CONILON
Coffee

3rd Edition
Updated and expanded

The Coffea canephora produced in Brazil

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Management of Conilon Coffee Cultivation: Planting, Spacing, Pruning and Pinching

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1 INTRODUCTION

The *Coffea canephora* species was introduced in the State of Espírito Santo at the beginning of the last century. Its commercial exploitation became, however, more expressive from the 1960s, especially with the use of areas considered marginally apt or even unfit for the cultivation of arabica coffee, because it is a more rustic species, with a higher tolerance to pests and diseases, more adapted to cultivation in low altitude areas, with higher temperatures and higher water deficiencies (FONSECA, 1999; FERRÃO et al., 2012a).

After the coffee eradication program in the country, which recommended the elimination of crops with productivity below 6 proces bags/ha and the finding that Espírito Santo had been the state of the Union that proportionately eradicated the most coffee in the country, coffee growers, notably those from the northern part of the State, chose, even against their will and with no support of the government, the *C. canephora* cultivation, better known in the State as "Conilon" (FONSECA, 1999).

The expansion of their cultivation in Espírito Santo took place on the fringes of scientific research, through the sexual multiplication of plants selected over the years by the coffee growers themselves, who, according to criteria established by them, selected matrices that distinguished themselves as possessing of characteristics of interest. This fact allowed the establishment of populations with wide genetic variability (CARVALHO et al., 1969; FONSECA, 1999; FONSECA, 2001b; FONSECA, 2013a). It is an allogamous, diploid species, composed of very heterogeneous populations. *C. canephora*, as well as all the other diploid species of the *Coffea* genus, present gametophytic self-incompatibility (BERTHAUD, 1980; LASHERMES et al., 1996).

Thus, in view of their natural cross-breeding characteristics, the traditional conilon coffee plantations, formed from seedlings, presented great heterogeneity, with very distinct plants in a series of aspects, such as: aerial part architecture, grain size and shape, time and uniformity of fruit maturation, susceptibility to pests and diseases, drought tolerance, vegetative vigor, productive capacity, inherent aspects of the intrinsic quality of grains, among others (FERRÃO et al., 2012a). This reality greatly hindered the agronomic performance of crops, limiting the productive potential and the final quality of the product.

With such distinct plants coexisting in the same crop, it became impracticable to define certain practices that are fundamental to obtaining high levels of productivity and that should be recommended for the crop as a whole. Among these practices are: definition of the most suitable spacing and number of stems per plant in each situation, best harvesting season, fertilization calculations and need for pest and disease control, among many others (FERRÃO R.; FONSECA; FERRÃO M., 1999; FERRÃO et al., 2012a).

Even nowadays, with the advances obtained with the species breeding, the same behavior can not be obtained for all the genotypes of the same cultivar in relation to a given practice. However, the differences in responses among the numerous previously cultivated genotypes from open pollination are no more so evident than in the improved cultivars, notably in clonal cultivars. Naturally, with the evolution of science, there is a possibility that in the future each clone of the same cultivar will receive more specific treatments depending on their particularities and needs. A series of biotic and abiotic factors, either alone or interacting with each other, determines the adaptation and agronomic performance of a certain species in a given region. In the beginning, attention should be paid to the species requirements, especially regarding edaphoclimatic conditions. It is also necessary to consider the particularities of each production system that is intended to be implemented, in order to define the most appropriate system of planting, management, spacing, cultivation and phytosanitary treatments. Many of these aspects are better approached in other chapters of this same work.

2 PLANTING

The conilon coffee planting can be carried out in open pits directly on the surface of the soil, previously clean and free of obstacles or grooves, prepared in places where the topography allows mechanization operations, whether motorized or by animal traction (Figure 1). In the first case, the pits can be opened manually using tools such as hoes and diggers or with the use of drill bits (FERRÃO et al., 2012a). If the option is for planting in grooves, ridgers are used alone or associated to subsoilers (SARAIVA et al., 1995). Details of these operations are found appropriately discussed in Chapter 12 “Management, Soil Preparation and Conilon Coffee Conservation”.

In general, there are two main recommended seasons for conilon coffee planting in Espírito Santo, each of them has advantages and disadvantages: in the hottest rainy season, from October to November, or in the colder and drier period, between March and April (TAQUES; DADALTO, 2007; FERRÃO et al., 2012a).

In the first season, the planting exposes the new plants to a very common and rigorous period of drought (summer), which usually occurs in January and February in the State of

Espírito Santo. Thus, even in the case of a more rainy period, one should be prepared for the need for eventual irrigation (FERRÃO et al., 2012a). In the hotter period, it is important that the seedlings are protected from the sun. Generally, the protection with Palm Tree leaves, fixed vertically in one or both sides of the seedling (Figure 2), offers good results (FERRÃO et al., 2012a).

Figure 1. Aspects of soil preparation and opening of pits for planting.

Figure 2. Protection aspects of newly planted seedlings in definitive field.

In plantations carried out in March/April, on the other hand, the greatest difficulty lies in the real need for regular water supplementation. At this planting time, plants usually have a slower development both in function of the lower temperatures and the greater shortage of water. Thus, even under these conditions, water supplementation is always a factor of great importance for the vigorous development of young plants.

In general, summer planting has been the most recommendable and preferred of coffee growers in the State of Espírito Santo due to the fastest and most vigorous initial development of the plants, which, in this case, will provide the first significant harvest when the plants are about 18 months old. In the colder period planting, the production begins 24 months after planting.

For the suitable formation of crops, it is fundamental that the seedlings, when used, have adequate quality, since they can jeopardize the enterprise success, leading to significant losses of invested resources, seedlings and labor costs, and by the loss of time.

No seedlings with a deformed root system should be used. Rena and Guimarães (2000) reported serious problems involving the malformation of the clonal seedlings root system in the northern region of the State of Espírito Santo. These authors observed that root deformations (roots interlacing or "hanging") increased when clonal seedling formation was performed in small tubes, especially when they remained in these containers for long periods before being taken to the bags or directly to the field (Figure 3). In this case, there is a serious impairment of the longevity of coffee trees, especially after years of good production, due to the exhaustion of the plant as a result of a reduction of its capacity to absorb water and nutrients. According to Silveira (1996), in situations like these, there are many losses records of more than 50% of the plants right after the first harvests.

The protection of newly planted seedlings promotes better conditions for plant survival and early development. In works conducted in Natividade/RJ and Mutum/MG, Matiello (1998) observed that the protection of the seedlings provided a reduction from 49% to 10% and from 25% to 0%, respectively, in the loss of seedlings evaluated six months after planting. The same author reported that it is advantageous, both for stem diameter increase and for plant height, that the planting be carried out in the depth of 10 to 20 cm, when compared to the superficial plantation, which provides greater humidity retention and temperature reduction in the seedlings. However, in irrigated conditions, care must be taken so the deepest planting does not lead to the "drowning" of the seedlings, according to Silveira (1996).

