UNIVERSITÀ POLITECNICA DELLE MARCHE

Department of Agricultural, Food and Environmental Sciences Degree Course

: Food and Beverage Innovation and Management

CHEMICAL AND PHYSICAL EVALUATION OF SOIL IN RELATION TO FRUIT QUALITY CHARACTERISTICS. THE CASE OF STUDY OF BLACKBERRY CULTIVATION IN THE MIDDLE HILLS OF MARCHE REGION

Type of Dissertation: Empirical

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ACADEMIC YEAR 2022/2023

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ABSTRACT

The present study assessed the performances of two different blackberry cultivars, Chester and Loch Ness, cultivated in Marche Region (central Italy) in relation to soil properties. To test their performance, the final product (fruits) was analysed through qualitative and nutritional analyses. The parameters considered for the fruit quality were color, firmness, soluble solids content, titratable acidity (all qualitative) and total phenolics (nutritional). In relation to soil analysis pH, particle size distribution and total organic Carbon were the parameters considered. A positive performance of both cultivars was observed in this type of soil. In comparing Chester and Loch Ness, this last cultivar showed better results from both qualitative and nutritional points of view. In conclusion, a significant difference in the vocationality of the soil in object was observed, with Loch Ness resulting as the more predisposed cultivar for a high-quality production on these kinds of soils.

1. INTRODUCTION

The Food and Agriculture Organization (FAO) defines soil health as the capacity of soil to function as a living system. Important soil properties to ensure a healthy soil are part of physical, chemical, and biological components. The soil physical component includes parameters like soil texture, structure, moisture content, and porosity (E.J.B.N. Cardoso, 2013) able to influence water and air circulation and the capacity to hold nutrients. The soil chemical component includes indicators like organic C, total N, available P and other macro and microelements. In the last decades, the biological component has acquired an increasingly important role to promote healthy soils since pedofauna and microorganisms act as organic matter decomposer, establish positive symbiotic relationships with plant roots, help to control pests and diseases, etc. (FAO, 2022). In detail, invertebrates improve soil structure, fragmentation and decomposition of plant residues, and create relationships at different levels with microorganisms (E.J.B.N. Cardoso, 2013).

The maintenance of soil health and fertility is therefore extremely important and crucial to support agrifood systems (Weil and Brady, 2017) since more than 95% of our food is produced from the soil(FAO.2022).

Failure to achieve a good soil health will result in an impoverishment of soil fertility, less structured soil, lack in presence of bio-indicators like beneficial microbes and meso-fauna, low levels of organic matter and both macro and micronutrients. As consequence, poor soil conditions represent an unsuitable ecosystem for the growth of several cultivars, with a strong decrease in yield or the impossibility of cultivating it. Improve the soil health is a relevant step to achieving the *Sustainable Development Goals* included in the *2030 Agenda*. The *2030 Agenda* was signed by 193 ONU Members, and it defines sustainable strategies to achieve the 17 Sustainable Development Goals

(SDGs). Several measures will be taken to reach each SDG. The protection of soil waste and degradation is included in these measures as well as the 55% reduction of GHG emissions by 2030. In relation to the agriculture sector, an important strategy linked to the 2030 Agenda and included in the European Green Deal is *The Farm to Fork Strategy*, that aims to reach the Green Deal Target of "carbon-neutral continent" by 2050 through several measures focused on strengthening connections between agriculture, food and environment. The main actions are: increasing of agricultural surfaces managed with organic farming techniques; increase sustainability and affordability of food; ensuring food security and human health reducing emissions; reducing food lost and waste (European Union, 2020).

Thus, soil health is crucial to ensure a sufficient crop yield and quality production. In this context, the FAO introduced also the concept of "Land suitability", defined as the fitness of a given type of land for a defined use, considering the actual settlement of the territory or after an improvement action (FAO. 2022). To maintain good soil conditions and increase the probability to have a land suitable for the intended use, a sustainable agricultural management with conservation techniques like e.g. organic farming, crop rotation, permanent soil cover or avoiding tillage as much as possible is fundamental.

Using appropriate agronomic techniques with conservative management of the soil result in an improvement in the quality of the final product, especially if we refer to vocationality in relation to fruits with specific needs like blackberries.

Blackberry (*Rubus fruticosus* L.) is a berry fruit particularly appreciated by the consumer thanks to its taste, flavour, nutritional, and beneficial properties. This fruit is low in sugar and contains high levels of vitamins and other phytochemicals useful for human health. For example, phenolic compounds present in blackberries have demonstrated to: *i)* help in cancer prevention thanks to their antioxidant activity (Tianyou Xu et al., 2022); *ii)* reduce the risk to develop chronic and inflammatory diseases and age-related cognitive disorders (Kaume, Howard, and Devareddy, 2012); and *iii)* inhibit free radicals, that are toxic compounds synthesized in the organism exposed to UV light, smoke or pollution, or during the transformation process of food in energy (U.S. DHHS, 2021), improving skin health and avoiding osteoporosis problems. Hundred grams of blackberry contain the 35%, 10%, and 25% of the daily human recommended intake in vitamin C, E, and K, respectively (Tianyou Xu et al., 2022). Dietary fibers represent one of the main components in blackberries. The content of insoluble and soluble fibers in hundred g of these fruits are about 29% of the daily recommended dose. Insoluble fibers help the digestion process and in avoiding constipation, while soluble fibers (more fermentable) bind cholesterol, preventing it from entering in the blood circulation (Tianyou Xu et al., 2022). Anthocyanins are antioxidant pigments belonging to the group of flavonoids, a class of phenolic compound present in abundant doses in blackberries. They exert several beneficial properties on the human health, regulating blood pressure, helping in diabetes prevention, having antioxidant, anticancer and anti-inflammatory activity, and enhancing brain cognitive activities (Tianyou Xu et al., 2022).

