Revista GEAMA
The Journal of environment

# Strawberry farming with lichens: an alternative to the environment

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## ABSTRACT

The strawberry culture demand for labor, it requires special care to prevent pest problems. Its cultivation is characterized by indiscriminate use of pesticides, which leads researchers to seek more natural alternatives for improving soil conditions, and decreased use of chemicals. In this context, lichens can be a viable alternative, since its properties in modifying the chemical composition of the soil, addition of antimicrobial action and their insecticidal substances. The aim of work is to inform about the strawberry cultivation your climate conditions and possible use of lichens in your cultivation.
**Keywords:** *Fragaria x ananassa*, lichen, environment.

## INTRODUCTION

The strawberry belongs to the family Rosaceae, genus Fragaria. The species Fragaria x ananassa Duch. is an original hybrid by crossing two species, chiloensis F. and F. virginiana (TESSARIOLI NETO et al., 2003). The strawberry is a meaty and pseudo juicy bright red color. Has in its true fruits end called achenes (COSTA, 2012).

It is rich in fructose, sucrose, vitamin C and vitamin B complex, riboflavin, pyridoxine, niacin, minerals (magnesium, manganese, calcium, iron, phosphorus and potassium) and poor in carbohydrate. When consumed in a well balanced meal and due to the presence of malic acid, salicylic acid and citric acid, increases iron absorption rates in this vegetables, eggs and meat. It is slightly laxative and a diuretic, has Quercetin, which has the function to neutralize the action of free radicals, responsible for stress and aging cells (TACO 2006; Bason et al, 2010;. Wasim et al, 2012.).

Strawberry is a crop of great economic and social importance in many world countries, especially the United States and some European countries. However, in recent decades there have been

significant increases in production in some countries, including Latin American (VEIRA, 2001). The cultivation of this fruit in Brazil was initiated in Rio Grande do Sul, which was later brought to São Paulo, where it spread by their municipalities and other states.

The great interest in culture is its high profitability and great hand demand work, generating a significant increase economy and contributing to the process of social development (VIEIRA, 2001). For the country, the culture of revenue is around 150 million. Net revenue of R $ 41,500.00 per hectare, 40%, 45% and 15% involving the producer, partners and employees, respectively (IBGE, 2006). Brazilian production in 2006 was 3016 tons planted in an area of 376 hectares (FAO, 2011). Brazil's main producing states are Minas Gerais, Rio Grande do Sul, Paraná and São Paulo, which together have 85% of all national production. Pernambuco has 0.05% of national production (IBGE, 2006). Data published in journalism vehicles demonstrate that the municipality of Gravatá / PE have stopped much of the State strawberries production and currently is in decline. The reasons may vary productivity to storage and sales systems. So are needed Alternative ways to improve the production of this fruit, which may contribute to local development, and the need of the expansion of the agricultural frontier to regions hot weather in Brazil.

On the other hand, problems are presented as a result of strawberry crop, with emphasis on the more general, common to all cultures in the country, which is the use of pesticides and fertilizers indiscriminately. This fact encourages researchers to think about alternatives to reduce its effects, which mostly are harmful products to human health and the environment, in this context, appears natural alternatives to improving physical and chemical properties of the soil, with the possibility of reducing the quantity of nutrients to be added, as well as the herbicides, there may be lower costs, less investment and more incentives for planting.

One of the innovative ways that can be investigated is the use of mosses, living beings formed by association of algae and fungi. Are organisms that alter the properties chemical and microbial soil by leaching of its secondary metabolites (Silva et al, 2012.; Tigre et al., 2012). Thus, serve as an alternative to improve the soil conditions supporting the reduction of indiscriminate use of products toxic.

In the Northeast, several species of lichens Cladoniaceae family have been tested, in order to verify its interaction with the underlying soil. The results are promising, the which justifies the extension of this study with economic crops (Silva et al., 2012).

Because of the problem addressed and the properties attributed to lichens, this work aimed to determine the most favorable areas in the state of Pernambuco for cultivation of strawberry; and to evaluate the productivity of strawberry and their pseudofruits by use of lichens Cladonia verticillaris and C. salzmannii as inducers improving the quality of the plant. To this, it was determined with the variety of strawberry improved productivity in high temperature conditions, the influence of lichens in increased plant productivity, the physicochemical characteristics of pseudofruits with view to industrial trade, physiology and biometric characteristics of plant and microbiology from soil. Specific objectives was determined the most suitable municipalities to growing strawberry in

Pernambuco; to cultivate more adapted to the city of Recife / PE through productivity parameters and the influence of lichens verticillaris C. and C. salzmannii to climatic conditions of the city of Recife / PE through the physicochemical parameters pseudofruits, productivity, biomass, gas exchange, chemical and microbiological soil.