Figure 3. Roots aspects in seedlings produced in tubes (left) and directly in appropriate bags (right).

Despite the care that is usually taken for the occasion of planting, it is necessary to carry out, when necessary, about 20 to 30 days after planting, replacing dead, weaker and defective seedlings (FERRÃO et al., 2001). To reduce the need for replanting, it is recommended to use new seedlings, which have three to four pairs of definitive leaves, previously submitted to the acclimatization process. It is also advisable that at the time of planting, the pits, prepared and fertilized, are reopened only where the root ball containing the seedling will be introduced (Figure 4); that the bags are cut to 1.0 cm in the inferior part aiming the elimination of the committed roots (Figure 5A); that the rest of the bag that surrounds the seedling is eliminated (Figure 5 B and C); that the seedling be introduced into the pit until the height of the neck (Figure 6) and that a slight lateral compaction of the soil around the seedlings is made, never pressing the seedlings or the surrounding soil, from the top to the bottom (FERRÃO et al., 2012a).

Figure 4. Pits reopening at the moment of seedlings planting.

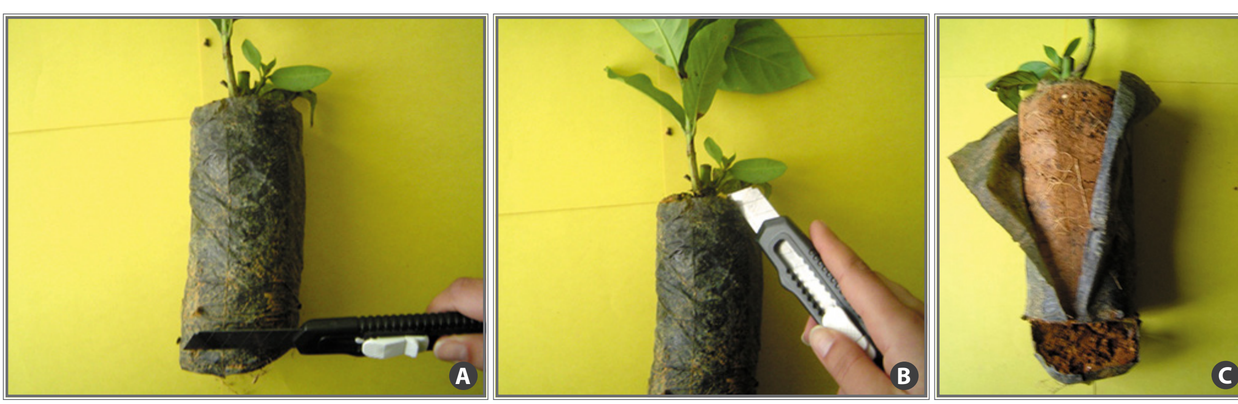

Figure 5. Seedlings preparation for field planting. Elimination of the tangled roots by cutting the bottom of the root ball (A) and the rest of the bag (B and C).

2.1 PLANTING IN LINES

Until 1999, the recommendation for the planting of the first three clonal conilon cultivars, made available by the Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - Incaper (Capixaba Institute for Research, Technical Assistance and Rural Extension) for cultivation in Espírito Santo, was for the respective clones of each of them were planted in the same proportions, but distributed in the field in a random way, avoiding agglomerations of the same clone, in order to facilitate the necessary cross-pollination among all of them, since within each cultivar the clones had the same fruit maturation time.

Figure 6. Seedlings being introduced into pits and covered up to the high of the neck of plants.

With the evolution of the research work for the development of new cultivars, it was possible to obtain a new clonal cultivar with different behavior in conditions of more severe water deficiency, an important factor that limits to reach higher productivity. The cultivar Emcapa 8141 - Robustão Capixaba was obtained, whose clones presented the desired behavior, but did not have, however, the same time of fruit maturation.

This fact would constitute a regression to the evolution in the quality obtained by the first cultivars, whose fruits were uniformly mature at the same time. Thus, it was recommended the planting in rows, which consists in the arrangement of each clone of a given clonal cultivar in a single line in each field and successively, so that there is no possibility of mixing the fruits during the harvesting procedures, given the differences in maturity between them.

Thus, in the case of an option for the cultivation of the clonal cultivars launched by Incaper from 1999, planting must be carried out in lines (Figure 7), as it is a practice of great importance to guarantee the success in productivity, product quality, stability, safety and activity longevity (FONSECA et al., 2005a, 2005b; FERRÃO et al., 2012a). As conilon coffee is a cross-fertilization plant due to the presence of the genetic self-incompatibility system, all plants originated from the same matrix by the cloning process (asexual propagation) have the same genetic constitution (FONSECA et al., 2013a). which makes it impossible the cross and the production.

The composition of the clonal varieties of the Incaper is studied in detail in relation to a series of variables considered of great importance for the activity (FERRÃO, R.; FONSECA; FERRÃO, M., 1999; FONSECA et al., 2001a, 2001b, 2004; FERRÃO et al., 2012a, 2012b; FONSECA et al., 2013a). They must be formed from homogeneous clones in relation to different characteristics, such as architecture, productive potential, time and uniformity of fruit maturity, among others (Figure 8). However, it is critical that clones show good genetic compatibility. In addition, there are many reasons to recommend them together, as each clone has a role to play in the clonal cultivar. Some are chosen for their productive capacity, others for the stability of production over time or for the small biennial variation of production, or for their ample adaptation to different environments, others for disease resistance or for drought tolerance, or for being good "crosses""with the others (FONSECA et al., 2004). In this way, it is advised that each variety recommended by Incaper be planted with the inclusion of all its respective clones (FERRÃO et al., 2012a; FERRÃO et al., 2013, 2015a, 2015b, 2015c, 2017).

Figure 7. Aspects of planting in clone lines components of improved clonal varieties.

It is a big mistake planting crops with clonal varieties, not using all the recommended clones. This fact may compromise the performance of the crop, particularly in adult crops, when the plants themselves constitute barriers to the wind, which is the main pollinator agent, making the process deficient (Figure 9).

Another important problem caused by the use of a small number of clones is related to the stability of the production process (FONSECA et al., 2005b). Thus, for example, when the nine clones of the cultivar Diamante ES8112 are cultivated, if one of them presents a problem, in the future, just a little more than 10% of the crop could be compromised. However, if the crop is made up of four or five clones, the problem would not be "diluted", but, on the contrary, aggravated, because in that case, the commitment would be from 20% to 25% of the total plants.

Figure 8. Cultivars formed of homogeneous clones in relation to different characteristics, such as architecture, productive potential, time and uniformity of fruit maturation, among others.

Figure 9. In more mature dense crops, there may be problems of pollination due to the difficulty of wind passing through the plants.

Since the first recommendations of clonal cultivars made by Incaper, in 1993 some coffee growers have inadvertently deployed and conducted crops with few clones reaching extreme cases with a single clone (FONSECA et al., 2005b). Even today, there are coffee growers insisting on the cultivation of smaller numbers of clones growing intercalary lines with what they call "cross clones" (FONSECA; FERRÃO, M.; FERRÃO, R. 2013c).

