LIFE Project Number

<LIFE15 ENV/IT/000641>

Deliverable "Report on initial soil and plant data in selected vineyards"

Soil and plant data_Part 1

Sub-action B2.4 "SWOT analysis"

LIFE+ PROJECT Soil4Wine

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Abstract

Aim of the Deliverable *"Report on initial soil and plant data in selected vineyards"* is to present and comment the features of demonstrative vineyards at the beginning of Project, before the implementation of demonstrative solution. Sampling scheme for the entire project period is also presented.
According to characteristics of data that have to be collected in project action this Deliverable will be presented in two parts:
- *Part 1* (M12) presenting chemical and physical soil properties and vines behavior features. Data on vines features concerning harvesting and pruning of season 2017.
- *Part 2* (M18) presenting biological soil properties.
For each vineyard statistical analysis on vines behavior related to action plan scheme was performed and discussed.
Conclusions presents preliminary discussion about soil properties.

• Introduction: Project overview

Soil4Wine project "*Innovative approach to soil management in viticultural landscape*" is aimed to achieve a better soil management in the whole viticultural eco-system, developing and testing an innovative Decision tool and management solutions in farms located in the Project area and in Europe.
This report presents the structure and main outcomes of sub-action B2.4 related to Soil4Wine project Action B.2 "Demonstration in vineyards", in particular it present first part of data at beginning of the project regarding soil chemical and physical properties and vines behavior.
HORTA is the responsible for this action, while other partner involved is UCSC .

• Aim of the "Report on initial soil and plant data in selected vineyards"

The assessment of advantages and possible drawbacks rising from the use of the Decision Tool and the implementation of demonstrative actions will be performed through a SWOT approach.
Data will be collected before the adoption of Action plans and after their implementation.

In Table 1 the sampling plan developed by UCSC and HORTA is shown.

			Initial data	**Mid-term data**	**Final data**
Soil data	Physical and chemical properties	– Chemical and physical properties	autumn 2017		autumn 2019
	Biological properties	– QBSar – Soil Enzymes – Earthworms – Microbial N and C biomass	spring 2018		spring 2019
	Water movement	– infiltration test	spring 2018		spring 2019
	Analysis of weed population	– visual assessment of soil areas colonized by weeds – floristic study of the weed population	spring 2018		spring 2019
	Microclimate	– soil moisture – soil temperature – air temperature – relative humidity – rainfall – leaf wetness	From autumn 2017		End of project
Vine behavior data		– yield – shoot fruitfulness	summer 2017	summer 2018	summer 2019
		– winter pruning weight – degree of cane maturation	winter 2017	winter 2018	winter 2019
		– sprouting		spring 2018	spring 2019

		regularity			
Demonstrative action implementation Data	Growth	– visual assessment of soil cover – floristic study of the sowed cover crops	spring 2018		spring 2019
	Biomass	– weight of grass biomass in TBC1 Demo Farm	summer 2018 autumn 2018		spring 2019 summer 2019 winter 2019
		– weight of green sward biomass	spring 2018		spring 2019

Table 1: sampling plan of Soil4Wine project for soil and plant data.

The subject of this report is the presentation of the initial data collected by UCSC on soil (physical and chemical parameters) and vine behavior (yield and shoot fertility from harvest 2017). Data have been collected before the adoption of Action Plans.
Data on biological properties will be presented in Summer 2018 in deliverable "*Report on initial soil and plant data in selected vineyards - Soil and plant data Part 2*"

• Materials and Methods

• Soil and Geological frameworks

Soil Maps
Information about soil framework of selected vineyard were collected from the Soil Maps of Emilia-Romagna Region available in .KML format accessible by using Google Earth© software. Soil maps are available at 1:250.000 and 1:50.000 scales.
The 1:50.000 soil map covers the alluvial flat terrains and part of the hills of the region. In the map each delineation (polygon) is identified by a unique numerical ID and for each polygon morphology, land use percentage, distribution and location of the soil units are described. For each soil type a benchmark local site is linked and it is possible to download chemical and physical information derived by analysis carried out between 1980 and 2015. Delineation with similar features forms a mapping unit.

Geological map (1:10.000 scale)
This map was reviewed in 2003 including quaternary cover and geological substrate. Geological map is available as Web Map Service for GIS tool or on Regional WebGIS.

• Chemical and Physical properties from Regional Map services

○ Percentage of Organic Carbon Content and Organic Matter content

Maps (1:50.000 for plain and 1:250.000 for mountain) were produced as results of statistical and geostatistical analysis derived from data points collected on field.
Maps are composed by a pixel grid of 500 x 500 meters for plain and 1000 x 1000 meters for mountain and inside each cell a value of organic carbon in soil is estimated.
Organic matter content was estimated using the Van Bemmelen factor equal to 1.724 (Jackson, 1965).

○ Carbon Stock (0-30 cm layer)

A map indicating the Carbon Stock (t/ha) in plain and mountain is also available.

- **Salinity map at 0-50 cm**

  This map is available for the Emilia-Romagna Region at the 1:250.000 scale.

- **Soil sampling**

In order to collect a representative sample of soil for each farm a sampling scheme was design and three samples were collected randomly in the vineyard. If soil map revealed the presence of more than one soil typologies a double sampling was made. Samples were mixed to obtain a unique sample.
Sampling was performed from 4th to 12th October 2017.
Undisturbed soil samples were extracted using a manual Dutch Augers to represent 50-70 cm depth (Figure 1) following EN216 protocol.

Figure 1: Dutch Augers

- **Soil chemical and physical analyses**

Soil samples were analyzed in an external laboratory. Each sample was coded (Table 2) to maintain anonymity of Demo Farms with soil laboratory. Codes are reported in the attached analysis report provided by the laboratory.

Farm Code	Farm name	Code
SP1	Az. Vitivinicola Barbuti Giuseppe	2267
SP2	Az. Podere Le Lame	2268
SP3	Az. Vitivinicola Visconti Massimo	2269
SP4	Az. Vini Colombi	2270
VT1	Az. Agr. La Pagliara	2271
VT2	Az. Agr. Carrà Stefano	2272
TBC1a	Az. Monte delle Vigne	2273
TBC1b	Az. Monte delle Vigne	2274
TBC2	Az. Vitivinicola Palazzo	2275
RES1a	Az. Res Uvae	2276
RES1b	Az. Res Uvae	2277
RES2	Az. Res Uvae	2278

Table 2: Soil samples codes

In Table 3 all the parameters analyzed are reported with indication of units and methods (according to Italian Ministry Decree 13.09.1999).

Parameter	Unit	Method
Sand	*%*	D.M. 13/09/99 Annex II.5
Silt	*%*	D.M. 13/09/99 Annex II.5
Clay	*%*	D.M. 13/09/99 Annex II.5
Soil acidity (pH in water)		D.M. 13/09/99 Annex III.1
Total $CaCO_3$	*%*	D.M. 13/09/99 Annex V.2
Active $CaCO_3$	*%*	D.M. 13/09/99 Annex V.2
Electrical conductivity	*µS/cm*	D.M. 13/09/99 Annexes XIII.2-XIII.5
Organic Carbon	*g/kg*	D.M. 13/09/99 Annex VII.3
Organic Matter	*g/kg*	D.M. 13/09/99 Annex VII.3
Total Nitrogen	*g/kg*	D.M. 13/09/99 Annexes XVI.2-XIV.3
C/N ratio		Calculation
DH_degree of humification	*%*	D.M. 13/09/99 Annex XVI.1
Available Phosphorus	*mg/kg*	D.M. 13/09/99 Annex XV.3
Soil exchange acidity	*cmoli/kg*	D.M. 13/09/99 Annex XIII.3
CSC	*meq/100g*	D.M. 13/09/99 Annex XIII.2
Calcium	*meq/100g*	D.M. 13/09/99 Annex XIII.5
Exchangeable Calcium	*mg/kg*	D.M. 13/09/99 Annex XIII.5
Magnesium	*meq/100g*	D.M. 13/09/99 Annex XIII.5
Exchangeable Magnesium	*mg/kg*	D.M. 13/09/99 Annex XIII.5
Potassium	*meq/100g*	D.M. 13/09/99 Annex XIII.5
Exchangeable Potassium	*mg/kg*	D.M. 13/09/99 Annex XIII.5
Sodium	*meq/100g*	D.M. 13/09/99 Annex XIII.1
Exchangeable Sodium	*mg/kg*	D.M. 13/09/99 Annexes XIII.2-XIII.5
Ca/Mg		D.M. 13/09/99 Annexes XIII.2-XIII.5
Ca/K		D.M. 13/09/99 Annexes XIII.2-XIII.5
Mg/K		D.M. 13/09/99 Annexes XIII.2-XIII.5
Nitrates	*mg/kg*	D.M. 13/09/99 Annex XVI.5
Available Boron	*mg/kg*	D.M. 13/09/99 Annex XVI.1
Available Iron	*mg/kg*	D.M. 13/09/99 Annex XII.1
Available Mn	*mg/kg*	D.M. 13/09/99 Annex XII.1
Available Cu	*mg/kg*	D.M. 13/09/99 Annex XII.1
Available Zn	*mg/kg*	D.M. 13/09/99 Annex XII.1

Table 3: Soil parameters analyzed with indication of analytical methods

Some parameters were derived using data obtained from soil samples analyzed in order to better describe soil properties:

- ***Mineralization coefficient (K2)***

Two equations, *Remy and Marin-Lefeche (1976)* and *Boffin et al. (1986)* were used to evaluate the mineralization coefficient that considers different parameters. At the beginning of the project, the *Boiffin et al. (1986)* equation could not be used because data on yearly average air temperature were not available; in future analysis this equation will be used as it takes into account temperature that is an important variable in the mineralization process.

- <u>*Remy and Marin-Lefleche (1974)*</u>

Estimation of mineralization coefficient according to Soil Total Carbonate content.

$$K2 = \frac{1200}{(C + 20)(TC + 20)}$$

where *C*=clay content (%) and TC= soil total carbonate (%)

- *Boiffin et al. (1986)*

  Estimation of stability/instability of organic matter and in particular the rate of humus that each year is mineralized according to soil texture and temperature.

$$K2 = \frac{1200\left(0.2(T - 0.5)\right)}{(200 + c)(200 + 0.03 \times l)}$$

where *c*=clay content (g/kg), *l*=lime content (g/kg) and *T*=yearly average temperature (°C).

- ***Bulk density (BD):*** estimated on the basis of Organic Carbon, using the Manrique and Jones (1991) formula:

$$BD = 1.66 - 0.318\sqrt{OC}$$

where *OC*= organic carbon content (g/kg).

- **Soil water characteristics**

Soil water features were estimated by texture and organic matter using SPAW software (Saxton and Willey, 2006) (https://hrsl.ba.ars.usda.gov/SPAW/SPAWDownload.html) developed by USDA (Figure 2). Values were obtained based on statistical correlation between soil texture, soil water potential and hydraulic conductivity.

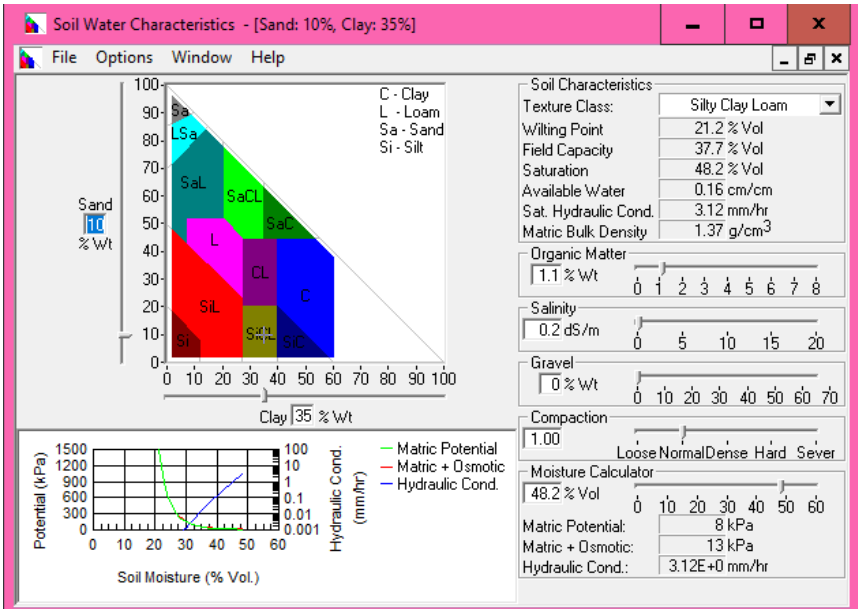

Figure 2: SPAW software layout

Estimated soil features are the followings: (Table 4)

Parameter	Unit	Description
Wilting point (water holding at 1500 kPa)	%	Water content below which plants are generally unable to extract water from the soil. It is estimated as a hydraulic tension of 1500kPa (15bar) and it depends only from soil texture and is unaffected by salinity or gravel.
Field capacity (water holding at 33 kPa)	%	Water content of the soil matrix approximating the water content of a saturated soil that has been allowed to freely drain. Estimated at hydraulic tension of 33kPa (0.33bar) depends only from soil texture and is unaffected by salinity or gravel.
Saturation	%	Saturation moisture content of the soil matrix such that the entire soil porosity is water filled and dependent only on the soil texture and unaffected by salinity or gravel.
Available water	*cm/cm*	Quantity of water that plants are able to extract from a soil at field capacity
Saturation Hydraulic Conductivity	*mm/h*	Capability of water to move within the soil matrix driven by matrix and gravitational potentials, dependent on soil texture and moisture content.

Table 4: Soil water characteristic parameters obtained with SPAW software

- **Weather data**

Automatic agro-meteorological stations (Figure 3) were installed in the Demo farms in December 2017. Stations measure hourly data on air temperature (°C), relative humidity (%), rainfall (mm) and leaf wetness (h) and send them real-time via GPRS to HORTA's server. The weather station chosen is model iMETOS IMT200 from Pessl Instruments, HORTA has a good experience with this kind of weather stations and good statistics of data reliability (other 200 are connected to HORTA's weather station network).