As previously mentioned, the nutritional quality is one of the most attractive aspects for blackberry consumers; to fulfil this increasing request, the blackberry industry grew considerably during last years, introducing new high-quality cultivar in the market, while research and breeding processes to obtain new cultivars are still on course. A study carried out in 2005 highlighted an increase of 44% of the worldwide land destined to blackberry cultivation respect to the data collected in 1995. In Europe in 2005 there were 7692 hectares of commercially cultivated blackberries, the majority (69%) located in Serbia, with an extension of 5300 hectares. These data show how the increasing of blackberry demand on the market has already started around 20 years ago (John R. Clark & Chad e. Finn, 2014). It is difficult to find more updated data regarding the surface cultivated with blackberries, but the aggregate data with other minor berries confirmed a continuous increasing trend of the cultivated surface from 2005 to 2021 worldwide, passing from 22105 ha to 44790 ha of minor berries (FAOSTAT, 2023). The increase of this surface has been related to the fact that berry production for the fresh market has undergone significant transformations, such as the introduction of out-of-season cultivation and growth in non-traditional areas. In the era of globalization, various berry cultivars are now being cultivated in locations with climatic conditions divergent from their original breeding grounds (Kruger and Josuttis, 2012). Unfortunately, berries as a category are especially vulnerable to temperature shifts and soil changes, and the increase in cultivated surface did not lead to an increase in the total worldwide production, that remained almost stable from 2005 (152219 tons) to 2021 (157248 tons), with a corresponding loss of yield (from 6,9 ton/ha to 3,5 ton/ha).

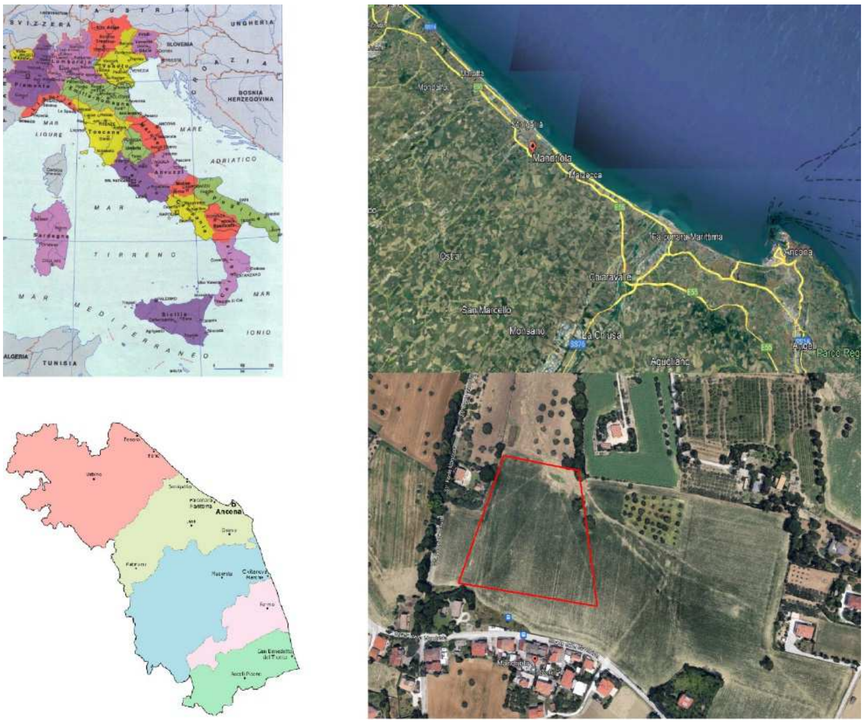
These data affirm the need for increased on-site physiological research across all berry crops to enhance our comprehension of potential and final yield development, along with its influencing factors. This information appears crucial not only for contemporary and economically significant cultivars but potentially for all newly released cultivars as well. It empowers growers to make optimal cultivar choices tailored to their specific regions and cultivation practices. Moreover, this heightened understanding is indispensable for breeders seeking to develop cultivars that align with evolving demands in various global regions and adapt to the challenges posed by climate change. In this context, with the current research we would like to: *i)* analyze the relation between soil properties and fruit quality of two blackberry (*Rubus fruticosus* L.) cultivars (var. Chester and Loch Ness); and *ii)* hypothesize the land suitability of the studied soil according to the selected cultivars, considering pedoclimatic conditions and final land use.

2. MATERIALS AND METHODS

2.1 STUDY SITE AND CROP FIELD SETTLEMENT

The study was run in the “Società Agricola La Mandriola s.s.” located in Senigallia (AN), in a hilly area (42 m a.s.l.) 2 km far from the Adriatic Sea, of Marche region (Italy) (Figure 1).

Figure 1: territorial framework



The land was originated from soil formed on terraced alluvial deposits prevailing gravels associated with subordinate sands, silts, and clays. (R.Marche, 2000). Following the Köppen-Geiger climate classification, the climate of the studied area is Mediterranean, characterized by mild wet winters and dry summers that goes from warm to hot (P. Lionello et al. 2006). (Kottek et al., 2006; Belda et al., 2014). The studied field consists of 0.75 ha of blackberries settled in December 2021 and managed with organic and minimum-tillage practices. The cultivation is equipped with microirrigation through a drip irrigation system. The plants are spaced 1 x 2 m. To support the plants during growing, three metal wires at different height are present. The first wire is placed at 30 cm from the ground, the second at 90 cm and the third row at 160 cm.

2.2 PLANT MATERIAL

Among the wide variety of *Robus fruticosus* L., the cultivars present are Chester and Loch Ness, both cultivated in the same number of plants. These cultivars are considered semi-erect. Vegetative canes called primocanes are produced in the planting year; after the dormant period they produce flowers and fruits. In this last productive phase primocanes are called floricanes. The floricanes will senesce while new vegetative primocanes are produced (John R. Clark et al. 2014). The pollination is entomophilous. Both Chester and Loch Ness, thanks to good productivity and quality characteristics, are very appreciated among blackberries cultivars.

2.3 SOIL DESCRIPTION, SAMPLING AND ANALYSIS

Three representative soil profiles were sampled at approximately 20 m from each other, until the depth of ≈0.40 m and then morphologically described using Schoeneberger et al. (2012). Soil samples of about 1 kg were collected from each horizon. After the collection, samples were maintained inside a portable fridge and, once in the laboratory, they were air-dried and finally sieved at 2 mm to remove the skeletal particles (USDA, 2003).

