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Sustainable agriculture in Ilha da Madeira - Portugal

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ABSTRACT

Ilha da Madeira is an autonomous region of Portugal located in Atlantic Ocean, in center coordinates 32º43'N 17º43'O, is considered the largest island of archipelago of the same name. The island covers an area of 740 km². The island has many climate peculiarities mainly influenced by altitude and barriers formed by sharp reliefs, and that they provide North / South axis. Climate variability existing of the island is defined in two types temperate in north and subtropical climate in south. The part of North is cooler and wetter than the south, due to winds from North and end up having a barrier relief inherent to region. Since the year of 1419, the island was subject to various economic and agricultural cycles. Actually, the agricultural occupation of the territory is predominantly winery, horticultural and fruit production. The study was conducted from January to May 2016. Data in census institutes and scientific articles were compared for discussion. The data of production, area of cultivation were intertwined with sustainable agriculture like organic farming and possibilities was available for openings boundaries according to adjustment of the culture temperature, photoperiod and precipitation, and may contribute to increase economy and quality of life in island. The agriculture of the island is formed basically by agriculture family subsistence, involving more than 45,000 people, representing 20% of Madeira population resulting only 3% of the region's economy.

Keywords: Ilha da Madeira, organic farming, permanent crops, temporary crops

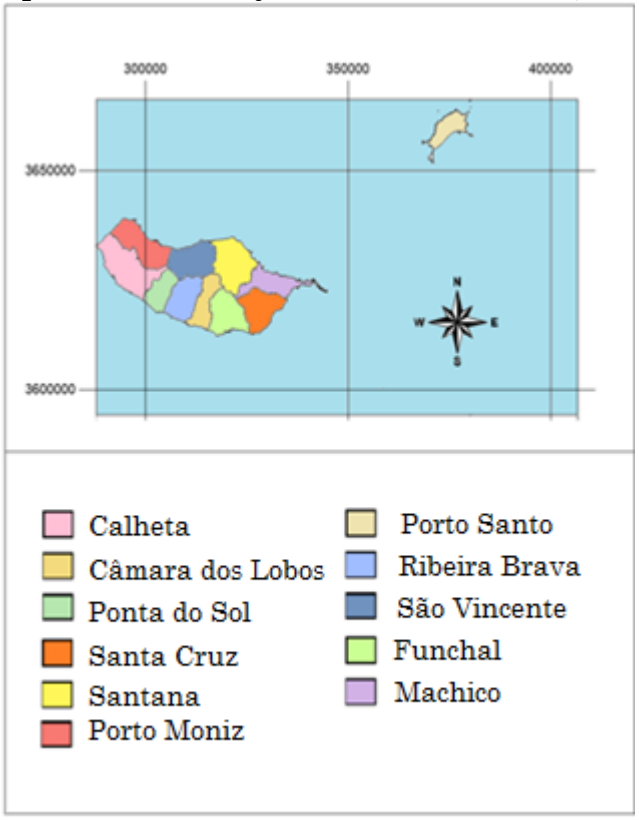
INTRODUCTION

Ilha da Madeira, is an autonomous region of Portugal located in Atlantic Ocean, in center coordinates 32º43'N 17º43'O, at 978 km southwest of Lisbon and about 700 km from the coast African. Is considered the largest island of archipelago of the same name. The island covers an area of 740 km², with a length of 57 km in the direction east - west and a width of 22 km in north - south direction. It

has volcanic formation, comprising mainly of igneous rocks and almost exclusively by basaltic rocks (ALMEIDA et. al, 2010; FREITAS, 2014; SILVA, 2013).

The districts of the island are Calheta, Câmara dos Lobos, Ponta do Sol, Porto Santo, Ribeira Brava, São Vicente, Funchal, Machico, Porto Moniz, Santa Cruz e Santana (Figure 1).

Figure 1 – Divisão municipal da Madeira. Source: Authors, 2016.