## REVIEW

### 1. Economic and social importance of strawberry

The strawberry is produced in various regions of the world (Oliveira et al., 2005 ), and a culture of great economic importance in many countries, especially the temperate ( VIEIRA, 2001; ROSA et al , 2013 . ) . Statistics show that the world production of strawberries in 2011 was 4,591,768 tons , occupying an area of 244,005 hectares with an average yield of 18.81 t ha- 1 ( FAO , 2011) . The producers of this fruit are the United States , Spain, Turkey , Egypt , Mexico and Russia . These countries together produced in 2011 , 2,782,587 tons , meaning 60.59 % of world production ( FAO , 2011) . Brazil ranks 53rd place in the world producing a total of 3,016 tons with productivity of 8.02 t ha- 1 ( Table 1). The main producing states are Minas Gerais, Rio Grande do Sul and Paraná ( Table 2 ), and Pernambuco is in 11th with 0.054 % of national production (IBGE , 2006).

**Table 1.** Major global producers of strawberries in 2011 .

| Posição | País | Produção (tonelada) | Área (ha) | Produtividade (t ha$^{-1}$) | Produtividade (g/planta) | Produção (%) |
|---|---|---|---|---|---|---|
| 1 | Estados Unidos | 1.312.960 | 23.260 | 56,44 | 508,46 | 28,59 |
| 2 | Espanha | 514.027 | 6.857 | 74,96 | 675,31 | 11,19 |
| 3 | Turquia | 302.416 | 11.967 | 25,27 | 227,65 | 6,59 |
| 4 | Egito | 240.284 | 5.628 | 42,69 | 384,59 | 5,23 |
| 5 | México | 228.900 | 6.978 | 32,80 | 295,49 | 4,99 |
| 6 | Rússia | 184.000 | 27.000 | 6,81 | 61,35 | 4,01 |
| 7 | Japão | 182.091 | 6.074 | 29,97 | 270,00 | 3,97 |
| 8 | Coréia do Sul | 171.519 | 5.816 | 29,49 | 265,67 | 3,74 |
| 9 | Polônia | 166.159 | 50.522 | 3,28 | 29,54 | 3,62 |
| 10 | Alemanha | 154.418 | 13.848 | 11,15 | 100,45 | 3,36 |
| 11 | Itália | 150.000 | 6.000 | 25,00 | 225,225 | 3,27 |
| 12 | Marrocos | 140.733 | 3.207 | 43,88 | 395,31 | 3,06 |
| 13 | Reino Unido | 106.890 | 4.972 | 21,49 | 193,60 | 2,33 |
| 14 | Ucrânia | 56.000 | 8.200 | 6,82 | 61,44 | 1,22 |
| 15 | França | 50.589 | 3.102 | 16,30 | 146,84 | 1,10 |
| 16 | Bielorrússia | 50.000 | 6.077 | 8,22 | 74,05 | 1,09 |
| **53** | **Brasil** | **3.016** | **376** | **8,02** | **72,25** | **0,07** |
| Todos países | | 4.591.768 | 244.055 | 18,81 | 169,45 | 100 |

Source: FAO, 2011.

**Table 2.** Main Brazilian strawberry producing states in 2006.

| Posição | Estado | Produção (%) |
|---|---|---|
| 1 | Minas Gerais | 55,706 |
| 2 | Rio Grande do Sul | 13,591 |
| 3 | Paraná | 8,672 |
| 4 | São Paulo | 6,962 |
| 5 | Espírito Santo | 6,046 |
| 6 | Distrito Federal | 5,184 |
| 7 | Santa Catarina | 3,398 |
| 8 | Goiás | 0,154 |
| 9 | Rio de Janeiro | 0,087 |
| 10 | Bahia | 0,072 |
| **11** | **Pernambuco** | **0,054** |
| 12 | Mato Grosso do Sul | 0,050 |
| 13 | Pará | 0,007 |
| 14 | Paraíba | 0,007 |
| 15 | Mato Grosso | 0,007 |
| 16 | Tocantins | 0,001 |
| 17 | Ceará | 0,001 |
| | Brasil | 100 |

Source : IBGE, 2006.