Such procedures are due to the fact that these producers only choose genetic materials with high productive capacity or with other characteristics that are of interest, under their point of view, disregarding aspects of coffee cultivation security and stability. It occurs that the identification of these plants considered superior is often performed when they are surrounded by other genetically different plants, that serve like pollinators. The planting of seedlings resulting from one or a few matrices will deprive adult plants of this favorable fertilization condition. This option can lead to disastrous results for the coffee producer and, in the future, for the coffee industry, due to the reduction of the amplitude of the genetic base in conilon coffee (FERRÃO et al., 2012a), a preponderant factor for the activity sustainability.

As an example of this problem, a case was accompanied by Incaper in the north of the State of Espírito Santo. According to Fonseca et al. (2005b), on his own and mistaken initiative, a producer implemented a crop with only one clone. This crop was constituted of 59 lines, with 120 plants each. At the site, there were two other crops consisting of mixtures of several other clones. One distant of 30 m, and another separated from the crop in question by only one road with width of approximately 2.5 to 3.0 m. Figure 10 shows the layout of the crop in question planting lines, the location of crops close to it and the variation of the "coffee from the field" production in the first two harvests (2003 and 2004), in liters/ line of 120 plants.

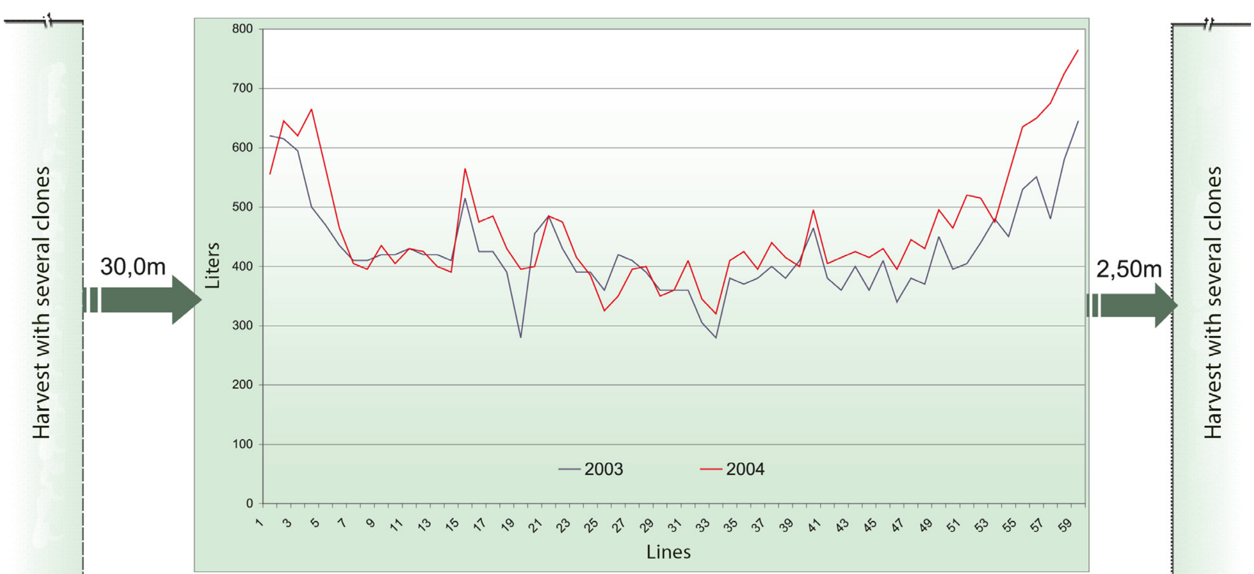

Figure 10. Average production of cherry coffee (liters of harvested fruits/lines with 120 plants) in the first two harvests of a clonal crop formed by only one clone, implanted between two other crops composed of several clones.

It was observed that the production of the outermost lines was substantially superior to the most central ones. The average production of the innermost lines was 400 L, reaching less than 300 L in some of them, corresponding to less than half of the production achieved in the outermost lines.

On the left side, where the production of the first lines reached values close to 650 L in the average of the two harvests, the reduction of the production was more expressive, arriving, in the seventh line, to values of about 400 L. To the right, probably due to the greater proximity to the oldest crop, the reduction of the lines average production occurred less intensely, reaching 400 L only in the forty-eighth line. The greater proximity to the tillage of several clones may also probably be related to the higher production levels obtained from this side of the crop, which reached almost 800 L at the end line in the second crop.

Another factor worthy of note in this example is the small difference in values from the first to the second crop. Under normal conditions, the second harvest is, at least, double the first harvest. In the situation presented, it increased from 434 to 472 L, corresponding to a growth of less than 10%. The more dense the crop, the greater the difficulty for the pollen grains penetration between the plants, and the situation tends to be aggravated in the next harvests, with plants growth and greater difficulty of pollen circulation. It is noteworthy that, after the second harvest, considering the production achieved, the producer opted for an intervention in the crop, which prevented the evaluations continuity.

Thus, it can be summarized as being the main consequences of the use of small numbers of clones in the crops formation: problems in pollination and fertilization leading to the formation of rosettes with few fruits; increase in the number of flowering plants contributing to a greater degree of maturation uniformity; erosion or genetic vulnerability, which can promote a higher incidence of pests and diseases, leading to the need for routine phytosanitary control; less longevity of the crop; and compromise of production productivity and quality. These consequences, among others, may constitute important threats to conilon coffee cultivation, as it happens in other countries producing the species.

3 SPACING

Among the characteristics of the coffee tree aerial part that interfere in the production capacity of the plants, can be mentioned: the plant height; the crown diameter; the number and length of orthotropic stems and plagiotropic branches; the number of nodes; the length of internodes; and the capacity of issuing new shoots, which provide the effective possibility of replacing the productive branches through pruning. The production capacity of a cropping are also interfered by factors related to the different cropping systems, such as the variety, the technological level used, the topography, the possibility of mechanization, the rainfall distribution throughout the year, the use of irrigation, the fertility and fertilization levels, among others. All of these are factors that influence in some way the recommendation of spacing to be adopted in conilon coffee crops (FERRÃO et al., 2012a).

In the past, spacing ranging from 4.0 to 5.0 m between lines and from 3.0 to 4.0 m between plants were quite common. From the 80's, a trend began of using smaller spacing. However, plant density per unit area was still too low to provide satisfactory productivity rates (SARAIVA et al., 1995), as it can be seen in Figure 11.

In these growing conditions, conducted without any form of pruning or planting, the plants were still very young and had an excessive number of orthotropic branches, many of them unproductive, contributing to obtain low yields by promoting the crops "closure" and their precocious exhaustion (Figure 12), since they require a large amount of photoassimilates for their maintenance and growth.

Figure 11. Too "open" spacing used in the past.

Figure 12. Excessive "closure" in crops not routinely pruned.

