Incaper
Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural

CONILON COFFEE

Production Techniques with Improved Varieties

TECHNICAL CIRCULAR Nº 03-I

ISSN Nº 1519.0528

Incaper
Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural

CONILON COFFEE

PRODUCTION TECHNIQUES WITH IMPROVED VARIETIES

4th Edition – Revised and Updated

Romário Gava Ferrão
Aymbiré Francisco Almeida da Fonseca
Maria Amélia Gava Ferrão
Abraão Carlos Verdin Filho
Paulo Sergio Volpi
Lúcio Herzog De Muner
José Antônio Lani
Luiz Carlos Prezotti
José Aires Ventura
David dos Santos Martins
Aldo Luiz Mauri
Eugênia Maria Gama Marques
Francisco Zucateli

Vitória, ES
2012

Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural
Rua Afonso Sarlo, 160 – Bento Ferreira – CEP 29052-010 – Vitória - ES - Brazil - Caixa Postal 391
Telefax: (55) (27) 3636 9866 – 3636 9846 – coordenacaoeditorial@incaper.es.gov.br – www.incaper.es.gov.br

Technical Circular nº 03-I – 4th edition (Revised and Updated)
ISSN 1519-0528
Editor: DCM/Incaper
Print run: 2.000
May 2012

Graphic design, desktop publishing and cover: Laudeci Maria Maia Bravin e Thiago Farah Cavaton
Revision of Portuguese version: Raquel Vaccari de Lima Loureiro
Translation: Peter Ward Inglis
Cataloguing: Meirelen Frasson da Silva
Photos: Authors and Incaper archives

This work used the resources of the Coffee Research Consortium.

CDD 633.73
F368c
2012

FERRÃO, R. G. et al.
Café Conilon: Techniques for Production with Improved Varieties. 4. ed. Revised and Updated, Vitória, ES: Incaper, 2012.
(Incaper: Technical Circular, 03-I)
74p.

ISSN 1519.0528

1. Conilon Coffee 2. Coffea canephora – Production Techniques 3. Coffee – Genetic Improvement 4. Coffee – Varieties I. FERRÃO, R. G.; II. FONSECA, A. F. A. da.; III. FERRÃO, M. A. G.; IV. VERDIN FILHO, A. C.; V. VOLPI, P. S. VI. DE MUNER, L. H.; VII. LANI, J. A.; VIII. PREZOTTI, L. C.; IX. VENTURA, J. A.; X. MARTINS, D. dos S.; XI. MAURI, A. L.; XII. MARQUES, E. M. G. XIII. ZUCATELI, F. XIV. Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural XV. Título XVI. Série

ACKNOWLEDGEMENTS

To all those who, in some way, contributed to this work, especially the researchers and extension agents who were involved in the technologies and knowledge presented in this publication; the agricultural technicians, Alonso José Bonisson Bravin, Tragino Paulo Henrique, José Luiz Tóffano and Aldemar Polonini Moreli, who carried out high quality field work with rigor; researchers and peer reviewers for their suggestions, for their prompt and continued attention.

To the Coffee Research Consortium, which has contributed effectively in the development of coffee in Espirito Santo state and Brazil.

FORWARD

Among the low-cost technologies produced by the Espirito Santo Institute of Research, Technical Assistance and Rural Extension (Incaper), aimed at improving productivity and product quality and, consequently, the efficiency of Conilon coffee plantations; within the breeding program, the development of varieties stands out.

The improved variety, in isolation from other production practices, provides no guarantee of success in the activity of the coffee producer. Thus, the grower must be ready to seek and use information generated by research in different areas of knowledge, especially those relating to the coffee business.

This publication, in its fourth edition, has the primary purpose of providing technical recommendations for Conilon coffee production in Espírito Santo state, especially the information generated by Incaper; in order to provide suitable conditions for the improved varieties of the Institute to express, viably, their capabilities and characteristics. To this end, the following issues were addressed: improved varieties, plantlets and the management of nurseries, choice of site and land preparation, spacing and planting density, planting in rows, liming and fertilization, pruning and disbudding, soil conservation, control of weeds, irrigation, pests and diseases, harvesting, drying, processing and storage.

The information is of fundamental importance for the guidance of technicians and producers, aiming to increase the competitiveness of Espírito Santo coffee in the Brazilian and international scenario.

The revised and updated edition of this publication is a technical action to celebrate **One hundred years of history and evolution of Conilon coffee in Espírito Santo – Brazil**, as a central theme of the International Conference on *Coffea canephora*, held on the 11th to 15th of June 2012, in Vitória, Espírito Santo.

The Directors

INDEX

CONILON COFFEE
PRODUCTION TECHNIQUES WITH IMPROVED VARIETIES

Romário Gava Ferrão[1]
Aymbiré Francisco Almeida da Fonseca[2]
Maria Amélia Gava Ferrão[3]
Abraão Carlos Verdin Filho[4]
Paulo Sergio Volpi[5]
Lúcio Herzog De Muner[6]
José Antônio Lani[7]
Luiz Carlos Prezotti[8]
José Aires Ventura[9]
David dos Santos Martins[10]
Aldo Luiz Mauri[11]
Eugênia Maria Gama Marques[12]
Francisco Zucateli[13]

1. INTRODUCTION

Conilon coffee (Coffea canephora Pierre ex Froenher) is the coffee species most planted in Espírito Santo, and is cultivated at about 40 000 properties, especially on family farms. About 657 million coffee trees in production are planted on 300,000 hectares and provide an average yield of 30.33 sacks per hectare. The state produced 8.5 million sacks of coffee in 2011, representing 20% of national production, 6.3% of world production, 76% of Brazilian Conilon, and 17% of world Robusta production.

The Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (Incaper) (Espirito Santo Institute of Research, Technical Assistance and Rural Extension) established, from 1985, a coffee research program, starting with the area of genetic improvement, which was later extended to other research areas, such as plant physiology; soils and nutrition; soil conservation; biological

1 Engº Agrº, D.Sc. Genética e Melhoramento, Pesquisador do Incaper, romario@incaper.es.gov.br
2 Engº Agrº, D.Sc. Fitotecnia, Pesquisador Embrapa Café/Incaper
3 Engª Agrª, D.Sc. Genética e Melhoramento, Pesquisadora Embrapa Café/Incaper
4 Adm. Rural, M.Sc. Produção Vegetal, Pesquisador do Incaper
5 Adm. Rural, BSc. Práticas Agrícolas, Pesquisador do Incaper
6 Engº Agrº, D.Sc. Recursos Naturais e Sustentabilidade - Agroecologia, Extensionista do Incaper
7 Engº Agrº, M.Sc. Solos e Nutrição de Plantas, Pesquisador do Incaper
8 Engº Agrº, D.Sc. Solos e Nutrição de Plantas, Pesquisador do Incaper
9 Engº Agrº, D.Sc. Fitopatologia, Pesquisador do Incaper
10 Engº Agrº, D.Sc. Entomologia, Pesquisador do Incaper
11 Engº Agrº, D.Sc. Fitotecnia, Pesquisador do Incaper
12 Engª Agrª, Pesquisadora aposentada do Incaper
13 Engº Agrº

control of coffee berry borer; spacing, pruning and disbudding; irrigation and its management; vegetative multiplication; molecular biology; pests and diseases; production of plantlets; and post-harvest processing, among others. It is noteworthy that many studies have been done in partnership with other research institutions, universities and farmers' organizations. These studies have generated many technologies and information that have contributed to enlarge the knowledge base in the species, Coffea canephora.

The availability of these results, together with the work of technology transfer, has contributed significantly to the professionalization of the coffee growers, leading many to attain crops yields higher than 50 sacks/ha without irrigation, and 100 sacks/ha in irrigated plantations; both with superior product quality.

The existing genetic variability on plantations was the original basis for planning the breeding program. The plants with superior agronomic traits were selected in several municipalities and experimentally evaluated under different environmental conditions. As a result, other strategies for improvement were implemented, such as the maintenance, expansion and characterization of the genetic base, and the recombination of superior germplasm (ferrão et al., 2007c).

In the first phase of this program, the results of development work allowed us to recommended six improved varieties for the State of Espírito Santo: 'Emcapa 8111', 'Emcapa 8121', 'Emcapa 8131', 'Emcapa 8142 – Robustão Capixaba', 'Emcaper 8151 – Robusta Tropical' and 'Vitória Incaper 8142'. These improved Conilon coffee varieties were the first to be developed, recommended and officially registered in the country (BRAGANÇA et al., 1993; FERRÃO, R.; FONSECA; FERRÃO, M. 1999; FERRÃO, R. et al., 2000ab; 2007ab; FERRÃO, M. et al., 2011; FONSECA, 1996; FONSECA; FERRÃO, M.; FERRÃO, R. 2002; FONSECA et al., 2004).

In recent years, the implementation or substitution with Conilon coffee, in the process of renewal of plantations, and has been predominantly made with the aforementioned varieties, whose use, coupled with the adoption of other technologies that were introduced in parallel to production systems, as shown in Figure 1, has occurred particularly in Espírito Santo in the Brazilian scenario and internationally, in relation to the production of Robusta coffee.

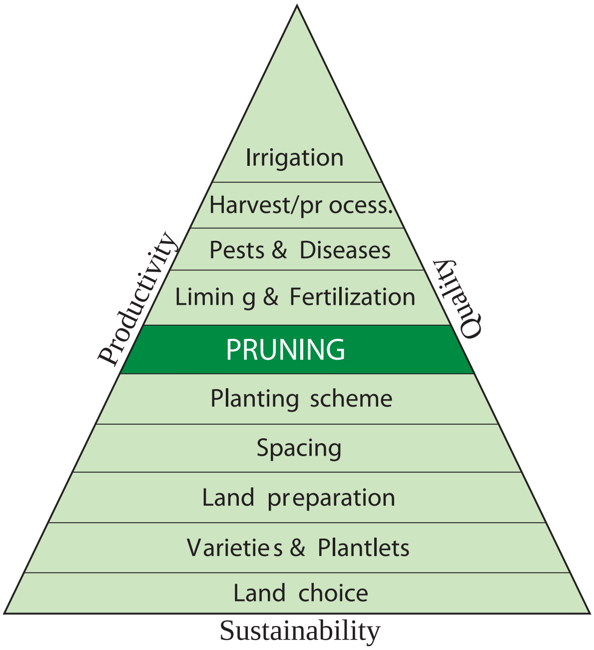


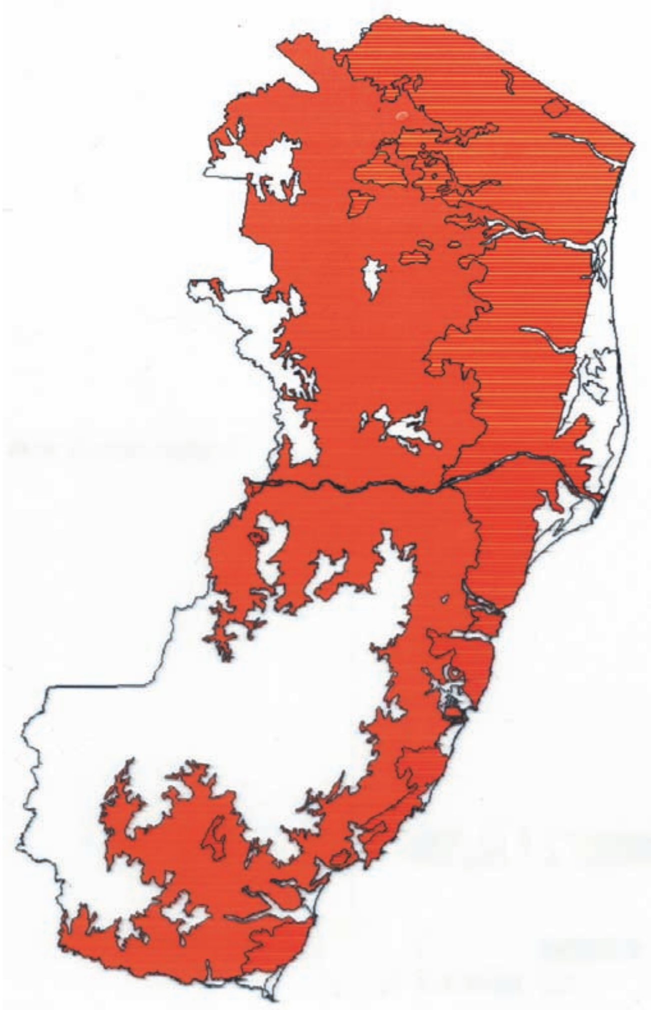
Figure 1. Production pyramid of Conilon coffee indicating the principal technologies.

The purpose of this publication is to describe, based on the results of scientific research and the experience of professionals working in the coffee industry, technical recommendations suitable for the cultivation of improved varieties of Conilon coffee, in order to enable them to fully express their characteristics. This will be based on a description of the varieties mentioned and on suitable production technologies that can promote the expression of their genetic potential for production and coffee quality.

2. CHOICE OF SITE

The planting site must be carefully chosen, since coffee is a perennial crop, and mistakes made in its implementation may jeopardize the success of the crop. Planting in unsuitable places, hinders the establishment and management of the plantation, decreases the profitability of the producer, and, by compromising productivity levels, raises production costs and affects the longevity of the crop.

The site must meet the requirements of the crop in relation to soil fertility, growing conditions, altitude, climatic conditions, including rainfall and its distribution, temperature and winds. To this end, the location of the plantation in the State must be inserted in regions suitable for the cultivation of Conilon coffee (DADALTO; BARBOSA, 1997; taques; dadalto, 2007), where the mean annual temperature should be between 22° and 26° C, be of less than 500 meters in altitude, and show no pedological impediment, including annual hydric deficit of over 350 mm, with poorly distributed rainfall (Figure 2).



Source: Dadalto; Barbosa (1997).

Figure 2. Areas suitable for Conilon coffee cultivation (red) in Espírito Santo State.

The soils best suited for the deployment of plantations are deeper ones, with easy outflow and medium texture. It is recommended to avoid flat areas subject to flooding, even if only temporary, and very sandy soils, more prone to erosion.

3. VARIETIES

Conilon coffee is an allogamous plant, 100% cross-pollinated, caused mainly by gametophytic self-incompatibility, which prevents self-pollination or crossing between plants that have the same genetic makeup. In this way, the components of the same clonal variety must be compatible, and need to be pre-tested through controlled crossings.

This incompatibility system is governed by a gene called "S", and the joint presence of these alleles in different "individuals" impedes outcrossing, and in consequence, fruit production (BERTHAUD, 1980, LASHERMES *et al.*, 1996). The procedure for verifying the possibility of interbreeding between two "individuals" is the achievement of controlled crosses among all clones (two by two), for subsequent groups of the same variety, eliminating the group of clones that express any incompatibility with respect to others.