The strawberry cultivation expanded in Brazil in the 60s due to the introduction new techniques and development of cultivar Campinas (CONTI et al., 2002ab). From there strawberry cultivation spread to subtropical and temperate regions, representing an economic and social role important in the South and Southeast of the country due to the high yield per area (OTTO et al., 2009) and characterized by use intense hand labor family occupying small areas (Casian et al., 2002 and PONCE et al. 2010).

Currently domestic production is for the domestic market, mainly in getting fresh fruit, pastries, ice cream, jellies, etc. The marketing system in operation of strawberry, in horticulture and in general is quite different. normally the producer delivers its output to one or more wholesalers, which may be an entity organized by the farmers themselves (associations), middlemen and sometimes direct the important markets, usually located in cities, in central supply in local markets in urban centers, or even for those who go to the property get the product (VIEIRA, 2001).

The foreign market is underexplored but with great prospects for the future. Thus, the search for new agricultural frontiers would increase the country's revenue generating more employment, income for municipalities and states, increase in the share of GDP and generating greater social development (VIEIRA, 2001).

## 2. Origin and botanical aspects

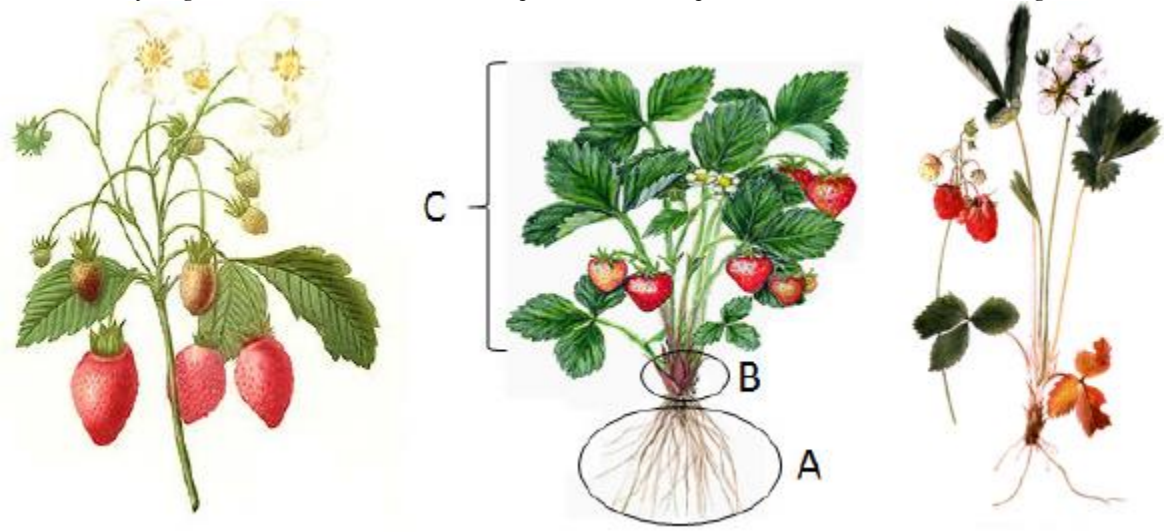
The strawberry is an old vegetable crop. Wild species have existed for 50 million years, but the species was domesticated by the fourteenth century A.D. At that time, these species were taken from the wild for medicinal purpose and garden ornamentation (VIEIRA, 2001).

There are indications that the genetic improvement of strawberry was started by Indians who inhabited Chile before its discovery, who selected wild plants pseudofruits larger sizes. The first kind of crossing works were carried out by Duchesne in 1760, while studying and characterizing the species of strawberry (CASTRO, 2004).

The strawberry (Fragaria x ananassa) is a fruit belonging to the family Rosaceae, subfamily Rosoidea, Potentilla tribe and genus Fragaria (SANHUEZA et al., 2005). Their species originated by interspecific cross of two kinds: Fragaria virginiana and F. chiloensis (Antunes et al., 2010).