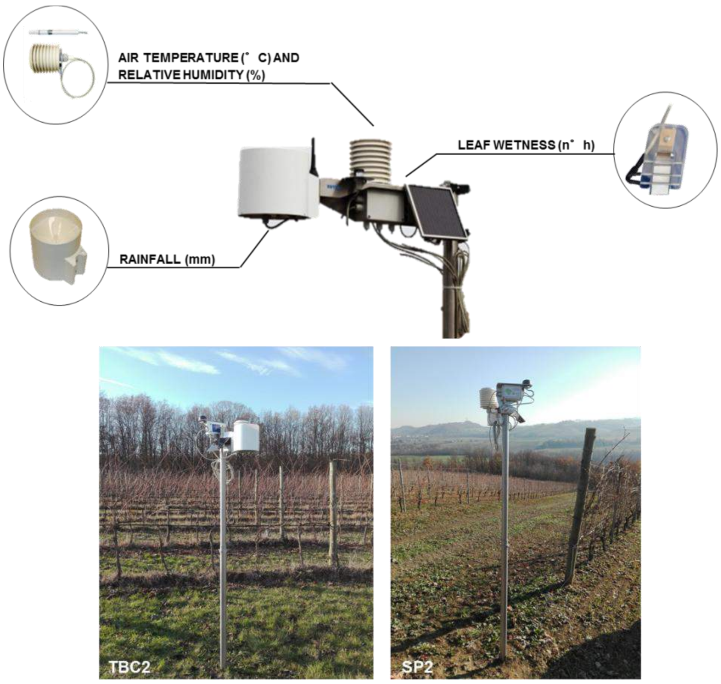

Figure 3: Agrometeorological station installed in Demo farms, top part sensors scheme, bottom part some example of stations installed in the vineyards

In each Demo farm a sensor (Figure 4) for soil temperature (°C) and humidity at 10-20 and 30 cm depth was also installed. Sensor chosen is iMETOS ECO D3 with SENTEK DRILL & DROP PROBE provided by Pessl Instruments. It measures data every hour and sends them via GPRS to HORTA's server.

Figure 4: Soil sensors installed in Demo farms, top part sensors scheme, bottom part some example of semsors installed in the vineyards

- ## Vineyard features

Demonstrative vineyards have different features (age, rootstock, density of vines, training system and vine variety) as summarized in Table 5.

Demo Farm	Rootstock	Year of planting	Density (vines/ha)	Grapevine variety	Training system
SP1	SO4	2005	3333	Barbera	Guyot
SP2	N.A.	2006	3333	Barbera	Guyot
SP3	420A	2002	3077	Croatina	Guyot
SP4	N.A.	N.A.	2525	Barbera	Double Guyot
VT1	1103P	2011	3344	Ortrugo	Guyot
VT2	N.A.	N.A.	3344	Croatina	Guyot
TBC1	N.A.	2008	5682	Sauvignon Blanc	Guyot
TBC2	N.A.	2010	6494	Malvasia di Candia Aromatica	Spur pruned cordon
RES_1a **RES_1b**	SO4	2001	4348	Croatina	Guyot
RES_2	N.A.	N.A.	3472	Croatina	Double Guyot

Table 5: Demonstration vineyard features

In the selected vineyards two adjacent blocks were identified corresponding to traditional management and demonstrative practices. Within each block, 10 uniform vines were randomly chosen and tagged.

Moreover for each vineyard a scheme was defined indicating two factors: the first was *treatment* (traditional or demonstrative) and the second was *limiting factor* (position, vine vigor or water logging).

At harvest, occurred from August to September 2017, (Table 6) the following parameters were determined:

- **number and total weight of clusters per vine (kg)**

Additional parameters were then calculated:

- **mean cluster weight (g)**
- **mean total soluble solids (TSS as °Brix)** of randomly sampled berries (3 berries for each vine) using a sugar refractometer ATAGO- DBX55

Starting mid-November winter pruning was carried out and the following parameters were assessed:

- **pruning weight per vine (g)**
- **degree of cane maturation (low, medium and high)**

Demo Farm	Harvest date (2017)	Pruning date (2017)
SP1	14th September	7th December
SP2	5th September	6th December
SP3	14th September	5th December
SP4	12th September	7th December
VT1	21th August	29th November
VT2	31th August	30th November
TBC1	07th August	5th December
TBC2	18th August	5th December
RES1	29th August	6th December
RES2	30th August	6th December

Table 6: Harvesting and pruning dates of Soil4Wine Demo vineyards in the 2017season

From collected data Ravaz Index (ratio of yield-to-winter pruning weight) was calculated.
Data collected were analyzed for variance using IBM software SPSS (Release 24.0.0.1). The Tukey test was used to compare means ($p < 0.05$)

- ## Soil chemical and physical properties obtained from cartography

- ### Geological map (1:10.000 scale)

The Geological map is available as Web Map Service for GIS tool or on Regional WebGIS.
In Table 7 there is the list of geological cartographic units in which demonstrative vineyards are located.

Demo Farm	Code	Geological Unit
SP1	KER2	Subsistema di Monte Giogo
SP2	FCN	Formazione di Rio della Canala
SP3	FAA	Argille Azzurre
SP4	CMZ	Sistema di Costamezzana
VT1	APA	Argille a palombini
VT2	VLU3	Formazione della Val Luretta - Membro di Genepreto
TBC1	FAA	Argille azzure
TBC2	CMZ	Sistema di Costamezzana
RES1	CMZ	Sistema di Costamezzana
RES2	CMZ	Sistema di Costamezzana

Table 7: List of geological cartographic units in which demonstrative vineyards are located

- ### Percentage of Organic Carbon (0-30 cm layer)

Demo Farm	Organic Carbon (%)	Organic matter (%)
SP1	1.9	3.27
SP2	0.86	1.48
SP3	0.69	1.19
SP4	0.99	1.71
VT1	1.94	3.34
VT2	1.29	2.22
TBC1	0.75	1.29
TBC2	1.58	2.72
RES1	0.34	0.59
RES2	0.64	1.10

Table 8: Percentage of Organic Carbon (0-30 cm layer) derived from Emilia-Romagna Maps data

2. Carbon Stock 0-30 cm layer

Demo Farm	Carbon Stock (t/ha)
SP1	98.33
SP2	38.78
SP3	29.22
SP4	41.99
VT1	66.03
VT2	54.77
TBC1	31.45
TBC2	73.28
RES1	92.22
RES2	93.44

Table 9: Carbon Stock (0-30 cm layer) derived from Emilia-Romagna Maps data

- **3. Soil salinity in plain area (0-50 cm layer)**

Demo Farm	Electrical conductivity (dSm^{-1})
SP1	N.A.
SP2	N.A.
SP3	N.A.
SP4	1
VT1	N.A.
VT2	N.A.
TBC1	0.94
TBC2	0.94
RES1	1.04
RES2	1.14

Table 10: Soil salinity in plain area (0-50 cm layer) derived from Emilia-Romagna Maps data

- **DEMO FARMS Soil chemical and physical properties**

DEMO FARM SP1_Az. Vitivinicola Barbuti Giuseppe

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as *"**complesso dei suoli GUSANO/SIGNAROLDI**"*. These soils are located in low Appennines and are characterized by slopes between 35-60%. Usually they are extremely rocky, shallow, with medium texture and good oxygen availability, calcareous and moderately alkaline.

- **GUSANO Soil (GUS):**
  - *FAO (1990): Calcaric Regosols*
  - *Soil Taxonomy: loamy, mixed (calcareous), mesic Lithic Ustorthents*
- **SIGNAROLDI (SGD)**
  - *FAO: Haplic Lixisols*
  - *Soil Taxonomy: loamy-scheletal, mixed, mesic Typic Haplustalf.*

2. Soil Map Emilia Romagna Region 1:50.000

The vineyard is located on soils classified as "***complesso dei suoli SAN FAUSTINO franchi/ MONTE MAGGIORE/ GORGOGNANO - SFA1/MOG0/GOR (Delineation: 10893; Cartographic unit: 0788)***"

Soil name and code	Regional presence	Classification
SAN FAUSTINO franchi SFA1	45%	*Soil Taxonomy:* (2010) Udic Haplusteps fine silty, mixed, active, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
MONTE MAGGIORE franco argillosi limosi MOG1	20%	*Soil Taxonomy:* (2010) Udic Haplusteps fine silty, mixed, active, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
RIO RUMORE 15-40% pendenti RIR2	15%	*Soil Taxonomy:* (2010) Typic Ustorthents coarse loamy, mixed, superactive, calcareous, mesic *WRB:* (2007) Haplic Regosols (Calcaric, Arenic)
MONTE MAGGIORE franchi MOG2	10%	*Soil Taxonomy:* (2010) Udic Haplusteps fine silty, mixed, active, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
GORGOGNANO GOR	5%	*Soil Taxonomy:* (2010) Typic Ustirthents loamy, mixed, superactive, calcareous, mesic *WRB:* (2007) Endoleptic Regosols (Calcaric)
RIO RUMORE 40-80% pendenti RIR1	5%	*Soil Taxonomy:* (2010) Typic Ustorthents coarse loamy, mixed, superactive, calcareous, mesic

		<u>*WRB:*</u> (2007) Haplic Regosols (Calcaric, Arenic)

<u>3. Soil properties</u>

A complete chemical and physical soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	*%*	44.6
Silt	*%*	36.4
Clay	*%*	19

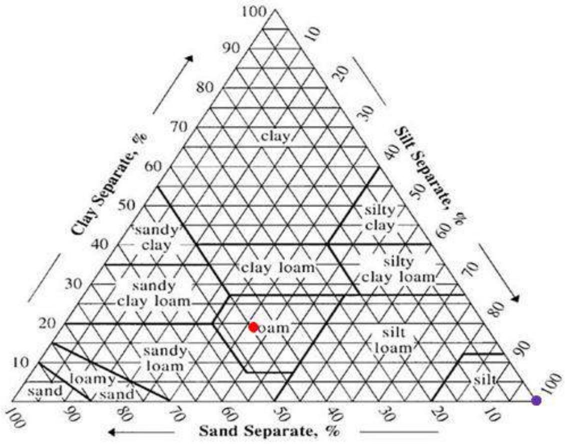

Figure 5: Soil texture triangle (USDA). Red dot identifies soil texture of the DEMO farm.

Soil texture		Loamy
Soil acidity (pH in water)		8.43
Total $CaCO_3$	*g/kg*	125
Active $CaCO_3$	*g/kg*	220
Electrical conductivity	*µS/cm*	0.13
Organic Carbon	*g/kg*	2.4
Organic Matter	*g/kg*	4.1
Total Nitrogen	*g/kg*	0.48
C/N ratio		5.02
DH_degree of humification	*%*	38.7
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	1
Soil exchange acidity	*cmoli/kg*	0.1
CSC	*meq/100g*	12.8
Exchangeable Calcium	*mg/kg*	2438
Calcium	*meq/100g*	12.16
Exchangeable Magnesium	*mg/kg*	273
Magnesium	*meq/100g*	2.25
Exchangeable Potassium	*mg/kg*	77
Potassium	*meq/100g*	0.2
Exchangeable Sodium	*mg/kg*	1
Sodium	*meq/100g*	0.01
Ca/Mg		5.4

Ca/K		61.6
Mg/K		11.4
Nitrates	*mg/kg*	78
Available Boron	*mg/kg*	0.18
Available Iron	*mg/kg*	11
Available Manganese	*mg/kg*	5
Available Copper	*mg/kg*	8
Available Zinc	*mg/kg*	6.5

Parameter	**Unit**	**Value**
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	6.99
Bulk density *(Manrique and Jones, 1991)*	*g/cm*^{3}	1.167

- **Soil water characteristics**

Parameter	**Unit**	**Value**
Wilting point	*%*	13.2
Field capacity	*%*	26.5
Saturation	*%*	45.5
Available water	*cm/cm*	0.13
Saturation Hydraulic Conductivity	*mm/h*	17.8

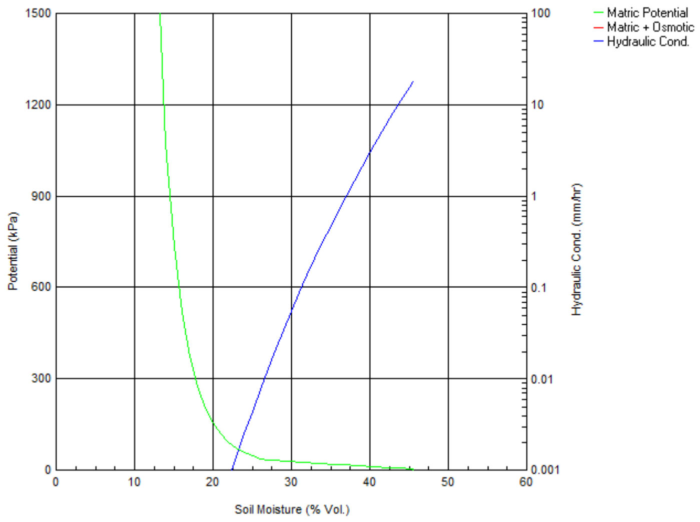

Figure 6: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*) two different vine vigor areas were identified, with high vigor (HV) vines localized in the bottom part of the vineyard, while low vigor (LV) vines localized in the top of the vineyard mostly affected by erosion processes. Table 11 shows the results of univariate analysis and is clear that erosion causes large differences in terms of yield, pruning weight and grape composition. High vigor vines were characterized by higher pruning weight and yield and much lower cluster weight and TSS. In terms of yield differences between treatments, it has to be noted that many clusters were damaged by wild boars in the top vineyard so weights were likely underestimated. Moreover, it is clear that also in the bottom part of the vineyard there is a gradient of vigor that is evident in the yield of HV areas of traditional and demonstrative treatment. Regarding cane maturation, at pruning time all canes had an high level of ripeness.