Due to this natural form of cross-fertilization, the natural populations, as well as those produced from seed, even if collected from a single mother plant, are characterized by a high level of heterozygosity, causing great variability among plants in natural populations of the species. Thus, the traditional plantations, propagated sexually (seeds), show great heterogeneity, with plants of very different aspect, including architecture of the shoot, shape and size of coffee bean, timing and uniformity of fruit maturation, susceptibility to pests and diseases, drought tolerance, vegetative vigour, and productive capacity, among other characteristics (FERRÃO, R. G.; FONSECA, A. F. A. da; FERRÃO, M. A. G., 1999; 2000; FONSECA, 1996; 1999).

The structure of the program of genetic improvement of Conilon coffee of Incaper, considered the genetic variability of the species *Coffea canephora*, its form of reproduction and the possibility of asexual multiplication of superior genotypes, and the need to obtain material possessing adaptation to different environments and stability of production, among other attributes. For this, improvement methods were used simultaneously with the aim of obtaining superior materials, propagated by cloning and by seeds.

The main characteristics of varieties launched and recommended for the State of Espírito Santo are presented as follows (FERRÃO *et al.*, 2007ab; FERRÃO *et al.*, 2011).

3.1 'EMCAPA 8111'

Clonal variety released in 1993, formed by a group of nine clones compatible with each other, of early and uniform maturation, with harvest in April / May. The first four, non-irrigated crops, yielded on average 58.0 sacks of processed beans per ha, and average sieve of 14.

3.2 'EMCAPA 8121'

Clonal variety released in 1993, formed by a group of fourteen clones compatible with each other, of intermediate and uniform maturation, with harvest in June. The first four non-irrigated crops, yielded an average of 60 sacks per / ha of processed beans with average sieve of 15.

3.3 'EMCAPA 8131'

Clonal variety released in 1993, formed by a group of nine clones compatible with each other, of late maturity, with harvest between July and August. The first four non-irrigated crops, yielded an average of 60 sacks per / ha of processed beans with average sieve of 14.

The use of these first three varieties (Figure 3) permitted the scheduling of harvests and optimized the use of labour, particularly for family-based producers at harvest time, and for fruit drying and bean processing.

Figure 3. First improved clonal varieties from Incaper: ‘Emcapa 8111’ (A), ‘Emcapa 8121’ (B), ‘Emcapa 8131 (C), with early, intermediate and late maturation, respectively.

3.4 ‘EMCAPA 8141 - ROBUSTÃO CAPIXABA’

Clonal variety launched in 1999, formed by a group of ten clones, compatible with each other, possessing the principal characteristic of drought tolerance. In the first four harvests, in two regions with elevated hydric deficit, an average yield of 53.0 sacks of processed beans per ha, with average sieve of 14 was obtained (Figure 4).

Figure 4. Demonstration plot with variety Emcapa 8141 – Robustão Capixaba, planted in rows.

Recommended primarily for cultivation under non-irrigated conditions, particularly in regions of hydric deficit, or if the producer has economic problems or there is lack of water on the property, thus not allowing the use of irrigation.

It is also recommended that the component clones of this variety are planted in rows, in order that the maturity of each occurs at different times between May and July. This practice ensures that the separate harvests do not detract from the quality of the final product. The technical details of the planting scheme are found in section 8.1 of this publication.

3.5 'EMCAPER 8151 – ROBUSTA TROPICAL'

Variety propagated by seed, and launched in 2000, produced in an isolated field by random recombination by pollination of 53 elite clones from the improvement program, that Incaper has identified so far. Possesses average productivity, and the first four harvests yielded 50.3 sacks of processed beans per ha. Because of its hardiness and yield stability, it is recommended, preferably, for family-based producers, with restricted financial resources for the adoption of technologies, such as the purchase of cloned plantlets that have higher cost.

3.6 'VITÓRIA INCAPER 8142'

Clonal variety launched in May 2004, formed from a group of thirteen clones. To compose this variety, we selected clones that had a set of features of interest, with emphasis on productivity and yield stability, drought tolerance and resistance to rust (Figure 5). The average productivity in eight non-irrigated crops was 70.4 sacks of processed beans per ha; about 21% superior to the other improved Incaper varieties.

Because the clones that make up this variety have different maturation times, the planting of the clones must be in rows, in a similar way to the Robustão Capixaba variety, whose details are in item 8.1.

The improved clonal varieties have achieved yields higher than 120 sacks of processed beans per ha, in different farms in the State of Espírito

Santo, when grown correctly following technologies generated by research. These varieties are recommended for growers who can use the technologies adequately.

Improving the quality of the final product is among the priorities of research in genetic improvement carried out with Conilon. To evaluate the genetic variability of bean biochemical and sensory components, of the clones that make up the six coffee varieties released by Conilon Incaper (stinger et al., 2007a), bean samples of 53 elite clones of the improvement program of the institute were sent to Nestlé (France). The results showed the presence of variability in the genetic materials, and 85% of the clones that make up the previously released cultivars showed positive attributes of interest to industry regarding the components studied (Lambon et al., 2008).

Figure 5. Clonal variety Vitória Incaper 8142.

3.7. CLONAL VARIETY: GENETIC INCOMPATIBILITY AND STABILITY OF ESPIRITO SANTO COFFEE CULTIVATION

The selection of clones that form part of each Incaper clonal variety was based on some preliminary agronomic criteria considered most relevant; among them: productivity, plant architecture and vigour, susceptibility to pests and diseases, uniformity of fruit ripening and concentration of ripening at different times, yield stability, size and percentage of sterile cherries, ratio of weight of cherry to processed bean, as well as studies of genetic compatibility through controlled crosses between them.

In such cases, interest is focused not only on an isolated characteristic, but also on the simultaneous manifestation of many of them. To this end, clones are grouped according to the characteristics that they have in common, to equip each of the new varieties homogenous characteristics, especially those that are the objectives of each work of improvement. Thus, each clonal variety has a set number of clones that only together express the production potential, yield stability, and crop longevity, besides maintaining a broader genetic base.

It is essential that producers do not exclude individual clones of the variety they deem inferior, thus degrading the cultivar. This attitude gradually compromises the stability of the species.

The segments of the coffee business need to be watchful and imbued with the commitment to enhance the maintenance of the genetic makeup of each variety, especially clonal varieties, since each component clone is included for a reason and has a defined role within the developed cultivar.

It is important for the long-term survival of the activity that there is genetic variability in the material grown, because within the variability, it is possible to find individuals with desirable characteristics, and that the genes which confer good characteristics can be incorporated into commercial materials.

Thus, the cultivation of crops with a limited number of clones, especially in relation to their genetic constitutions, which can only be assessed by detailed studies, generates, over time, the problem called genetic erosion and genetic vulnerability, a problem that worries most geneticists and plant breeders of different species grown throughout the world.

4. PLANTLETS

4.1. PRODUCTION OF CLONED PLANTLETS

The success of the crop is closely related to the use of good quality planting material. This practice provides security for the farmer in the pursuit of high productivity, on the condition that the farmer correctly follows the technical recommendations for the crop.

Healthy plantlets with a good genetic background are more likely to establish quickly in the field. They have increased tolerance to attack by pests and diseases, develop faster and produce more in the first harvests, suffer less competition with weeds, and are better prepared to develop and survive in the dry season.

Vegetative propagation of Robusta coffee has been used for over 50 years in many African countries, and has been used ever more frequently by the Espírito Santo producers.

To succeed in the activity of producing cloned plantlets, the nurseryman needs to be aware of the need to produce with quality. He should be knowledgeable about Conilon coffee cultivation, have an appropriate infrastructure for production, be supervised by a coffee technician, be registered, along with his nursery, with the Ministry of Agriculture, Livestock and Supply (MAPA), and have access to suitable cuttings from the clonal gardens and be familiar with the varieties to be multiplied.

4.1.1. Nursery

A basic infrastructure for the production of coffee plantlets permits the dequate realization of the following operations: preparation of cuttings and their substrate, filling of potting bags, organization of beds, transit of machinery and personnel and the installation of irrigation.

The producer of plantlets should choose a suitable location for installation of the nursery, which should be in a location with good topography, with easy access, without excessive moisture, with easy availability of irrigation water of good quality and be protected from strong winds and floods.

The nursery should be constructed with its shading oriented North-South, following the technical specifications. The beds should be 1.20 m wide, with lengths that can be varied, with a spacing between beds of 0.60 m, to facilitate the passage of operatives for cultivation activities, for phytosanitary purposes and for the collection of plant genetic materials. The top and lateral protection can be made from simple materials existing on the property, such as bamboo and the leaves of palm trees, or by specialized shade netting, which provides between 40 and 50% shade (Figure 6).

Figure 6. Nursery of cloned plantlets, mist- irrigated and covered by a shade net.

4.1.2 Planting containers

The planting bags used are of black polyethylene of 11 cm width, 20 cm length and 0.006 cm thickness, with holes in their lower half so that excess water can drain (Figure 7).

Figure 7. Type and size of planting bag, and insertion of cuttings in the containers for development of cloned plantlets.

4.1.3 Planting medium

For each cubic meter, the planting medium should have the composition:

- 70 to 80% of sieved subsoil;
- 20 to 30% composted cattle manure or composted coffee straw;
- 1.0 to 2.0 kg of dolomite lime;
- 5.0 kg of superphosphate;
- 0.5 kg of potassium chloride.

The full bags should remain unplanted, with irrigation, in the nursery for 30 days prior to planting.

4.1.4 Preparation of clonal plantlets

The cuttings should be taken from the orthotropic (vertical) branches from the clonal gardens of reputable institutions. They should be prepared in the shade, immediately after their removal from the clonal garden, as follows (FERRÃO et al., 2001; 2007b; fonseca et al., 2007):

- eliminate the primary (productive) branches just above their insertion;
- remove 2/3 of the blade of the two leaves of each node;
- do not use the extremities of the internodes;
- individualize the cuttings with a bevel cut, 3.0 cm below the insertion of the leaves and with a horizontal cut 1.0 cm above the insertion (Figure 8);
- leave the cuttings immersed for two minutes in a fungicide solution specific for phytosanitary treatment;

Figure 8. Conilon coffee cuttings and cloned plantlets in the nursery.

- insert the cutting up to the leaf insertion point, directly in the substrate in the planting bag (Figure 8);
- keep the cuttings in the nursery with mist irrigation until two pairs of leaves have developed (approximately 100 days);
- acclimatise the rooted cuttings for 30.

From the appearance on the cuttings of their first pair of leaves (about 40 days in the nursery), fertilizing and the control of pests and diseases should be started, when needed. The fertilizer used may be 20 g of urea dissolved in 20 liters of water, applied every 30 days, giving a maximum of four applications during the production of the plantlets. In addition to the nitrogen fertilizer, micronutrient-based products should be applied every 40 days at a dose of 1/3 the amount that is used in adult crops (BRAGANÇA; LANI; DE MUNER, 2001; Fonseca et al., 2007). Also conduct monitoring and control of diseases and pests in the nursery.

After fertilizer is applied, the plants must be irrigated immediately with pure water to wash the leaves, thereby preventing scorch.

4.1.5 Nursery practices

For good rooting of cuttings, the environment should be kept shaded, be between 40 to 50% humidity and be at an elevated temperature. The nursery should be suitably equipped with a form of micro-irrigation (misting), preferably with automatic control of the time interval between successive irrigations (Figure 6).

By technical scrutiny, recommendations should be followed for weed control, fertilizer coverage and control of pests and diseases. The most common pests in nurseries are caterpillars, crickets and ants, and common diseases are damping off, grey leaf spot and Cercospora leaf spot. The diseases are common when susceptible clones are propagated, which may be controlled with a copper-based product.

4.1.6 Clonal garden

The clonal gardens are plantations for the production of cuttings for plantlet production from clonal varieties. The gardens planted with the improved varieties of Incaper, are distributed in different regions of the State, and are in partnership with cooperatives, educational institutions, municipal governments, producer associations and nurseries registered with the Ministry of Agriculture (Figure 9).

Figure 9. Clonal garden, with improved varieties of Incaper, set up and run by Cooperativa Agrária dos Cafeicultores de São Gabriel (COOABRIEL), São Gabriel da Palha, ES.

The clonal gardens must be deployed and run for the maximum production of orthotropic branches, to be transformed into plantlets. They should therefore be sited in an appropriate location with proper spacing, with adequate management practices for fertilization and irrigation, pest and diseases control and other best practices.

To maximize the production of cuttings, the clonal garden should be managed so that there is good light penetration, which, together with adequate soil moisture and fertilization, will assist in the emergence of large numbers of vigorous shoots. For good penetration of light, orthotropic branches (vertical) may be bent or pruned to a height of about 1.20 m. In general, three months after treatment of the stock plants, the new shoots can be removed to produce cuttings.

In plants older than two years, it is possible to produce 400 cuttings from two cuts per year (Figure 9).

4.2. CARE IN THE ACQUISITION OF PLANTLETS

Upon acquisition of plantlets for the formation of plantations, farmers must certify that:

- the plantlets are from nurseries registered with the Ministry of Agriculture, Livestock and Supply;
- the plantlets were established from cuttings from trustworthy clonal gardens which have all the clones which comprise the variety;
- the acquired variety has all its clones in balanced quantities;
- clones of the same variety were delivered in separate batches, to permit planting in rows;
- the nursery is of good quality and was monitored by a technician trained in the production of coffee plantlets;
- the planting bag is the correct size of (11 x 20 x 0.006 cm), with drainage holes, quality substrate, adequate rooting, plantlet vigour, absence of disease, and the nursery complies with technical recommendations;
- the plantlets are not too old. The recommended age of plantlets for permanent planting is 120-150 days, with an average of three to four pairs of leaves.

5. 5. SITE PREPARATION

The proper preparation of the plantation depends on soil type, topography, size of area to be planted, natural vegetation and on the budget and technological level of the producer.

In areas suitable for mechanization, site preparation should be done by plowing and harrowing. The depth of plowing should be 25-30 cm. Next, the soil should be graded twice and the terrain made uniform.

In compacted soils, a subsoiler or mole plow should be used to a depth of about 40 cm.

In steeply sloping areas, where use of soil preparation machinery it is not recommended (plowing, disk plowing and mechanical harrowing), land may be cleared in strips with mowing, weeding or herbicide use, and then by opening the planting holes with the drill (mechanized) or manually (hoe).

After preparing the area, the coffee planting scheme must be set out following the land contours, corridors, and planting pits or trenches (Figure 10).

Figure 10. Area prepared for planting coffee, showing the planting rows following the land contours, and detail of the planting trench.

6. PLANTING HOLE PREPARATION

Once the ground is prepared, and the rows and their levels demarcated, the opening of the planting holes can commence (Figure 10).