Works conducted in the Incaper, in the most representative environmental conditions of the State northern region, have shown that a combination of factors must be observed to achieve the most suitable spacing arrangements and planting densities for a given cultivation condition. Considering the predominant systems, with the use of technologies capable of providing productivity greater than 60-80 bags/ha, the most promising results have been obtained at spacing of about 3.0 m between lines and from 1.0 to 1.2 m between plants totaling about 3,333 and 2,777 plants/ha, respectively.

In all experiments involving different spacing, it is observed that the most important is the average population of orthotropic stems/ha. Thus, assuming a population of 3,000 plants/ha, the recommendation is that about four to five orthotropic stems should be maintained in production per plant, totaling between 12 and 15 thousand stems/ha, being, of course, the spacing arrangement according to the other conditions of the production system adopted.

In more recently observed situations, even using these spacing, producers who generally cultivate larger areas (where they apply the highest technological level), with well established and nurtured plants, properly managed and irrigated, have achieved good results, maintaining lower densities of stems/ha (9 to 12 thousand). Such situation is justified by the fact that the maintenance of fewer stems in the plantations facilitates the execution of all their management, especially when mechanized or semi-mechanized: cultivation treatments, phytosanitary control and harvesting operations.

It is also observed that in some more particular cases, small producers use the most noble areas of their properties for denser crops (4 to 5 thousand plants/ha). In cases like these, it generally observes high productivity that reach 150 processed bags/ha, since, for that, the conduction of a smaller number of stems per plant (2 to 3) is adjusted.

In non-irrigated crops, implanted in poorer soils and conducted at a lower technological level, the most advantageous results have been achieved, when the association of higher plant densities (4 to 5 thousand/ha) and stem density ranging from 16 and 20 K/ha (VERDIN FILHO et al., 2014).

Due to the numerous cultivation systems verified in the existing plantations, it is not possible to establish a fixed number of orthotropic stems for all plants, especially in the case of crops whose seedlings have been formed by seeds, since there is a great variation in the architecture, vigor and height between plants, making it necessary to determine the ideal average number of branches for each plant, adjusting this variable for these circumstances, while (SILVEIRA et al., 1993) keeping in mind the number of stems/area desired.

The spacing greatly influences the distribution of the coffee tree root system. In denser plantations, there is a trend to deepen the main roots leading to a more efficient use of water and minerals available in both the superficial and deep layers of the soil, as observed by Rena and Guimarães (2000).

In addition, Guarçoni M., Bragança and Lani (2005) verified a significant increase in the availability of phosphorus (P) and potassium (K) in the soil, when conilon coffee was planted at a density of 5,000 plants/ha, in relation to the densities of 2,222 and 3,333 plants/ha. Guarçoni M. (2011) considers that the increase of nutrient contents in soils under heavy cultivation is mainly due to the cycling of nutrients in the soil-plant system, lower adsorption of P in soil and greater retention of nutrients that would be lost due to erosion or leaching. Such observations may be an indicative that, in areas cultivated by small farmers, the recommended spacing could be reviewed in order to increase density and adjust spacing to the production system.

The response of the conilon coffee grown in a dense planting system, with different doses of N, P and K, was evaluated by Bragança et al. (2005) in a study on Latosol for seven harvests (1998-2004), on the experimental farm of Maryland, northwest of the State of Espirito Santo. Four doses of N (0, 150, 300 and 450 kg/ha), four of P_2O_5 (0, 50, 100 and 150 kg/ha) and four of K_2O (0, 150, 300 e 450 kg/ha), were studied in the following spacing: 2.0 x 1.0 (5,000 plants/ha); 2.5 x 1.0 (4,000 plants/ha); 3.0 x 1.0 (3.333 plants/ha) and 3.0 x 1.5 m (2,222 plants/ha). They observed a significant response between planting densities and doses of N_2 and P_2O_5, in the average of seven harvests. The productivity presented a linear response with the increase of planting density. With the increase of N doses, a quadratic effect on productivity was observed, with a maximum of 59.3 proces bags/ha, which corresponded to a dose of 298 kg/ha of N. There was a linear response for P, with a maximum productivity of 57.7 proces bags/ha when 150 kg/ha of P_2O_5 was used. Naturally, these results need to be analyzed according to the conditions in which they were obtained.

In addition, Guarçoni M., Bragança and Lani (2005) verified that the densification of conilon coffee plantations presented a consistent effect only on the availability of P and K, but only when the annual fertilization with NPK was carried out, being that as denser is the planting as higher is the availability of soil P and K, both on the surface (0 to 20 cm) and in the subsurface (20 to 40 cm). P levels increased by 315 and 956% in the surface and subsurface layers, respectively, when a density of 2,222 (3.0 x 1.5 m) plants/ha was increased to 5,000 (2.0 x 1.0 m) plants/ha. In the case of K, the increase was less expressive than for P, but nonetheless high, reaching 189 and 248% in the superficial and subsurface layers, respectively, when a density of 2,222 (3.0 x 1.5 m) changed to 5000 (2.0 x 1.0 m) plants/ha. Thus, it is understood that for conilon coffee denser plantings, the adoption of balanced fertilizer management is even more important.

Closing the crop, however, when too much, hinders the entry of light into the lower and inner parts of plants, hampering the management of new shoots that will replace those that are being eliminated for having become unproductive. In these cases, young buds undergo a process of internodes (Figure 13), which requires their elimination, which delays the process of plant renewal with pruning (SILVEIRA et al., 1993).

Figure 13. Etiolation of the most orthotropic branches due to lack of light penetration inside the plants crown with production pruning.

4 CONDUCTION SYSTEM OF PLANT - PRUNING

4.1 PLANTS CONDUCTION IN FREE GROWTH, ARCHED AND 'DECOTE'

In general, the first productions of conilon coffee crops, especially when grown from clonal cultivars, occurs between 18 and 24 months old, depending on the planting time, cultivation conditions and cultivation practices.

In traditional planting, the plants develop themselves naturally, without the coffee grower interference regarding the architecture of their crowns formation. The plants that present this kind of development, begin a slow process of orthotropic growth from the first weeks after planting, and the small crowns are then defined. In this way, plants initially have a single orthotropic stem, and, more rarely, two will sustain the plagiotropic or productive branches at the time of the first harvests. On the other hand, in those conducted with the use of bending of the main orthotropic stem, there is the development of innumerable shoots at its base induced by exposure to sunlight.

Thus, in more traditional, free-growing crops, the fruits existing at the time of the first harvest will be distributed in only one or two orthotropic stems in each plant, while in arched plants, on the same occasion, fruits would be present on several stems, depending on the density initially established. In this way, there is a clear trend that in the first harvests there is a greater production in arched plants, when compared to those conducted in free growth. In addition, the plants would occupy all the space reserved for it, reducing the occurrence of weeds and promoting the quicker coverage of the soil, improving the water conditions and the availability of nutrients to the plants.