Soil samples were analysed for how concern pH, total organic carbon (TOC), and particle size distribution. The pH was measured potentiometrically in water (1:2.5 solid:liquid ratio), using a combined glass-calomel electrode immersed into the suspension. The content of total organic C (TOC) was estimated by K-dichromate digestion, heating the suspension at 165◦C for 30 min (Allison, 1965). To determine the particle-size distribution were used an aliquot of 15 g of fine earth in suspension with 100 ml of distilled water, then sand was retrieved by wet sieving at 0.053 mm, while silt and clay were obtained by column sedimentation at 19–20 ◦C (Day, 1965).

2.4 FRUIT SAMPLING AND ANALYSIS

For the fruit sampling, 3 plots (named A, B, and C) were selected per each cultivar, for a total number of 6 plots. The number of plants per plot was 3, so the total number of sampled plants was 9 for each cultivar. During the selection of the plants, those located at the edges of the cultivation field were not considered. For the qualitative analyses (fruit color, firmness, titratable acidity, and soluble solids content), 20 fruits per plot were harvested for 3 harvest dates, and each plot was analysed independently. The fruits were collected on the base of their external characteristics: homogeneity in color and shape and absence of defects (bruises, wounds). Blackberries in the right ripening phase, with appreciable size, uniformity in color and homogeneity in shape were selected. To perform qualitative analysis, fruits collected were kept at room temperature and analyzed during the same day of harvest.

To perform nutritional analyses (Total Phenolic Content), a total of 20 fruits per plot were harvested during the season in different dates, and each plot was analyzed independently. In this case, the chosen fruits were completely free from any physical damage, without any defect and as much homogeneous as possible for color, dimension and maturity level. These fruits were immediately frozen at -20°C after harvesting and kept frozen until the day of analysis.

2.4.1 Fruit qualitative analysis

The fruit color analysis was evaluated through the Minolta Chromameter CR 400 (Konica Minolta, Tokyo, Japan). Briefly, each fruit was red two times (on the two opposite faces) by the instrument and the data were registered by the instrument as the CIELAB color space parameters (L*, a*, b*), and the final data of this study were expressed as L* and Chroma.

The International Commission on Illumination (CIE) defines L* as perceptual lightness (L* = 0 indicates black, and L* = 100 indicates diffuse white) (Ian L Weatherall and Bernard D Coombs. 1992). The Chroma (C) was calculated from a* and b* values, according to the equation: $C = [(a^{*2} + b^{*2})]^{½}$

The evaluation of fruit firmness was performed with a durometer hardness tester, model BAREISS HPE III BASIC Shore A – DIGITAL (Bareiss, Stouffville - Ontario, Canada). As for the fruit color, the firmness was measured on two sides of each fruit. Values are expressed as Shore A hardness scale. After the color and firmness analyses, fruits were frozen at -18°C until the moment of Soluble Solids Content and Titratable Acidity analyses.

The evaluation of Soluble Solids Content (SSC) is the most common method for the estimation of soluble sugars in the fruits. The frozen blackberry fruits were thawed and crushed to obtain the juice necessary for SSC analysis. The analysis was performed through a digital refractometer (PR-101 ATAGO, Tokyo, Japan), putting some drops of juice on the lens; data were expressed in °Brix.

The titratable acidity of the blackberry fruits was analysed through the automatic titrator, model HI-84502-02 (Hanna Instruments Italia, Ronchi di Villafranca Padovana, Italy). For this analysis, the previously obtained blackberry juices were diluted 1:10 using MilliQ water and then automatically red by the instrument. The results were expressed as % of citric acid.

2.4.2 Fruit nutritional analysis

Nutritional analyses have been carried out in two steps: a previous sample preparation (extraction) and then the Total Phenolic Compounds measurement.

For the sample preparation, also called methanolic extraction, an extraction buffer (80% Methanol; 20% MilliQ water; 1% extravolume of Acetic acid) was previously prepared. Then, frozen fruits were cut into small pieces and a sample of 10 g of fruit was put in 100 mL of extraction buffer. This mixture was then homogenized with ultraturrax T25 homogenizer (Janke and Kunkel, IKA Labortechnik, Staufen, Denmark). This solution was placed at refrigeration temperature of 4°C for 48 hours storage. The following step was a centrifugation at 2500 rpm, at 4°C, for 20 minutes, performed with Heraeus Megafuge 16 R Centrifuge (Thermo Fisher Scientific, Waltham, Massachusetts, USA). The surnatant was collected and an aliquot was finally stored in six 2 mL-amber vials at -18°C until total phenolic analyses were performed. This procedure was repeated for each blackberry sample.

For the evaluation of the Total Phenolic Content, the procedure was adapted from Singleton-Rossi method (V. L. Singleton and Joseph A. Rossi. 1965). Each methanolic extract previously obtained was diluted at a ratio of 1:20 using MilliQ water. Subsequently, Folin-Ciocalteau reagent was added and, after 3 minutes, Sodium Carbonate was added to alkalize the samples. After 60 minutes in the dark, each sample was red with an UV-1800 Shimadzu spectrophotometer (Shimadzu Italia S.r.l., Milano, Italy) at a wavelength of 760 nm. The final results were expressed as mg Gallic acid/g of fresh fruit.

2.5 DATA TREATMENT AND STATISTICAL ANALYSES

The data presented in this study regarding the blackberry fruit parameters were presented as the average, integrated with the standard deviation (SD) values in the graphs. A one-way analysis of variance (ANOVA) was applied to test the differences among the cultivars. Statistically significant differences in means were determined with the Fisher test (Least Significant Difference, LSD) (p=0.05). Statistical processing was carried out using STATISTICA software (Stasoft, Tulsa, OK, USA).