The excavation of planting holes may be mechanical of manual. If the area is flat and the producer possesses agricultural machinery or is able to rent it, planting may also be conducted along contour lines in open furrows, of 40 to 50 cm deep and 40 cm wide or by using an earth auger for the opening of pits (Figure 11). After the opening of the furrows and the application of fertilizer, the pit opening operation may be completed with a mattock. For extensive areas, effective equipment is available, to be coupled to tractors, effecting the mixing of the fertilizer with soil.

Where the mechanization for tillage operations is impossible, the holes can be opened with a hoe or mattock. After marking the ground, the holes should be opened with the dimensions 40 x 40 x 40 cm. The fertilizer should be mixed with the most fertile soil, which is in the topmost layer.

Figure 11. Earth Auger, or soil drill, with a diameter of 18’’ employed to make planting holes.

7. SPACING AND DENSITY OF PLANTING

The planning of spacing and planting density depends on a number of factors, including: variety, technological level of producer, topography, soil fertility, use of irrigation, rainfall, the possibility of mechanization and cultural and phytosanitary practices that are intended to be used.

With the increasing need to reduce production costs and to make better use of land, we have investigated the use of different spacing and planting densities and the number of stems allowed per plant.

The best results were obtained with a spacing of 2.5 m between rows and 1.0

m between plants within the row, resulting in a density of 4,000 plants per hectare. However, with the aim of facilitating handling, the spacings indicated vary from 3.0 to 3.20 m between rows and 1.0 m between plants. Upon completion of pruning, which should be started immediately after harvest, the plants should be managed so that the present crop averages 12,000 stems per hectare in production. Each stem should remain for at most, four seasons, and then be removed from the plant by pruning.

8. PLANTING

Planting in non-irrigated areas should be conducted when rain, wet soil and mild temperatures are most likely.

In irrigated areas, planting should be done preferably during the season with cooler temperatures. The months of April and May are good choices for planting. Irrigation should be regular, taking evapotranspiration into account, the potential of the species in the region, soil texture, time of year, type of equipment, and the form of irrigation, among other factors.

The plantlets should be of high quality, be planted when they have three to four pairs of leaves, and after having undergone the process of acclimatization for at least 30 days.

When planting, the following is recommended: reopening of previously prepared planting holes; cutting off the bottom 1 cm of the plant bag, in order to eliminate wound roots, removal of the plastic bag containing the plantlet, placing the plantlet in the planting hole to crown height; and applying lateral compression of soil around the plantlet, without applying vertical pressure.

Soon after planting, plantlets should be protected from wind and sun, using palm leaves or similar material, for a period of 90 days. This operation provides better fixation and early development of the plant. When necessary, replanting should be done 20-30 days after planting, replacing the dead and most weak and defective plants.

8.1. PLANTING IN ROWS

Planting in rows is a technology of fundamental importance for the cultivation of the clonal varieties Robustão Capixaba and Vitória Incaper 8142. The process begins with the aquisition of plantlets, where each clone that makes up the variety to be planted must be obtained in separate lots. For example, if the variety is formed by thirteen clones (Incaper variety Victoria 8142), these must be transported to the planting site in thirteen distinct batches, which will be grown separately, and each clone planted in a row. After planting the last clone, planting is resumed with the first ones, although it is very important that the sequence is alternated with a view to providing greater opportunity for random mating, i.e., the line of a given clone is next to different clones in each new sequence.

In order to minimize the effect of reducing the genetic base, which can occur when opting for cultivation of clonal varieties; growers should always use the recommended varieties, planting all the clones that compose them. At the same time, the clones of each variety must be planted in the field in a balanced manner, i.e. using the same proportions of each component. The planting scheme can be adjusted according to the amount and arrangement of the available cultivated area. To illustrate, if the producer desires the cultivation of the variety Incaper Victory 8142, consisting of 13 clones, then the area might be marked with 39 planting rows. The recommended planting scheme is that the 13 clones are planted one in each row, and from the first distribution of all 13 clones, the remaining sequences of genetic material should be arranged in alternate forms, and the process then repeated. Figure 12 illustrates an example of a row planting scheme.

Planting in rows provides the following advantages over conventional planting: increase in productivity; improvement in the quality of the final product, where all the plants of the same row reach the stage of ripeness at the same time; the possibility of planting clones with different maturation times in the same area, facilitating the scheduling of harvesting; simplification of harvesting, pruning and thinning operations, since all plants in the same row are very similar; and the possibility of effecting plant manuring and phytosanitary controls differentially in each row.

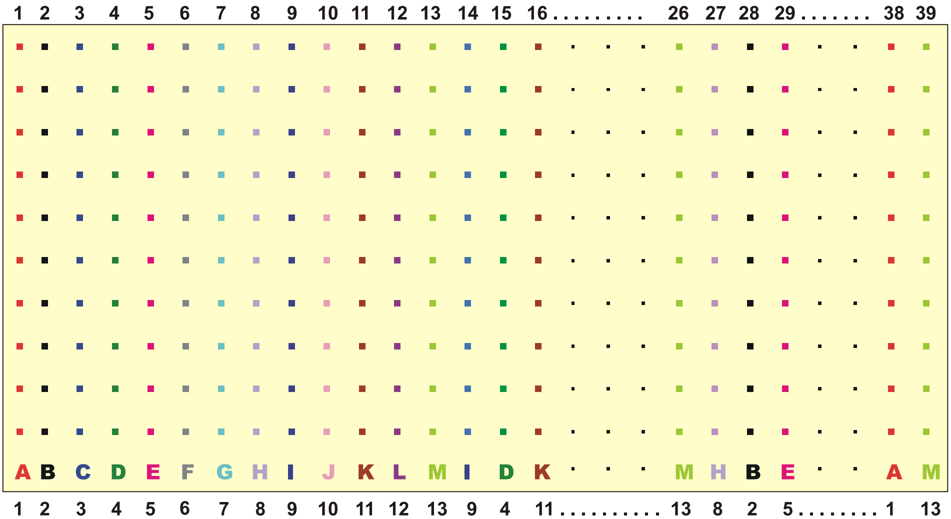


Figura 12. Exemplo de um arranjo de plantio em linha com a variedade Vitória Incaper 8142.

Many coffee growers have inadvertently deployed and conducted plantations with few, or in extreme cases, only one clone. This is due to the selection of genetic material of high productive capacity, among other characteristics of interest.

The identification of these plants, considered to be superior, is often performed when they are surrounded by genetically different plants which serve as pollinators. Planting of cuttings derived from one or a few of these mother plants deprives other adult plants of these favorable conditions.

So to summed up, the main consequences of the use of a small number of clones in the formation of crops: problems with pollination and fertilization, leading to the formation of rosettes with few fruits; increase in the number of flowering periods, thus contributing to reduced uniformity of ripening, thereby interfering with the final product quality; genetic erosion and genetic vulnerability, which can promote a higher incidence of pests and diseases, leading to the need for more pest control activities, reducing longevity of the crop, compromising productivity and production quality. These consequences are disastrous and could become a threat to Robusta coffee cultivation (FERRÃO *et al.*, 2007b; FONSECA *et al.*, 2007).

The planting of crops with few clones can cause irreparable damage to

Conilon coffee in the state of Espirito Santo, significantly reducing, over the coming years, the great variability in populations grown today.

9. PRUNING

The Conilon coffee tree is a plant with continuous growth which has vertical stems (orthotropic) and horizontal branches (plagiotropic), which, after a number of harvests, are aged and unproductive (Figure 13). Given this characteristic of the culture, the plantations of Conilon coffee need to be pruned periodically. The pruning method includes the elimination of the vertical stems and horizontal branches which are becoming unproductive, for replacement by fresh growths. The etiolated branches of low vigor, and excess shoots are also eliminated. The main advantages of production pruning are to increase the useful life of the coffee tree; reinvigoration of the crop, increased aeration and light penetration within the canopy, facilitation of cultivation and phytosanitary practices; reduction in height and diameter of the plant, which simplifies harvesting; improvement of physical and chemical conditions of the soil by incorporating organic matter from the removed vegetative parts; substantial improvement in the average productivity of the crop.

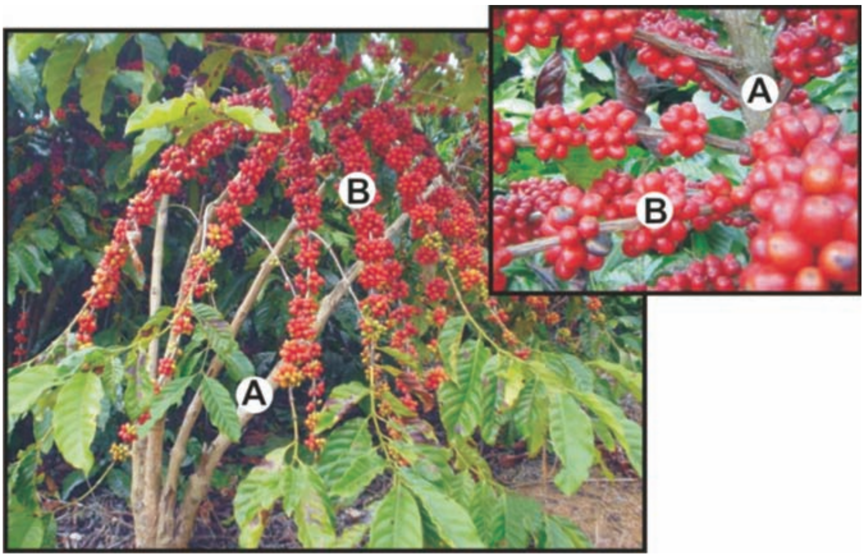


Figure 13. Vertical stem (A) and horizontal branch (B) of Conilon coffee plants.

The pruning technique, recommended by the Espírito Santo Institute of Research, Technical Assistance and Rural Extension – Incaper, since 1993 (Silveira et al., 1993), has been adopted by most producers in Espirito Santo. However, there was a need for standardization in the practice. Some producers began pruning from the second harvest, others from the third and others from the fourth harvest. The lack of uniformity in the use of pruning was associated with a lack of understanding of the principles of the technique and the differences in size, architecture, vigor and production of plants, plus the costs of the operation.

Throughout the fifteen years that the technique has been recommend, the most efficient management of Conilon coffee plants has been studied by Incaper and the private sector, and gradually introduced into the productive system (SILVEIRA et al., 1993; FONSECA *et a*l., 2007). As a result of this work, the Programmed Pruning Cycle was developed (SILVEIRA et al., 2008; ferrão *et al.*, 2010).

9.1. PROGRAMMED PRUNING CYCLE

The programmed pruning cycle should be carried out with the following guidance:

- After planting the crop and its thinning in the first year, it is recommended to leave a number of vertical stems compatible with the technology employed herein, i.e., around 10000-14000 stems / ha. To guarantee this number of stems early in the useful life of the crop, the multiple stem (Parra) system, involving the bending of the main stem of young Conilon coffee plants may be used (Volpi et al., 2012). The main objective of the technique is to prepare the plant for the programmed pruning cycle. To do so, use the following principles should be adhered to: a) plant the culture as recommended, b) perform the bending of the plant about 91 days after planting the crop between rows, c) 45 days after bending, when the shoots are a maximum of 10 cm, begin thinning, leaving 3-4 vertical stems on each plant.
- After the first, second and third, and in some cases fourth harvest, remove the horizontal branches which have reached about 70% of the production and the new shoots.
- Pruning of vertical stems begins only after the third or fourth harvest, cut to the height of 20 cm from the soil surface, eliminating 50-75% of the less

productive stems of the plant. In more open plantings, it is recommended to start after the fourth harvest, and in closely-spaced crops, start pruning from the third harvest. The distinction between the third and fourth harvest is a function of vigor, plant growth, light penetration, genetic material, spacing, and level of technology, among other factors. In parallel, elimination of the horizontal branches and Thinning should be performed, leaving a number of new shoots to recompose the crop with the number of recommended stems. The following year, remove the remaining old vertical stems disbud. At this stage, the plants are reinvigorated. In subsequent years, the plantation should be managed in the same way.

EXAMPLE: For an open crop, with a density of 3,000 plants / ha and managed with four stems / plant (12,000 stems / ha); the indication is to prune 75% of stems / plant at the fourth harvest. It is recommended to eliminate a total of 9,000 vertical stems immediately after the fourth harvest and the 3,000 remaining vertical stems, after the fifth harvest. In the following years, a new cycle is begun, where between the sixth and eighth harvest, the horizontal branches are removed Thinning done; at the ninth harvest, removal of about 75% of vertical stems, horizontal branches and Thinning is done; at the tenth harvest, removal of the rest of the vertical stems and Thinning is done, and so on (Table 1 and Figure 14).

Scheme 1. Comparison of the programmed pruning cycle with the traditional method.

Pruning	Ativity	Harvest									
		1	2	3	4	5	6	7	8	9	10
Programmed cycle	Elimination of vertical stems				X	X				X	X
	Thinning and elimination of horizontal branches	X	X	X	X	X	X	X	X	X	X
Traditional	Elimination of vertical stems		X	X	X	X	X	X	X	X	X
	Thinning and elimination of horizontal branches	X	X	X	X	X	X	X	X	X	X

The programmed pruning cycle has the following advantages:

- Average reduction of 32% of labour over 10 harvests.
- Facilitates understanding and practice.33

- Standardized management of pruning.
- Great simplification of thinning and other cultivational practices.
- Greater uniformity of flowering and fruit ripening.
- Improved management of pests and diseases.
- Provides more than 20% increase in average productivity of the crop.
- Increased stability of production per cycle, and better final product quality.

Unpruned coffee **Sprouting after elimination of vertical stems**

Production of stems in the last harvest. **Plants reinvigorated with four stems**

Figure 14. Illustration of the Programmed Pruning Cycle of Conilon coffee.

The vegetative parts detached during pruning should not be removed or eliminated from the field. Their return to the soil, between crop rows, promotes the following benefits to the orchard: they serve as sources of nutrients, improve the soil organic matter content, protect the soil against the baking sun, promotes a reduction in weeds, controls erosion and helps maintain soil moisture.

10. THINNING

With the elimination of the vertical stems and horizontal branches by the programmed pruning cycle, there is greater penetration of light inside the plant, which, associated with fertilization, rain or irrigation, promotes intense sprouting.

Thinning is the practice of removal of excess shoots that normally appear after pruning, especially those located inside the crown of the plant. Thinning should preferably be performed shortly after the pruning, and as many times as necessary, when the shoots are about 10 cm long. The operation consists of leaving only one vigorous shoot on each pruned branch, preferentially located in the lower, external parts of the plant.

By means of pruning and thinning, following the technical recommendations, the crop is always maintained in an energized state, with an optimal number of vertical stems for each particular situation.