In the case of bending, about 90 days after definitive planting, the upper part of the plants is fixed using bamboo, wire or similar "forks", forcing them to turn downwards. Bending should be done by turning the stems always in the direction of the planting lines, in a single direction, preferably in the direction of the rising sun, in order to expose the base of the plants to sunlight (Figure 14). At the same time, the lower plagiotropic branches are removed in order to facilitate the penetration of light and promote the emission of buds.

When the buds are about 10 to 15 cm long, the pinching should be started (Figure 15) so that only the most well-distributed shoots around the trunk of the plant are kept in a number coherent with the previously adopted spacing defined for the conduct of the crop in question and other particularities imposed by the cultivation system used, such as soil fertility, irrigation use, fertigation, among others.

Figure 14. Plant submitted to bending.

Figure 15. Plants at the appropriate moment to be submitted to the pinching to establish the number of planned stems.

The arched stem should be removed from the plant when there is full definition and development of the new stems to be maintained (VERDIN FILHO et al., 2012b, 2013b) (Figure 16) or right after the first harvest. This technique makes it possible to standardize the number of stems/plant from the first year of planting, which facilitates the conduction of the plants for subsequent pruning and, in general, allows the achievement of higher yields in the first harvests (FONSECA et al. 2013b).

As an alternative to bending, it has been quite useful to practice the 'decote' of young plants that, from 90 to 120 days after planting, have their upper portion eliminated at a height of 30 to 40 cm from the ground. This practice aims to stimulate the growth of secondary shoots that will form the definitive crown. In this way, it is possible to define the most appropriate shoots and standardize the height of the crown opening in all plants, which is an important factor in cases of mechanized crops, as well as facilitating cultivation treatment. However, this practice can also be used in crops to be manually harvested.

This way of conducting the plants has been specially used by coffee growers who adopt mechanized or even semi-mechanized harvesting, a practice that has been largely spread among conilon coffee producers, especially in the northern region of the State of Espírito Santo and in the south of Bahia , in places where the topography is less rugged.

The plants 'decote' facilitates the standardization of the shoots height, as well as their alignment, the reduction of the possibility of etiolation and consequent tipping of stems, gives vigor and uniformity to the seedlings, the accomplishment of the cultivation treatments and, above all, the harvest operationalization (Figure 17) and, for their operationalization, they must undergo a rigorous acclimatization period of about 35 days before being definitively taken to the field. In this phase, the seedlings should be replaced in beds in order to better standardize them.

Figure 16. Shoots remaining after the first pinching.

Figure 17. Plants from 90 to 120 days after planting, cut to increase the number of stems and the standardization of the shoots insertion height.

In crops implanted with the objective to perform mechanized or even semi-mechanized harvesting, the spacing and density of orthotropic stems should not be the same as those used in crops to be manually harvested. It is necessary to take into account the type of mechanization and the dimensions required for the displacement and operation of the machines used. In general, in the many experiments so far carried out in works of this nature, the planting has generally been in lines spaced from 3.0 to 3.2 m.

In the case of the use of automotive harvesters, it is necessary that the orthotropic stems are conducted in an aligned manner, in row shape. To do so, the plants need to be conducted with fewer stems with reduced spacing so that a stem density is maintained within the recommended range. Thus, by conducting the plants with two stems, spacing between them of about 60.0 cm is necessary to achieve a final density of about 11thousand stems/ha.

In situations such as the one described above, it has been important that the 'decote' should always be carried out just above the productive branches, towards the planting lines to facilitate their alignment along the line, even allowing, crops combined with annual crops between the lines. In manually harvested crops, for the use of this way of plant conduction, there is no need to observe this alignment, and it is possible to maintain the spacing, numbers and density of stems indicated above.

In crops conducted from the young plants 'decote', as well as in the case of the arched ones, the first significant harvests depend on the time of the planting. When carried out in October/November, the plants are cut in February/March, and the flowering of the same year is almost always unimpressive, since the branches will only have about 5-6 months. However, in the following year, there will be a possibility of a full flowering, since the branches will be around 17-18 months old, allowing a good harvest 27-28 months after planting the seedlings. For planting at this time, care must be taken to ensure that the clonal garden matrices enable the production of cuttings for the formation of seedlings from April/May.

Choosing the planting in March/April, the 'decote' is held in August, and the first significant harvest will occur in brunches of only about 9-10 months from the budding. Thus, this first crop will be still small and the harvest may have higher cost due to the lower yield of the operation, whether carried out manually or mechanized.

The advantage of this practice in relation to bending is the agility and cost of the procedures, in addition to the fact of not exposing the still very young plants to the more intense insolation that, in more severe situations, can favor the increase of mortality.

4.2 PRUNING

Until the early 1990s, conilon coffee plantations were conducted without the use of any form of pruning (SILVEIRA, 1996). Free growth crops show a production curve reaching maximum values between the third and fifth harvests, declining from there (SILVEIRA, 1995). Conilon is a plant of continuous growth, presenting the development of several vertical branches, called orthotropic, and horizontal, the productive ones, which are the plagiotropics (CANNELL, 1985).

After successive harvests, the branches have reduced vigor and there is no compensatory growth to maintain high yields (Figure 18). Thus, it gradually begins an imbalance between the leaf area of the plant and the total dry matter begins, that is, there is a reduction in the leaf area ratio and a continuous decrease in the relative growth rate (BRAGANÇA, 2005). Thus, the dry matter is constituted to a large extent by the orthotropic branches that were not eliminated and by the plagiotropics that have endured many harvests (SILVEIRA, 1995; SILVEIRA; ROCHA, 1995; BRAGANÇA, 2005; VERDIN FILHO et al., 2008; FERRÃO et al., 2012a).

The performance of any pruning system promotes changes in the relationship between the aerial part and the root system of the coffee tree, and these changes are all the more drastic as the pruning is more severe, leading to the death of roots at intensities proportional to the eliminated aerial part always affecting more intensively the roots of smaller diameter, precisely those more actively involved in the absorption of water and nutrients (RENA; GUIMARÃES, 2000).

The very depleted crops were early eliminated or submitted to the 'recepa', which was practically the only system used in the attempt to reinvigorate the conilon crops in the State of

Espírito Santo and even in Brazil as a whole. It was adopted, in general, in very old crops and worn by successive productions, with low vegetative vigor and, almost always, in crops with compromised stands.

Figure 18. Plants conducted in free growth showing aspects of exhaustion due to lack of pruning.

The 'recepa' consists of the elimination of all or almost all aerial part of the plants. It is an aggressive and drastic practice, whose efficiency is very dependent on the conditions in which the crops are found, and is therefore questionable as to its real efficiency for the crops invigoration. In any case, it is usually carried out at a height of 20 to 40 cm from the ground, and it is possible to choose leaving a small number of stems intact, which increases the yield in the first harvests of the reinvigorated crops by giving greater vigor to the buddings (MATIELLO, 1998).

