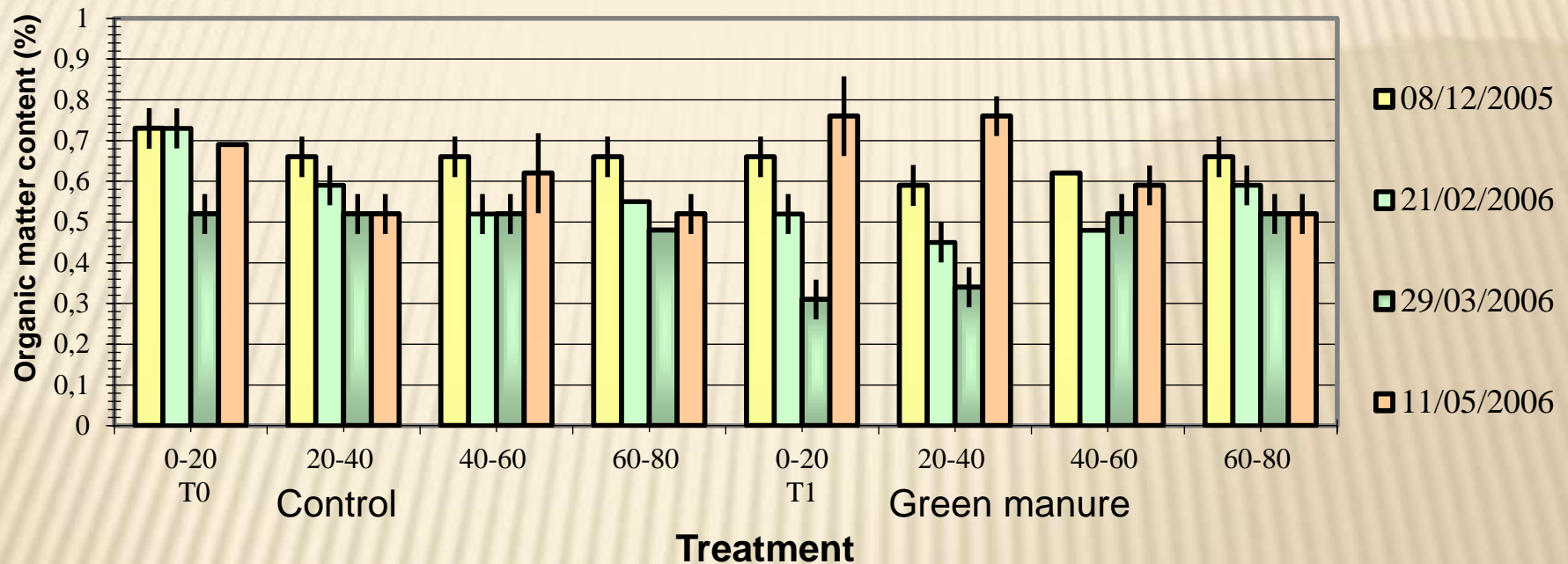
- ✓ Low organic matter content = low mineralization rate
- ✓ Very poor area = urgent amendment needed
- ✓ Others = frequent organic fertilization needed

# RESULTS, GREEN MANURE APPLICATION



Keeping spontaneous plants in the field during winter period under arid climate

# RESULTS, GREEN MANURE APPLICATION



- ✘ Organic matter content increased in upper soil layers,
- ✘ Increased carbon fixing from atmosphere,
- ✘ No effects on soil water balance

# CONCLUSION

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- ✘ Alarming situation concerning soil fertility evolution in rainfed olive orchards especially organic matter content;
- ✘ Organic matter content and mineralization rate showed an important spatial variation at orchard level;
- ✘ The application of precise organic farming:
  - + Applying organic fertilizer according to real needs;
  - + Fertilization frequency meeting mineralization rate;
  - + Increase orchard productivity
  - + Achieve organic olive production sustainability

# CONCLUSION

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- ✘ Application of green manure:
  - + Increasing soil organic matter content;
  - + Fixing carbon from the atmosphere
  - + Contributing to reduce greenhouse effect

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**MANY THANKS**