Treatment (T)	**Vine Vigor (V)**
Tr: Traditional management **D**: Demonstrative management	**H:** High vine vigor **L:** Low vine vigor

	Clusters/ vine	**Yield (Kg/vine)** [(a)]	**Cluster weight (g)**[(a)]	**Total Soluble Solids (°Brix)**	**Pruning weight (g/vine)**	**Ravaz Index (kg/kg)**
Treatment (T)						
Tr	27.0	5.45	202.7	22.9	420	6.54
D	23.2	3.46	146.2	24.1	790	5.66
Vine vigor (V)						
H	26.7	6.45	245.4	21.6	980	6.8
L	23.2	2.46	103.5	25.5	510	5.4
Interaction Treatment x Vine Vigor (T x V)						
T_H	28.4	8.18	301.0	21.1	960	8.73
T_L	25.6	2.72	104.5	24.8	620	4.35
D_H	25.0	4.72	189.9	22.0	1000	4.88
D_L	21.4	2.20	102.5	26.2	400	6.44
ANOVA Probability p<0.05						
T	ns	*	*	ns	ns	ns
V	ns	***	***	***	***	ns
T x V	ns	*	***	ns	ns	**

Table 11: Univariate analysis. Effect of soil management and vine vigor on vine behavior (season 2017) and summary of the analysis of variance
.[(a)] *Some clusters were damaged by wild boars and no weight was recorded*

DEMO FARM SP2_Az. Podere Le Lame

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as "complesso dei suoli ***"complesso dei suoli TERRA DEL SOLE/DOGHERIA/SANT'ANTONIO (Delineation 0664; Cartographic Unit 5Ab)***".

- **TERRA DEL SOLE franco argilloso limosi (TRS1)**
  - *FAO (1990): Calcaric Regosols*
  - *Soil Taxonomy: (1990) fine, mixed (calcareous), mesic, shallow Vertic Ustorthents*

- **SANT'ANTONIO (SAN)**
  - *FAO (1990): Vertic Cambisols*
  - *Soil Taxonomy: (1990) fine, mixed, mesic Vertic Ustochrepst.*

- **DOGHERIA (DOG2)**
  - *FAO (1990): Haplic Calcisols*
  - *Soil Taxonomy: (1990) fine, mixed, mesic Fluventic Ustochrepts.*

2. Soil Map Emilia Romagna Region 1:50.000

The vineyard is located on soils classified as ***"complesso dei suoli AGELLO franco argillosi limosi/ DOGHERIA, 15-25% pendenti /GRIFONE franco argillosi limosi, Delineation 9448, Cartographic Unit 0664)***

Soil name and code	Regional presence	Classification
AGELLO franco argilloso limosi AGE1	30%	*Soil Taxonomy:* (2010) Typic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
GRIFONE franco argilloso limosi GRI3	30%	*Soil Taxonomy:* (2010) Typic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
DOGHERIA 15-25% pendenti DOG2	20%	*Soil Taxonomy:* (2010) Typic Calciustepts fine, mixed, active, mesic *WRB:* (2007) Hypocalcic Haplic Calcisols
BANZOLA franco argilloso limosi, 5-35% pendenti BAN3	15%	*Soil Taxonomy:* (2010) Oxyacquic Ustorthents fine, mixed, active, calcareous, mesic *WRB:* (2007) Haplic Regosols (Calcaric, Oxyaquic)
ARCELLI 8-15% pendenti ARC2	5%	*Soil Taxonomy:* (2010) Vertic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)

3. Soil properties

A complete chemical and physical analysis soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	*%*	9.7
Silt	*%*	55.2
Clay	*%*	35.1

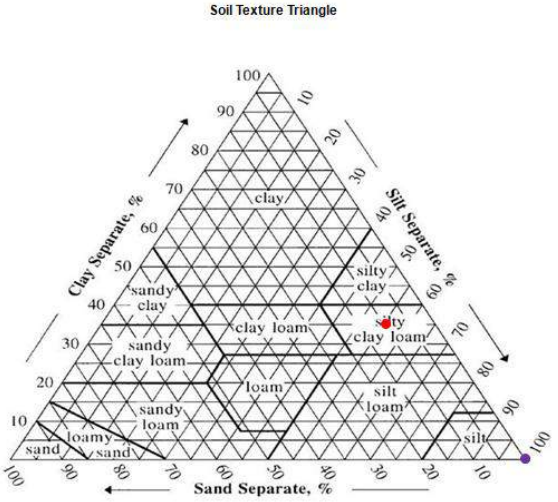

Figure 7: Soil texture triangle (USDA) and soil profile (0-70 cm). Red dot identifies soil type of the DEMO farm

Soil texture		Silty Clay Loamy
Soil acidity (pH in water)		8.34
Total $CaCO_3$	*g/kg*	138
Active $CaCO_3$	*g/kg*	243
Electrical conductivity	*µS/cm*	0.15
Organic Carbon	*g/kg*	6
Organic Matter	*g/kg*	10.4
Total Nitrogen	*g/kg*	0.97
C/N ratio		6.19
DH_degree of humification	*%*	37
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	2
Soil exchange acidity	*cmoli/kg*	0.18
CSC	*meq/100g*	16.6
Exchangeable Calcium	*mg/kg*	4174
Calcium	*meq/100g*	20.83
Exchangeable Magnesium	*mg/kg*	476
Magnesium	*meq/100g*	3.84
Exchangeable Potassium	*mg/kg*	138
Potassium	*meq/100g*	0.35
Exchangeable Sodium	*mg/kg*	3
Sodium	*meq/100g*	0.01
Ca/Mg		5.4
Ca/K		59.2
Mg/K		10.9
Nitrates	*mg/kg*	74

Available Boron	*mg/kg*	1.32
Available Iron	*mg/kg*	15
Available Manganese	*mg/kg*	7
Available Copper	*mg/kg*	3
Available Zinc	*mg/kg*	7.6

Parameter	**Unit**	**Value**
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	4.48
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	0.881

- **Soil water characteristics**

Parameter	**Unit**	**Value**
Wilting point	*%*	21.2
Field capacity	*%*	37.7
Saturation	*%*	3.12
Available water	*cm/cm*	0.16
Saturation Hydraulic Conductivity	*mm/h*	48.2

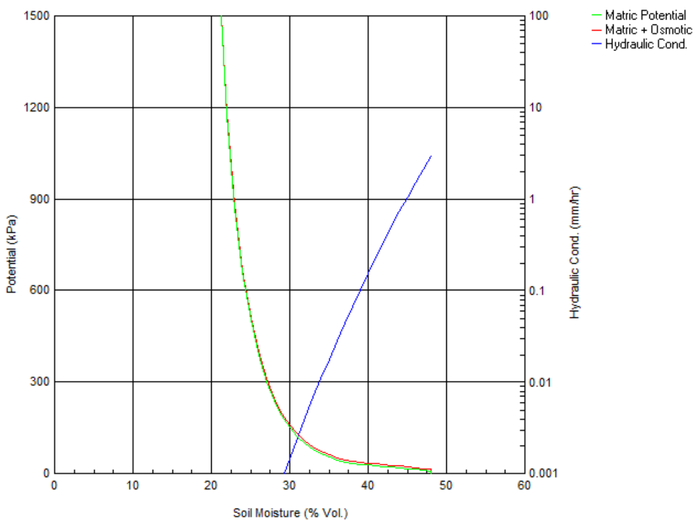

Figure 8: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*) the vineyard was divided in two areas, top and bottom (Position). Table 12 shows the results of univariate analysis. Significant differences were found in mean cluster weight depending on the position along the versant. Regarding cane maturation, at pruning time all canes had high level of lignification.

Treatment (T)	**Position (P)**
Tr: Traditional management **D**: Demonstrative management	**TO:** Top vineyard **BO:** Bottom vineyard

	Clusters/ vine	Yield (Kg/vine) [(a)]	Cluster weight (g)[(a)]	Total Soluble Solids (°Brix)	Pruning weight (g/vine)	Ravaz Index (kg/kg)
Treatment (T)						
Tr	20.8	2.64	130.0	21.8	550	4.98
D	25.2	3.00	120.7	21.8	620	4.93
Position (P)						
TO	21.2	2.87	137.2a	21.7	580	5.1
BO	24.8	2.77	113.4b	22.0	590	4.81
Interaction Treatment x Position (T x P)						
Tr_TO	18.2	2.48	138.1	21.6	500	5.13
Tr_BO	23.4	2.80	121.8	22.0	600	4.83
D_TO	24.2	3.26	136.3	21.7	660	5.07
D_BO	26.2	2.74	105.1	22.0	500	4.79
ANOVA Probability $p<0.05$						
Tr	ns	ns	ns	ns	ns	ns
P	ns	ns	*	ns	ns	ns
Tr x P	ns	ns	ns	ns	ns	ns

Table 12: Univariate analysis. Effect of soil management and position on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM SP3_Az. Vitivinicola Visconti Massimo

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as ***"complesso dei suoli TERRA DEL SOLE/DOGHERIA/SANT'ANTONIO (Delineation 0664; Cartographic Unit 5Ab)"***.

- **TERRA DEL SOLE franco argilloso limosi (TRS1)**
    - *FAO (1990): Calcaric Regosols*
    - *Soil Taxonomy: (1990) fine, mixed (calcareous), mesic, shallow Vertic Ustorthents*
- **SANT'ANTONIO (SAN)**
    - *FAO (1990): Vertic Cambisols*
    - *Soil Taxonomy: (1990) fine, mixed, mesic Vertic Ustochrepst.*
- **DOGHERIA (DOG2)**
    - *FAO (1990): Haplic Calcisols*
    - *Soil Taxonomy: (1990) fine, mixed, mesic Fluventic Ustochrepts.*

2. Soil Map Emilia Romagna Region 1:50.000:

The vineyard is located on soils classified as ***"complesso dei suoli AGELLO franco argillosi limosi/ DOGHERIA, 15-25% pendenti /GRIFONE franco argillosi limosi, Delineation 9448, Cartographic Unit 0664)"***

Soil name and code	Regional presence	Classification
AGELLO franco argilloso limosi AGE1	30%	*Soil Taxonomy:* (2010) Typic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
GRIFONE franco argilloso limosi GRI3	30%	*Soil Taxonomy:* (2010) Typic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
DOGHERIA 15-25% pendenti DOG2	20%	*Soil Taxonomy:* (2010) Typic Calciustepts fine, mixed, active, mesic *WRB:* (2007) Hypocalcic Haplic Calcisols
BANZOLA franco argilloso limosi, 5-35% pendenti BAN3	15%	*Soil Taxonomy:* (2010) Oxyacquic Ustorthents fine, mixed, active, calcareous, mesic *WRB:* (2007) Haplic Regosols (Calcaric, Oxyaquic)
ARCELLI 8-15% pendenti ARC2	5%	*Soil Taxonomy:* (2010) Vertic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)

3. Soil properties

A complete chemical and physical analysis of soil samples was performed in October 2017.

Parameter	Unit	Value
Sand	*%*	34.8
Silt	*%*	36.2
Clay	*%*	29

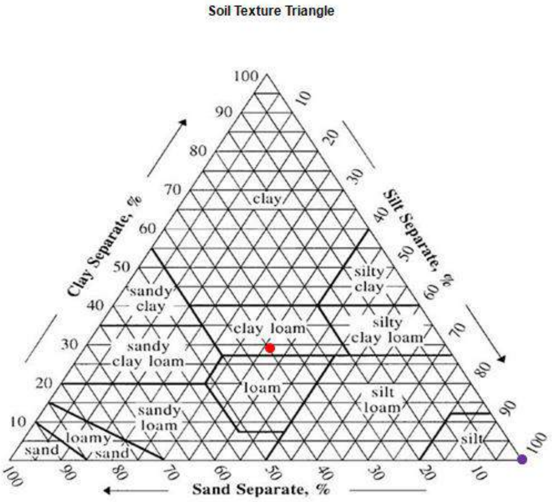

Figure 9: Soil texture triangle (USDA) and soil profile (0-70 cm). Red dot identifies soil type of the DEMO farm

Soil texture		Clay Loamy
Soil acidity (pH in water)		8.4
Total $CaCO_3$	*g/kg*	202
Active $CaCO_3$	*g/kg*	356
Electrical conductivity	*µS/cm*	0.15
Organic Carbon	*g/kg*	4.8
Organic Matter	*g/kg*	8.3
Total Nitrogen	*g/kg*	0.78
C/N ratio		6.16
DH_degree of humification	*%*	24.7
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	3
Soil exchange acidity	*cmoli/kg*	0.14
CSC	*meq/100g*	13.4
Exchangeable Calcium	*mg/kg*	4384
Calcium	*meq/100g*	21.88
Exchangeable Magnesium	*mg/kg*	506
Magnesium	*meq/100g*	4.16
Exchangeable Potassium	*mg/kg*	181
Potassium	*meq/100g*	0.46
Exchangeable Sodium	*mg/kg*	2
Sodium	*meq/100g*	0.01
Ca/Mg		5.3
Ca/K		47.3
Mg/K		9

Nitrates	*mg/kg*	164
Available Boron	*mg/kg*	0.62
Available Iron	*mg/kg*	16
Available Manganese	*mg/kg*	12
Available Copper	*mg/kg*	3
Available Zinc	*mg/kg*	6.5

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	3.44
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	0.963

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	17.9
Field capacity	*%*	31.5
Saturation	*%*	43.6
Available water	*cm/cm*	0.14
Saturation Hydraulic Conductivity	*mm/h*	4.66

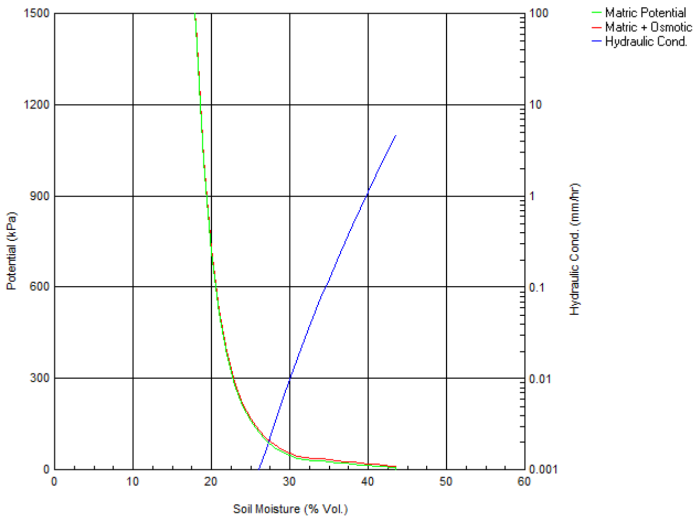

Figure 10: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*), the vineyard was divided in two parts depending on the impact of water logging . In particular, low impact of water logging corresponding to higher vine vigor (HV) and high water logging impact corresponding to low vine vigor (LV). In Table 13 statistical analysis shows that water logging affects yield per vines in LV plots.