This type of pruning should only be used for conditions where it is no longer feasible to use other types of management for the renewal of the crop, since, as in the case of arabica coffee, it can cause the death of roots, especially those of small caliber and located in the most superficial layers (MATIELLO, 1998; THOMAZIELLO; PEREIRA, 2008), exactly the most actively involved in the absorption of water and nutrients (RENA; GUIMARÃES, 2000).

Although programmed cycle pruning (PCP), discussed later in this chapter, also causes reduction of the functional root system, the losses are proportionally much smaller when compared to those observed in the plants that suffered 'recepa', since an expressive percentage of the aerial part, on average 30 to 40%, is maintained for another year, so that there is probably a reduction of excessive root losses and faster recovery of the system as a whole.

Care should be taken to ensure that, after the 'recepa', the plants are conducted with the number of stems adjusted in order to achieve the planned stem density/ha, as previously discussed.

In order to recommend any pruning system in already implanted crops, it is necessary to take into account criteria such as: plant age, spacing, closing intensity, depletion level, evolution of plant production, price of the product and even the level of the producer dependence in relation to the future productions (SILVEIRA; ROCHA, 1995).

4.2.1 Pruning of conilon coffee production

The first pruning system recommended by Incaper for conilon coffee was presented by Silveira et al. (1993), followed by Silveira (1995), Silveira; Rocha (1995) and Silveira (1996). This system was called "Pruning of Conilon Coffee Production".

The production pruning includes consecutive pinchings. It is a system in which crops, with more than three to four harvests, conducted without any previous interference, have their older and unproductive orthotropic stems eliminated and replaced with new ones, which originate from vigorous shoots selected at the base of those that were removed (Figure 19). The most central shoots and those that were badly located, preventing the light penetration inside the plants, should be eliminated, remaining only those that will recompose the plants (SILVEIRA et al., 1993; SILVEIRA; ROCHA, 1995).

This practice provides the crops renew and favors the increase of productivity by providing the establishment of new branches, invigorated and with greater production potential. It also allows the conduction of a number of new stems compatible with the plant population existing in a given area and distributed at a same distance around the trunk (SILVEIRA et al., 1993; FERRÃO et al., 2012a).

Figure 19. The performance of the pruning of conilon coffee production by removing the older and already unproductive vertical stems.

As until then the crops were conducted without routine and orderly adoption of any pruning systems, the great majority of them were plants that had excess orthotropic stems. Thus, the system was initially recommended for adult crops in order to recover their productive capacity (Figure 20), although it is also recommended for younger crops (Figure 21).

In crops whose management does not yet contemplate routine pruning systems, the process can be started in a gradual way. There is no need to eliminate all unproductive crops at a single opportunity if this is considered inappropriate as regards the vigor of the plants or even economically unfeasible for certain coffee growers. It can be started with the elimination of the older branches at each harvest and the plant is being gradually renewed. In cases like these, one can also choose the use of pruning in successive plots so that there is no reduction or even interruption in the coffee growers' income (FERRÃO et al., 2012a).

In substitution for the use of 'recepa" the pruning of production can also be used in aged plantations, but that still maintain a minimum of vigor, appropriate stand and capacity to support the necessary procedures. In this case, the pruning system can be operated at once or over time, in two or more occasions, so as not to cause excessive loss of plants. When choosing two or more times, one must start with the elimination of the oldest, badly located and more depleted stems.

Figure 20. Aspect of adult plant conducted without pruning and two years after the beginning of this practice.

Figure 21. Crops with the Emcaper 8151 - Robusta Tropical cultivar, spaced 3 x 1 m with plants pruned after the second harvest, with about four orthotropic stems per plant.

Pruning is done by cutting the orthotropic stem at a height of 20 to 30 cm from the soil surface (Figure 22) or right above the waiting bud, eliminating stunted, old, or unproductive branches, and excessive sprouting located inside the plant. When this pruning system is started early, losses are avoided by etiolation of the lower branches and the appropriate conformation work of the plants can be initiated according to the arrangement adopted and the chosen spacing.

Studies on pruning of production, conducted by Incaper in Linhares/ES, have shown that it is a highly effective crop management technique for increasing production. There was a 53% increase in the average yield of four successive harvests with the use of annual pruning (SILVEIRA et al., 1993). According to these authors, pruning is one of the most important crop management practices and has the following advantages: it increases the useful life of the coffee; provides the reinvigoration of crops; improves aeration and penetration of light into the crown; facilitates cultivation and phytosanitary treatment; provides better coexistence with water stress; reduces the percentage of withered beans; decreases the biennial effect; reduces the height and diameter of the plant facilitating the harvesting and maintenance of more productive stems per area; improves the soil physical and chemical conditions by incorporating the organic matter originated from the vegetative parts eliminated.

Figure 22. Pruning of unproductive orthotropic stems at a height of 20 to 30 cm from the soil surface.

The vegetative parts that come from pruning must remain in the crop, once they promote a series of benefits to the coffee plantation, work as a source of nutrients after their decomposition, improve the organic matter content of the soil, protect the soil from the direct incidence of the solar rays, promote the reduction of weeds in the field, control erosion and help to maintain soil humidity (SILVEIRA et al., 1993).

This conilon coffee pruning system was adopted by the great majority of the coffee growers in the state of Espírito Santo until 2008, when Incaper presented a new and more adjusted system of plants conduction, called Programmed Cycle Pruning (PCP).

4.2.2 Programmed Cycle Pruning for conilon coffee

Pruning systems, both for training and for production, generate a great capacity for reinvigorating less productive crops, and in most cases in the State of Espírito Santo, it is certainly one of the practices that can provide the most benefits to short-term producers. Such benefits, however, are more significant when pruning is associated with other technologies, since even if it increases the productive potential of plants, it is necessary to use appropriate genetic material, nutritional and water supply management, capable of allowing that the crops express their potential.

PCP, according to Verdin et al. (2008), constitutes a pruning of production improvement, recommended until then. Over the last two decades, the work has been continued with the aim of obtaining additional benefits, identified above all from the massive use of the production pruning system, which could be developed in favor of the most appropriate management of plants and crops as whole, improving its productive and economic performance.

The new technology is also based on the same principle as the previous one. It consists of the elimination of vertical stems and horizontal branches that becomes unproductive along several harvests, with the purpose of being replaced by newer ones, renewing the crops productive capacity. It is also necessary to eliminate the orthotropic etiolated stems, badly localized, low vigor and the excess of shoots.

Although production pruning has been successfully adopted by the vast majority of conilon coffee producers in the State, leading to an expressive productivity, the practice was intended for use in mature crops or for those ones already after the second, third or even fourth production and for older crops. Due to the different conditions of the plantations conducted at the time, it was not possible to establish standard procedures to be adopted, and this compromised the possibility of the full achievement of the technology results.