11. LIMING AND FERTILIZING

Aplication of fertilizer is the practice that contributes most to the increase in productivity in coffee, especially when it comes to improved varieties with high yield potential, as they demand increased amounts of nutrients.

The recommendations for fertilizing and liming in this publication are based on the work of Bragança, Costa and Lani (2000ab); Bragança, Lani and De Muner (2001), Costa, Bragança and Lani (2000), Dadalto and Fullin (2001), De Muner et al. (2002), Prezotti and Bragança (1995), Prezotti (2007).

The recommendations for fertilizing and liming should be done based on analysis of soil and leaves and the expected production of cultivated plots. Tables 1 and 2 show, respectively, the levels of nutrients and soil organic matter and nutrient content of leaves, considered suitable for Conilon coffee (COSTA; BRAGANÇA, 1996).

In already installed plantations, the soil should be sampled every year, in the strips where fertilizers and lime were applied, at a depth of 0 to 20 cm, where occurs the bulk of the coffee root system. Acidity is analyzed in the subsurface layer, between 20 and 40 cm deep. For proper liming and fertilizing, the results of soil and leaf analyses should be combined, taking into account the soil type, the technological level of the producer, if the crop is grown with or without irrigation, and the potential productivity of the variety, among other factors.

Table 1. Levels of nutrients and soil organic matter considered adequate for the development of Conilon coffee trees

Nutrients	Units	Levels
Phosphorus[1]	mg / dm^3	15-20
Potassium[1]	mg / dm^3	100-120
Calcium[2]	$cmol_c$ / dm^3	3,0-4,0
Magnesium[2]	$cmol_c$ / dm^3	0,8-1,0
Sulphur	mg / dm^3	15-30
Zinc[1]	mg / dm^3	2,0-3,0
Boron[3]	mg / dm^3	0,8-1,0
Copper[1]	mg / dm^3	0,5-1,0
Manganese[1]	mg / dm^3	5,0-10
Iron[1]	mg / dm^3	100-200
Organic matter[4]	dag / dm^3	2,0-3,0

Source: Bragança; Lani (2000).
[1]Extract: HCl 0.05N + H2SO4 0.025N
[2]Extract: KCl 1N
[3]Extract: BaCl2 0.125%
[4]Oxidation: Na2Cr2O7H2O4N + H2SO410N

Table 2. Levels of leaf nutrients adequate for the development of Conilon coffee trees

dag /kg[1/]					mg / kg[2/]				
N	P	K	Ca	Mg	Fe	Zn	Mn	B	Cu
3,0	0,12	2,1	1,4	0,32	131	12	69	48	11

Source: Costa; Bragança (1996)
[1]dag/kg = %
[2]mg/kg = ppm

11.1. LIMING

Liming is one of the practices that most benefits coffee due to a favorable combination of several effects: it raises the pH of the soil, provides calcium and magnesium, increases the efficiency of fertilizer, increases microbial activity and nutrient release from organic matter mineralization, decreases or eliminates the toxic effects of aluminum, manganese and iron, frees the phosphorus in the soil, improves soil physical conditions favoring the development of roots, and improves symbiotic nitrogen fixation by leguminous plants and increases the productivity of the crops as a result of the effects cited (De MUNER, 2002).

The correction of acidity in the soil is done through the application of lime, and the type and amount required is estimated as a function of soil type and its chemical analysis.

For liming recommendations, we use the method of base saturation (BRAGANÇA; COSTA; LANI, 2000b; PREZOTTI; BRAGANÇA, 1995; prezotti, 2007), according to the following expression:

$$NC = \frac{T(V_2 - V_1)}{PRNT}$$

Where:

NC = Necessity for liming

T = CTC at pH 7 + SB + (H + Al), in cmolc/dm^3

V_2 = Desired base saturation (60% to 70%)

V_1 = Base saturation of soil (actual) = 100 SB/T, in %

PRNT = Relative neutralization power (total), of the lime to be used.

For crop establishment, limestone should be evenly distributed on the soil surface, two months before planting and, if possible, incorporated into the soil by plowing and harrowing. The amount of lime to be applied in the planting hole should be calculated based on the volume of the pit.

In steeply sloping areas or with the crop already in place, the lime should be applied on the soil surface, in split doses, because of the impossibility of its incorporation.

11.2. APPLICATION OF GYPSUM

The application of gypsum is recommended for soils of high aluminum content. In the subsurface layers, gypsum promotes deeper root growth, making the plant more tolerant to drought. When the soil analysis from 20-

40 cm shows high aluminium levels present, with values above 40%, and/or when the calcium level is less than 0.5 cmolc / dm^3, application of gypsum should be performed at a dose equivalent of 30% of lime recommended for this depth. For soils which do not need lime, but have low calcium and sulfur levels, gypsum is used as a fertilizer, by applying it on the soil surface, using a dose of 60 to 70 g/m^2 (BRAGANÇA; LANI; DE MUNER, 2001). The application of gypsum should be done after liming, without the need for physical incorporation.

11.3. FERTILIZATION

In the establishment of crops, according to results of the soil analysis, and based on the organic matter content, use 5 to 10 liters per pit of cow manure, composted coffee straw or other similar organic fertilizers. If the option chosen is poultry manure or equivalent, the amount used should be reduced to one third of the previous recommendation based on cow manure. The organic fertilizer to be applied in the pit or in the furrow should be mixed with the soil about 20 days before planting.

11.3.1 Fertilization for planting

Phosphate fertilizer in the pit or furrow

System of planting	**P-rem**	**Soil P levels (mg/dm^3)**		
		Low	**Medium**	**High**
	< 20	< 10	10 – 20	> 20
	20 – 40	< 20	20 – 50	> 50
	> 40	< 30	30 – 60	> 60
		g of P_2O_5 per pit or linear metre of furrow		
40 x 40 x 40 pit		40	30	20
Furrow		60	50	30

Apply 2.5 g of Zn and 1 g of B, in soil with zinc and boron content of less than 6 mg/dm_3 and 0.6 mg/dm_3 respectively, adding 2 g of Mn and 1 g of Fe to soils regions in tablelands. These doses are estimated for a soil volume of 64 dm_3 and should be corrected proportionally for planting in furrows or trenchs with different volumes.

Apply 5 g of N and 10 g of K_2O to the surface in three monthly doses, after the establishment of the plantlets. In soils with potassium content exceeding 80 mg/dm^3, reduce the dose to 5 g K_2O.

For surface fertilizing with N and K, the formula 20-00-20 can be used, in three doses of 25 g, spaced by one month. In soils with potassium levels above 80 mg/dm3, the formula 20-00-10 can be used.

Fertilizer dosage

Age	N dose	Soil K level (mg/dm^3)			
	g N/plant/ aplicação [1/]	< 60	60 - 120	120 - 200	> 200
		g K_2O/plant/application [1/]			
1 year	10	20	10	5	0
2 years	20	30	20	10	0

[1/] Three applications during the rainy season.
Source: Lani et al. (2007).

For irrigated coffee, increase the dose by 50%, repeating every 30 days on sandy and sandy loam soils, or on clay soils, every 60 days, starting from the first month after planting.

From the second year of crop establishment, fertilization appropriate for production should be used. The amount of fertilizer to be applied will depend on the desired and expected yield, plant age, the results of analyses of soils and leaves, spacing, and soil texture and fertility.

In most early crops, formed from clonal varieties, it is suggested to start fertilization in the second year of production.

11.3.2 Fertillization for production of Conilon coffee in accordance with desired productivity

Application of nitrogen and potassium based fertilizer

Productivity mean (sc/ha)	N dose (kg/ha/year)	Soil K level (mg/dm^3)			
		< 60	60 - 120	120 - 200	> 200
		K_2O dose (kg/ha/year)			
20 - 30	260	230	160	90	0
31 - 50	320	290	220	150	0
51 - 70	380	350	280	210	80
71 - 100	440	410	340	270	140
101 - 130	500	470	400	330	200
131 - 170	560	530	460	390	260
> 170	620	600	520	450	320

The fertilizer should be evenly distributed between the projection of the crown and stem, in lots of at least three applications during the rainy season.

Application of phosphorus fertilizer

P-rem (mg/L)	Soil P level (mg/dm³)			
	Very low	Low	Medium	High
< 20	< 3	3 - 6	7 - 10	> 10
20 - 40	< 5	5 - 10	11 - 20	> 20
> 40	< 10	10 - 20	21 - 30	> 30
Produtivity	**P_2O_5 Dose**			
sc/ha	**kg/ha/year**			
20 - 30	45	35	0	0
31 - 50	60	45	0	0
51 - 70	75	60	20	0
71 - 100	90	75	35	0
101 - 130	105	90	50	20
131 - 170	120	105	65	40
> 170	140	120	80	60

In crops with micronutrient deficiencies, these should preferably be supplemented to the soil at the beginning of flowering, as recommended below.

Nutrient	Fertility class	Level in soil (mg/dm³)	Dose (kg/ha)
Zinc[1/]	Low	< 2,0	3
	Medium	2,0 – 6,0	2
	High	> 6,0	0
Boron[2/]	Low	< 2,0	2
	Medium	2,0 – 6,0	1
	High	> 6,0	0
Cobre[1/]	Low	< 0,5	3
	Medium	0,5 – 1,5	2
	High	> 1,5	0
Manganese[1/]	Low	< 5,0	15
	Medium	5,0 – 15,0	10
	High	> 15,0	0

- Mehlich-1 extract
- Hot water extract

In years of high load and / or on clay soils, it is recommended to complement fertilizer with micronutrients applied via foliar spray. This must be done in three sprays, spaced from two months from flowering, with a solution containing the following salts:

- Zinc sulphate – 0.3%
- Boric acid – 0.3%
- Copper sulphate – 0.5%
- Potassium chloride – 0.3%
- Dispersant - adherant – 0.05%

Note: The potassium has the function of increasing absorption of Zn.

Considering the high yielding improved clonal varieties of Conilon coffee (Figure 15), and when crops are grown in soils with low CEC (Cation Exchange Capacity), fertilizer is best applies in a higher number of doses in order to prevent loss of nutrients by leaching.

Figure 15. High productivity in plants with balanced fertilization.

The estimate of the amount of limestone, gypsum and fertilizer can be based on the recommendations contained in Prezotti (2007) or the computerized system of liming and fertilization from Incaper, available on the website: (www. incaper. es.gov.br / downloads)

To assess the nutritional status of crops, the integrated diagnosis and recommendations for Conilon coffee can be used (DRIS) (costa; BRAGANÇA; LANI, 2000).

12. SOIL CONSERVATION

Most of the areas suitable for Conilon coffee cultivation have soils with a sandy texture, some of which, in places, are significantly sloping. These conditions, if improperly managed, and worked without observing conservation practices, will be subject to serious environmental problems, such as erosion; soil depletion; decreased fertility; decreased productivity; increased need for supplemental watering; silting of rivers and other water sources; in addition to water contamination, among others problems (Lani *et al.*, 2007).

There are various conservation techniques that can be recommended in order to increase vegetation cover and reduce the speed of runoff water in the soil. Among the economically viable practices of soil conservation, can be cited: select areas suitable for planting (soil must have adequate physical properties, be deeper with good water retention and be well drained), make corridors and correctly align and locate the crop; open planting pits or furrows along contours; use a planting density from 2222 to 3333 plants per hectare, and prune and thin correctly. The coffee should be planted preferably in areas with slopes of less than 30% and areas less prone to erosion. Regardless of slope, practices for controlling erosion should be implemented.

Dense planting inside the staggered rows is associated with the proper management of weeds between rows, which themselves form retention strips, slowing runoff water and loss of soil and nutrients. This practice is inexpensive and is effective in controlling erosion and in conserving soil.

The construction of dry boxes along access roads and corridors, and in areas external to the plantation, has been an effective conservation technique in order to capture and store rain water and to prevent soil erosion (LANI *et al.* (2007).

Losses of soil, water and nutrients are very large when the techniques of soil conservation are not properly applied, which was verified in an experiment collecting data after rainfall of 70.80 mm and 49.60 mm in Marilândia, ES, by Lani et al. (1996), who evaluated different types of weed management, as shown in Table 3.

Table 3. Loss of soil nutrients and water after rains in the city of Marilândia, ES, during experiments with different types of weed control, Incaper

Treatment	Chemical composition						
	Soil (kg/ha)	Water (L/ha)	P (mg/dm^3)	K (mg/dm^3)	Ca (cmol/dm^3)	Mg (cmol/dm^3)	M.O (dag/dm^3)
1- No strips	9.0	8.444	92	785	7.7	1.7	3.2
2- 1:3	6.3	8.269	83	390	8.3	1.6	3.5
3- 1:2	5.0	6.746	101	755	10.3	2.4	4.5
4- 1:1	2.1	3.777	88	555	7.2	1.4	3.6

Treatments:
1 – without strips, area totally cultivated (Control);
2 – 1:3, one strip of cleared forest for three rows of coffee;
3 – 1:2, one strip of cleared forest for two rows of coffee;
4 – 1:1, one strip of cleared forest for one row of coffee.
Source: Lani *et al.* (1996).

13. WEED CONTROL

Weeds are a major problem for the coffee grower, and if not properly controlled, greatly compete with the culture, especially for nutrients, water and light, resulting in decreased plant productivity.

Weed control can be performed manually, mechanically or by the use of herbicides. One way to efficiently and economically control weeds is to use integrated control options through the following simultaneous operations: 1) hoeing in the rows to control weeds and herbicide application between rows; 2) hoeing in the rows and mowing between rows; 3) hoeing in the rows and use of a harrow or rotary culvator at a shallow setting between rows (Rocha, 2007).

The rational management of weeds can be accomplished through the use of retention strips, leaving the desiccated natural vegetation between the rows of coffee, previously cut by mowing or killed by herbicides prior to weed flowering. It is recommended that weed control is accomplished by hand weeding or herbicide application, between the coffee stems, up to 50 cm beyond the projection of the canopy, especially during the establishment phase of the crop.

The use of post-emergence herbicides has been considered as a method of weed control and conservation at the same time, due to its efficiency, economy and formation of mulch in the soil. This operation, besides increasing the organic matter content and its improvement in moisture holding capacity in the area, protects the soil from erosion.

14. IRRIGATION

In Espírito Santo State, 72% of areas are classified as being transitional wet / dry and dry with a hydric deficit of -50 to -550 mm per year over a period of four to eight months per year (FEITOSA, 1986). The majority of the Conilon coffee plantations are situated in these areas (DADALTO; BARBOSA, 1997).

Drought results in reduced productivity, reduction in the final quality of the product and causes instability for producers.

Irrigation has been a practice that, if well implemented and managed, has provided increased productivity, improved product quality and safety for the producer. This practice can even double the crop yield, and is incorporated into the production technologies recommended for culture.

Currently, about 50% of Conilon coffee plantations in the State are irrigated (140,000 hectares). Despite this significant area, there are several poorly dimensioned projects, requiring better technical monitoring.