Treatment (T)	Water logging (W)
Tr: Traditional management **D**: Demonstrative management	**H:** high impact of water logging **L:** low impact of water logging

	Clusters/ vine	**Yield (Kg/vine)** [(a)]	**Cluster weight (g)**[(a)]	**Total Soluble Solids (°Brix)**	**Pruning weight (g/vine)**	**Ravaz Index (kg/kg)**
Treatment (T)						
Tr	19.4	3.30	180.3	23.5	2.0	2.2
D	14.0	2.70	196.8	22.9	2.1	1.6
Water Logging (W)						
H	18.3	2.70	151.8	22.8	1.9	1.7
L	15.1	3.40	225.3	23.6	2.2	2.1
Interaction Treatment x Water Logging (T x W)						
Tr_H	22.3	3.03	138.5	22.9	2.1	1.6
Tr_L	16.6	3.64	222.2	24.0	1.9	2.9
D_H	14.4	2.40	165.1	22.6	1.7	1.8
D_L	13.6	3.10	228.5	23.2	2.5	1.3
ANOVA Probability p<0.05						
T	ns	ns	ns	ns	ns	ns
W	ns	*	ns	ns	ns	ns
T x W	ns	ns	ns	ns	ns	ns

Table 13: Univariate analysis. Effects of soil management and waterlogging on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM SP4_Az. Vini Colombi

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as ***"complesso dei suoli "CITTADELLA/TAVASCA"***.
In this cartographic unit soils are moderately steep (12-30%), stony, very deep on shingle alluvium. Soils have good oxygen availability; they are not calcareous, neutral or weak alkaline. Texture is highly variable.

- **CITTADELLA franco limosi, 5-10% pendenti (CTD2)**
  - *FAO (1990): Haplic Luvisols*
  - *Soil Taxonomy: (1994) fine silty, mixed, mesic Aquic Paleustalf*

- **TAVASCA (TAV3)**
  - *FAO (1990): Haplic Lixisols*
  - *Soil Taxonomy: (1990) loamy-skeletal, mixed, mesic Typic Haplustalf*

2. Soil Map Emilia Romagna Region 1:50.000

The vineyard is located on soils classified as ***"complesso dei suoli CITTADELLA franco limosi/ RIVERGARO franco argilloso limosi / ARCELLI (Delineation 8543, Cartographic Unit 0507)***"

Soil name and code	Regional presence	Classification
RIVERGARO franco limosi RIV1	25%	*Soil Taxonomy:* (2010) Aquertic Haplustalf fine, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols (Ferric, Clayic)
ARCELLI 15-40% pendenti ARC1	20%	*Soil Taxonomy:* (2010) Vertic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)
CITTADELLA franco limosi 1-5% pendenti CTD1	20%	*Soil Taxonomy:* (2010) Aquic Paleustalf fine silty, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols
ARCELLI 8-15% pendenti ARC2	15%	*Soil Taxonomy:* (2010) Vertic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)
CANTALUPO 8-15% pendenti CAT2	10%	*Soil Taxonomy:* (2010) Vertic Calciustepst fine, mixed, active, mesic. *WRB:* (2007) Hypocalcic Vertic Calcisols
TAVASCA TAV	10%	*Soil Taxonomy:* (2010) Typic Haplustepts clayey skeletal, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Eutric, Endoskeletric)

3. Soil properties

A complete chemical and physical soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	*%*	32.7
Silt	*%*	38.1
Clay	*%*	29.2

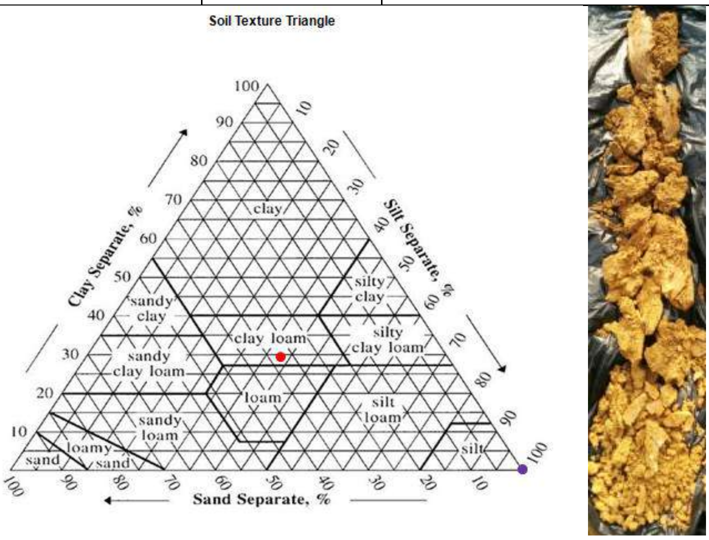

Figure 11: Soil texture triangle (USDA) and soil profile (0-70 cm). Red dot identifies soil type of the DEMO farm.

Soil texture		Clay Loamy
Soil acidity (pH in water)		6.73
Total $CaCO_3$	*g/kg*	10
Active $CaCO_3$	*g/kg*	18
Electrical conductivity	*µS/cm*	0.1
Organic Carbon	*g/kg*	7.5
Organic Matter	*g/kg*	12.9
Total Nitrogen	*g/kg*	0.89
C/N ratio		8.4
DH_degree of humification	*%*	33.9
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	3
Soil exchange acidity	*Cmoli/Kg*	0.14
CSC	*Meq/100g*	16
Exchangeable Calcium	*mg/kg*	3037
Calcium	*meq/100g*	15.15
Exchangeable Magnesium	*mg/kg*	513
Magnesium	*meq/100g*	4.22
Exchangeable Potassium	*mg/kg*	72
Potassium	*meq/100g*	0.18
Exchangeable Sodium	*mg/kg*	39
Sodium	*meq/100g*	0.17
Ca/Mg		3.6
Ca/K		82.5
Mg/K		23

Nitrates	*mg/kg*	87
Available Boron	*mg/kg*	0.44
Available Iron	*mg/kg*	27
Available Manganese	*mg/kg*	29
Available Copper	*mg/kg*	5
Available Zinc	*mg/kg*	10

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	67.75
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	0.789

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	17.9
Field capacity	*%*	31.8
Saturation	*%*	43.8
Available water	*cm/cm*	0.14
Saturation Hydraulic Conductivity	*mm/h*	4.58

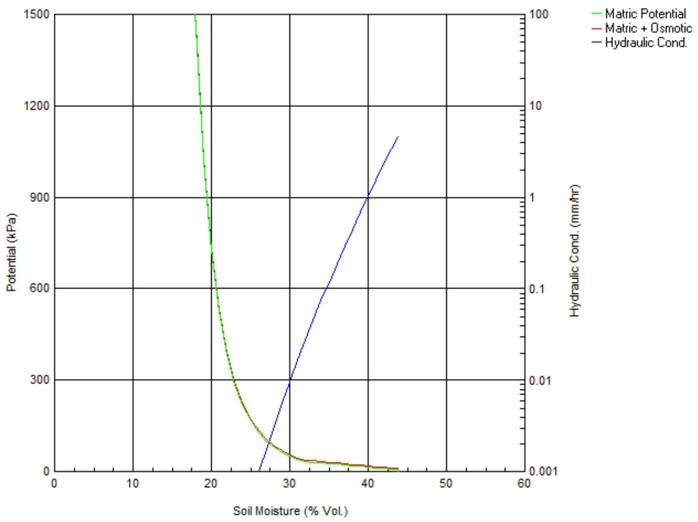

Figure 12: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*) vineyard was divided in two parts depending on the impact of water logging and effect of vine vigor. In Table 14 statistical analysis shows that Tr has higher values for all parameter and is clear the water logging strongly affect DH portion of vineyard, due to morphology of vineyard terrain. This should be considered with attention in the description of results of implementation of demonstrative action. In particular in DH all parameter are lower, except for grapes maturation.
Regarding canes maturation, at pruning time in traditional treatment canes had medium-low level of lignification.

Treatment (T)	Water logging (W)
Tr: Traditional management **D**: Demonstrative management	**H:** high impact of water logging **L:** low impact of water logging

	Clusters/ vine	Yield (Kg/vine) [(a)]	Cluster weight (g)[(a)]	Total Soluble Solids (°Brix)	Pruning weight (g/vine)	Ravaz Index (kg/kg)
Treatment (T)						
Tr	39.5	6.71	172.5	21.54	710	9.73
D	28.3	3.20	110.9	23.75	490	6.95
Water Logging (W)						
L	35.8	4.88	135.4	22.51	630	8.22
H	32.0	5.03	148.0	22.77	570	8.46
Interaction Treatment x Water Logging (T x W)						
Tr_L	39.2	6.16	163.4	21.68	720	8.66
Tr_H	39.7	7.25	181.5	21.39	700	10.80
D_L	32.4	3.60	107.3	23.34	540	7.78
D_H	24.2	2.80	114.4	24.15	440	6.12
ANOVA Probability p<0.05						
T	*	**	ns	**	ns	*
W	ns	ns	ns	ns	ns	ns
T x W	ns	ns	ns	ns	ns	ns

Table 14: Univariate analysis. Effect of soil management and water logging on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM VT1_Az. Agr. La Pagliara

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as ***"complesso dei suoli BADI/PIANELLA"***.
In this cartographic unit soils are moderately steep (8-20%), very deep with medium coarse texture and moderate oxygen availability. Soils are calcareous and moderately alkaline.

- **BADI (BAD):**
    - *FAO (1990): Calcaric Regosols*
    - *Soil Taxonomy: (1990) fine-loamy, mixed (calcareous), mesic, shallow Typic Udorthents.*

- **PIANELLA (PIA)**
    - *FAO (1990): Calcaric Cambisols*
    - *Soil Taxonomy: (1990) fine, mixed, mesic Aquic Eutrochrepts*

2. Soil Map Emilia Romagna Region 1:50.000

Soil map for mountain areas of Emilia Romagna region at 1:50.000 scale are not available yet.

3. Soil properties

A complete chemical and physical soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	*%*	17.4
Silt	*%*	41.8
Clay	*%*	40.8

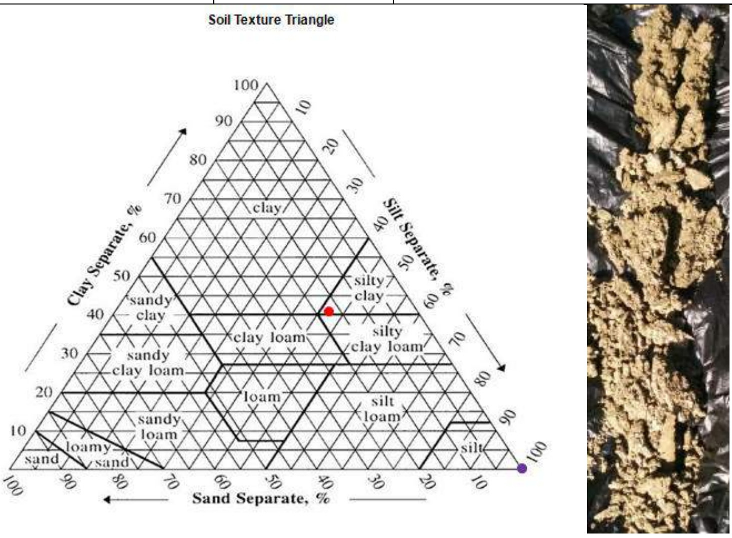

Figure 13: Soil texture triangle (USDA) and soil profile (0-70 cm. Red dot identifies soil type of the DEMO farm.

Soil texture		Silty Clay
Soil acidity (pH in water)		8.42
Total $CaCO_3$	*g/kg*	100
Active $CaCO_3$	*g/kg*	177
Electrical conductivity	*µS/cm*	0.25
Organic Carbon	*g/kg*	4.2

Organic Matter	*g/kg*	7.2
Total Nitrogen	*g/kg*	0.83
C/N ratio		5.07
DH_degree of humification	*%*	40.5
Available Phosphorus	*mg/kg*	2
Available P_2O_5	*mg/kg*	4
Soil exchange acidity	*cmoli/kg*	0.1
CSC	*meq/100g*	16.3
Exchangeable Calcium	*mg/kg*	3717
Calcium	*meq/100g*	18.55
Exchangeable Magnesium	*mg/kg*	835
Magnesium	*meq/100g*	6.87
Exchangeable Potassium	*mg/kg*	218
Potassium	*meq/100g*	0.56
Exchangeable Sodium	*mg/kg*	76
Sodium	*meq/100g*	0.33
Ca/Mg		2.7
Ca/K		33.2
Mg/K		12.3
Nitrates	*mg/kg*	202
Available Boron	*mg/kg*	4.13
Available Iron	*mg/kg*	17
Available Manganese	*mg/kg*	8
Available Copper	*mg/kg*	6
Available Zinc	*mg/kg*	10

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	5.58
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	1.01

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	24.5
Field capacity	*%*	39
Saturation	*%*	48.4
Available water	*cm/cm*	0.14
Saturation Hydraulic Conductivity	*mm/h*	2.11

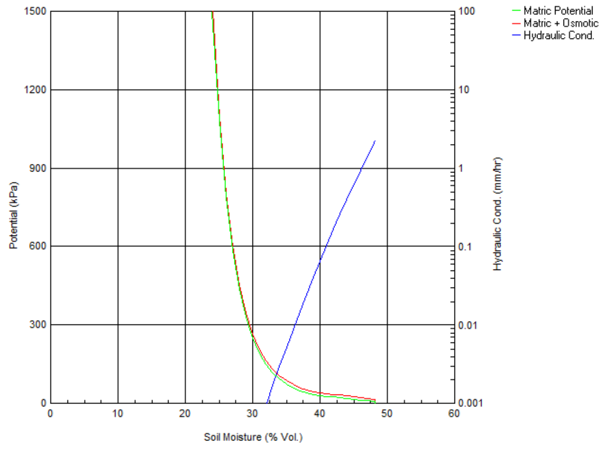

Figure 14: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*) the vineyard was divided in two areas, top and bottom, in the bottom part erosion was more severe. Table 15 shows the results of univariate analysis. Significant differences were found in mean cluster weight between top and bottom of the vineyard, with the former having lighter clusters; moreover, Tr had higher pruning weight than D. Regarding cane maturation, at pruning time in the demonstrative treatment some canes had medium-low level of maturity, whereas other canes had good lignification.