The need to plan the management of the plantations, since its implementation, has arisen in order to standardize the recommendations, especially for those who would effectively operationalize the pruning. Thus, it would become a more precise and less intuitive activity, given that, in the pruning of production, the definition of stems to be eliminated was made by rural workers, often without technical background. The lack of standardization of the operations to be used in each plant, as well as the difficulty of understanding the whole process, most notably in identifying the stems to be eliminated, made it difficult to perform an effective pruning. Such difficulties were associated with differences in size, architecture, vigor and productive capacity, even in clonal crops. However, the operational cost of the practice in question increased (SILVEIRA et al., 1993; VERDIN FILHO et al., 2008).

In this way, the planning of activities related to the conduction of plants should be established before planting, in the definition of genetic material, local, soil preparation and opening of pits, spacing, fertilization, among others. However, PCP can also be started in adult crops.

There are two situations in which PCP can be used in plantations to be implanted, depending on the system of planting to be adopted; the traditional one (free growth in the initial phase) or the one with posterior bending of the young plants, as previously exposed.

In both systems, with or without bending, plants still freshly transferred to definitive pits should be conducted over successive harvests, with the elimination of excessive orthotropic shoot. This practice avoids the closure of the lower part of the crown, as well as the waste of water, nutrients and photoassimilates, facilitating cultivation treatment, fertilization and harvesting.

Research work carried out by Incaper indicates that the favorable influence of young plants bending might result in different intensities responses, depending on the cultivar, environments, use of irrigation and planting time (FONSECA et al., 2013b; VERDIN FILHO et al., 2013b; VERDIN FILHO et al., 2014).

According to Verdin Filho et al. (2012b), the main stem arched at the beginning of the process can be eliminated as soon as the crown is defined, since it does not influence productivity levels, and may also make it difficult to operationalize certain cultivation and harvest practices them with their presence.

Research work carried out by Incaper indicate that the favorable influence of young plants bending might result in different intensities responses, depending on the cultivar, environments, use of irrigation and planting time (FONSECA et al., 2013b; VERDIN FILHO et al., 2013b; VERDIN FILHO et al., 2014).

Fonseca et al. (2013b) verified that the response of conilon coffee submitted to young plants bending is influenced by the genetic material and whether the crop is irrigated or not. The authors conclude that the highest yields are reached in arched and irrigated crops, and that in non-irrigated crops, the bending of young plants led to yields similar to those obtained in irrigated crops, but were conducted without bending.

At the time of the PCP first stage, after completion of the third, fourth or even fifth harvest as previously scheduled, all the most central stems of each plant shall be eliminated at a height between 20 and 30 cm from the ground (VERDIN FILHO, 2008). In the plant, there should be a maximum of two outermost stems, always facing the planting lines, giving the plant a "V" shape, that facilitates the light penetration, promotes the formation of new shoots and their vigorous development, with high productive potential. For this, the remaining rods may have all their lower plagiotropic branches eliminated so that they do not impair the formation of new orthotropic shoots (Figure 23).

Figure 23. Elimination of the most central stems of the plant and the maintenance of two lateral stems without shoots and without productive lower branches.

Between 30 and 40 days after the elimination of the central stems, it is necessary to select the new shoots. The selection should be made before they exceed 12 cm in height, since the competition among them can hinder the development of the branches that will remain, etiolating them and compromising their production capacity (VERDIN FILHO et al., 2014).

Usually between 50 and 75% of the stems are eliminated. In very closed crops, pruning should be started from the third harvest, while in not very closed crops, it is recommended to start the second stage of the PCP from the fourth or fifth harvest. The definition between the third, fourth or fifth harvests is based on vigor, plant growth, light input, genetic material, spacing, technological level, among other factors, including economic ones.

At the base of the eliminated stems, there is the development of numerous shoots. These shoots should then be selected according to their vegetative vigor, position and height of insertion in the plant, and number of stems to be maintained for another three, four or five harvests, which will constitute the second cycle of production using the technology in question.

In the year following the first stage of the PCP, the new shoots will be one year old and will be on average about 80 to 100 cm high. On this occasion, the new stems may hold a small load of fruits (Figure 24), however the plant will be in full productive capacity from the next harvest, two years after the first stage. After harvesting the fruits from the remaining stems, these should also be eliminated in order for the crop to begin a new production cycle (Figure 25).

Figure 24. Crop showing vigorous shoots and the remaining stems that will be eliminated after the harvest.

Figure 25. Elimination of the remaining stems after the cycle programmed pruning (PCP) in its last harvest (A); and crop renewed by this system (B).

For comparison, Table 1 shows the schedules of activities for the use of the two conduction forms of conilon coffee according to Verdin Filho et al. (2008).

Table 1. Periods of activities in the management of programmed cycle pruning (PCP) and the pruning of conilon coffee production

Pruning type	Activities	Harvests									
		1	2	3	4	5	6	7	8	9	10
Programmed cycle prunig (PCP)	Elimination of vertical stems				X	X				X	X
	Pinching and elimination of horizontal branches	X	X	X	X	X	X	X	X	X	X
Pruning of production	Elimination of vertical stems		X	X	X	X	X	X	X	X	X
	Pinching and elimination of horizontal branches	X	X	X	X	X	X	X	X	X	X

Source: Verdin Filho et al. (2008).

PCP can also be used in older crops, not previously conducted in this system. Thus, it is necessary to eliminate all excess stems from the plants, keeping only the recommended ones for each situation. It is not appropriate to eliminate all stems ('recepa'), because, in works carried out comparing the recovery of conilon coffee plantations with the use of the 'recepa' with other types of pruning, it was verified superior gains in the production over the years with the use of PCP, in addition to other benefits already mentioned (VERDIN FILHO et al., 2012a; 2013b).

In a given crop, that from now on receives the orientation of being conducted with five orthotropic stems/plant, all the others must be eliminated, naturally maintaining, in this case, those five younger, vigorous and well distributed around the trunk. This operation can be carried out just once or, gradually, in consecutive years, depending on each situation.

In the case of a one-time operation, in the following year, the elimination of the three most central stems can be initiated so that only in the following year the process can be completed with the plants revitalized for a further production cycle of three to five harvests.

Works were carried out in order to study the influence of PCP and plant and stem density in the municipality of Marilândia, Espírito Santo, in experiments implanted in clonal crops formed by the cultivar Emcapa 8111, conducted in a non-irrigated condition (VERDIN FILHO et al. 2014). The crops were conducted with PCP, and harvests from 2008 to 2011. In the first of two studies, spacing of 2.0 x 1.0 m and 2.5 x 1.0 m were used, both conducted with two, three and four stems per plant. The average productivity using the first spacing was significantly different when using two, three or four stems per plant, respectively 47.51; 58.38 and 68.25 proces bags/ha. In the second spacing, there was no significant difference in the treatments conducted with three or four stems, but these were higher than those achieved in plants with two stems (Table 2).

Table 2. Conilon coffee productivity conducted with 2, 3 or 4 orthotropic stems/plant at different spacing on the experimental farm of Incaper in Marilândia/ES

Spacing (m)	Productivity (bags/ha)			
	2 stems	3 stems	4 stems	Mean
2,0 x 1,0	47.51 Ca	58.38 Ba	68.25 Aa	58.05
2,5 x 1,0	39.36 Bb	53.50 Aa	60.64 Ab	51.17
Mean	43.43	55.94	64.44	54.61

Source: Verdin Filho et al. (2014).