To decide on the necessity to irrigate, different factors must taken into account: the technical and economic aspects, the climate, temperature, precipitation and potential evapotranspiration, the physico-chemical properties of soil, the topography of the land, the cultural and phytosanitary practices, and the quantity and quality of available water (SARAIVA; SILVEIRA,1995; Silva, 2007).

There are several irrigation systems successfully used in the State. The most common are conventional sprinklers, center pivot, drip and mist systems. The choice depends on the topography, plant spacing, cultivar, quality and quantity of available water, the speed and direction of winds, climatic conditions, the technical and economic resources of the producer and the cost of equipment.

The central pivot sprinkler is recommended for situations with producers with high technical capacity, in areas of flat topography and in places where the amount of water is not a limiting factor. The mist sprayer and drip systems may be employed in any type of topography and where there are limited amounts of water available at the site.

The research work carried out by Silveira (1996) showed that the highest yield in irrigated crops were obtained when water applications were made during the budding stages of flowering, flowering, fruit set and bean swelling phases.

It is recommended that, when opting for irrigation, a good plan is drawn up by a professional with experience in Conilon coffee, in order to properly source the correct equipment (hydraulics, pipes, and sprinklers, among other components) and to provide a monitoring technician in the different phases of the project.

Appropriate design of the irrigation system and its management with technical monitoring will deliver lower water consumption, energy and equipment wear, better utilization of water and nutrients, less use of labor, improved productivity and product quality with higher profitability for the producer.

15. PESTS

There are a large number of insects and mites associated with Conilon coffee, but only a few species are considered of importance to the culture. Among the most frequently occurring species and most important for Conilon coffee is the coffee berry borer, the major pest of the crop, leaf miner and rosette mealybug. However, some species even though considered of secondary importance, such as the red mite, black twig borer, and defoliating caterpillars among others, have been shown in some regions, to sporadically cause considerable damage to the crop.

Coffee berry borer - *Hypothenemus hampei* (Ferrari, 1867) **-** Scolytidae: Coleoptera.

It is a small black colored beetle, with a cylindrical body, which can attack the Conilon coffee fruits at all stages of maturation, in immature and ripe coffee cherries and in dried fruits (Figure 16). The complete cycle, from egg to adult occurs in 27-30 days on average, and a female may live for 156 days.

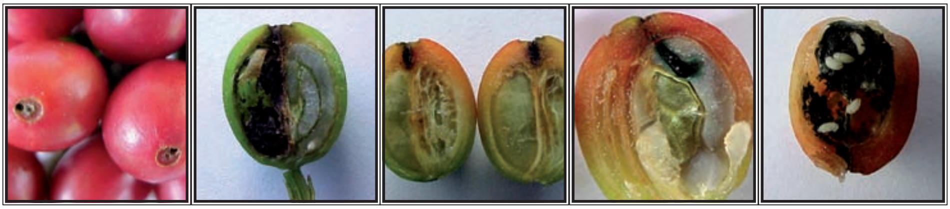


Figure 16. Coffee cherries damaged by coffee weevil in different stages of maturity.

The adults and immature forms survive from one harvest to another in coffee beans lying on the soil or retained on the plants, provided there are favorable conditions of moisture for their survival. Lack of uniformity of flowering also favors the multiplication of the borer, by providing more time for their feeding.

The principal quantitative damages caused by the borer are reduced fruit weight, fruit drop, and deterioration of the seeds. Quality is also significantly affected by increasing the number of defects in the coffee beans, contamination by micro-organisms, and the presence of insect residues.

The coffee berry borer should be controlled by integrating cultural, biological and chemical methods. Cultural control is one of the most efficient, where removal of the coffee beans remaining on the soil or retained on the plant after harvest, significantly reduces the source of infestation by transfer in the crop. Abandoned crops must be eradicated so as not to serve as a source of multiplication and dissemination of the insect. The very green fruits attacked by the borer in the crop, and those fallen on the soil must also be collected as they provide shelter for future infestations. For the storage of beans, it is necessary to promptly proceed to the proper drying procedure, in order to prevent the borer from continuing its propagation, especially in coffee stored without prior hulling (dry cherry) (FORNAZIER; BENASSI; MARTINS, 1995; FORNAZIER *et al.*, 2000a; De MUNER *et al.*, 2000a).

Biological control can be used as a complementary measure in a program of integrated management of the borer, to help reduce the population of the insect and the consequent damage caused by this pest. The maintenance of vegetation cover between the rows of coffee, interspersed with cleared areas, use of selective pesticides are among other measures to promote the presence and multiplication of natural enemies (predators and parasitoids) into crops which play an important role in controlling the pest. The main natural enemies of the borer are African parasitoids: *Prorops nasuta*, known as the Uganda wasp; *Cephalonomia stephanoderis*, the Ivory Coast wasp; *Heterospillus coffeicolla and Phymastichus coffea*, the Togo wasp. These wasps can be bred in borer infested coffee fruits and subsequently released into the plantation when borer infested fruits first start to appear in the crop. In addition to parasitoids, the entomopathogenic fungus, *Beauveria bassiana*, can also be used, and is available in commercial formulations on the market. However, to exercise control over the borer, the application must coincide with the period of ripening of fruits from the first flowering, when the borer is located in the crown of the fruit, and also depends on climatic conditions of high temperature and relative humidity.

Chemical control should be performed when an initial infestation is found in 3-5% of the fruit.

Bicho-mineiro - *Leucoptera coffeella* (Guérin-Menéville, 1842) - Lyonetiidae: Lepidoptera

This moth is very small, with a 6.5 mm wingspan, and the wings are white on the back. During the day they hide on the underside of leaves, and in late afternoon and early evening, they leave the hideout and begin their activities, laying eggs on the upper side of leaves. The larvae hatch, on average, 5 to 21 days later, depending on conditions of temperature and humidity. The larvae penetrate directly into the mesophyll, lodging between the two epidermises, forming the "mine" to feed on the parenchyma. The attacked tissues are dry and easily detachable (Figure 17), and it is common to find a large numbers of caterpillars in a single leaf.

Figure 17. Damage by coffee leaf miner and detail of larva in the leaf lesion.

The generation time varies, depending on temperature, from 19 to 87 days, with 7 to 9 generations annually.

Losses result from the reduction of photosynthetic capacity caused by the destruction of the leaves and especially, leaf fall. The symptoms are most visible in the upper part of the plant, where extensive defoliation can be observed in severe attacks. The drastic defoliation of coffee trees, caused by high pest infestation can affect fruit set, with malformation of flower buds and fruit. It has been observed that infestations may be more pronounced during dry spells, common in the months of January and February. The hot and dry climate, which is characteristic of the northern part of Espírito Santo, in the cultivation of traditional Conilon, has favored a significant increase in pest populations throughout the year, with a peak in the dryer months.

The leaf miner is parasitized by a large number of insects, and in other countries some authors consider that the frequent use of copper fungicides and indiscriminate use of insecticides can change the complex of parasitoids and predators and, consequently, cause population explosions of L. coffeella.

The rational management of the local vegetation is recommended, with the use of mulching and intercropping in the formation of Conilon coffee plantations.

In order to perform any kind of chemical treatment to control leaf miner, it is necessary to recognise the infestation of the pest and its natural enemies in the area planted with coffee. The minimal and localized use of insecticides, will help in the preservation of beneficial insects that act effectively in natural control of leaf miner.

Rosette mealybug - *Planococcus citri* (Risso, 1813) and *Planococcus minor* (Maskell, 1897) - Peseudococcidae: Hemiptera

The species *P. citri* and *P. minor* are very similar, and are a part of a complex of rosette mealybugs of Conilon coffee. Females are oval and 3-5 mm in length. When young, they are pinkish, and when adult, brownish-yellow. The body is covered by a white powdery secretion, and have 18 appendages each side and two terminal appendages, longer than the lateral. Nymphs appear 10-20 days after egg laying and are adult at about 10 days. They live in colonies made up of individuals at various stages of development. The complete life cycle is 25 days on average.

The rosette mealybug has increased in importance by causing direct losses to productivity in Conilon coffee (FORNAZIER et al., 2004). Both nymphs and adults suck flower bud and fruit sap during their formation and growth (Figure 18), causing severe fruit drop or sterile fruit development (FORNAZIER *et al.*, 2000b; 2001).

There are several natural enemies that can efficiently control mealybugs; among them are two small beetles (ladybugs), *Azya luteipes* Mulsant and *Pentilea egena* Mulsant, and fungi of the genera *Cephalosporium* and *Acrostalagmus.*

For chemical control of rosette mealybug, the application of insecticides should occur when the first infestation is found, and localized in foci, preventing mealybug spread throughout the crop.

Figure 18. Flower buds, branches and coffee rosette, infested with rosette mealybug.

Black twig borer - Xylosandrus compactus (Eichhoff, 1875) - Scolytidae: Coleoptera

The black twig borer of coffee is a major pest of Robusta coffee in several countries in Africa and Asia. In Brazil, it has recently appeared in Robusta coffee in southern Bahia (MATIELLO; NEVES; SILVA, 1999), in Conilon coffee, in the northern, central and southern regions of Espírito Santo (MATIELLO; FREITAS, 2005; FORNAZIER *et al.*, 2008; 2011), and in the "Zona da Mata" of Minas Gerais in Robusta Apoatã plants (MATIELLO *et al.*, 2009).

This is a small beetle, black in color, similar to the coffee berry borer, which attacks both the primary and orthotropic branches (FORNAZIER *et al.*, 2007). The insect makes a small hole in the coffee branches, which opens into a gallery in the central part of the branch, where eggs are laid (Figure 19). The infested branch dries, usually above the egg chamber, and, temporarily, part of the branch below the gallery remains green. This feature is a sign of twig borer attack, because other causes of naturally dried branches, such as that caused by other stresses, usually kills the branch as a whole, or in part, but without the perfect distinction of the green and dry parts, that occur in during borer attack (MATIELLO *et al.*, 2009).

Since there are no products registered for control of this pest in coffee, it is recommended to be careful in the use of more susceptible clones of Robusta, observe planting in rows, to facilitate the monitoring of the pest and its control by periodic removal of infested branches as a way of hindering the multiplication of this insect (FORNAZIER *et al.*, 2011).

Figure 19. Coffee branches attacked by black twig borer.

16. DISEASES

16.1 COFFEE RUST
Hemileia vastatrix Berk et Br.

The disease was first found in Brazil in 1970 in Bahia, and now occurs widely throughout the State of Espírito Santo, with varying degrees of severity, depending on weather conditions, load status of the plants, unbalanced fertilization, spacing and resistance or susceptibility of cultivars and clones used. Rust can occur both in nurseries and on farms where it has caused significant losses of up to 50%, also affecting the quality of coffee. Control with fungicides increases the cost of production and often causes significant environmental impacts (VENTURA et al., 2007; ZAMBOLIM, L.; VALE; ZAMBOLIM, E., 2003).

Symptoms of the disease are very distinct, easy to identify, and manifest themselves particularly on the underside of the leaves, forming translucent yellow spots of 1-3 mm diameter. The spots are develop rapidly and in a few days gradually increase in size, forming circular pustules, appearing powdery, yellow to orange, covered by uredospores of the fungus, giving the appearance of a “yellow dust” (Figure 20a). There may be coalescence of several spots, covering most of the leaf, which is shown covered by a mass of spores, and in some Conilon coffee clones, leaf fall may occur (Figure 20b).

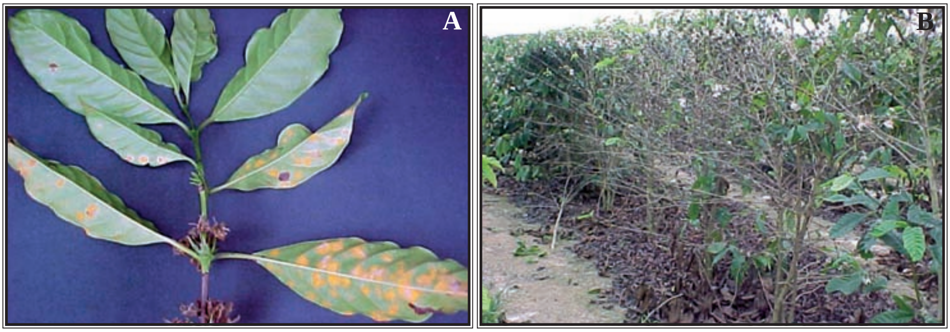


Figure 20. Symptoms of coffee rust in Conilon coffee, showing pustules formed by the fungal spores (A). Defoliation in susceptible plants (B).
Source: Ventura *et al.* (2007).

The causative agent of rust is the fungus, Hemileia vastatrix, whose cycle is initiated by uredospores that, when in contact with the underside of the leaves, in the presence of water, germinate, penetrate and infect, producing urediniospores that can also infect leaves of the same, or another plant (VENTURA et al., 2007). Knowledge of the epidemiology of coffee rust is important, since it allows the prediction of conditions that favor the disease, its incidence and severity; contributing to strategies for control. Temperature has a significant effect on the initial infection and the development of the disease. The sporulation period usually varies from 10-16 days depending on the genotype, climatic conditions and the physiological race of the fungus, with 14 days interval being more frequent (ZAMBOLIM et al., 2002; Zambolim, L.; Vale; Zambolim, E., 2003).

The spores spread by wind, insects, rain, animals, and by contaminated plants, and man is an important disseminator of inoculum over longer distances. The seasonal periodicity of rust differs markedly from one region to another, mainly due to climatic conditions. In Espírito Santo, epidemiological curves of rust in coffee Conilon have shown on average that epidemics begin in January / February, evolving progressively with maximum severity in the months of July to September (VENTURA et al., 2007).

Several management measures may be taken to control coffee rust, in particular:

Resistance: The cultivation of clones and resistant varieties is the most effective and economical way to control the disease, while minimizing impacts on the environment, by reducing chemicals used in control.

The results of the research program for genetic improvement of Conilon coffee of Incaper have, in the last 20 years, allowed us to make available improved varieties and be able to recommend to the state of Espirito Santo, clones grouped into uniform ripening and compatible plants. These improved varieties of Conilon coffee were the first to be created, recommended and officially registered in the country (FERRÃO et al., 2007ab).

In assessments of disease severity under the conditions of the Experimental Farm in Marilândia; Incaper showed that 96.4% of the clones in the Incaper breeding program were resistant to disease, and in 61.82% of the clones symptoms were not observed. In Sooretama Experimental Farm, under irrigated conditions, 70.9% of the clones were resistant to rust and 5.5% had no symptoms of the disease, while in rainfed conditions, 43.6% of the clones showed no symptoms (VENTURA et al., 2007).