The island presents many climate peculiarities mainly influenced by altitude and barriers formed for sharp reliefs, and that they provide North / South axis. Climate variability existing north to south of the island is defined in two types: temperate and subtropical climate, respectively. The region north of the island in comparison to the south region, has more cooler and wetter, due to winds from north and end up having a barrier relief inherent to the region. At higher altitudes, decrease in temperature occurs and therefore increased precipitation (Figures 2, 3, 4 and 5). That climatic conditions show how this island is so small and at the same time provides us with different climatic aspects. Furthermore, this directly affect in agriculture (FREITAS, 2014; SILVA, 2013).

In the north of the island temperatures range between 9 and 22 ° C and the annual rainfall from 1500 to 2000mm, because they are exposed to the prevailing north-west winds. However in the south has a subtropical climate, with mild temperatures that can range from 12 to 28ºC and moderate rainfall 500 mm (FREITAS, 2014).

The average monthly temperatures of the Ilha da Madeira vary little throughout the year, being higher in the summer, especially in August and September and less between January and April, how as can be seen in (Figure 3).

Figure 2 – Temperaturas médias anuais na Ilha da Madeira. Fonte: Fernandes, 2009.

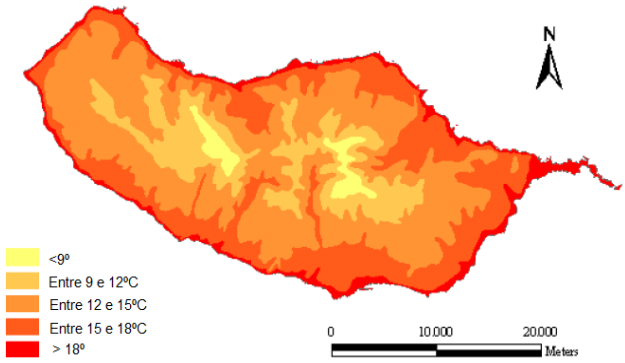


Figure 3 – Temperaturas médias mensais na Ilha da Madeira. Fonte: Climate, 2016.

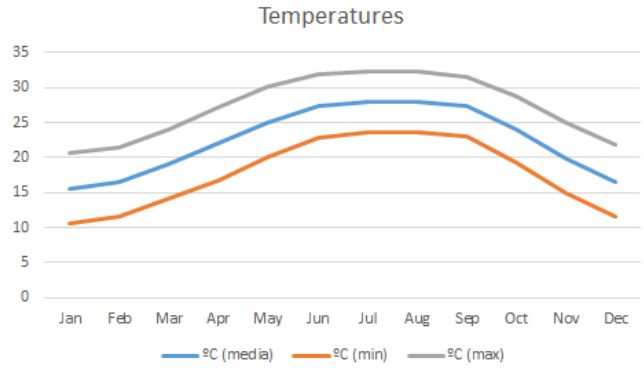


Figure 4 – Precipitação média anual na Ilha da Madeira. Fonte: Fernandes, 2009.

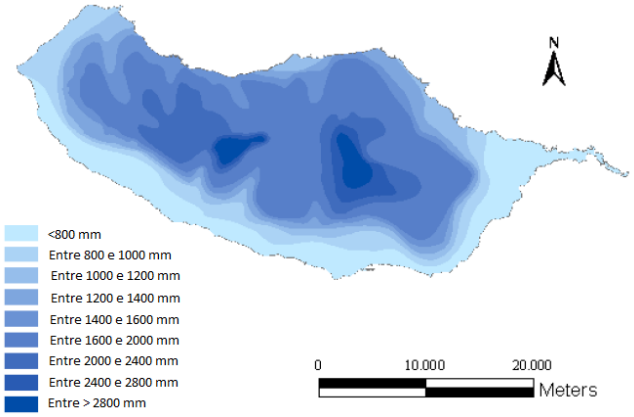
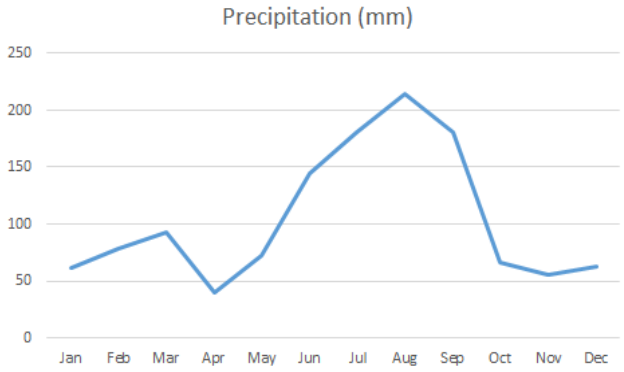