The Fragaria genus (Figure 1) is classified according to the level of ploidy. The Basic chromosome number is equal to seven (x = 7). This genus comprises seventeen wild species. The species Fragaria x ananassa Duch. is octaplóide (2n = 8x = 56) (Li et al, 2010;. Castro, 2002). Studies show that the genome is considered homologous to the genome of diploid F. vesca. Borrego and Bringhurst (1990) in his work suggested the genomic formula 2A2A'2B2B 'to octaplóides F. x ananassa, chiloensis F. and F. virginiana due to cytogenetic evidence that these species are polyploid-dissômicos with meiotic behavior identical to that of diploid.

**Figure 1** - Gender Fragaria species . Left F. chiloensis in F. x ananassa center and right F. virginiana . A- Root B- and C- marrow Crown. Sources: http://www.finerareprints.com/print_detail.html?stock_no=16093(Left ) http://www.redbubble.com/people/kirke/works/285140-garden-strawberry-fragaria-ananassa-no-2 ( Centre ) http://forum.fok.nl/topic/1609790/8/25?allowcookies ( Right).

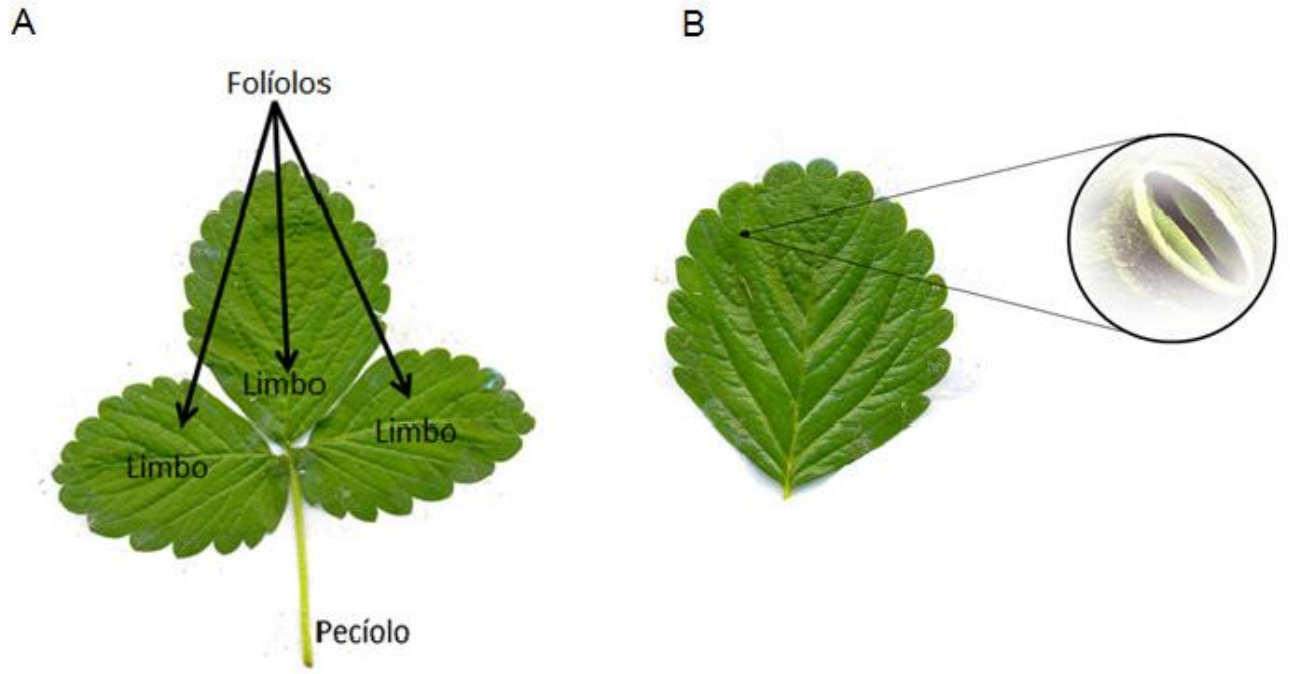



Characterized by being a herbaceous and creeping plant, its root system has fasciculate and shallow roots (CASTRO, 2002). The roots (Figure 1) and are renewable They have a length of 50 to 60 cm (Filgueira, 2000), with 90% of them are only 10 cm from the soil surface (CASTRO, 2002). The roots have fibrous appearance and arise from the crown at the base of each new leaf and are divided into primary and secondary. These They are derived from primary and have the main function of absorption of water and nutrients (BRAZANTI, 1989). As they grow older form clumps that over time will increase in size and volume (snore, 1998 and ROSA et al., 2013).