Chemical control: The use of chemicals must be preceded by a sampling in the field, to determine the incidence of rust and to verify check the actual need for control. For the management of rust in Conilon coffee, the reduction of initial inoculum should take into account. Some clones do not retain infected leaves from year to year, which is often sufficient to achieve an economic level of control of the disease, thus the use of fixed schedule for fungicide application is not justified (VENTURA *et al.*, 2007).

The most widely used fungicides to control coffee rust are the triazole group of systemic agents. But even with the growing use of synthetic fungicides, the use of copper fungicides as a protective is still a good alternative control measure under conditions of low severity (VENTURA *et al.*, 2007; ZAMBOLIM *et al.*, 2002). It is recommended that for monitoring of rust, land should be divided into uniform sampling plots and to collect 5 to 10 leaves per plant, at the 3rd or 4th pair of leaves, from the branches located in the middle third of the plant (Figure 21), and count the number of leaves with rust, to assess the incidence of disease in the area. Sampling must be started from the month of November / December, with at least monthly assessments. If the percentage of diseased leaves is between 3-5%, application of protective contact fungicide, preferably copper or "calda viçosa", is recommended. If the percentage of rust is equal or greater than 6%, using systemic fungicides alternated with contact agent is recommended.

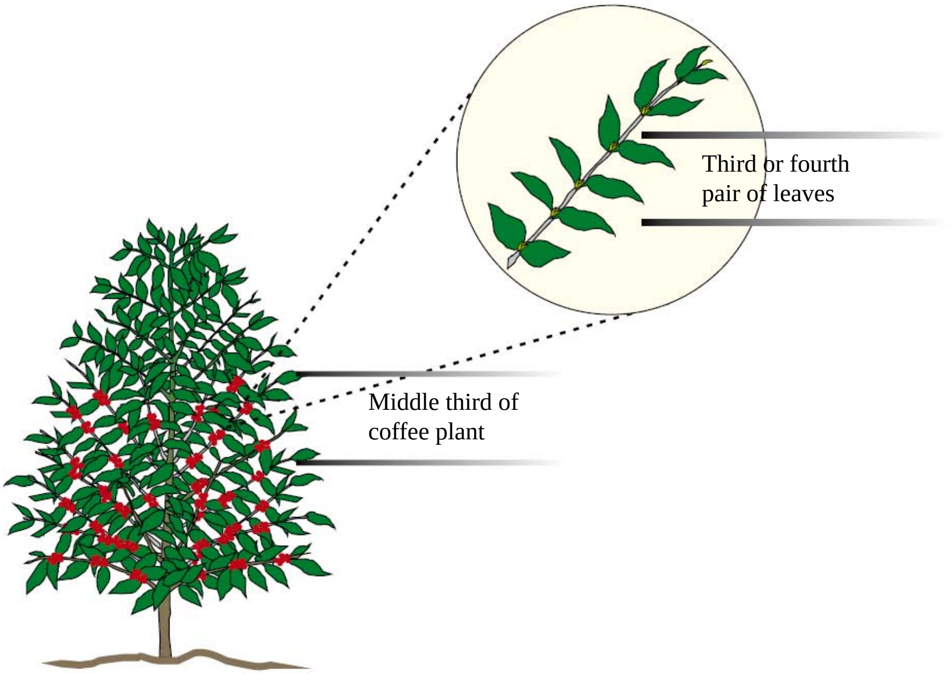


Figure 21. Schematic representation of the monitoring of rust in coffee plants and the sampling of the third and fourth leaf pairs of branches in the middle third of the plant canopy. **Source**: Ventura *et al.* (2007).

For the control of rust in Conilon coffee, one must know which clones are planted and the harvest time (early, middle or late), since in some cases the disease occurs after harvest, which does not justify the application of fungicides, since pruning will considerably reduce the inoculum of the fungus (VENTURA *et al.*, 2007).

16.2. BROWN EYESPOT OR CERCOSPORA LEAF SPOT
Cercospora coffeicola. Berk et Cook

This is a disease that occurs in the conditions of the nursery, in the early stage of transplanting in the field, or in formed plantation, especially when plants are located in soils with low fertility, causing severe defoliation. In Conilon coffee, its severity is very variable, depending on the clone and climatic conditions, with greater importance in the nursery, in which many affected plantlets fail to develop. In case of high severity, elevated losses may occur in plantlets, since the disease causes defoliation and may delay their readiness for the fieldfield (Figure 22-A).

Figure 22. Symptoms of Brown Eyespot, caused by the fungus Cercospora coffeicola, in plantlets (A) in mature plants (B) of Conilon coffee, in the north of Espírito Santo. **Source**: Ventura et al. (2007).

The leaf symptoms are circular light, or dark brown-colored marks of variable diameter (Figure 22b), which usually have a grayish-white center, with or without the presence of a yellowish halo. With the aid of a magnifying lens, black spots can be observed, which are the fruiting structures of the fungus. The circular lesions have the appearance of a "bird's eye", which is why the disease is also known in some regions as "pigeon-eye". The infected fruits have necrotic spots, depressed, and dark-brown in color. Usually the diseased fruits fall prematurely, and the skin adheres to the parchment, making pulping difficult (VENTURA *et al.*, 2007).

The causative agent is the fungus Cercospora coffeicola Berk et Cooke, which produces conidia in the lesions, on both sides of the leaf, which is easily spread to other neighboring leaves or plants (VENTURA *et al.*, 2007). The disease develops more rapidly when the temperature is between 20° to 25°C, together with high relative humidity. However, the fungus can develop in a temperature range from 10° to 25° C, where the fungus is spread by wind and rain splash or by spray irrigation.

To manage the disease it is recommended to choose the appropriate site for the nursery, avoiding poorly drained and wet lowlands. The choice of substrate for the filling of the planting bags, irrigation and shading techniques should follow the recommendations for the production of plantlets. The balanced fertilization of plants based on soil and leaf analysis is very important for the correct application of macro- and micronutrients necessary for the plants (ZAMBOLIM; VENTURA, 1993). In cases of high severity of the disease, fungicides can be used, especially with the following management guidelines:

a) Nursery:

- use substrate with adequate levels of nutrients;
- avoid locations with high humidity;
- use copper-based fungicidas or “calda viçosa”;
- take special care during the acclimatization of the plantlets when grown in covered nurseries;
- in highly shaded nurseries, with an excess of irrigation, damage can be observed to start in small foci.

b) Field:

- practice balanced fertilization (based on soil analysis);
- avoid sandy and compacted soils;
- in rainy years, spray more frequently with micronutrientes (e.g.: “calda viçosa” associated with copper fungicide);
- avoid installing plantations in highly sun-exposed locations, particularly areas with afternoon sun.

16.3. BUTTERY SPOT

Colletotrichum spp

It is a disease that occurs sporadically in the state of Espirito Santo in certain varieties and clones of Conilon coffee, which can eventually cause plant death. Currently the disease occurs is infrequent, depending on the selection of resistant clones. The first report of disease in Conilon coffee in Brazil was in 1977, in the state of Espírito Santo (MANSK; MATIELLO, 1977). The typical symptoms are observed on the leaves, where there are small oily marks with well defined edges, typically 1-3 mm in diameter, which may coalesce and become necrotic. On branches, the necrotic symptoms may progress downward, injuring the nodes. The fruits when infected show depressed lesions, which can cause the fruit to fall prematurely. In advanced stages of the disease, the branches dry and subsequently, diseased plants may die.

The samples with the symptoms of the disease often yield the fungus Colletotrichum gloeosporioides and in some cases Colletotrichum acutatum, which represent a broad population present in the tissues of the trees, with and without symptoms of the disease, being a constant presence in the tissues in the apical region of the branches (VENTURA et al., 2007). The difficulty in completing the pathogenicity tests on the tree and proving causation is still widely debated (VENTURA et al., 2007; ZAMBOLIM, L.; VALE; ZAMBOLIM, E., 2003).

For the management of the disease in Conilon coffee, it is recommended that only plant varieties resistant to disease are planted. Never use seeds or cuttings from diseased plants, which must be disposed of if they have the characteristic symptoms of the disease.

16.4. NEMATODES

The nematodes live in soil and feed on plant roots, causing direct damage by destroying the cells and tissues of roots, as well as indirectly, by opening gateways to other pathogens.

There are more than 30 genera of nematodes reportedly associated with roots of coffee plants in Brazil, standing out as the most frequent are Meloidogyne, Pratylenchus and Helicotylenchus (VENTURA et al., 2007; LIMA; VENTURA; COSTA, 2011). Many of these species can occur simultaneously in the root system, although the potential damage which may be caused by some of these species is not evidenced in Conilon coffee. In Espírito Santo, nematodes found in roots and the rhizosphere soil of Conilon coffee include Aphelenchoides sp., Criconemella sp., Ditylenchus sp., Helicotylenchus sp., Meloidogyne sp., M. incognita, Pratylenchus sp., Rotylenchulus sp., Tylenchus sp. and Xiphinema sp. (DIAS; Liberato; costa, 1996; VENTURA et al., 2007).

In the interaction of M. incognita and M. paranaensis with Conilon coffee, can be observed the same symptoms as those displayed when these parasites interact with Arabica coffee. For example, the clone 12V da cultivar Vitória-Incaper 8142, when parasitized by M. incognita or M. paranaensis, shows root deformations such as localized thickenings, less localized in typical galls, especially in older roots, alternating thickened parts with the healthy parts (Figure 23 A and B). Cracks, splits and detachment of the cortical tissue (stripping) may also be observed in addition to a reduction of the root system (LIMA; Ventura; Costa, 2011).

Figure 23. Symptoms typical of parasitism by Meloidogyne spp. in roots of Coffea canephora. Meloidogyne paranaensis in root of Conilon coffee (A); Meloidogyne incognita in root of clone 12V of cultivar Vitória Incaper 8142 (B). **Source**: Lima, Ventura and Costa (2011).

The main strategy for management of nematode parasites of coffee is to avoid contamination of the area and plantations, where the spread is primarily controlled through the use of phytosanitary legislative measures allied to the health of the planting stocks (LIMA; Ventura; Costa, 2011; VENTURA *et al.*, 2007). The plantlets used in the deployment of crops should be healthy and free of nematodes, and grown in nurseries registered with the Ministry of Agriculture, Livestock and Supply (MAPA). Furthermore, it is recommended, whenever possible, the to conduct soil nematological analysis in areas where new coffee plantations are to be deployed, avoiding the planting in areas infested with nematodes (LIMA; Ventura; Costa, 2011; VENTURA *et al.*, 2007).

16.5. CORYNESPORA LEAF SPOT

Corynespora cassiicola (Berk. & MA Curtis) C.T. Wei

The fungus infects leaves, flowers, fruits, roots and stems of several species of tropical and subtropical plants. In 2007, it was reported in Conilon coffee, in the state of Espirito Santo, causing spots appearing circular to elliptical or irregular, and sometimes coalescing, causing dark brown necrosis, with severe senescence and, consequently, drying up of branches, thereby causing a reduction in productivity (SOUZA *et al.*, 2009). In fruits, the initial symptoms are small necrotic lesions of 1 mm in diameter, which later become necrotic and may trigger a drop of coffee cherries. The pathogenicity of the fungus was demonstrated in mature leaves of the clonal variety Victória (Clone V3), and a molecular identification confirmed, for the first time, the fungus C. cassiicola as the causative agent of the diseasein coffee Conilon under field conditions (SOUZA *et al.*, 2009).

17. HARVEST, DRYING, PROCESSING AND STORAGE OF CONILON COFFEE

Recommendations for the production of quality coffee should be followed by producers, because this offers the grower sustainability, security of market, added value and the opening of new markets.

Production of good quality coffee begins when the farmer correctly follows the recommendations, which starts in the choice of variety and extends through the running of the plantation, cultivation and phytosanitary practices, in nutrition, in irrigation, in pruning, and principally at harvest and in post-harvest processing (RIOS, 2003).

Proper use of improved varieties, fertilization, irrigation, pruning and cultural and phytosanitary practices provides better development of coffee beans, good uniformity of maturation and a lower percentage of sterile cherries; and these characteristics have a positive affect on the amount and quality of the final product.

We recommend the following procedures for harvesting, drying, processing and storage, aiming to produce quality coffee (FONSECA *et al.*, 1995; FERRÃO *et al.*, 2001; DE MUNER *et al.*, 2003; RIOS, 2003; Fonseca *et al.*, 2007; Fonseca *et al.*, 2011).

17.1. HARVEST AND PREPARATION

A harvest done well is essential to produce quality coffee. Before starting the harvest, the producer should be organized, making sure he has purchased sieves, tarps, sacks, and has cleaned and repair yards, warehouses and machines.

The harvest should begin when more than 80% of coffee is already ripe, and the fruits have acquired a cherry color (Figure 24).

The coffee must be spread out on screens or tarpaulins, and should never be spread directly on the ground.

After harvesting, and while still in the field, coarse impurities such as sticks and leaves should be removed.

In a harvest done well, fruit should not be left on the plant or on the soil. Failures such as these promote the increased incidence of coffee berry borer in the next crop.

Transport the harvested coffee to the drying yard or dryers every day to prevent fermentation.

Figure 24. Crop with 80% mature fruit.

Do not let the freshly harvested coffee form heaps in the yard.

If possible, use the washer / separator to remove impurities and separate the ripe fruits from green cherries.

For the production of processed coffee by the wet method, the ripe and green cherries are passed through the pulping machine for the separation and removal of skin and pulp from the fruits, preferably on the day of harvest.

17.2. DRYING

17.2.1 Drying on patios/yards

If the choice is to dry the coffee naturally in the sun, the coffee should be spread into thin layers, 3-5 cm thick, spreading with a rake, an average of ten times per day, orientated east-west, to accelerate drying and prevent fermentation of the cherries (Figure 25).

Figure 25. Coffee drying on cement patios or on suspended platforms.

Before the coffee is half-dry, it is not to be heaped or covered with canvas. In the early days of drying, rake the coffee into windrows up to 5 to 10 cm high every afternoon in the direction of the slope of the patio. As days pass, the windrows may be increased to a thickness of 20 to 30 cm, until the coffee is half-dried.

After the half-dry point, the coffee must be covered in the evening, so that there is uniformity of drying.

If rainfall occurs at night, move the windrows around until the entire patio is dry, when the coffee should be spread again. If rain continues, rake the windrows 3-4 times a day.

Drying is complete when the coffee reaches 12% moisture content.

17.2.2 Machine-drying

The coffee crop at harvest has high humidity. Thus, it is recommended to be subjected to three to four days pre-drying before being passes on to the dryer. If this is not possible, the dryer should be adjusted so that the temperature at the start of drying is lower, and with more ventilation.

To avoid reducing the quality of the coffee, drying should be performed with an indirect fire source. The dryer should work at full load and with homogeneous product lots. If wood is used as fuel, it must be very dry. The temperature in the mass of coffee must be checked and should not be greater than 60° C.