Treatment (T)	Position (P)
Tr: Traditional management **D**: Demonstrative management	**TO:** Top vineyard **BO:** Bottom vineyard

	Clusters/ vine	Yield (Kg/vine) [(a)]	Cluster weight (g)[(a)]	Total Soluble Solids (°Brix)	Pruning weight (g/vine)	Ravaz Index (kg/kg)
Treatment (T)						
Tr	11.6	3.27	288.0	22.2	410	7.90
D	15.2	4.32	296.0	21.5	570	7.66
Position (P)						
TO	12.5	4.01	327.5	21.6	510	8.02
BO	14.3	3.57	256.0	22.0	470	7.54
Interaction Treatment x Position (T x P)						
Tr_TO	10.5	3.23	315.2	22.3	400	8.06
Tr_BO	12.6	3.30	260.8	22.1	420	7.73
D_TO	14.4	4.80	339.9	21.0	620	7.98
D_BO	16.0	3.84	252.0	22.0	520	7.35
ANOVA Probability p<0.05						
Tr	Ns	ns	ns	ns	**	ns
P	Ns	ns	*	ns	ns	ns
T x P	Ns	ns	ns	ns	ns	ns

Table 15: Univariate analysis. Effect of soil management and position on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM VT2_Az. Agr. Carrà Stefano (Castello di Montichiaro)

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as ***"complesso dei suoli CAMINATA/CORTICELLI/STROGNANO".***
In this cartographic unit soils are moderately steep (10-25%), stony with fine texture, calcareous and moderately alkaline.

- **CAMINATA (CMN):**
  - *FAO (1990): Calcaric Regosols*
  - *Soil Taxonomy: (1990) fine, mixed (calcareous), mesic Typic Ustorthens*
- **CORTICELLA (CRT)**
  - *FAO (1990): Vertic Cambisols*
  - *Soil Taxonomy: (1990) fine, mixed, mesic Vertic Ustochrepts*
- **STROGNANO (STG)**
  - *FAO (1990): Calcaric Regosols*
  - *Soil Taxonomy: (1990) fine, mixed (calcareous), mesic Aquic Ustorthents*

2. Soil Map Emilia Romagna Region 1:50.000:

The vineyard is located on soils classified as ***"complesso dei suoli CAMINATA/CORTICELLI - CMN/CRT, Delineation 13078, Cartographic Unit 0682)"***

Soil name and code	Regional presence	Classification
CORTICELLI argilloso limosi **CRT**	55%	*Soil Taxonomy:* (2010) Vertic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Calcaric)
CAMINATA **CMN**	45%	*Soil Taxonomy:* (2010) Typic Ustorthents fine, mixed, superactive, calcareous, mesic *WRB:* (2007) Endolptic Regosols (Calcaric)

3. Soil properties

A complete chemical and physical soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	%	24.7
Silt	%	40.7
Clay	%	34.6

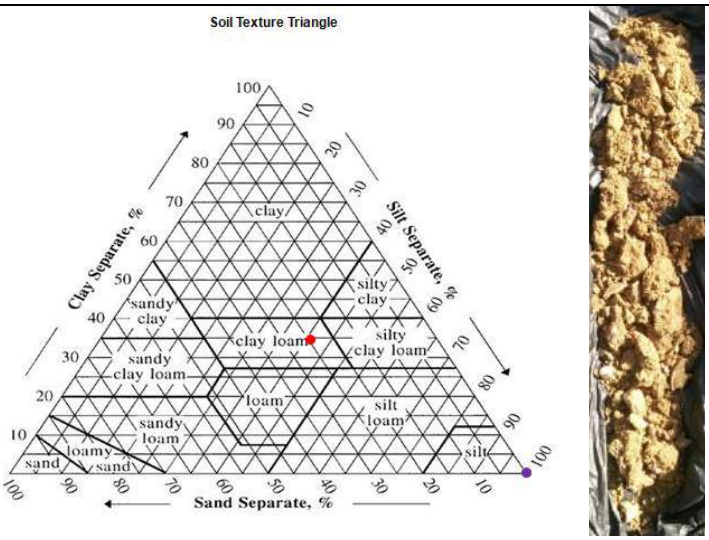

Figure 15: Soil texture triangle (USDA) and soil profile (0-70 cm). Red dot identifies soil type in this DEMO farm.

Soil texture		Clay Loam
Soil acidity (pH in water)		8.26
Total $CaCO_3$	*g/kg*	128
Active $CaCO_3$	*g/kg*	226
Electrical conductivity	*µS/cm*	0.14
Organic Carbon	*g/kg*	10.2
Organic Matter	*g/kg*	17.6
Total Nitrogen	*g/kg*	1.05
C/N ratio		9.76
DH_degree of humification	*%*	35.4
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	3
Soil exchange acidity	*Cmoli/Kg*	0.2
CSC	*meq/100g*	22.1
Exchangeable Calcium	*mg/kg*	6418
Calcium	*meq/100g*	32.02
Exchangeable Magnesium	*mg/kg*	246
Magnesium	*meq/100g*	2.02
Exchangeable Potassium	*mg/kg*	130
Potassium	*meq/100g*	0.33
Exchangeable Sodium	*mg/kg*	1
Sodium	*meq/100g*	0.01
Ca/Mg		15.9
Ca/K		96.4
Mg/K		6.1
Nitrates	*mg/kg*	166
Available Boron	*mg/kg*	0.81
Available Iron	*mg/kg*	27
Available Manganese	*mg/kg*	9
Available Copper	*mg/kg*	22
Available Zinc	*mg/kg*	17.1

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	4.86
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	0.644

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	21.5
Field capacity	*%*	36.1
Saturation	*%*	47.3
Available water	*cm/cm*	0.15
Saturation Hydraulic Conductivity	*mm/h*	3.71

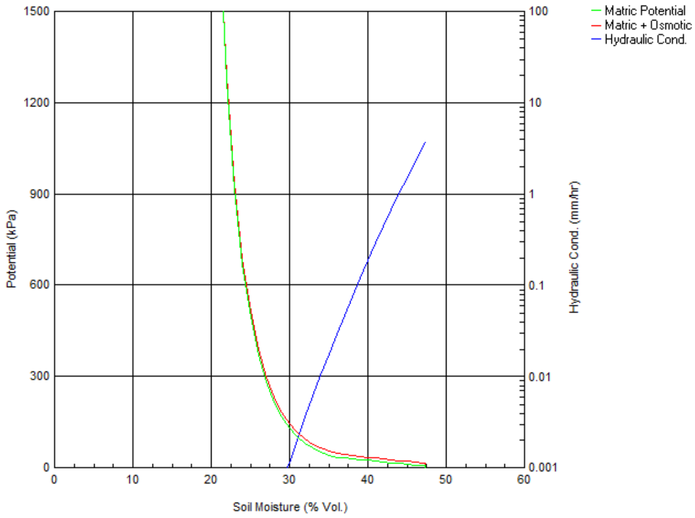

Figure 16: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*) two different vine vigor areas were identified, high vigor vines are localized in the bottom part of vineyard while low vigor vines are localized in top of vineyard mostly affected by erosion processes and gravel in the superficial layer. Table 16 shows the results of univariate analysis and it is clear that erosion causes differences in terms of yield and clusters/vine; moreover differences are visible also in mean cluster weight depending on vine vigor in each treatment, with HV vines producing heavier clusters. It is clear a gradient of vigor inside the HV vines. No significant differences in pruning weight were recorded. Regarding cane maturation, at pruning time all canes had high level of maturity.

Treatment (T)	Vine Vigor (V)
Tr: Traditional management	**H:** High vine vigor
D: Demonstrative management	**L:** Low vine vigor

	Clusters/ vine	**Yield (Kg/vine) [a]**	**Cluster weight (g)[a]**	**Total Soluble Solids (°Brix)**	**Pruning weight (g/vine)**	**Ravaz Index (kg/kg)**
Treatment (T)						
Tr	7.2	1.32	181.1	25.9	340	4.63
D	11.2	2.32	203.6	25.3	360	6.76
Vine vigor (V)						
H	9.8	2.06	210.7	25.4	370	5.79
L	8.6	1.56	174.0	25.8	330	5.6
Interaction Treatment x Vine Vigor (T x V)						
Tr_H	7.2	1.38	201.7	25.7	340	4.56
Tr_L	7.2	1.26	160.5	26.0	340	4.7
D_H	12.4	2.74	219.7	25.0	400	7.02
D_L	10.0	1.90	187.6	25.5	320	6.5
ANOVA Probability p<0.05						
T	*	*	ns	ns	ns	ns
V	ns	ns	*	ns	ns	ns
T x V	ns	ns	ns	ns	ns	ns

Table 16: Univariate analysis. Effect of soil management and vine vigor on vine behavior (season 2017) and summary of the analysis of variance.

DEMO FARM TBC1_Az. Monte delle Vigne

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as "complesso dei suoli ***"complesso dei suoli TERRA DEL SOLE/DOGHERIA/SANT'ANTONIO (Delineation 5366; Cartographic Unit 0077)"***:

- **TERRA DEL SOLE franco argilloso limosi (TRS1)**
  - *FAO (1990): Calcaric Regosols*
  - *Soil Taxonomy: (1990) fine, mixed (calcareous), mesic, shallow Vertic Ustorthents*

- **SANT'ANTONIO (SAN)**
  - *FAO (1990): Vertic Cambisols*
  - *Soil Taxonomy: (1990) fine, mixed, mesic Vertic Ustochrepst.*

- **DOGHERIA (DOG2)**
  - *FAO (1990): Haplic Calcisols*
  - *Soil Taxonomy: (1990) fine, mixed, mesic Fluventic Ustochrepts.*

- ***consociazione dei suoli MONFALCONE***

- **MONTEFALCONE franco argillosi, 1-5% pendent**
  - *WRB: (2007) Vertic Cambisols (Eutric)*
  - *Soil Taxonomy: (2010) Udertic Haplustepts fine, mixed, superactive, mesic*

2. Soil Map Emilia Romagna Region 1:50.000:

The vineyard is located on two different soils classified as:

- ***Soil "a": "consociazione dei suoli MONTEFALCONE argilloso limosi, 1-5% pendenti"***

Soil name and code	Regional presence	Classification
MONTEFALCONE franco argilloso limosi, 1-5% pendenti MFA1	75%	*Soil Taxonomy:* (2010) Udertic Haplusteps fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)
GHIARDO franco limosi GHI1	20%	*Soil Taxonomy:* (2010) Typic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
MONTEFALCONE franco argilloso limosi, 5-20% pendenti MFA2	5%	*Soil Taxonomy:* (2010) Udertic Haplusteps fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)

- ***Soil "b":*** ***"complesso dei suoli DEMANIO/BANZOLA 5-35% pendenti / DOGHERIA - DEM/BAN3/DOG0 (Delineation 8784, Cartographic Unit 0580)"***

Soil name and code	Regional presence	Classification
DEMANIO DEM	40%	*Soil Taxonomy:* (2010) Oxyacquic Haplustepts fine, mixed, active, mesic *WRB:* (2007) Haplic Cambisols (Calcaric, Oxyaquic)
BANZOLA Franco argilloso limosi, 5-35% pendenti BAN3	30%	*Soil Taxonomy:* (2010) Oxyacquic Ustorthents fine, mixed, active, calcareous, mesic *WRB:* (2007) Haplic Regosols (Calcaric, Oxyaquic)
GRIFONE Franco argilloso limosi GRI3	10%	*Soil Taxonomy:* (2010) Typic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Calcaric)
DOGHERIA 15-20% pendenti DOG2	10%	*Soil Taxonomy:* (2010) Typic Calciustepts fine, mixed, active, mesic *WRB:* (2007) Hypocalcic Haplic Calcisols
DOGHERIA 7-15% pendenti DOG1	10%	*Soil Taxonomy:* (2010) Typic Calciustepts fine, mixed, active, mesic *WRB:* (2007) Hypocalcic Haplic Calcisols

3. Soil properties

A complete chemical and physical soil characterization was performed in October 2017.

- ***Soil "a":*** ***"consociazione dei suoli MONTEFALCONE argilloso limosi, 1-5% pendenti"***

Parameter	Unit	Value
Sand	%	15.7
Silt	%	47.4
Clay	%	36.9

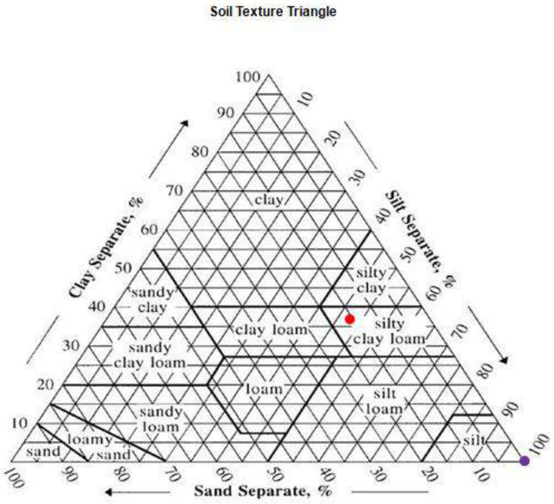

Figure 17: Soil texture triangle (USDA) and soil profile (0-70 cm). Red dot identifies soil type of the DEMO farm

Soil texture		Silty Clay Loam
Soil acidity (pH in water)		8.22
Total $CaCO_3$	*%*	38
Active $CaCO_3$	*%*	66
Electrical conductivity	*µS/cm*	0.17
Organic Carbon	*g/kg*	5.8
Organic Matter	*g/kg*	9.9
Total Nitrogen	*g/kg*	0.8
C/N ratio		7.23
DH_degree of humification	*%*	43.6
Available Phosphorus	*mg/kg*	2
Available P_2O_5	*mg/kg*	4
Soil exchange acidity	*cmoli/Kg*	0.39
CSC	*meq/100g*	23.7
Exchangeable Calcium	*mg/kg*	5553
Calcium	*meq/100g*	27.71
Exchangeable Magnesium	*mg/kg*	913
Magnesium	*meq/100g*	7.51
Exchangeable Potassium	*mg/kg*	151
Potassium	*meq/100g*	0.39
Exchangeable Sodium	*mg/kg*	35
Sodium	*meq/100g*	0.15
Ca/Mg		3.7
Ca/K		72
Mg/K		19.5
Nitrates	*mg/kg*	98
Available Boron	*mg/kg*	0.55
Available Iron	*mg/kg*	12
Available Manganese	*mg/kg*	5
Available Copper	*mg/kg*	4
Available Zinc	*mg/kg*	6.6