The part of the plant above ground appears is called crown (Figure 1). Some species may have a crown measuring up to 60 cm (BRAZANTI, 1989).

The crown It has a peripheral spiral conductive fabric in both directions, attached to the sheets. THE marrow is prominent and very susceptible to frost. Inasmuch as the crown ages It may originate from eight to ten new crowns. The leaves of stem helically crown (Figure 2 A and B) with shape and color varying according to cultivar. The leaves are made with three leaflets, with a petiole each (Figure 2) (Folquer, 1986). Some cultivars have 4 or 5 leaflets (Snore, 1998). The size of these may vary between 3 and 20 cm (Folquer, 1986). The leaflets are of the toothed type (Figure 2) having a large number of stomata (300 to 400 per mm 2) (Figure 2). Therefore, the strawberry is quite vulnerable to a lack of water, low relative humidity and temperatures above 25 ° C (SANHUEZA et al., 2005). Thus, each sheet is able to perspire 25 ml of water per day (snore, 1998). The limbus (Figure 2). has color ranging from light green and dark green, ranging from hair to glabrous and from bright to dull (Queiroz-VOLTAN et al., 1996).

**Figure 2** - Petiole , leaflets and limbs in strawberry leaf (A); Stomata of the leaflets of strawberry ( B). Source : http://www.brasilescola.com/biologia/celulas-guardas.htm.

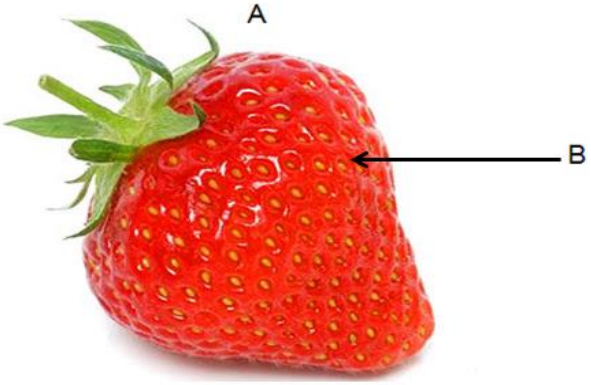



The pollination of strawberry depends on the pollen transport by wind and insects, and is an important factor for high crop production . Typically pollination in culture is deficient because pistils (female part of the flower ) with pollination problems originate deformed fruits (Figure 3 ) . The pollen is released from two to three days , from 9 hours to late afternoon . For pollination is successful , the minimum temperature should be around 12 ° C and relative humidity below 94 % . It is recommended to beekeeping near the plantation areas , especially at the beginning of flowering, emphasizing the practice in bad times for activity of bees in low temperature (SANHUEZA et al . , 2005) .

**Figure 3** - Pistil of strawberry . Source : http://www.baixaki.com.br/papel-de-parede/18614-flor-de-morango.htm.


The fruits of the strawberry are the achenes (Figure 4) of brown color , hard , very small and in large quantity involving fleshy and juicy piece called pseudofruit ( CAMARGO and STEPS , 1993, Steps , 1994) , which has red coloring intense increasing from the inside to the outer part .

**Figure 4** - the pseudo strawberry ( A) with achenes and fruits indicated ( B).




Source : http://frutano.com.br/produto/morango

### 3. Climatic aspects

The strawberry cultivation requires great care and good planning for planting. It is strongly influenced by temperature and photoperiod, and this exerts less influence (Verheul et al., 2007). Besides these two factors, others are also important, but less expressive as: precipitation, dew point, humidity and relative light intensity. These other factors are less significant because the crop is carried in tubes, and drip irrigated strawberries (RESENDE, 2001). The requirement of photoperiod and temperature varies widely according to each cultivar. These variants directly influence the plant development stages as growing, seedling production, flowering and fruiting (SONSTEBY and HEIDE, 2008; Opstad et al., 2011).