3. RESULTS AND DISCUSSION

3.1 Soil morphological description and physical-chemical analyses

In the BB field, the soils belonged to the order of Inceptisols according to Soil Survey Staff (2014), due to the presence of A (ochric) and Bw (cambic) horizons (Table 1). In general, A and Bw horizons showed olive brown colours and a moderate degree of aggregation made generally of blocks from very fine to very coarse. Roots were rather abundant, from very fine to coarse in size. Skeleton were everywhere under 2% of abundance. The Bw horizons showed slickensides, due to the abundance of fine particles originated from the parent material weathering.

Table 1 – Soil morphological description

Horizon[a]	Depth	Thickness	Boundary	Color[b]	Structure[c]	Roots[d]	Skeleton	Observation
		cm						
Blackberry cultivation								
BB P1 - soil cover: 100% grassed								
Ap	0-17	9-14	CW	2.5Y 4/4	2 sbk vf,f,m,co,vc	3 vf,f	< 2% mm	
Bw1	17-36	20-22	CW	2.5Y 4/4	2 sbk vf,f,m,co,vc	2 vf,f	< 2% mm	Presence of slickensides
Bw2	36-42+	-		2.5Y 4/4	2 sbk vf,f,m	3vf	< 2% mm	Presence of mottles
BB P2 - soil cover: 100% grassed								
Ap	0-10	5-10	CW	2.5Y 4/4	2 gr vf,f; sbk vf,f,m,co	3 vf,f	< 2% mm	
Bw1	10-38	26-28	CW	2.5Y 4/4	1 sbk vf,f,m,co,vc	2 vf,f	< 2% mm	
Bw2	38-40+				1 sbk f,m,co,vc	2 vf,f	< 2% mm	
BB P3 - soil cover: 100% grassed								
Ap	0-15	8-15	CW	2.5Y 4/4	2 sbk-abk vf,f,m,co,vc	2 vf,m	2% mm	
Bw1	15-29	10-11	CW	2.5Y 4/4	2 sbk-abk f,m,co,vc	2 vf	2% mm	Lithochromic features (blue clay)
Bw2	29-43+	-		2.5Y 4/4	1 sbk-abk f,m,co,vc	1vf	2% mm	Lithochromic features (blue clay)

[a] Horizon nomenclature according to Schoeneberger et al. (2012).

[b] mixed at field humidity, according to Munsell Soil Color Charts

[c] 1=week, 2=moderate, 3=strong; f=fine, m=medium, co=coarse; vc=very coarse; gr=granular, abk=angular blocky, sbk=subangular blocky

[d] 1=few, 2=common; 3=abundant; vf=very fine, f=fine, m=medium, co=coarse.

[e] C=clear, W=wavy

Figure 2- Soil Profiles under blackberry cultivation in “Società Agricola La Mandriola s.s”, Senigallia (AN), Italy.

Table 1 show chemical and physical analysis performed on the soil samples.

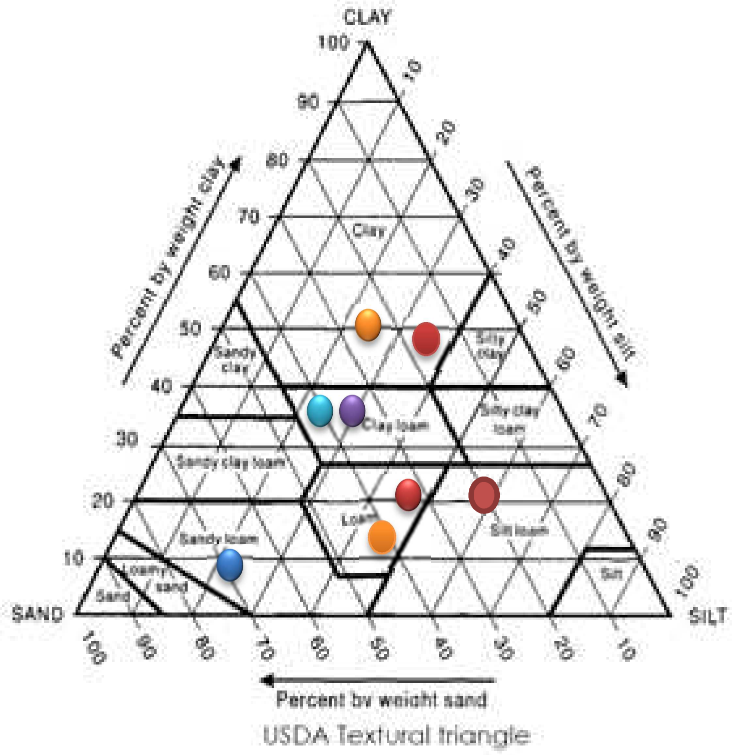
The pH is in line with previous studies on Marche region soils (Tavoletti et al., 2023; Brecciaroli et al., 2012), with values that range between 8.14 of the Ap horizon (P3) and 8.41 of Bw1 (P1). The sub-alkaline pH value of this soil is derived from the parent material composed of calcareous sedimentary rocks. Considering the recent implant of blackberries, it can be hypothesized that the plant-soil relationship that lead to a soil acidification (Mike Bolland et al. 2004) is not highlighted.

The TOC content recorded the maximum value in the Bw1 horizon of profile P1, (17,70 g kg^{-1}), with an averaged content of organic C of 13.00 g kg^{-1} in Ap horizon and 12.70 g kg^{-1} in Bw horizons. The moderately content of OC counterbalance the fine texture of this soil in supporting plant growth. The presence of considerable content of organic matter (used as proxy of OC) in a soil improve nutrients retention, soil fertility, infiltration rates and, soil aeration reducing soil

compaction. Additionally, organic matter has a buffer effect preventing from rapid changes in pH in the soil and acts as energy source useful for soil microorganisms (R. J. A. Jones et al. 2005). The particle size distribution is described in the Table 2. Physical properties, related to morphological structures (Table 2), showed a good state of aggregation and the fine texture (mainly silt loam, clay loam, and clay) (Table 2 and Figure 3), indicated these soils as moderately drained and, consequently, with good water-holding capacity. Generally,
the textural class of the profile is Clay Loam, independently from the genetic horizon.

Table 2 – Chemical and physical soil analysis. Number in brackets are standard deviation with n=number of the samples used for the mean calculation (AVG).