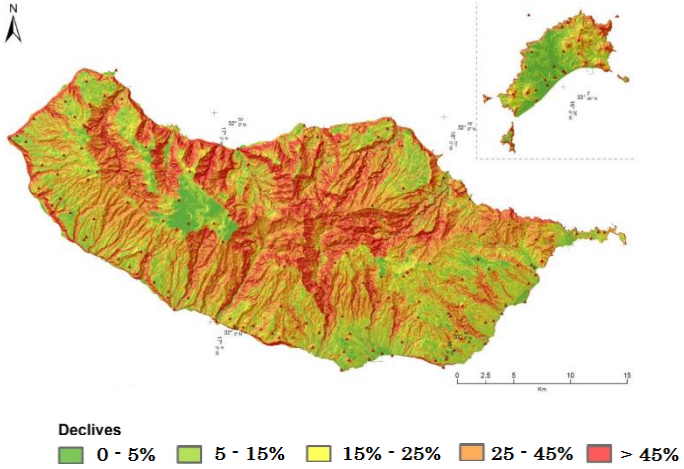
Figure 5 – Precipitação média mensal na Ilha da Madeira. Fonte: Climate, 2016.



The highest altitudes of the island are located in central region. With high levels of altitude, which have the highest altitude, the Bica da Cana, which has an altitude of 1620 meters. From central highlands towards the coast, the slopes are very steep, especially on the north coast, forming several spikes quite sharp falls (SILVA, 2013). Around 47% of the total area of the island is located above 700 m (Figure 6). Since most of the surface of the island 66% have slopes, greater than 25% and only 11.5% have slopes below 16% (Figure 7). Most of the island's agricultural land lies on the slope zone between 16 and 25% (FREITAS, 2014). Is possible seen in (Figures 6 and 7) the difference among altitude and slopes of Ilha da Madeira.

Figure 6 – Relief of Ilha da Madeira. Source: Map for free, 2016.

Figure 7 – Mapa com representação dos declives do Arquipélago da Madeira. Source: Uriel Abreu, 2015.



The Ilha da Madeira, by presenting a mountainous relief with few flat areas, which occur mainly on slopes, presents a low yield. Furthermore, traditional crops must make room for organic agriculture, which are not used pesticides, fertilizers and other forms that may be harmful to humans and the environment by polluting and can cause eutrophication. Additionally, increase soil fertility and ward off pests. These practices favor the aggregation of products values to giving, and provide a better quality of life, health, and a charm to agricultural products that is characteristic of the people and island.

This study aims to bring alternatives to increase agricultural production through increased agricultural borders and reduction of pesticides in Ilha da Madeira, Portugal.

MATERIALS AND METHODS

This study was conducted from January to May 2016. Data in census institutes and scientific articles were compared for discussion. The data of production and area of cultivation in the Island were intertwined with possibilities of sustainable agriculture, like organic agriculture and was available possibilities for openings boundaries according to climate and photoperiod requirements of culture.

RESULTS AND DISCUSSION

Since the year of 1419, the island was subject to various economic and agricultural cycles such as the culture of cane sugar. The agricultural occupation of the territory is predominantly winery, horticultural and fruit production, with particular relevance to banana crop, horticultural and greenhouse crops (AGUIAR, 2004).