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	15.98
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	0.89

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	22.5
Field capacity	*%*	37.9
Saturation	*%*	49
Available water	*cm/cm*	0.15
Saturation Hydraulic Conductivity	*mm/h*	3.64

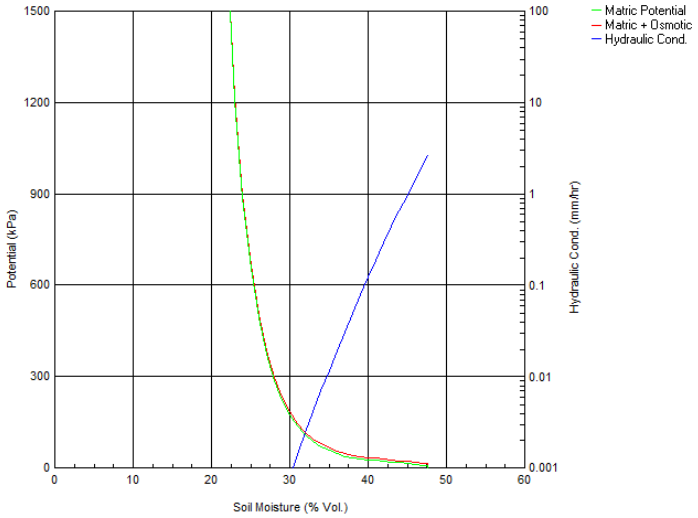

Figure 18: Figure 9: Moisture-Tension-Conductivity Graph (SPAW software)

- ***Soil "b": "complesso dei suoli DEMANIO/BANZOLA 5-35% pendenti / DOGHERIA - DEM/BAN3/DOG0 (Delineation 8784, Cartographic Unit 0580)"***

Parameter	Unit	Value
Sand	*%*	13.3
Silt	*%*	46.1
Clay	*%*	40.6

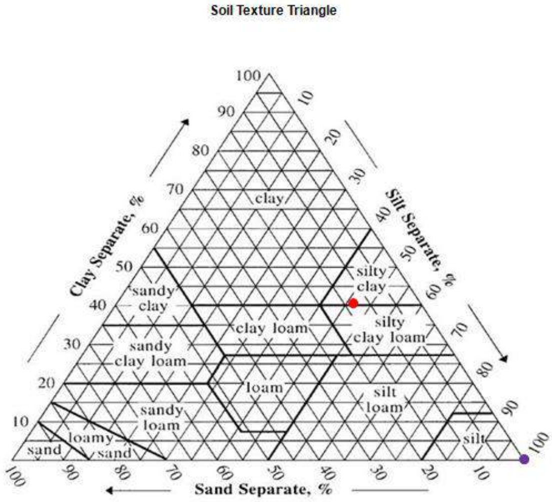

Figure 19: Soil texture triangle (USDA) and soil profile (0-70 cm. Red dot identifies soil type of the DEMO farm

Soil texture		Silty Clay Loam
Soil acidity (pH in water)		8.44
Total $CaCO_3$	*g/kg*	100
Active $CaCO_3$	*g/kg*	177
Electrical conductivity	*µS/cm*	0.16
Organic Carbon	*g/kg*	4.1
Organic Matter	*g/kg*	7
Total Nitrogen	*g/kg*	0.65
C/N ratio		6.29
DH_degree of humification	*%*	39.6
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	1
Soil exchange acidity	*cmoli/kg*	0.21
CSC	*meq/100g*	11.6
Exchangeable Calcium	*mg/kg*	3886
Calcium	*meq/100g*	19.39
Exchangeable Magnesium	*mg/kg*	353
Magnesium	*meq/100g*	2.9
Exchangeable Potassium	*mg/kg*	193
Potassium	*meq/100g*	0.49
Exchangeable Sodium	*mg/kg*	14
Sodium	*meq/100g*	0.06
Ca/Mg		6.7
Ca/K		39.2
Mg/K		5.9
Nitrates	*mg/kg*	168
Available Boron	*mg/kg*	0.48
Available Iron	*mg/kg*	12
Available Manganese	*mg/kg*	9
Available Copper	*mg/kg*	2
Available Zinc	*mg/kg*	5.2

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	5.59
Bulk density *(Manrique and Jones, 1991)*	*g/cm³*	1.02

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	24.5
Field capacity	*%*	39.4
Saturation	*%*	48.6
Available water	*cm/cm*	0.15
Saturation Hydraulic Conductivity	*mm/h*	2.02

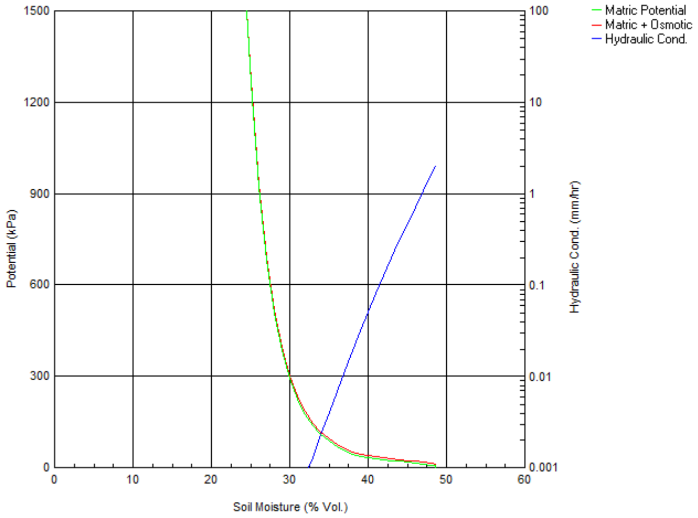

Figure 20: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (Deliverable B2.1) two different vine vigor areas were identified, high vigor vines are localized in the bottom part of the vineyard while low vigor vines are localized in top of the vineyard. No data on cluster weight are available due to logistical problems in the definition of harvesting calendar with the farmer. No significant differences in pruning weight and number of clusters were found (Table 17). Regarding cane maturation, at pruning time all canes had high level of lignification.

The farmer provided general information about vine features that were not used in statistical analysis:
- *Mean yield*: 4.4 t/ha corresponding to 770 g/vine.
- *Mean Total Soluble Solids*: 20°Brix.

Treatment (T)	Vine Vigor (V)
Tr: Traditional management **D**: Demonstrative management	**H:** High vine vigor **L:** Low vine vigor

	Clusters/ vine	Yield (Kg/vine) [(a)]	Cluster weight (g)[(a)]	Total Soluble Solids (°Brix)	Pruning weight (g/vine)	Ravaz Index (kg/kg)
Treatment (T)						
Tr	12.5	-	-	-	380	-
D	12.3	-	-	-	310	-
Vine vigor (V)						
H	13.3	-	-	-	360	-
L	11.5	-	-	-	630	-
Interaction Treatment x Vine vigor (T x V)						
Tr_H	14.0	-	-	-	250	-
Tr_L	11.0	-	-	-	500	-
D_H	12.7	-	-	-	470	-
D_L	12.0	-	-	-	750	-
ANOVA Probability p<0.05						
T	ns	-	-	-	ns	-
V	ns	-	-	-	ns	-
T x V	ns	-	-	-	ns	-

Table 17: Univariate analysis. Effect of soil management and vine vigor on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM TBC2_Az. Vitivinicola Palazzo

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soil classified as ***"complesso dei suoli GHIARDO/BARCO"***.

- **GHIARDO franco limosi Soil (GHI1):**
  - *FAO (1990): Haplic Luvisols*
  - *Soil Taxonomy: silty, mixed, mesic Aquic Haplustalf*
- **BARCO franco limosi (BAR1)**
  - *FAO: Chromic Luvisols*
  - *Soil Taxonomy: silty, mixed, mesic Kanhaplic Haplustalf*

2. Soil Map Emilia Romagna Region 1:50.000:

The vineyard is located on soil classified as ***"consociazione dei suoli MONFALCONE argilloso limosi, 1-5% pendenti - MFA1 (Delineation: 7320 ; Cartographic unit 0077)"***

Soil name and code	Regional presence	Classification
MONFALCONE franco argilloso limosi, 1-5% pendenti MFA1	100%	*Soil Taxonomy:* (2010) Udertic Haplustepts fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)

3. Soil properties

A complete chemical and physical soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	%	19.8
Silt	%	53.1
Clay	%	27.1

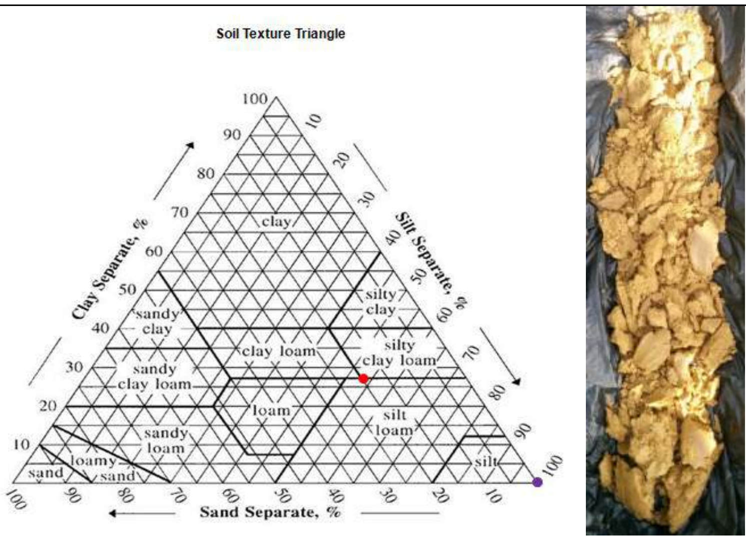

Figure 21: Soil texture triangle (USDA) and soil profile (0-70 cm). Red dot identifies soil type of this DEMO farm.

Soil texture		Silty Clay Loam
Soil acidity (pH in water)		7.53
Total $CaCO_3$	*g/kg*	8
Active $CaCO_3$	*g/kg*	14
Electrical conductivity	*µS/cm*	0.1
Organic Carbon	*g/kg*	3
Organic Matter	*g/kg*	5.1
Total Nitrogen	*g/kg*	0.44
C/N ratio		6.78
DH_degree of humification	*%*	4.9
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/kg*	1
Soil exchange acidity	*Cmoli/Kg*	0.22
CSC	*meq/100g*	11
Exchangeable Calcium	*mg/kg*	3843
Calcium	*meq/100g*	19.18
Exchangeable Magnesium	*mg/kg*	722
Magnesium	*meq/100g*	5.94
Exchangeable Potassium	*mg/kg*	82
Potassium	*meq/100g*	0.21
Exchangeable Sodium	*mg/kg*	2
Sodium	*meq/100g*	0.01
Ca/Mg		3.2
Ca/K		91.2
Mg/K		28.3
Nitrates	*mg/kg*	66
Available Boron	*mg/kg*	0.39
Available Iron	*mg/kg*	16
Available Manganese	*mg/kg*	5
Available Copper	*mg/kg*	1
Available Zinc	*mg/kg*	5.8

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	90.99
Bulk density *(Manrique and Jones, 1991)*	*g/cm³*	1.109

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	16.6
Field capacity	*%*	32.9
Saturation	*%*	43.7
Available water	*cm/cm*	0.16
Saturation Hydraulic Conductivity	*mm/h*	3.6

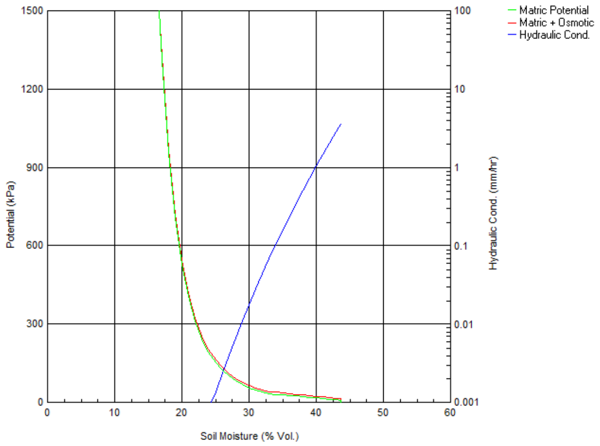

Figure 22: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (*Deliverable B2.1*) two different vigor areas were identified, one characterized by low vigor and one with higher plant vigor. Some vines were without clusters and they were excluded from the statistical analysis. A significant interaction between treatment and vine vigor for pruning weight was found. Regarding cane maturation, at pruning time all canes had high level of lignification.

Treatment (T)	Vine Vigor (V)
Tr: Traditional management **D**: Demonstrative management	**H:** High vine vigor **L:** Low vine vigor

	Clusters/ vine	Yield (Kg/vine) [a]	Cluster weight (g)[a]	Total Soluble Solids (°Brix)	Pruning weight (g/vine)	Ravaz Index (kg/kg)
Treatment (T)						
Tr	4.25	0.75	179.5	23.06	325	2.38
D	4.38	0.63	135.0	22.86	350	1.93
Vine vigor (V)						
H	4.25	0.76	164.0	23.59	375	2.09
L	4.38	0.61	150.5	22.33	300	2.23
Interaction Treatment x Vine Vigor (T x V)						
Tr_H	4.50	0.83	176.9	23.31	300	2.69
Tr_L	4.00	0.68	182.1	22.81	350	2.08
D_H	4.00	0.70	151.0	23.88	450	1.49
D_L	4.75	0.55	118.9	21.84	250	2.38
ANOVA Probability p<0.05						
T	ns	ns	ns	ns	ns	ns
V	ns	ns	ns	ns	ns	ns
T x V	ns	ns	ns	ns	*	ns

Table 18: Univariate analysis. Effect of soil management and vine vigor on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM RES1_Az. Res Uvae (Fertirrigazione)

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as ***"complesso dei suoli "CITTADELLA/TAVASCA"***.