Each cultivar requires a number of hours of light necessary to get a good crop growth and good productivity. For the development vegetation is essential to heat (Resende, 2001;. ROSA et al, 2013), while the seedling production requires temperatures above 25 ° C associated with long days (VILELA JUNIOR et al., 2004; KUMAR et al., 2011). The favoring of flowering and fruiting is considered optimal at temperatures below 15 ° C, while above 25 ° C are disadvantaged (ANTUNES et al, 2006;. Resende, 2001). According Ledesma et al. (2007) and Rose et al. (2013), reproductive development of strawberry is more sensitive to high temperatures than the vegetative growth because fertility of the plant decreases considerably as the temperature increases. Very cold weather, the strawberry in general, is a fruit not very tolerant of Temperatures above 25 ° C (Antunes et al., 2006), acid is excessively low in flavor, aroma and with less consistency. In the case of mild temperatures, the strawberries are firm with pleasant taste and aroma (FILGUEIRA, 2000). Nevertheless, depending on the cultivate, can adapt to high temperature locations (above 25 ° C) and humidity relatively low (RESENDE, 2001). The first study on the resistance to high temperatures was made by Darrow (1966) which considered the Blakemore and Missionary cultivars resistant to heat. Archbold and Clement

(2002) found that the high temperature was in favor of Fragaria virginiana, wild species that gave rise to the current strawberry, from the east of America North.

Ledesma et al. (2007) reported that in medium and high temperatures, around 18/23 ° C and 25/30 ° C (day / night), the number of inflorescences was significantly lower, as well as the number of days for maturation of the pseudo compared to milder temperatures as temperate climate. Besides the decrease of flowering, ripening is quite short and its production decreases considerably. The cultivar Toyonoka is quite sensitive to high temperatures, it reduces production of flowers more than half as grown in elevated temperatures. Temperatures above 30 ° C encourage deformation, weight reduction and production the pseudo. Mori (1998) found that at temperatures between 27 and 32 ° C there is reduced amount of achenes per fruit.

In relation to the weight of the fruit, temperature 18/23 ° C responded better than temperature 25/30 ° C. The diameter of the strawberry was very affected at high temperatures 25/30 ° C over a temperature 18/23 ° C (night / day). It was also found that high temperature reduced the length of the fruit. Cultivar Toyonoka subjected to temperature high production had greatly compromised in the number of fruit diameter, length and weight (LEDESMA et al., 2007).

Wang and Camp (2000) proved that the weight of strawberries decreases with increasing temperature, but there was no significant difference between the Earliglow and Kent cultivars.

These authors found differences in the composition of the lipid membrane in some cultivars exposed to high temperatures. According Ledesma et al. (2007), the optimum temperature for crop development is found mainly in temperate countries ranging between 10 and 26ºC, but the culture responds well to tropical regions of high altitude such as the Philippines that has temperature ranging between 12 and 26 ° C (Days et al., 2007).

In addition to adapt better in the South, strawberry also fits in the south of Minas Gerais, other states in the Southeast and in non-traditional areas of hot weather as the North of Minas Gerais (Casian, 2002; Dias et al., 2007).

## 4. Strawberries production in non-traditional areas

The strawberry is a culture that can be grown in various aspects of climate and ground. The most favorable climate is temperate, but there are cultivars that produce within the satisfactory conditions in the subtropics and yet even in tropical regions (KUMAR et al., 2011). The planting season varies according to region. In general, for tropical plant is from January to May (Resende, 2001).

With the advancement of breeding cultivars have been developed in order to increase their adaptation and production at higher temperatures and humid climates. Starting hence, considered non-traditional areas (temperatures above 25 ° C) to the strawberry culture began to join the practice, primarily due to higher profitability It offers. The pioneering tropical regions were Bauru in São Paulo and Norte de Minas Gerais These regions are being developed research intensified to improve the culture implantation (DIAS et al., 2007).

In 2002, researchers from CTNM - North Technology Center of Mines EPAMIG - Agricultural Research MINAS GERAIS they began research aimed at analyzing the strawberry behavior in semi-arid state. In the same year work on the adaptation proved to be very satisfactory. At Sweet Charlie

cultivars Dover and 53 yielded t ha-1 and 46 t ha-1, respectively. These yields were higher than some traditional states in strawberry production, keeping the fruits within the standards of quality and pesticide free (DIAS et al. 2007).

In 2004, started a pioneering research project in order to assess the strawberry behavior submitted to organic production system in Center- West and North of Minas Gerais, where it was concluded that it is feasible that production in both regions.

The cultivars used were Sweet Charlie and Dover, the results presented yield averages 40 and 35 tha-tha 1-1, respectively (Dias et al., 2007). Starting from data analyzed these two projects could be concluded that the first survey showed higher productivity than the second, probably due to fertilization conditions (Dias et al., 2007). So one of the key points in the implementation of culture in the region of interest is the management and the selection of appropriate cultivar.