The agriculture in island is basically formed by farming family subsistence, involving more than 45,000 people, representing 20% of Madeira population resulting only 3% of region's economy. Madeira Island in the years 2011, 2012 and 2013, had a production in tons and an agricultural area of strawberry, which showed no significant variation remained at 5 hectares and 175 tons (Figures 8 and 9).

The single crop tends to cause physical, chemical and biological degradation of the soil and falling crop yields. In addition to providing conditions more favorable for the development of diseases, pests and weeds (EMBRAPA, 2004). Organic agriculture provides a broad set of practices that increase resilience in farms (BORRON, 2006). Organic management practices combine traditional conservation-minded farming methods with modern farming technologies but exclude such conventional inputs as synthetic pesticides and fertilizers, instead putting the emphasis on building up the soil with compost additions and animal and green manures, controlling pests naturally, rotating crops and diversifying crops and livestock (REGANOLD et al., 2001). While techniques such as green fertilization concede recycle nutrients from the soil by plant species, furthermore, it can also have the purpose of fixing atmospheric nitrogen when employed leguminous plants (DUARTE- JÚNIOR, 2008). For the increasing production with efficient use of natural resources. Needs food systems use, like cover crop, crop rotation, organic fertilizers and adequate watering management, in addition to other techniques that are important alternatives for increasing sustainable food production, farmer profitability and environmental quality (GOMES et al., 2014). The combination of no-tillage system use of cover crops showed potential to recover organic matter content and, consequently, sequestering carbon in the soil and help to mitigate the greenhouse effect (AMADO et al., 2001).

Intercropping are characterized by maximizing space through the simultaneous cultivation, in same place, two or more species with different characteristics as to its plant architecture, growth habits and physiology (HERNANI et al., 2016). Also, provide favoring populations of beneficial organisms in the agro-ecosystem, reduced incidence of insect pests and even prevent soil erosion as well (BORRON, 2006; HOOKS & JOHNSON, 2003; IIJIMA et al., 2004; ZHANG et al., 2004). Intercropping as a technique, that comprises no-tillage system (HERNANI et al., 2016).

The no-tillage constitutes a technology that prove to contribute more for sustainable agriculture, particularly with regard to grain production. However, the success of such a system requires attention to some basic principles, among which stands out the use of crop rotation (FRANCHINI et al., 2011).

Crop rotation consists of alternating annually plant species in the same agricultural area. Having several advantages. Among them, to be consider, like a low-cost method, which promotes reduction or eradication of pathogens, helps control of weeds, diseases and pests. As well, have the possibility to be easy integrate with other methods, usually does not cause damage to the environment and provides a diversified production of food and other agricultural products. If the technic is adopt and conduct properly for a long enough period, this practice improves the physical, chemical and biological soil propriety and reduces losses by erosion due to the constant presence vegetation cover, replenish the organic matter and the work done by the root system of species, and reduce the degree of soil compaction in intensive systems. In addition, promote income diversification of ownership and increased profitability for the producer with the best use of land and labor (EMBRAPA, 2004; FRANCHINI et al., 2011; LOURENÇO et al., 2016).

The use of sustainable practices such as succession and rotation of different botanical families cultures is recommended even if you have not observed diseases in the area, as a preventive measure, because through these practices can reduce or eliminate propagules of soil borne pathogens planting a non-susceptible species. Besides being easy to adopt practices which allows to reduce production costs and environmental contamination due to the decrease in the use of fungicides, antibiotics, nematicides (LORENÇO et al., 2016)

1. Temporary crops

Temporary crops have short life span and are subject to replanting after harvest, as they are uprooted from the ground for a new planting is done (CARMO, 2015). In the island are grown as temporary culture pumpkin, lettuce, potatoes, sweet potatoes, sugarcane, onion, carrot, Cabbage - Broccoli, cauliflower, cabbage, green beans, mature beans, yams, corn for maçaroca, strawberries, turnips and tomatoes. As can be seen respectively in (Figures 8 and 9), the area cultivated in hectares and production in tons. Potato's crop was the highest acreage in hectares in the years 2011 to 2013, with an increase in the cultivated area of 13 hectares comparing the years 2011 and 2013. Therefore, was the culture with the highest production tons in those years ranging between 39.173 and 47.150 t, showing a significant increase of 7.977 t when compared to the year 2011 to 2013.