When the coffee reaches about 17% moisture, the dryer should be turned off for the coffee to "rest." So during this phase, it reaches the desired moisture content for storage. Care must be taken not to dry the coffee excessively, because this leads to weight loss and breakage of the beans during processing (Figure 26).

17.3. CHERRY PROCESSING

Figure 26. Drying in a mechanical dryer, with the use of an indirect fire.

If the producer has appropriate infrastructure and wants to make processed coffee, it should first be sorted into lots by immersion in water: floating fruit (unripe), and the green and cherry fruits, which sink. The former batch should go directly to drying. The green and ripe cherries go to the pulper, and are then rinsed and spread out for drying, being placed in thicker layers and continuously turned, until dry (Figure 27).

The pulped cherries, can be partially demucilaged, and must be spread in layers 2-3 cm thick in the yard or patio and turned up to 20 times per day. This procedure allows rapid drying. It is recommended to protect this type of coffee from rain and dew (Figure 27).

The production of processed coffee provides the following benefits: improved final product quality, reduced time, and reduced labor and drying times, increased assurance of market and price.

17.4. STORAGE

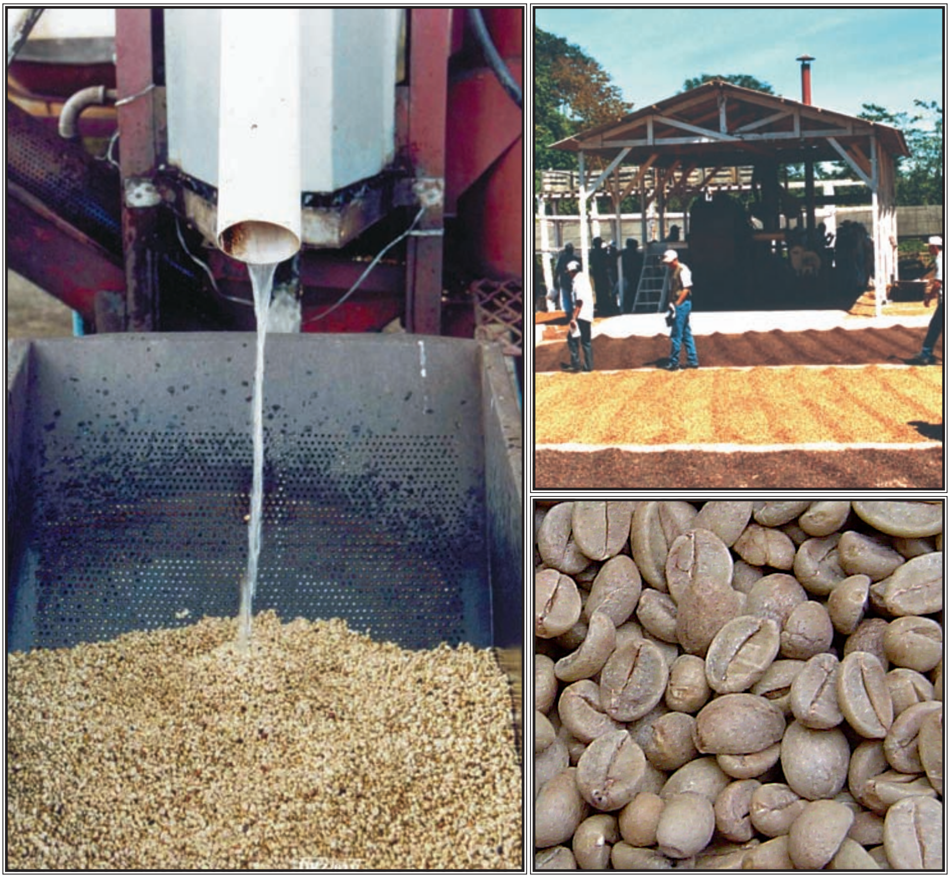


Figure 27. Coffee processing using a technique of cherry hulling for the improvement of the quality of the final product.

Once dry, the coffee should be stored in bins or warehouses built in an easily accessible location, and in a sunny, dry and well ventilated location. Construction should be of wood or masonry and be partitionable for the storage of different batches of the product.

The bins or warehouses should be clean. The commercialization of the product may be carried out gradually, according to the needs of production, and to the favorability of the market, after grading into type and quality lots.

Hulled coffee beans should be stored in jute sacks, in good clean conditions, with a maximum humidity of 12%.

18. FINAL CONSIDERATIONS

The development, launch and availability of the improved varieties Emcapa 8111 (early ripening), Emcapa 8121 (intermediate ripening), Emcapa 8131, (late ripening), Emcapa 8141 Robustão Capixaba (drought tolerant), Emcaper 8151 – Robusta Tropical and Vitória–Incaper 8142 has contributed in an effective form to an increase in the productivity and an improvement in the quality of Conilon coffee in Espírito Santo State.

Many producers, by growing the improved varieties and applying correctly the other technologies recommended by Incaper, such as spacing, planting in rows, nutrition, pruning, and irrigation, have obtained yields of more than 100 sacks of processed coffee per hectare, of good final quality.

The varieties have particular characteristics, and their recommendation is made on the basis of the type, budget and technological level of producer and also based on the region where the varieties will be planted.

Each clone has a defined role within the varieties. The set of clones from each variety provides stability and robustness of the genetic material.

The use of varieties comprising a small number of clones may lead to degradation of the variety, and is associated with the problems of incompatibility and genetic vulnerability, may cause serious consequences for coffee growing in the State.

For Conilon coffee cultivation to remain as a competitive activity, the available technology should be deployed, from the growing of crops, through to harvesting, processing and marketing. In this way, coffee producers can obtain a high yield and a better quality product, with viable costs and good economic returns, with less collateral harm to the environment and a guaranteed market.

19. REFERÊNCIAS

BERTHAUD, J. L’Incompatibilitê chez coffea canephora: méthode de teste et déterminisme gènétique. **Café Cacao Thé**, v. 24, n. 4, p. 267-274. 1980.

BRAGANÇA, S. M.; CARVALHO, C. H. S.; FONSECA, A . F. A . da.; FERRÃO, R. G. **Emcapa 8111, Emcapa 8121, Emcapa 8131**: primeiras variedades clonais de café conilon lançadas para o Estado do Espírito Santo. Vitória, ES: Emcapa, 1993. 2p. (Emcapa, Comunicado Técnico, 68).

BRAGANÇA, S. M.; COSTA, A. N. da; LANI, J. A. Absorção de nutrientes pelo cafeeiro Conilon (*Coffea canephora* Pierre ex *Froenher*) aos 3,6 anos de idade: Micronutrientes. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 1., 2000, Poços de Caldas. **Resumos expandidos**... Brasília: EMBRAPA café, p. 1353-1355, 2000a.

BRAGANÇA, S. M.; COSTA, A. N. da; LANI, J. A. Absorção de nutrientes pelo cafeeiro Conilon (*Coffea canephora* Pierre ex *Froenher*) aos 3,6 anos de idade: Macronutrientes. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 1., 2000, Poços de Caldas. **Resumos expandidos**... Brasília: EMBRAPA café, p. 1350-1351, 2000b.

BRAGANÇA, S. M.; LANI, J. A.; DE MUNER, L. H. **Café Conilon**: adubação e calagem. Vitória, ES: Incaper, 2001 31 p. (Incaper– Circular Técnica, 01).

COSTA, E. B. da (Coord.). **Manual técnico para a cultura do café no estado do Espírito Santo**. Vitória, ES: Seag, 1995. 163 p.

COSTA, A. N. da; BRAGANÇA, S. M. Normas de referências para o uso do DRIS na avaliação do estado nutricional do café conilon. In: CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 22, 1996, Águas de Lindóia. **Anais**... Rio de Janeiro, IBC/CERCA, p. 103-104.

COSTA, A. N. da.; BRAGANÇA, S. M.; LANI, J. A. Software DRIS para o diagnóstico do estado nutricional e recomendação de adubação para cafeeiro conilon. In: SIMPÓSIO DOS CAFÉS DO BRASIL, 14., 2000, Poços de Calda. **Resumos expandidos**... Brasília: Embrapa Café MINASPLAN, v. 2, 2000, p. 1336-1338.

DADALTO, G. G.; BARBOSA, C. A . **Zoneamento agroecológico para a cultura do café no Estado do Espírito Santo**. Vitória, ES: Seag, 1997. 28 p.

DADALTO, G. G.; FULLIN, E. A . **Manual de recomendação de calagem e adubação para o Estado do Espírito Santo**. 4ª aproximação. Vitória, ES: SEEA/INCAPER, 2001, 266 p.

DE MUNER, L. H.; MARTINS, D. S.; FORNAZIER, M. J.; ARLEU, R. J.; BENASSI, V. L. R. M. **Programa de manejo da broca-do-café no Estado do Espírito Santo**. Vitória- ES, 6p. 2000. (Emcaper – Folder)

DE MUNER. L. H.; FERRÃO, R. G.; FONSECA, A. F. A . da.; LANI, J. A . ; VENTURA, J. A.; VERDIN FILHO, A. C. **Produção de mudas de café conilon por semente**. Vitória, ES: Incaper, 2000a. (Emcaper, Documentos, 105)

DE MUNER, L. H.; LANI, J. A.; GOMES, J. A.; SALGADO, J. S. **Calagem**: saiba fazer e colha muitos benefícios. Vitória, ES: Incaper, 2002 (Incaper, Documentos 109). Folder Técnico.

DE MUNER, L. H.; FONSECA, A . F. A . da.; PAGIO, V.;FORNAZEIR, M. J.; FAVORETO, O . S.; MOLINO, J. A. **Cafés qualidade**: Espírito Santo, colheita e processamento. Vitória, ES: Incaper, 2003. (Incaper, Documentos, 121). 1 Folder Técnico.

DIAS, W. P.; LIBERATO, J. R.; COSTA, H. Nematóides associados ao cafeeiro no Estado do Espírito Santo. **Revista Ceres**, 43, n.250, p.808-812, 1996.

FEITOSA, L. R. **Carta agroclimática do Espírito Santo**. Vitória, ES: Emcapa, 1986.

FERRÃO, R. G.; FONSECA, A . F. A . da.; FERRÃO, M. A. G. Programa de melhoramento genético de café robusta no Brasil. In: SIMPÓSIO DE ATUALIZAÇÃO EM GENÉTICA E MELHORAMENTO DE PLANTAS, 3., 1999. Lavras. **Anais**... Lavras. UFLA, v.1, p. 50-65.

FERRÃO, R. G.; FONSECA, A . F. A . da.; FERRÃO, M. A . G.; BRAGANÇA, S. M. **Robusta Tropical - 'Emcaper 8151'**: primeira variedade melhorada de café conilon de propagação por sementes para o Estado do Espírito Santo. Vitória, ES:, Emcaper, 2000a (Emcaper, Documentos 132). Folder Técnico.

FERRÃO, R. G.; FONSECA, A . F. A . da.; SILVEIRA, J. S. M.; FERRÃO,

M. A . G.; BRAGANÇA, S. M. Emcapa 8141 – Robustão Capixaba, variedade clonal de café conilon tolerante a seca, desenvolvida para o estado do Espírito Santo. **Revista Ceres**, n. 273, p. 555 - 560, 2000b.

FERRÃO, R. G.; FONSECA. A. F. A. da.; FERRÃO, M. A G. Banco ativo de germoplasma de *Coffea canephora*, variedade conilon do Estado do Espírito Santo. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 1., 2000. Poços de Caldas. **Anais**... Brasília: Embrapa café/MINASPLAN, v. 1 p. 389-392, 2000c.

FERRÃO, R. G.; FERRÃO, M. A. G.; FONSECA, A . F. A . da; BRAGANÇA, S. M.; LANI, J. A.; COSTA, A . N. da; SILVA, J. G. F.; BENASSI, V. L. R. M.; VENTURA, J. A. **Como produzir café conilon**. RESENDE, P (Roteiro). Viçosa, MG: CTP/INCAPER. Fita, 61 min. 2001.

FERRÃO, R. G.; FONSECA. R. E.; FERRÃO, M. A G.; BRAGANÇA, S. M.; VERDIN FILHO, A. C.; VOLPI, P. S. In: FERRÃO, R. G. et al. (Eds). Cultivares de café conilon. **Café conilon**. Vitória, ES: Incaper, 202-225. 2007a.

FERRÃO, R. G.; FONSECA, A. F. A. da; BRAGANÇA, S. M.; FERRÃO, M. A. G.; DE MUNER, L. H. (Eds). **Café conilon**. Vitória, ES: Incaper, 2007b. 702 p.

FERRÃO, R. G.; FERRÃO, M. A. G.; FONSECA, A. F. A. da; PACOVA, B. E. V. Melhoramento genético de *Coffea canephora*. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper, p. 121-173, 2007c.

FERRÃO, R. G.; VERDIN FILHO, A. C.; FONSECA, A. F. A. da.; FERRÃO, M. A. G.; VOLPI, P. S. Práticas culturais empregadas no café conilon. In: ZAMBOLIM et al. (Eds). **Estratégias para a produção de café com qualidade e sustentabilidade**. Viçosa, MG: UFV, DEP, p. 277-310, 2010.

FERRÃO, M. A. G.; FONSECA, A . F. A . da.; FERRÃO, R. G.; VERDIN FILHO, A. C.; VOLPI, P. S.; SOUZA, E. M. R.; MORELI, A. P. Cultivares de café arábica e conilon recomendações para o Estado do Espírito Santo. In: TOMAZ, M. A. et al. (Coord). **Tecnologias para sustentabilidade da cafeicultura**. Alegre, ES, CAUFES. p. 51-68. 2011.

FONSECA, A. F. A. da; SARAIVA, J. S. T.; BRAGANÇA, S. M.; BREGONCI, I. dos S.; PELISSARI, S. A. Colheita, preparo e armazenamento. COSTA, E. B. da et al. (Coord.). **Manual técnico para a cultura do café no Estado do**

Espírito Santo. Vitória, ES: SEAG, 1995. p.121-130.

FONSECA, A. F. A. da. Propagação assexuada de Coffea canephora no Estado do Espírito Santo. In: PAIVA, R. (Ed.) Workshop sobre avanços na propagação de plantas lenhosas, 1996, Lavras. **Anais**... Lavras. UFLA, v.1, p.31-34.

FONSECA, A . F. A . da. **Análises biométricas em café conilon** (*Coffea canephora* Pierre), 1999. 121 p. Tese (Doutorado em Fitotecnia) – Universidade Federal de Viçosa, Viçosa, 1999.

FONSECA, A . F. A . da.; FERRÃO, M. A. G.; FERRÃO, R. G. A cultura do café robusta. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 1., 2000. Poços de Caldas. **Palestras**... Brasília, DF: Embrapa/CBP&D/Café, p. 119-145, 2002.