Profile	Horizon	pH	TOC	Particle size distribution			Textural class
			$g\ kg^{-1}$	Sand	Silt	Clay	
				$g\ kg^{-1}$			
P1	Ap	8.36	13.20	535	310	155	Sandy loam
	Bw1	8.41	17.70	362	272	366	Clay loam
	Bw2	8.32	10.50	417	235	348	Clay loam
P2	Ap	8.39	11.40	177	369	454	Clay
	Bw	8.37	10.35	340	473	187	Loam
P3	Ap	8.14	14.40	524	281	195	Loam
	Bw1	8.37	13.50	119	335	545	Clay
	Bw2	8.29	12.60	179	613	209	Silt loam
AVG Ap	n=3	8.30	13.00	412	320	268	Clay loam
		(0.14)	(1.51)	(204)	(45)	(162)	
AVG Bw1	n=3	8.38	13.85	274	360	366	Clay loam
		(0.03)	(3.69)	(134)	(103)	(179)	
AVG Bw2	n=2	8.30	11.55	298	424	278	Clay loam
		na	Na	na	na	na	
AVG TOT	n=8	8.33	12.96	332	361	307	Clay loam
		(0.09)	(2.40)	(160)	(125)	(143)	



P1 Ap: ●	P1 Bw1: ●	P1 Bw2: ●
P2 Ap: ●	P2 Bw1: ●	
P3 Ap: ●	P3 Bw1: ●	P3 Bw2: ●

Figure 3: particle size distribution triangle

3.2 Blackberry fruits analyses

3.2.1 Color analysis

The color of blackberry fruits is a parameter strongly bound to fruit ripening phase. It is considered a qualitative parameter which influences the consumer's interest in the product (Pervin Basaran and Kahraman Kepenek, 2011).

Analysis performed with colorimeter highlighted a significant difference between the two blackberry cultivars taken in consideration. Loch Ness fruits have a bigger Chroma which indicate a higher saturation of fruit color (Figure 3). On the other side, fruits that belong to Chester cultivar present a higher brightness (L* value) (Figure 4). The statistical analysis revealed that these variations are significant, so the difference between the two cultivars for the fruit color is evident.

The data obtained in our trial resulted slightly different from other studies in literature. We obtained a higher Chroma and a lower L* values in comparison with Pervin Barsaran and Kahraman Kepenek (2011). Furthermore, Maja Mikulic-Petkovsek and collaborators (2017) found similar levels of L*, but different values of Chroma between the same two cultivars, with Chroma being higher in Chester rather than in Loch Ness. These differences can be bound to different pedo-climatic conditions in respect to our study, that may have influenced fruit characteristics.

Chroma and brightness, which are used to express the fruit color, can be related to the presence of other compounds in the fruit. E.g., a correlation between these values and anthocyanins level in blackberry fruit juice was found (Hankun Gong, Qui Li and Zhendong Yang, 2014). More specifically, Chroma was positively associated with anthocyanins, while at higher L* values were associated lower quantity of anthocyanins (Hankun Gong, Qui Li and Zhendong Yang, 2014).

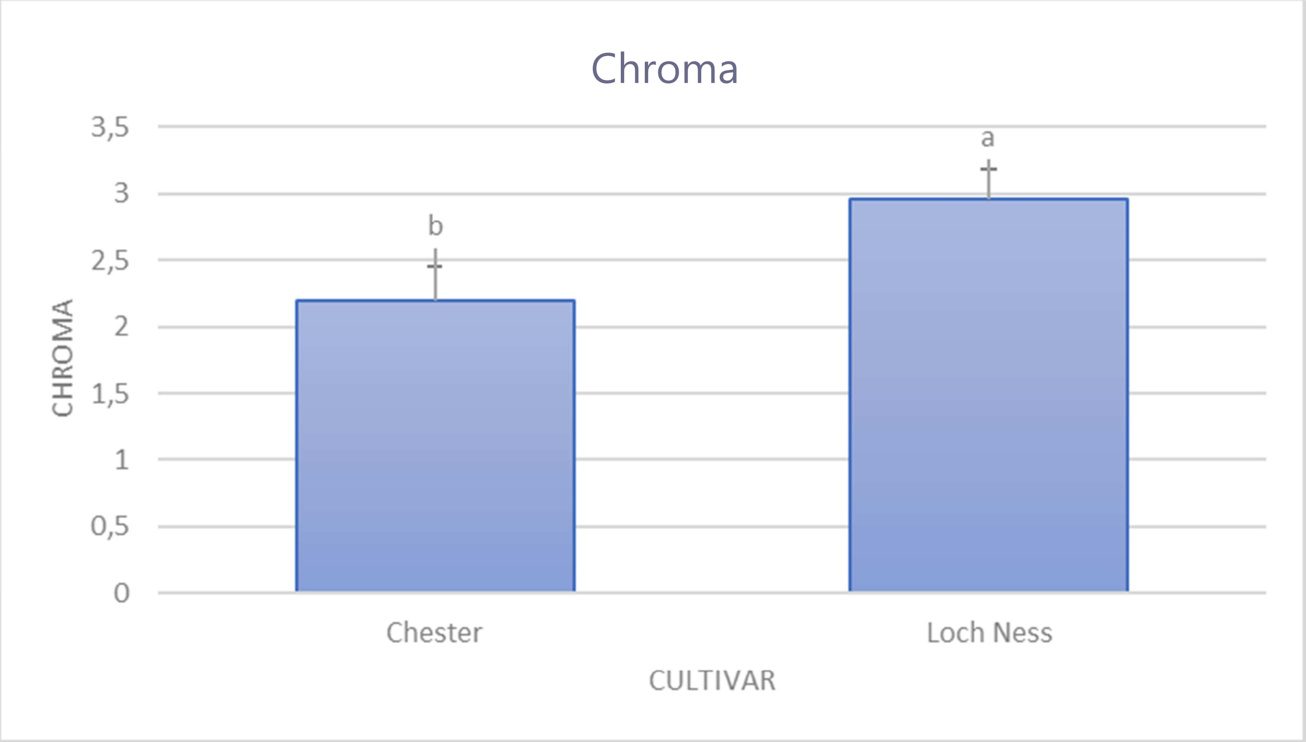


Figure 4: Chroma values of blackberry fruits from the studied cultivars. Data are expressed as means and standard deviation. Different letters indicate significant difference (LSD test, p≤0.05)