Figure 8 –Area cultivated of temporary crops, in hectares in the years of 2011, 2012 and 2013, in Ilha da Madeira - Portugal. Source: Authors, 2016.

Culturas	2011	2012	2013
Pumpkin	21	21	22
Lettuce	88	97	98
Potato	1 566	1 539	1 579
Sweet potato	460	520	541
Sugar cane	125	125	130
Onion	81	86	90
Carrot	50	40	44
Cabbage - Broccoli	53	57	57
Cauliflower	37	37	37
Cabbage	84	88	91
Green beans	9	9	9
Mature beans	75	80	82
Green bean	95	99	100
Yam	31	31	31
Corn to Maçaroca	95	100	105
Strawberry	5	5	5
Turnip	20	20	20
Tomato	189	198	179

Figure 9 –Produção de culturas temporárias, em toneladas nos anos de 2011, 2012 e 2013, na ilha da madeira. Source: Authors, 2016.

Culturas	2011	2012	2013
Pumpkin	630	504	645
Lettuce	2 640	2 904	2 933
Potato	39 173	45 954	47 150
Sweet potato	9 180	10 920	12 942
Sugar cane	5 472	5 721	5 825
Onion	2 842	3 013	3 163
Carrot	1 500	1 590	1 670
Cabbage - Broccoli	1 313	1 444	1 444
Cauliflower	1 155	1 155	1 155
Cabbage	4 200	4 410	4 101
Green beans	47	47	47
Mature beans	1 120	1 198	1 222
Green bean	1 691	1 403	1 403
Yam	628	628	628
Corn to Maçaroca	4 200	4 452	3 161
Strawberry	175	175	175
Turnip	600	600	600
Tomato	11 340	9 979	10 778

According to Lourenço (2016), vegetables of the *Brassicaceae* family like as cabbage, broccoli, cauliflower and turnips when rotated with hortalliças the *Poaceae* family, such as corn and sugar cane, provide a reduction of populations of pathogens in the soil. Moreover, the cultivation of species of the *Cucurbitaceae* family (pumpkin), or *Fabaceae* (bean) can be rotated with other plants like the families *Poaceae* (sugarcane, corn) or *Alliaceae* (onion), because in both rotations, has reduced the population of pathogens in soil.

The botanical species belonging to *Asteraceae* family for example lettuce can be rotated with species of the family *Solanaceae* (tomato, potato) or with family *Poaceae*, because according to Lourenço (2016), the *Asteraceae* family, *Solanaceae* and *Poaceae*, when rotated reduce nematode populations. That can be an alternative to reduce the use of pesticides in the island.

The Rosaceae family, which includes the strawberry, is a cultivar susceptible, the incidence of diseases that may appear at various stages of crop cycle (FADINI et al., 2004). According Coelho-Júnior (2013), the use of lichens on strawberry cultivation influence on soil microbiology decreasing the amount of fungi and bacteria, and may be an important alternative to pesticides reduction.

The culture of sugarcane allows the use of cover crops for nutrient recycling and soil protection, since sugarcane is reformed, usually after the fourth or fifth cut (DUARTE- JÚNIOR, 2008). The diversity of nematodes in sugarcane is higher than in most other cultures, more than 310 species of 48 genres endoparasites and ectoparasites (SANTANA et al., 2012). Crop rotation with non-host plants or antagonists, such as legumes, should be seen as one of the main alternatives for management of nematodes. Furthermore, to promoting a reduction in populations of these organisms and contribute to the improvement of general characteristics of the soil (ANSELMI, 2009; FERRAZ et al., 2010).