## 5. Production in Pernambuco

Through reports from local farmers and researchers , little is known about the Current production in the state of Pernambuco. It is known that in 2006 the production state represented 0.05 % of national production (IBGE, 2006) and that it is declining , reaching at certain times to zero. The low local productivity , incidence of pests and diseases, little study of cultivation in the region and little incentive to culture they may have been factors that have influenced the culture Agronomic failure .

## 6. Lichen and soil

Lichens are being resulting from a symbiotic association between fungi (Mycobiont) and algae or cyanobacteria (photobiont) (Margulis and Schwartz, 2001). They appear as a very diverse group, it is estimated that the quantity of species varies 13500-17000 (VALENCIA and CEBALLOS, 2002). Cyanobacteria, key agencies in many forest ecosystems, are presents around 10% of liquênicas species (Arsenault and Goward, 2000). They They play an important role in nitrogen fixation and nutrient cycling, depending these elements coming from the environment where they live, for your metabolism and development (NASH III, 2008). However, it is noteworthy that, so there is a growing typical of stems, levels of essential elements must be within precise limits (Legaz et al., 2006). The lichen community develops on various substrates and environments, many sometimes in places where other bodies would not be able to survive. Set in trunks and branches of trees (corticicolous) on leaves (foliícolas), rocks (saxicol) and, virtually any type of substrate provided that they are stable there for some time. They can also colonize extreme environments where temperature and humidity (Lemos et al., 2007). Contact algae / fungus facilitates the transfer of nutrients and photosynthesis products photobiont to mycobiont. This requires high amount of sugar produced from algae photosynthesis to biotroficamente derive their carbohydrates and phenols, known as liquênicas substances. This association takes on considerable importance in practice because increases markedly the availability of nutrients captured by lichen (NASH III, 2008). The liquênicas substances influence enough in the chemical and microbial soil. Thus, various nutrients in the presence of such substances may be transformed into other compounds leached or absorbed (NOBREGA et al., 2012). As a prime example has been the nitrogen volatilized when the soil can be lichens absorbed by

increasing its metabolism and production of phenols which can vary chemical composition of the soil (and CASTRO BARROS, 1999). Substances of lichens They have the ability of complexing with cations of the mineral substrate, so participating directly in the weathering of rocks. The ability to chemically modify the rocks through weathering, is a function of the type and amount of metabolites side, according to a study carried out with six different species of lichens (and PURVIS Halls, 1996).

Cladonia verticillaris (Raddi) Fr. is a lichen that occurs on sandy soils trays in vegetation type cerrado, the states of Paraiba and Pernambuco, northeast Brazil. Studies have shown that this species releases its metabolites to the underlying soil, interacting in nutrient cycling and modifying the chemical composition of the substrate and favoring the development of seedlings (Silva et al, 2012;. TIGRE et al, 2012.; WENSUO, 1996).

According to Silva et al. (2012) phosphate added to the soil modifies its composition chemistry, and this element can change the C. verticillaris metabolism in the synthesis of secondary metabolites. C. The verticillaris substances interact with soil minerals underlying, increasing the capacity of cation exchange and the availability of hydrogen, maintaining acidic pH. It is widely described in the literature that have stable soil lichens liquênicas substances that allow the occurrence of allelopathic phenomena, namely, effect direct or indirect such substances in other organisms (Legaz et al., 2006). It is suggested the usnic acid has allelopathic action (YANO et al., 1999) as well as acids protocetrárico and fumarprotocetrárico C. verticillaris (TIGRE et al., 2012), but little is known about its mechanism of action. Furthermore, lichens, through its substance, can affect the growth and reproduction of soil microorganisms, or even inhibit germinating seeds located in the soil profile (Giordano et al., 1999). For another side, and STARK HYVÄRINEN (2003) demonstrated that liquênicas substances acids and usnic perlatólico produced by Cladina stellaris, rather than exercising effect allelopathic can be carbon source for soil microorganisms. Thus, Lichens can affect soil microbiota in different ways (SEDIA and EHRENFELD, 2005).

According to Melo (2011), the sort Cladonia salzmannii, the amount of acid barbático produced by lichen stalk is directly proportional to the amount of this leached soil substance. Increases occur at pH values of C and N contents, and observed important contribution to the improvement of soil properties due to the presence of lichens of the species.

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