Figure 5: L* values of blackberry fruits from the studied cultivars. Data are expressed as means and standard deviation. Different letters indicate significant difference (LSD test, p≤0.05)

3.2.2 *Firmness analysis*

As for the color, also the fruit firmness represents an important parameter for the evaluation of the fruit ripening degree; this parameter is also appreciated by stakeholders involved in the blackberry production chain, because higher fruit firmness allows to the fruit to better resist to fruit manipulation, mechanical damage during transportation, and allows prolonged shelf life. However, too much fruit firmness can be not very appreciated by consumers, which associate the elevated fruit firmness to an unripe fruit.

In the present study, the difference between the fruit firmness of the two cultivars analysed through durometer is appreciable, with Loch Ness cultivar showing a significantly higher firmness than Chester (Figure 5). This analysis is one of the key points of this study, because it represents one of the first example of firmness measurement in blackberries that is possible to find in literature. In fact, due to the soft pulp and small size of these fruits, it results difficult to evaluate in a proper manner their firmness. The utilization of a durometer (non-destructive) instead of the most common penetrometer (destructive) for the analysis of blackberry fruit firmness has allowed us to obtain good results.

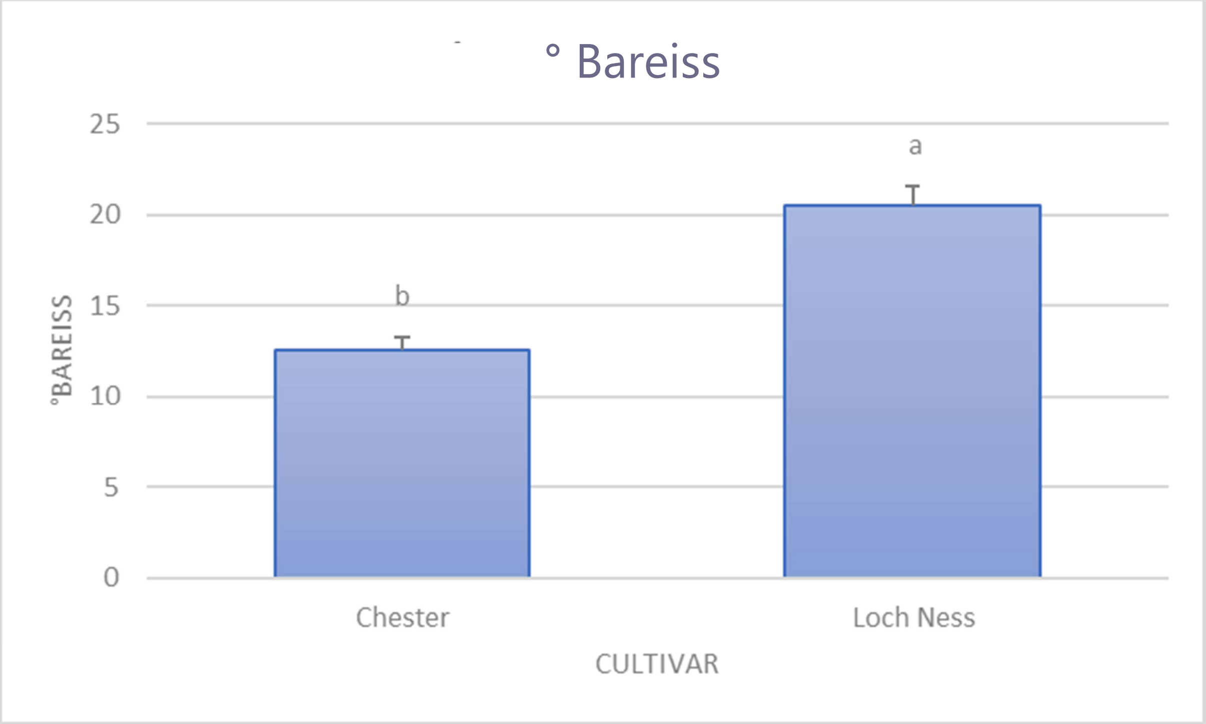


Figure 6: Firmness of blackberry fruits from the studied cultivars. Data are expressed as means and standard deviation. Different letters indicate significant difference (LSD test, p≤0.05)

3.2.3 Fruit titratable acidity and soluble solids content

The fruit acidity and soluble solids content represent the main parameters that constitute the fruit taste. For this reason, these parameters are considered of great interest both from the growers (to produce good fruits) and the consumers (whose choices are strongly influenced by the taste).

Regarding the fruit titratable acidity, the analysis performed on Chester and Loch Ness did not show a marked difference for the citric acid content (Figure 6). Maja Mikulic-Petkovsek et al. (2017) found a significant difference in citric acid content between these two cultivars, with fruits from Loch Ness showing higher values than Chester. This difference is slightly appreciable in our study, but not high enough to notice a significant variation.

About soluble solids content, the analysed berries differed in sugar quantity, with fruits of Loch Ness cultivar presenting significantly higher values than Chester (Figure 7). This different amount of sugars was clearly perceivable also by eating the fresh fruits. Our result is in line with the study carried out by Maja Mikulic-Petkovsek et al. (2017), that found fruits of Chester cultivar having lower amount of soluble solids than Loch Ness cultivar. In addition, results obtained in our research revealed a higher in sugar content than the same cultivars in the abovementioned study. The difference between the two cultivars in soluble solids content meet the results obtained also from another study, that reported fruits of Loch Ness richer in soluble solids content than Chester (Fan-Chiang & Wrolstad 2010).