- **CITTADELLA franco limosi, 5-10% pendenti (CTD2)**
  - *FAO (1990): Haplic Luvisols*
  - *Soil Taxonomy: (1994) fine silty, mixed, mesic Aquic Paleustalf*

- **TAVASCA (TAV3)**
  - *FAO (1990): Haplic Lixisols*
  - *Soil Taxonomy: (1990) lamy-skeletal, mixed, mesic Typic Haplustalf*
  -

2. Soil Map Emilia Romagna Region 1:50.000:

The vineyard is located on two different soils classified as:

- ***Soil "a": "consociazione dei suoli RIVERGARO franco limosi, 1-5% pendenti - RIV1 (Delineation 7316, Cartographic Unit 0464)"***

Soil name and code	Regional presence	Classification
RIVERGARO franco limosi RIV1	100%	*Soil Taxonomy:* (2010) Aquertic Haplustalf fine, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols (Ferric, Clayc)

- ***Soil "b": "complesso dei suoli RIO RUMORE/ARCELLI/CANTALUPO - RIR0/ARC0/CAT0 (Delineation 7317, Cartographic Unit 0509)"***

Soil name and code	Regional presence	Classification
ARCELLI 15-40% pendenti ARC1	30%	*Soil Taxonomy:* (2010) Vertic Haplustepst fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)
RIO RUMORE 40-80% pendenti RIR1	25%	*Soil Taxonomy:* (2010) Typic Ustorthents coarse loamy, mixed, superactive, calcareous, mesic *WRB:* (2007) Haplic Regosols (Calcaric, Arenic)
ARCELLI 15-18% pendenti ARC2	15%	*Soil Taxonomy:* (2010) Vertic Haplustepst fine, mixed, superactive, mesic *WRB:* (2007) Vertic Cambisols (Eutric)
CANTALUPO 8-15% pendenti CAT2	12%	*Soil Taxonomy:* (2010) Vertic Calciustepst fine, mixed, active, mesic *WRB:* (2007) Hypocalcic Vertic Calcisols

MASCONI **MAS**	7%	*Soil Taxonomy:* (2010) Typic Haplustepts coarse loamy, mixed, active, mesic *WRB:* (2007) Haplic Cambisols (Eutric)
CITTADELLA franco limosi, 5-10% pendenti **CTD2**	6%	*Soil Taxonomy:* (2010) Aquic Plaeustalfs fine, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols
TAVASCA **TAV**	5%	*Soil Taxonomy:* (2010) Typic Haplustepts clayesly skeletal, mixed, superactive, mesic *WRB:* (2007) Haplic Cambisols (Eutric, Endoskeletic)

3. Soil properties

A complete chemical and physical analysis of soil samples was performed in October 2017.

- ***Soil "a": "consociazione dei suoli RIVERGARO franco limosi, 1-5% pendenti - RIV1 (Delineation 7316, Cartographic Unit 0464)"***

Parameter	Unit	Value
Sand	%	38.3
Silt	%	38.7
Clay	%	23

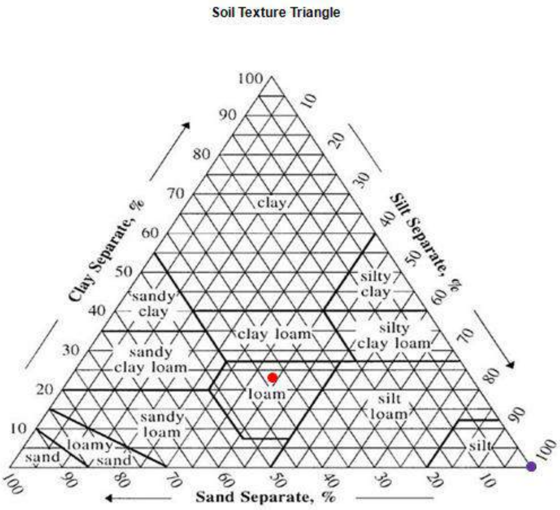

Figure 23: Soil texture triangle (USDA). Red dot identifies soil type of the DEMO farm

Parameter	Unit	Value
Soil texture		Loamy
Soil acidity (pH in water)		6.92
Total $CaCO_3$	*g/kg*	6
Active $CaCO_3$	*g/kg*	11
Electrical conductivity	*µS/cm*	0.09
Organic Carbon	*g/kg*	5.1
Organic Matter	*g/kg*	8.7
Total Nitrogen	*g/kg*	0.64
C/N ratio		7.96
DH_degree of humification	*%*	44
Available Phosphorus	*mg/kg*	2
Available P_2O_5	*mg/Kg*	2

Soil exchange acidity	*cmoli/Kg*	0.11
CSC	*meq/100g*	15.4
Exchangeable Calcium	*mg/kg*	2972
Calcium	*meq/100g*	14.83
Exchangeable Magnesium	*mg/kg*	532
Magnesium	*meq/100g*	4.38
Exchangeable Potassium	*mg/kg*	113
Potassium	*meq/100g*	0.29
Exchangeable Sodium	*mg/kg*	36
Sodium	*meq/100g*	0.16
Ca/Mg		3.4
Ca/K		51.2
Mg/K		15.1
Nitrates	*mg/kg*	76
Available Boron	*mg/kg*	0.37
Available Iron	*mg/kg*	22
Available Manganese	*mg/kg*	30
Available Copper	*mg/kg*	8
Available Zinc	*mg/kg*	12.9

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	126.85
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	0.94

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	14.5
Field capacity	*%*	28.4
Saturation	*%*	42.4
Available water	*cm/cm*	0.14
Saturation Hydraulic Conductivity	*mm/h*	7.48

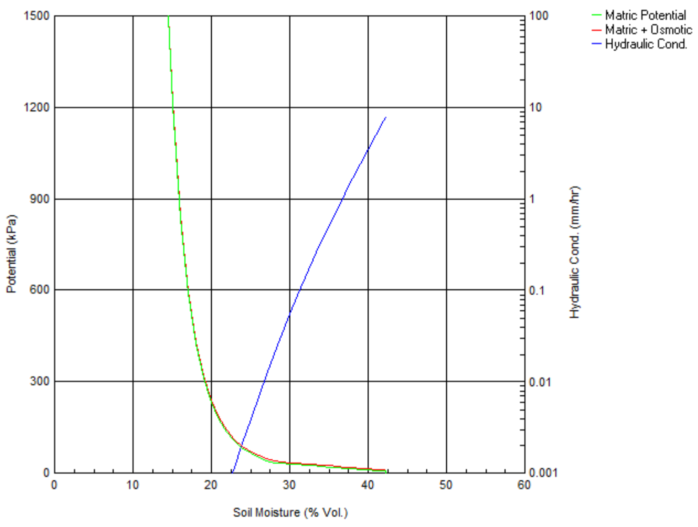

Figure 24: Moisture-Tension-Conductivity Graph (SPAW software)

- ***Soil "b": "complesso dei suoli RIO RUMORE/ARCELLI/CANTALUPO - RIR0/ARC0/CAT0 (Delineation 7317, Cartographic Unit 0509)"***

Parameter	Unit	Value
Sand	%	35.9
Silt	%	33.7
Clay	%	30.4

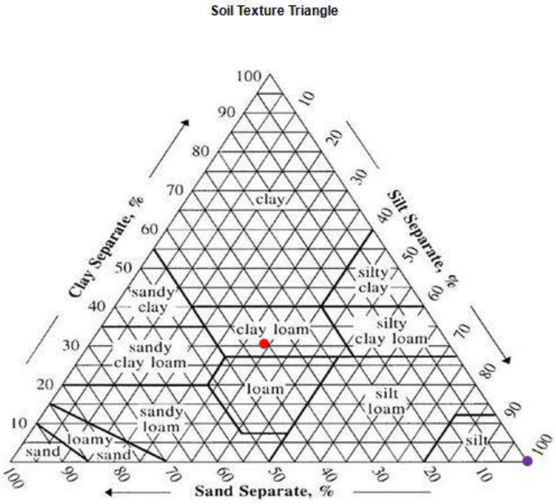

Figure 25: Soil texture triangle (USDA). Red dot identifies soil type of the DEMO farm

Soil texture		Clay Loamy
Soil acidity (pH in water)		6.63
Total $CaCO_3$	*g/kg*	6
Active $CaCO_3$	*g/kg*	11
Electrical conductivity	*µS/cm*	0.04
Organic Carbon	*g/kg*	2.6
Organic Matter	*g/kg*	4.6
Total Nitrogen	*g/kg*	0.47
C/N ratio		5.67
DH_degree of humification	%	38.6
Available Phosphorus	*mg/kg*	1
Available P_2O_5	*mg/Kg*	4
Soil exchange acidity	*cmoli/Kg*	0.14
CSC	*meq/100g*	18.6
Exchangeable Calcium	*mg/kg*	3315
Calcium	*meq/100g*	16.54
Exchangeable Magnesium	*mg/kg*	604
Magnesium	*meq/100g*	4.96
Exchangeable Potassium	*mg/kg*	131
Potassium	*meq/100g*	0.33
Exchangeable Sodium	*mg/kg*	23
Sodium	*meq/100g*	0.1
Ca/Mg		3.3
Ca/K		49.4
Mg/K		14.8
Nitrates	*mg/Kg*	197
Available Boron	*mg/kg*	0.45
Available Iron	*mg/kg*	22
Available Manganese	*mg/kg*	24

Available Copper	*mg/kg*	4
Available Zinc	*mg/kg*	12.5

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	108.23
Bulk density *(Manrique and Jones, 1991)*	*g/cm³*	1.15

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	18.3
Field capacity	*%*	31.5
Saturation	*%*	42.7
Available water	*cm/cm*	0.13
Saturation Hydraulic Conductivity	*mm/h*	3.71

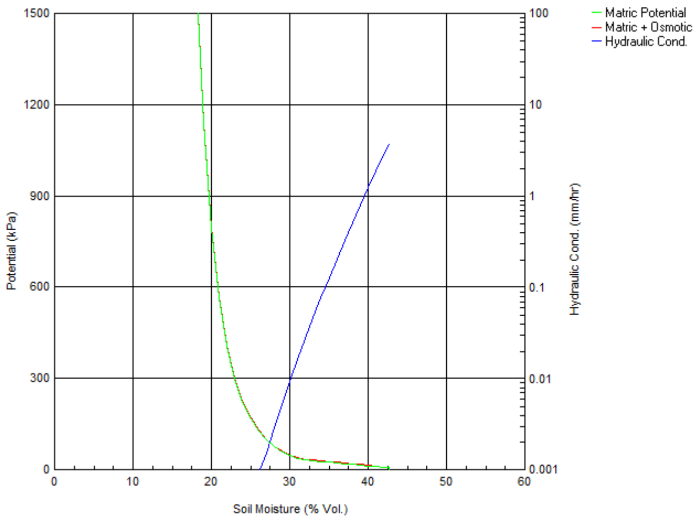

Figure 26: Moisture-Tension-Conductivity Graph (SPAW software)

2. Vines features

According to Action Plan (Deliverable B2.1) in this demonstration vineyard drainage will be designed and installed to reduce water logging. Here different fertilization methods have been already applied by demo farmers (as indicated in Action Plan), so interaction between innovative practices and fertilization were analyzed. Statistical analysis (Table 19) shows at the beginning of project no significant differences between treatment and fertilization techniques. Regarding canes maturation, at pruning time all canes had high level of lignifications.

Treatment (T)	Fertilization (F)
Tr: Traditional management **D**: Demonstrative management	**100%FI:** 100% mineral fertilization distributed on the row associated with drip irrigation system **50%FI:** 50% mineral fertilization distributed on the row associated with drip irrigation system and 50% mineral fertilization with granular fertilizer **100%MIN:** 100% mineral fertilization with granular fertilizer

	Clusters/ vine	Yield (Kg/vine) [(a)]	Cluster weight (g)[(a)]	Total Soluble Solids (°Brix)	Pruning weight (g/vine)	Ravaz Index (kg/kg)
Treatment (T)						
Tr	12.6	2.66	212.0	23.1	813	3.39
D	11.3	2.28	197.0	23.3	797.5	3.18
Fertilization (F)						
100%FI	12.5	2.39	189.9	23.9	817.5	3.27
50%FI	10.3	2.20	207.8	23.4	826.25	2.82
100% MIN	13.1	2.81	215.9	22.3	771.25	3.78
Interaction Treatment x Fertilization (T x F)						
Tr_100%FI	14.0	2.63	195.0	23.8	740	3.6
Tr_50%FI	9.3	2.25	224.7	22.4	877.5	2.57
Tr_MIN	14.5	3.10	216.3	23.2	820	4.01
D_100%FI	11.0	2.15	184.7	24.1	895	2.95
D_50% FI	11.3	2.15	190.8	24.4	775	3.06
D_MIN	11.8	2.53	215.4	21.3	722.5	3.54
ANOVA Probability p<0.05						
T	ns	ns	ns	ns	ns	ns
F	ns	ns	ns	ns	ns	ns
T x F	ns	ns	ns	ns	ns	ns

Table 19: Univariate analysis. Effect of soil management and fertilization on vine behavior (season 2017) and summary of the analysis of variance

DEMO FARM RES2_Az. Res Uvae (Riva)

1. Soil characteristics

1. Soil Map Emilia Romagna Region 1:250.000

The vineyard is located on soils classified as ***"complesso dei suoli "CITTADELLA/TAVASCA".***

- **CITTADELLA franco limosi, 5-10% pendenti (CTD2)**
  - *FAO (1990): Haplic Luvisols*
  - *Soil Taxonomy: (1994) fine silty, mixed, mesic Aquic Paleustalf*

- **TAVASCA (TAV3)**
  - *FAO (1990): Haplic Lixisols*
  - *Soil Taxonomy: (1990) lamy-skeletal, mixed, mesic Typic Haplustalf*

2. Soil Map Emilia Romagna Region 1:50.000

The vineyard is located on soils classified as ***"complesso dei suoli CITTADELLA/RIVERGARO franco limosi, 1-5% pendenti - RIV1 (Delineation 7316, Cartographic Unit 0464)"***

Soil name and code	Regional presence	Classification
CITTADELLA franco limosi 1-5% pendenti CTD1	45%	*Soil Taxonomy:* (2010) Aquic Paleustalf fine silty, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols
RIVERGARO franco limosi RIV1	30%	*Soil Taxonomy:* (2010) Aquertic Haplustalf fine, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols (Ferric, Clayc)
CITTADELLA franco limosi 5-10% pendenti CTD2	15%	*Soil Taxonomy:* (2010) Aquic Paleustalf fine silty, mixed, superactive, mesic *WRB:* (2007) Cutanic Stagnic Luvisols
RIO RUMORE 40-80% pendenti RIR1	10%	*Soil Taxonomy:* (2010) Typic Ustorthents coarse loamy, mixed, superactive, calcareous, mesic *WRB:* (2007) Haplic Regosols (Calcaric, Arenic)

3. Soil properties

A complete chemical and physical soil characterization was performed in October 2017.