As the culture of sugar cane requires a volume of water between 1,500 and 2,500 mm in order to achieve good levels of productivity (SILVA, 2014). According to EMBRAPA (2004) considering the variation of need for water, as sugarcane development stages and the local climatic conditions, it is possible to avoid water excesses in the culture, waste and losses. According to still Duarte- Júnior (2008), the no-tillage system, with the use of legumes in coverage, for the production of sugar cane generates a significant 37% increase in productivity compared with conventional tillage and vegetation incorporated spontaneous. With the use of these techniques, agriculture of the region tends to increase production and thus improve the economy

of the region, as this sector accounts for only 3% of the local economy.

2. Permanent crops

Cultures that have a minimum of four years, are considered permanent crops, as they are subject to remain bound to the soil and provide more of a harvest or production (CARMO, 2015). On the island are grown as permanent cultivars avocado, plum custard apple, banana, chestnut, cherry, kiwi, lemon, apple, mango, passion fruit, papaya, pear, apple for cider (pêro), tangerine and vineyard. As can be seen respectively in the (Figures 10 and 11), the cultivated area in hectares and production in tons. The culture of banana in the island had the biggest agricultural area in hectares and production in years 2011, 2012 and 2013. Getting an increase of 11 hectares when comparing 2011 with 2013 and an increase in the production of 1492 tones when compared to the year 2011 with 2012 and a decrease of 1127 tons when compared to the year 2012 to 2013.

Figure 10 –Área cultivada de culturas permanentes, em hectares nos anos de 2011, 2012 e 2013, na ilha da madeira. Source: Authors, 2016.

Culturas	2011	2012	2013
Avocado	34	36	36
Plum	47	47	48
Custard apple	102	107	115
Banana	711	718	722
Chestnut	94	94	94
Cherry	63	64	64
Kiwi	10	10	11
Lemon	78	81	81
Apple	99	95	94
Mango	19	19	19
Passion fruit	14	21	22
papayas	4	4	4
Pear	24	24	24
Pero p / cider	42	50	52
Tangerine	12	13	14
Grapevine (a)	479	476	471

Figure 9 –Produção de culturas permanetes, em toneladas nos anos de 2011, 2012 e 2013, na ilha da madeira. Source: Authors, 2016.

Culturas	2011	2012	2013
Avocado	420	525	525
Plum	224	255	273
Custard apple	602	840	1 100
Banana	15 809	17 301	16 174
Chestnut	76	76	94
Cherry	232	237	237
Kiwi	150	150	158
Lemon	1 000	1 242	1 242
Apple	1 911	1 790	1 581
Mango	190	190	190
Passion fruit	140	208	137
papayas	187	187	187
Pear	349	349	349
Apple for cider	712	756	809
Tangerine	96	106	149
Grapevine (a)	34 130	43 527Rv	37 978 Po

According to Alves (2003), the use of a vegetation cover in cultivated areas of banana prevent soil erosion, weed reduces nutrient losses, and reduce production costs. The use of legumes such as beans also provide a reduction in the cost of nitrogen fertilizer, because these plants can fixing atmospheric nitrogen. Subsequently this system could be adopted in Ilha da Madeira, since banana production fell from 260 tons when compared the year 2013 and 2012.

Also according to Alves (2003), banana cultivation can also be explored in partnership with other perennial crops such as avocado and mango, as well as transient or annual crops such as corn, beans and sweet potatoes.

Apples yield varies from 25 to 35 t ha^{-1} in adults' orchards and well conducted. May vary depending on the technology used and the adopted spacing (AGUIAR et al., 2014). However, on the island had a reduction of 1 ha area intended for apple cultivation, when compared the years 2013 to 2012. Likewise, a significant descent production of 209 tons in the year 2013 when compared with 2012. As a fall about 500%

higher than the average yield per hectare estimated by Aguiar (2014). Therefore, it can be considered that is drop in productivity was not caused only by the reduction of the cultivated area. According to Peck (2006) organic yields of apple were 33% greater than either of the other systems. Furthermore, the organic and integrated apple production systems is better for soil, the environment, greater energy efficiency, produced sweeter apples and higher profits (REGANOLD et al., 2001). With the use of organic system, in agriculture of the island tends to increase production and thus improve the economy.

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