FONSECA, A. F. A. da.; FERRÃO, M. A. G.; FERRÃO, R. G.; VERDIN FILHO, A. C.; VOLPI, P. C.; ZUCATELI, F. **Conilon Vitória - 'Incaper 8142'**: variedade clonal de café conilon. Vitória, ES: Incaper, 2004. (Incaper, Documentos 127)

FONSECA, A. F. A. da.; FONSECA. R. E.; FERRÃO, M. A. G.; SILVA, A. E. S. da; DE MUNER, L. H.; VERDIM FILHO, A. C.; VOLPI, P. C. **Jardins clonais de café conilon**: técnicas para formação e condução. 2 ed. Vitória, ES: Incaper, 2005. 56 p. (Incaper. Circular Técnica, 04-I)

FONSECA, A . F. A. da.; FERRÃO, R. G.; FERRÃO, M. A. G.; VERDIM FILHO, A. C.; VOLPI, P. C.; BITTENCOURT, M. L. C. Jardins clonais, produção de sementes e mudas. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper, 226-255. 2007.

FONSECA, A. F. A. da.; FERRÃO, M. A. G.; FERRÃO, R. G. Qualidade do café conilon no Espírito Santo. In: TOMAZ, M. A. et al. (Eds). **Tecnologias para a sustentabilidade da cafeicultura**. Alegre, ES: CAUFES, p. 183-204. 2011.

FORNAZIER, M. J.; BENASSI, V. L. R. M.; MARTINS, D. dos S. Pragas. COSTA, E. B. da et al. (Coord.). **Manual técnico para a cultua do café no Estado do Espírito Santo**. Vitória, ES: Seag, 1995. p. 68-81.

FORNAZIER, M. J.; BENASSI, V. L. R. M.; ARLEU, R. J.; MARTINS, D. S.; SOUZA, J. C.; FONSECA, A. F. A.; DE MUNER, L. H. **Manejo da broca-do-**

café. Vitória-ES, 6p. 2000a. (Emcaper – Documento nº 104).

FORNAZIER, M. J.; PERINI, J. L.; DE MUNER, L. H.; BENASSI, V. L. R. M.; MAZZO, G.; SANTA-CECÍLIA, L. V. C.; DAUN, S. C. Cochonilha branca da roseta em café conilon (*Coffea canephora*) no Estado do Espírito Santo. In: CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 26. Marília-SP. **Anais**... Marília, SP. p.176-177. 2000b.

FORNAZIER, M. J.; MARTINS, D. S.; CARMO, G. O.; DE MUNER, L. H.; SANTA CECÍLIA, L.V. C. Ocorrência de *Planococcus minor* Maskell, 1897 (Hemiptera:Pseudococcidae) em café na região sul do Espírito Santo. In: CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 27. Uberaba-MG. **Anais**... Uberaba, MG. p.250-251. 2001.

FORNAZIER, M. J.; FANTON, C. J.; MARTINS, D. S.; GOMES. W. R.; GOMES, M. A. **Guia do cafeicultor**: cochonilha da roseta do café conilon. COOABRIEL - Órgão informativo da cooperativa de São Gabriel. São Gabriel da Palha, p.7. set/2004.

FORNAZIER, M. J.; FANTON, C. J.; BENASSI, V. L. R. M.; MARTINS, D. dos S. Pragas do café conilon. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper. p. 404-449. 2007.

FORNAZIER, M. J.; MARTINS, C. L.; MARTINS, D. S.; VITORAZI, J. A. F. Ocorrência da broca dos ramos *Xylosandrus compactus* (Eichhoff) (Coleoptera: Scolytidae) em café conilon na região Sul do estado do Espírito Santo. In: Congresso Brasileiro de Pesquisas Cafeeiras, 34, Caxambu, 2008. **Resumos**... Caxambu, MG: SDC/MAPA/PROCAFÉ, SPAE/DECAF, Fundação PROCAFÉ; CBP&D-Café/Embrapa-Café, UNIUBE, SEAG-MG, UFLA. 2008. p.191-192.

FORNAZIER, M. J.; MARTINS, D. S.; GOMES, W. R.; CONTARATO, C. C.; WOLFGRAMM, R.; SCALFONI, A. Infestação da broca dos ramos *Xylosandrus compactus* (Eichhoff) (Coleoptera: Scolytidae) em clones de café conilon, região norte do Espírito Santo. In: Congresso Brasileiro de Pesquisas Cafeeiras, 37, Poços de Caldas, 2011. **Resumos expandidos**... Poços de Caldas, MG: SDC/MAPA/PROCAFÉ, SPAE/DECAF, Fundação PROCAFÉ; CBP&D-Café/Embrapa-Café, SEAG-MG, UNIUBE, UFLA, 2011. p.309.

LAMBON, C.; CROUZILLAT, D.; FONSECA, A. F. A. da.; LELAUP. V.; BROUNP, V.; BROUN, P.; PETIARD, V.; FERRÃO, M. A. G.; FERRÃO, R. G. Evaluation of conilon for genetic diversity, cup quality and biochemical composition. In: International conference on coffee science. 22. **Asic**. Campinas, SP: Asic, 2008.

LANI, J. A.; ZANGRANDE, M. B.; FONSECA, A. F. A. da.; FULIN, E. A.; VERDIM FILHO, A. C. Eficiência de práticas vegetativa no controle de erosão na cultura do café conilon. In: CONGRESSO BRASILEIRO DE PESQUISA CAFEEIRA, 22., 1996. Águas de Lindóia. **Resumo Expandido**... MAA/ PROCAFÉ, p. 105-107.

LANI, J. A.; BRAGANÇA, S. M.; PREZOTTI, L. C.; MARTINS, A. R.; DADALTO, J. G. Preparo, manejo e conservação do solo. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper, 278-295, 2007.

LASHERMES, P.; COUTURON, E.; MOREAU, N. PAILARD, M.; LOAURN, J. Inheritance and genetic mapping of self-incompatibility in *Coffea canephora* Pierre. **Teoretical and Applied Genetics**. v. 93, n. 3, p. 458-462, 1996.

LIMA, I. de M.; VENTURA, J. A.; COSTA, H. Nematóides do cafeeiro. In: IDAF. **Certificação fitossanitária de origem**. v.1, Pragas. Vitória: IDAF, 2011, p.147-163.

MANSK, Z.; MATIELLO, J. B. Ocorrência de mancha manteigosa em café "conilon" (*Coffea canephora*, Pierre) no estado do Espírito Santo. In: CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 5, Campinas: IBC/GERCA, 1977. **Anais**... Campinas:IBC/GERCA, 1977. p.172-173.

MATIELLO, J. B.; NEVES, A. M. B.; SILVA, C. A. M. Ocorrência da broca de ramos, *Xylosandrus compactus* em cafeeiros robusta no sul da Bahia. CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 25. Franca. **Anais**... Franca, SP. 1999. p.11.

MATIELLO, J. B.; FREITAS, J. L. Ocorrência de broca dos ramos do cafeeiro, em lavouras de conilon no norte do Espírito Santo. Congresso Brasileiro de Pesquisas Cafeeiras, 31. Guarapari. **Anais**... Guarapari, ES. 2005. p.23.

MATIELLO, J. B.; ALMEIDA, S. R.; ROSA, G. N.; LEITE FILHO, S. **Ocorrência da broca das ramos** (*Xylosandrus* (*Xyloborus) compactus*) **em cafeeiros robusta, na Zona da Mata de Minas Gerais**. Fundação Procafé. Clube de Tecnologia Cafeeira. Procafé on line. FT 17. 2009. 2p.

PREZOTTI, L. C.; BRAGANÇA, S. M. Nutrição. COSTA, E. B. da et al.

(Coord.). **Manual técnico para a cultura do café no Estado do Espírito Santo**. Vitória, ES: SEAG, 1995. p. 42-52.

PREZOTTI, L. C.; BRAGANÇA, S. M.; GUARÇONI, M. A.; LANI, J. A. Calagem e adubação. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper, 329-343. 2007.

RIOS, J. N. G. Certificação de origem e qualidade de café. ZAMBOLIM, L. (Ed.). **Produção integrada de café**. Viçosa, MG: UFV, DFP, 2003. p. 509-548.

ROCHA, M. A. M. Manejo de plantas daninhas. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper, 390-403. 2007.

SARAIVA, J. S. T.; SILVEIRA, J. S. M. Irrigação do café. COSTA, E. B. da et al. (Coord.). **Manual técnico para a cultura do café no Estado do Espírito Santo**. Vitória, ES: SEAG, 1995, p.111- 120.

SILVA, J. G. F. da; REIS, E. F. dos. Irrigação do cafeeiro conilon. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES. Incaper, 344-373. 2007.

SILVEIRA, J. S. M.; CARVALHO, C. H. S. de; BRAGANÇA, S. M.; FONSECA, A . F. A .da. **A poda do café conilon**. Vitória, ES. Emcapa, 1993. 14 p. (Emcapa, Documento 80).

SILVEIRA, J. S. M. Café conilon irrigado no Espírito Santo. In: SIMPÓSIO ESTADUAL DE CAFÉ, 2., 1996. Vitória. **Palestras, painéis de debates**... Vitória, ES: Cetcaf, p. 66-81, 1996.

SILVEIRA, J. S.; SILVEIRA, T. B.; VERDIM FILHO, A. C.; VOLPI, P. C.; FONSECA, A. F. A. da; FERRÃO, M. A. G.; FERRÃO, R. G.; GUARÇONI, M. A.; LANI, J. A.; COMÉRIO, F. **Poda programada de ciclo para o café conilon**: nova tecnologia de revigoramento de lavouras. Vitória, ES: Incaper, 2008. (Documentos nº 163)

SOUZA, A.F.; COSTA, H.; ZAMBOLIM, L.; MENDES, C.; FREITAS C. R. L.; ZAMBOLIM, E. M.; JESUS JUNIOR, W. C.; PEREIRA, O. L. First report of Corynespora cassiicola causing leaf and berry spots on Coffea canephora in Brazil. **Australasian Plant Disease Notes**, v.4, p.72–74, 2009.

TAQUES, R. C.; DADALTO, G. G. Zoneamento agroclimático para a cultura do café conilon no Estado do Espírito Santo. In: FERRÃO, R. G. et al. (Eds).

Café conilon. Vitória, ES: Incaper, 51-63 p. 2007.

VENTURA, J. A. Doenças. In: COSTA, E. B. da et al. (Coord.). **Manual técnico para a cultura do café no Estado do Espírito Santo**. Vitória, ES: SEAG, 1995. p.82-89.

VENTURA, J. A.; COSTA, H.; SANTANA, E. N. de; MARTINS, M. V. V. Diagnóstico e manejo das doenças do cafeeiro conilon. In: FERRÃO, R. G. et al. (Eds). **Café conilon**. Vitória, ES: Incaper, 450-497. 2007.

VOLPI, P. S.; VERDIM FILHO, A. C.; FONSECA, A. F. A. da; FERRÃO, M. A. G.; FERRÃO, R. G.; MAURI, A. L. Vergamento: tecnologia para preparação da planta do café conilon para a poda programada de ciclo. **Pesquisa em andamento**. Vitória, ES: Incaper, 2012 (prelo).

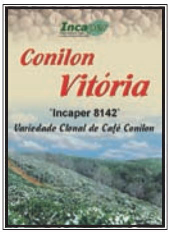
ZAMBOLIM, L.; VENTURA, J.A. Resistência a doenças induzida pela nutrição mineral das plantas. **Revisão Anual de Patologia de Plantas**, Passo Fundo, v.1, p.275-318, 1993.

ZAMBOLIM, L.; VALE, F. X. R. do.; COSTA, H.; PEREIRA, A. A. CHAVES, G. M. Epidemiologia e controle integrado da ferrugem do cafeeiro. In: ZAMBOLIM, L. (Ed.). **O estado da arte de tecnologias na produção de café**. Viçosa, MG: 2002. p. 369-450.

ZAMBOLIM, L.; VALE, F. X. R. do; ZAMBOLIM, E. M. Produção integrada do cafeeiro: manejo de doenças. In: ZAMBOLIM, L. **Produção integrada de café**. Viçosa-MG: UFV, 2003. p.443-508.

OTHER INCAPER PUBLICATIONS

Café Conilon
702 páginas



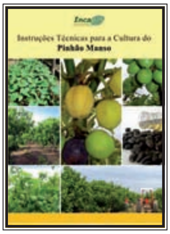
Conilon "**Vitória Incaper 8142**" Variedade Clonal de Café conilon, 2ª edição
28 páginas

Técnicas de produção de café arábica: renovação e revigoramento das lavouras no Estado do Espírito Santo - 56 páginas

Cultivares de Café Arábica para a Região das Montanhas do Estado do Espírito Santo, 2ª edição - 40 p.

Agroecologia e Agricultura Orgânica - 32 páginas

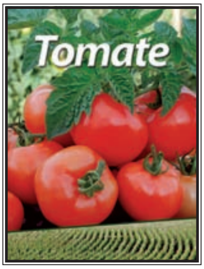
Compostagem Orgânica
36 páginas



Instruções Técnicas para a Cultura do Pinhão Manso
28 páginas

Manual de uso Agrícola e Disposição do Lodo de Esgoto para o Estado do Espírito Santo
126 páginas

Conhecimentos Tecnológicos para o Cultivo orgânico de Hortaliças, Milho e Feijão no ES - 56 páginas



Tomate
430 páginas

Recomendações técnicas para o cultivo do maracujazeiro - 56 páginas

Criação de Galinhas em Sistemas Agroecológicos
284 páginas

Recomendações Técnicas para a Produção de Manga
56 páginas

Recomendações Técnicas para a Cultura do Abacaxizeiro - 28 páginas

Recomendações Técnicas para o Cultivo de Bananeira no Estado do ES - 48 páginas

A Cultura da Pimenteira-do-Reino do Estado do Espírito Santo - 36 páginas

Mapa de unidades naturais do Estado do Espírito Santo
56 páginas

Agricultura Orgânica: tecnologias p/ a produção de alimentos saudáveis vol. II - 257 páginas

MAPA DAS UNIDADES NATURAIS DO ESTADO DO ESPÍRITO SANTO (com rios) e (sem rios)

Rua Afonso Sarlo, 160 - Bento Ferreira - Vitória-ES - Caixa Postal 391 - CEP 29052-010
Tel.: (27) 3636 9846 - biblioteca@incaper.es.gov.br

Realization

Rua Afonso Sarlo, 160 - Bento Ferreira - CEP 29052-010 - Vitória-ES - Brasil
Caixa Postal 391 - Tel.: 55 27 3636 9846
coordenacaoeditorial@incaper.es.gov.br - www.incaper.es.gov.br