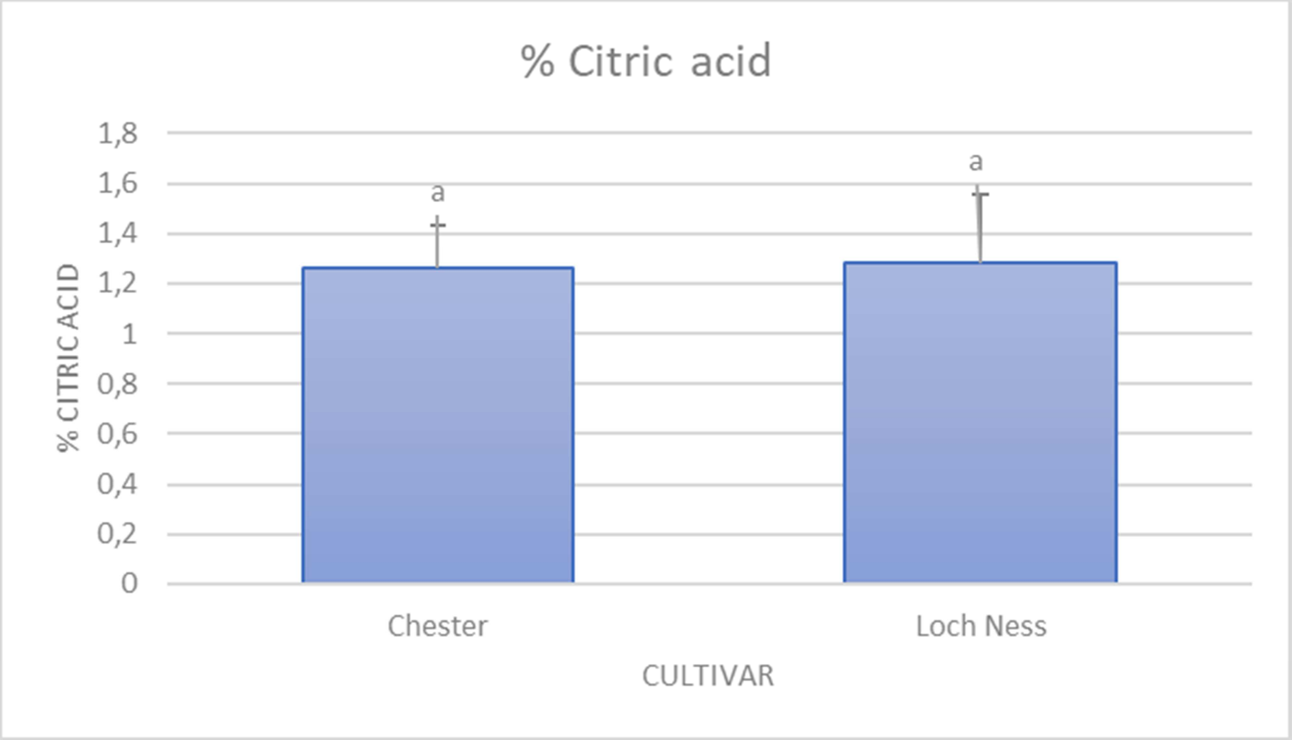


Figure 7: Titratable acidity of blackberry fruits from the studied cultivars. Data are expressed as means and standard deviation. Different letters indicate significant difference (LSD test, p≤0.05)

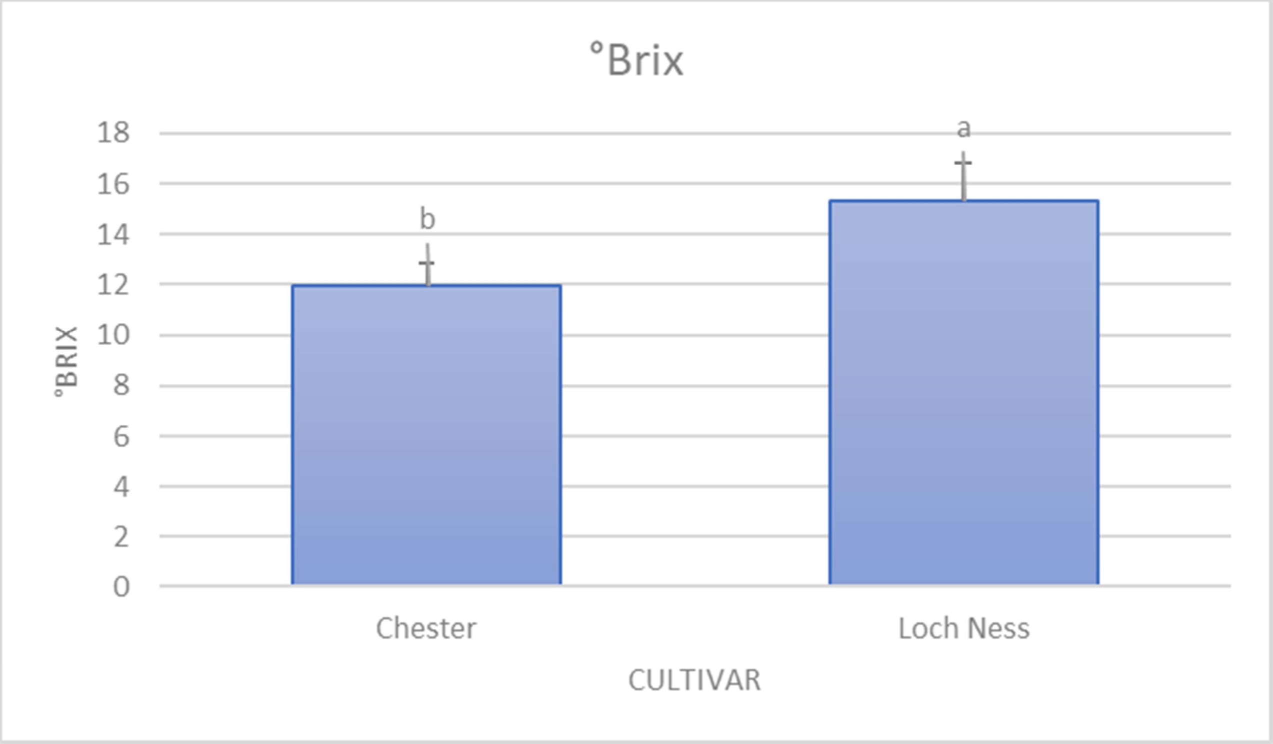


Figure 8: Soluble Solids Content of blackberry fruits from the studied cultivars. Data are expressed as means and standard deviation. Different letters indicate significant difference (LSD test, p≤0.05)