Parameter	Unit	Value
Sand	%	35.8
Silt	%	38.4
Clay	%	25.8

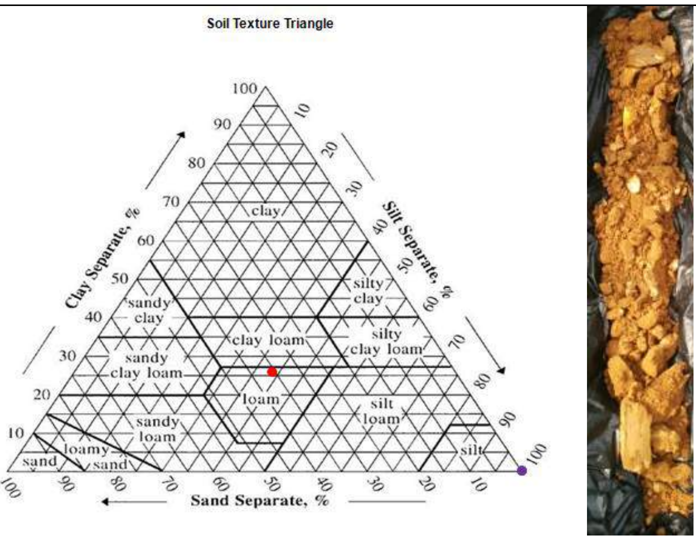

Figure 27: Soil texture triangle (USDA) and soil profile (0-70 cm. Red dot identifies soil type of the DEMO farm

Soil texture		Loamy
Soil acidity (pH in water)		5.53
Total $CaCO_3$	*g/kg*	4.9
Active $CaCO_3$	*g/kg*	7
Electrical conductivity	*µS/cm*	0.06
Organic Carbon	*g/kg*	4.3
Organic Matter	*g/kg*	7.4
Total Nitrogen	*g/kg*	0.59
C/N ratio		7.21
DH_degree of humification	*%*	24.8
Available Phosphorus	*mg/Kg*	1
Available P_2O_5	*mg/Kg*	2
Soil exchange acidity	*Cmoli/Kg*	0.25
CSC	*meq/100g*	15.4
Exchangeable Calcium	*mg/kg*	1725
Calcium	*meq/100g*	8.61
Exchangeable Magnesium	*mg/kg*	477
Magnesium	*meq/100g*	3.92
Exchangeable Potassium	*mg/kg*	102
Potassium	*meq/100g*	0.26
Exchangeable Sodium	*mg/kg*	7
Sodium	*meq/100g*	0.03
Ca/Mg		2.2
Ca/K		33
Mg/K		15.1
Nitrates	*mg/Kg*	123
Available Boron	*mg/kg*	0.55
Available Iron	*mg/kg*	38
Available Manganese	*mg/kg*	100
Available Copper	*mg/kg*	2
Available Zinc	*mg/kg*	12.3

Parameter	Unit	Value
Mineralization coefficient (K2) *(Rémy and Marine-Lafléche, 1974)*	*%*	187.15
Bulk density *(Manrique and Jones, 1991)*	*g/cm^3*	1

- **Soil water characteristics**

Parameter	Unit	Value
Wilting point	*%*	16.1
Field capacity	*%*	29.7
Saturation	*%*	42.4
Available water	*cm/cm*	0.14
Saturation Hydraulic Conductivity	*mm/h*	5.54

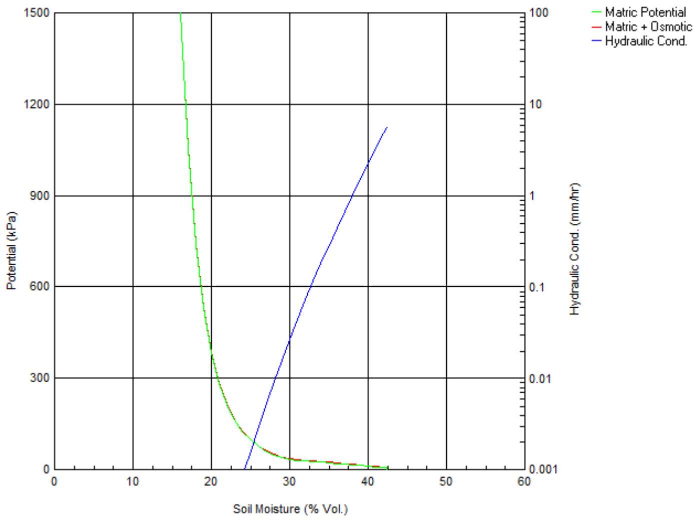

Figure 28: Moisture-Tension-Conductivity Graph (SPAW software)

2.Vines features

According to Action Plan (*Deliverable B2.1*) vineyard was divided also in two blocks (traditional and demonstrative management) with no definition of a second factor in the statistical analysis. The demonstrative block at the beginning of project was characterized by severe problems of erosion with deep rills and exposed roots system. Significant differences in collected data were found between treatments considering the number of clusters per vine that is lower in damaged rows (demonstrative treatment). Regarding cane maturation, at pruning time all canes had high level of lignification.

Treatment (T)	
Tr: Traditional management **D**: Demonstrative management	

	Clusters/ Vine	**Yield (Kg/vine) [a]**	**Cluster weight (g)[a]**	**Total Soluble Solids (°Brix)**	**Pruning weight (g/vine)**	**Ravaz Index (kg/kg)**
Treatment (T)						
Tr	16.2	2.55	174.5	23.3	651	5.32
D	9.5	1.95	220.2	23.8	560	4.86
ANOVA Probability $p<0.05$						
Significance	*	ns	ns	ns	ns	ns

Table 20: Univariate analysis. Effect of soil management and vine vigor on vine behavior (season 2017) and summary of the analysis of variance

- ## Preliminary discussion

Vineyards are located on different soils influencing chemical and physical characteristics.
In Demo farms soils have pH ranging from 8.44 (strongly alkaline) to 5.5 (moderately acid). Some of the analyzed parameters determined soil quality and resilience to main soil threats.
In particular *Soil Organic Matter (SOM)* is one of the most important parameters that have to be preserved and monitored because it is involved as main actor in physical and biological soil processes. SOM through mineralization becomes available for root uptake but it is also prone to erosion and leaching.
SOM and organic carbon were analyzed in Demo vineyards and results show that in all vineyards SOM content is poor or medium ranging from 0.41 to 1.76%.
An important indicator of soil organic matter quality is the *C/N ratio* that reflects the organic matter evolution process. Relative higher values was recorded in VT2 vineyard (9.76) corresponding to a balanced C/N ratio, other plots registered value less than 9. Low values of this ratio indicates that humification processes in soil are limited and organic matter is mineralized with releasing of Nitrogen in soil.
Also *Soil Organic Carbon* content (SOC) influences many soil characteristics including nutrients and water holding capacity, nutrients turnover, soil stability and micro-organisms nutrition. According to literature Demo farms soils are poor in Organic Carbon except for VT2 that registered normal value. The *degree of humification (DH)* indicates the ratio between humic and fulvic acids while the total organic carbon defines the level of humification of organic matter (when its value is 100%, organic matter is completely converted into *humus*). In Demo farms soils have DH value ranging from 24.7 to 43.6%, except for TBC2 farm in which DH value is 4.9% indicating that organic matter is "sealed" and not available for plants.
Analyzing the annual SOM *rate of mineralization (K2)* very high values (above 100%) were obtained in RES1, RES2 and TBC2 farms indicating that mineralization processes are really strong and farmers have to pay attention to organic matter content; under such circumstances adding of organic residues or amendants is advised. Definition of the mineralization coefficient with the integration of temperature values can give additional elements for better understanding of SOM turnover.
Regarding nutritional features soils in demo vineyards have mostly clay texture and this is an obstacle for nutrients exchanges. Interaction between pH and different ions is also very important because their availability depends on soil reaction as indicated in Figure 27.

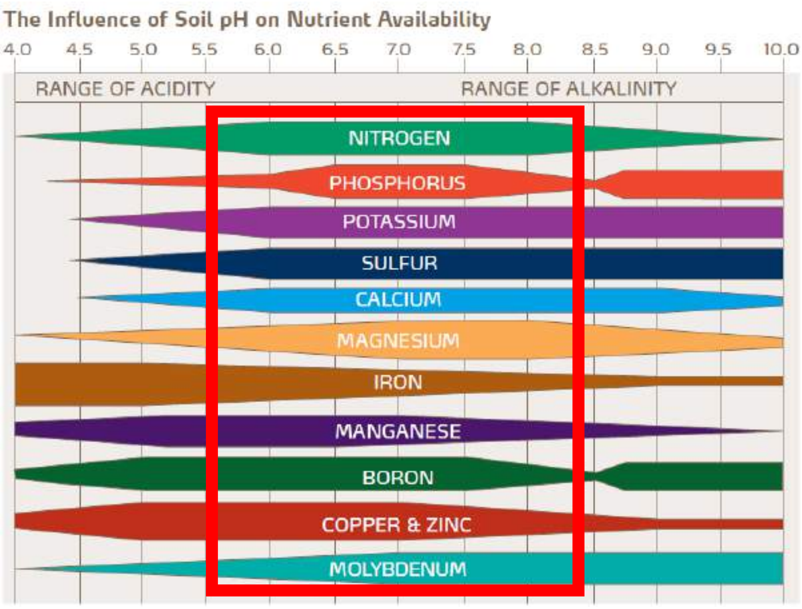

Figure 29: Influence of soil pH on nutrients availability

Nitrogen is scarce in all vineyards except for SP2 and VT2 that register sufficient content.
Nitrates ($^{-}NO_3$) are products of Nitrogen cycle and represent the available nitrogen in soil for plants. Their concentration varies widely according to soil typology, climate condition, rainfall and fertilization practices. Nitrates are subjected to leaching into deeper soil layers so rainfall strongly affects their concentration. Demo Farms VT2, TBC1, TBC2 are located in Nitrate Vulnerable Zones (NVZ) as highlighted by Nitrate

Directive 91/676/CEE, with soil nitrates values ranging from 66 to 168 ppm and, in other farms, reaching 202 ppm (VT1). Samples were collected in October 2017 after minimum precipitation in September and no precipitation in whole Summer, so leaching was minimum. Attention has to be paid in management of fertilizer to avoid extreme nitrogen concentration in underground water due to leaching processes.
Phosphorous was analyzed as soluble (P_2O_5) and total content, although soluble P is the form adsorbed by plant roots. Values of both Phosphorous forms are very low. Maximum range of availability of P is between pH 6 to 7.5 and maximum availability of P according to soil analysis performed is in Res Uvae and SP4 farms.

From the point of view of vines nutrition, quantities and ratio between exchangeable ions, Mg, Ca and K in soil solution are very important:

- *Mg/K:* defines the competition in roots absorption between these two ions and it is quite high in most demo vineyards indicating high Mg content and possible K deficiency. VT2 and TBC1 have an almost optimal balance between K and Mg and no fertilization is advised. In other Demo farms adding of Mg should be avoided while K fertilization is advised.
- *Ca/Mg*: is low in all vineyards (from 2.2 to 6.7) except for VT2 farm having medium-high value (15.9).

Potassium content is very variable in the demo farms soils, however to better interpret obtained value an analysis in relation with soil texture is recommended. Potassium content analysis should be done taking into consideration rootstock type as in case of soil K deficiency a right choose of rootstock should aid plant vigor overtaking competition with Magnesium adsorption. Demo farms with lower K content are SP1 and SP4. SP1 vineyard has SO4 rootstock that has a medium-high capacity of soil Potassium adsorption. In SP4 rootstock type is not available but for future planting this aspect has to be taken in consideration.
In SP3, VT1, VT2 and TBC1b K is high and this is confirmed by low values of Mg/K ratio.
Magnesium has an important role in plant physiology and Demo farms soils are rich in exchangeable Mg^{2+} as indicated also in elements ratio above cited (Mg/K and Ca/Mg).
Even if *Calcium* is abundant, it should be not available for plants because it is usually present in soil as complex (carbonate, phosphate, silicate) and/or in organic matter, this fact should reduce its solubility and consequently its availability for plants.

Total carbonates is a useful parameter for the interpretation of pH and the identification of water properties of soil. *Active carbonates* represent the fraction that affects the availability of Phosphorus and Iron due to creation of insoluble compounds not usable from plants. Carbonates act on phosphate solubility and high content tends to the formation of Calcium phosphate that is less available for plants.
According to carbonates content, SP4, TBC2, RES1 and RES2 farms are poor calcareous, other farms are rich in carbonates and SP3 reported an excess of carbonates. Active carbonates show the same trend.
Microelements are very important in small concentration for plant growth:

- *Boron*: Boron is strongly affected by pH and carbonates and in alkaline soils the availability of this element is very low. Only SP2 has optimal Boron content, other demo farms have either very low (SP1, TBC2, RES1a) or good (SP3, SP4, TBC1, REs1b and RES2) Boron availability. VT2 farm has a Boron concentration of 4.13 ppm that is considered above the toxicity threshold.
- *Iron (Fe^{3+})*: low values are reported in all demo farms.
- *Zinc (Zn^{2+})*: optimal Zinc contents were recorded in all demo farm vineyards (5.2-17.1 ppm). Optimal pH range for availability of Zinc is 5-7.5, so some of demo farms have soil pH above that threshold.
- *Manganese (Mn^{2+})*: except for RES2 soil, Manganese content is low in all vineyards; this is also due to the high pH of considered soils that strongly affect the Mn^{2+} concentration, indeed in calcareous or alkaline soils Mn is oxidized becoming unavailable compound for plants. Moreover, the high content of Calcium reduces the uptake of this ion.
- *Copper (Cu^{2+}):* demo farm soils have all good content of Copper, but VT2 have excess Cu. Excess of copper can reduce the availability of Iron and chlorosis becomes more likely. Optimal pH range for availability of Copper is 5-7.5, so some demo farms have soil pH above that threshold.

CSC recorded moderately high values and also for this parameter the difference in the two soils that are present in TBC1 farm is evident.
Regarding salinity, according to USDA, Demo Farms soils are not salty as electrical conductivity is less than 2 µS/cm.

• Annex A: Demo Farms Soil Analysis Reports

• References

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