3.2.4 Total phenolic content

Polyphenols is the class of secondary compounds mainly responsible for the healthy properties of blackberries, and their evaluation represent a good index of the potential health benefits of fruits. In the present study, the total phenolic content resulted significantly higher in fruits of the cultivar Loch Ness than in Chester, suggesting a higher healthy potential for the first one (Figure 8). The difference found in phenolic content between Chester and Loch Ness is in line with the result obtained in the study conducted by Teresa Pinto et al. (2018a). Further studies confirm this significative difference in phenolic content in favor of Loch Ness fruits (Teresa Pinto et al 2018b).

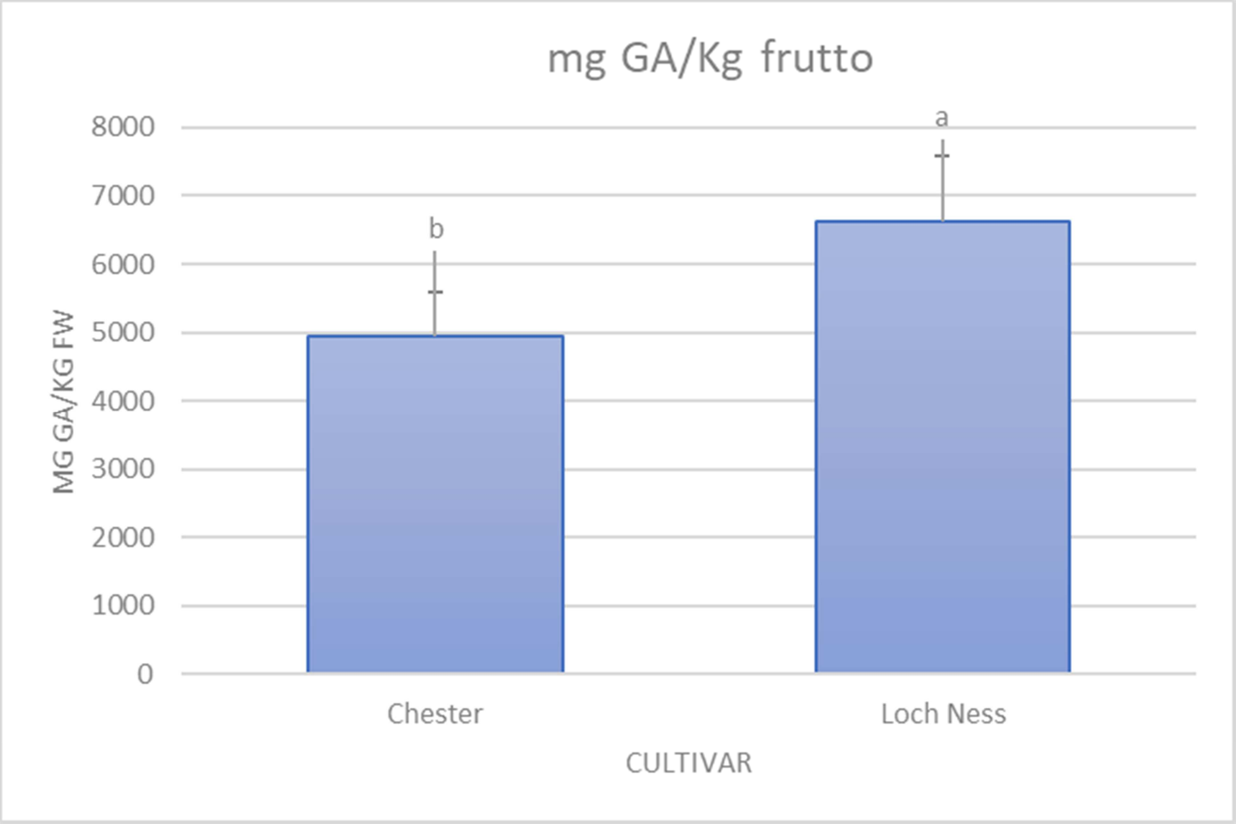


Figure 9: Total phenolic content of blackberry fruits from the studied cultivars. Data are expressed as means and standard deviation. Different letters indicate significant difference (LSD test, p≤0.05)

4 . CONCLUSIONS

Soils of “Società Agricola La Mandriola s.s.” showed a sub-alkaline reaction and a fine texture, counterbalanced by a moderate content of organic carbon. The fine particle size distribution consists in not suitable soil condition for the growth of berry plants, due to scarce soil porosity.

Nevertheless, conversely to the abovementioned pedological characteristics, the blackberry cultivation showed significant quantitative and qualitative productions. Between the two blackberry cultivars (Loch Ness and Chester) evaluated in this pedoclimatic condition, fruits of Loch Ness cultivar showed better qualitative performance, with significative higher Chroma, firmness, and soluble solids content. The fruit acidity was similar for both cultivars, and this contributed to a more balanced taste of Loch Ness fruits, combining high sugar content well equilibrated with citric acid value. A remarkable aspect relies in the nutritional quality found in these blackberry fruits, especially in relation to phenolic content, which resulted very high. This outcome can be very interesting not only for the fresh consumption of this fruit, but also for the processing step of blackberries into jam or juice; in fact, during processing, these beneficial compounds undergo degradation processes and their amount decrease, but an initial high level of polyphenols can guarantee a higher content in the final product (jam, juice).

The results obtained regarding fruit production were derived from observations made during the initial year of implantation. Since these cultivars reach the maximum production capacity after three years of cultivation, the results are preliminary. However, due to the lack of data available on this cultivar and on its suitability in literature, further analysis will be necessary during next years to test the trend and the full adaptation related to the parameter analysed.

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