Means followed by the same uppercase letter in the line and lowercase in the column do not differ by the Tukey test at 5% probability.

Verdin Filho et al. (2014), using spacing of 3.0 x 1.0 m and 3.0 x 1.5 m, also in works conducted with no irrigation, but with PCP, with three, five and six stems per plant, obtained yields of 30.38; 39.10 and 49.45 processed bags/ha, respectively, for three, five or six stems per plant spaced 3.0 x 1.0 m. Using the 3.0 x 1.5 m spacing, the yield was 27.39; 41.98 and 39.78 processed bags/ha for three, five or six stems, respectively (Table 3). These results indicate the possibility of obtaining positive responses in the coffee conilon productivity with reduction of the previously indicated spacing, when associated to the increase of the number of stems per plant.

Table 3. Productivity of conilon coffee conducted with 3, 5 or 6 orthotropic stems/plant in different spacing on the Experimental Farm of Incaper in Marilândia/ES

Spacing (m)	Productivity (bags/ha)			
	3 stems	5 stems	6 stems	Mean
3.0 x 1.0	30.38 Ca	39.10 Ba	49.45 Aa	39.65
3.0 x 1.5	27.39 Ba	41.98 Aa	39.78 Ab	36.39
Mean	28.89	40.55	44.62	38.02

Source: Verdin Filho (2011).

Means followed by the same uppercase letter in the line and lowercase in the column do not differ by the Tukey test at 5% probability.

In general, the works carried out aiming at the definition of the most suitable stem spacing and density for the conilon coffee conduction with the use of the PCP are in agreement with the fact that the density of the crop associated to the greater number of stems/ha increased productivity of the crop, at least within the limits that were studied (LANI et al., 2000; VERDIN FILHO, 2011; FERRÃO, et al., 2012a; VERDIN FILHO et al., 2013a).

A number of studies have shown that bending of young plants assists in the earlier establishment of the planned number of stems/plant, however, as previously mentioned, this practice has resulted in different behavior depending on genetic and environmental factors, production systems and planting season (FONSECA et al., 2013b).

4.2.3 Pruning of plagiotropic or productive branches

As soon as the recommendation of the first system of conilon plants and crops conduction in Espírito Santo was announced, little was known about the need to keep or not the oldest productive branches in the plant, practice popularly known as "sheds".

This practice is highly recommended and widely used in Espírito Santo, where it is currently applied to around 70% of coffee farms. It consists of the elimination of the plagiotropic branches located in the lower parts of the older and already exhausted by previous productions plants. Works indicate that it is advantageous to increase the productive potential and provide a number of other benefits (VERDIN et al., 2008). It facilitates the control of weeds, brushing, fertilizers application, phytosanitary control and, above all, harvesting operations. It favors the entrance of light inside the crowns, reduces the etiolation of orthotropic stems, the more harmonious vegetative development and reduces the annual variation of production.

Although it requires workforce for its accomplishment, it reduces the total necessity of this practice by favoring the factors mentioned above, whose balance will be decisive for the decision making that involves the removal or not of the plagiotropic branches (GUARÇONI M. et al., 2011).

There are, however, questions about the exact moment of this elimination, if with more than 50%, 60% or even 70% of the total productive potential, (Figure 26). Work in progress may offer the possibility of better elucidation to these issues in the near future.

Guarçoni M. et al. (2011) compared the cumulative productivity of three harvests obtained with the removal or not of plagiotropic branches that produced 50% or more of their extension, in two edaphoclimatic regions of Espírito Santo; Cachoeiro de Itapemirim (Eutrophic Red Acrisol, region classified as bumpy, warm and rainy/dry transition) and Northwest/ Marilândia (Dystrophic Red-Yellow Acrisol, classified as bumpy, hot and dry). The authors observed that the removal of the plagiotropic branches that produced in 50% or more of their extension reduced the accumulated productivity of conilon coffee plants in the most vigorous and productive crop (South/Cachoeiro do Itapemirim). However, there was no effect on productivity accumulated in the Northwest/Marilândia region. Despite this result, the authors recognize the value of the practice for the already related advantages.

Figure 26. Plagiotropic branches being eliminated after having expressed about 50% of their productive potential.

The same researchers explain that the plagiotropic branches would only work as a drain if they did not have enough leaf area to produce the carbohydrates needed to sustain their own energy demand (maintenance and growth breath regarding fruits). In this case, it would not make any difference if the coffee beans were supplied by photoassimilates produced by leaves of the same plagiotropic branch or by leaves present in other plagiotropic branches of the plant. Primordial would be the global balance of photoassimilates, not the balance of isolated plagiotropic branches. However, the referred work was not carried out according to the precepts established for the use of PCP in conilon coffee, which promotes a more suitable balance between the vegetative part and the potential production, a system that fully enables its performance(VERDIN FILHO et al. 2008).

Studies are being conducted by Incaper for the most adequate understanding of the process efficiency, its influence on the different cultivation systems, as well as the most appropriate moment to its accomplishment aiming at standardizing the recommendations.

4.3 PINCHING

With the elimination of orthotropic branches and old plagiotropic, there is greater penetration of light in the inner side of the plant, which, combined with fertilization and the rainy season or under irrigated conditions, promote intense budding in the plant. Therefore, pinching is the practice of eliminating the excess of these shoots, especially those located in the inner part of the crown, usually more etiolated by the mutual shading that usually occurs after pruning.

In regularly pruned crops, it is recommended that the pinching be done 30 to 40 days after pruning, as the cutting of branches causes an intense emission of shoots in the plant (FERRÃO et al., 2012a).

In the pinching process, it is necessary to initially select the shoots that will be maintained. Thus, excess malformed shoots with less potential for development are removed, and those located in the innermost parts of the trunk are removed by maintaining one to two more vigorous and better located shoots for each stem removed.

The pinching should be carried out in both the growing and the producing crops, every year, regardless of whether the plant has been pruned or not in the year in question, as often as necessary to maintain only those branches which will remain replacing the removed ones. Usually, about three annual operations are required, which should be done when shoots are still small, but depends largely on local climatic conditions, whether or not irrigation is used, soil fertility and plant nutrition, among other factors.

The first pinching should be done when shoots are at most about 12 to 15 cm height. At this stage, one can choose to maintain a number of shoots even greater than necessary for the most efficient future selection of those that will be kept and to guarantee the maintenance of the previously defined number of shoots.

In pruning of production, pinching should be carried out whenever older shoots are removed, at whatever intensity, while in the implementation of the PCP, they are necessary again after the first stage, that is, after the elimination of the most central orthotropic stems, about 30 days after its cutting.

The operation consists in leaving a vigorous shoot to replace each one of the definitive ones existing from the beginning of the activity, that is, if the plants were kept from the planting until that stage with five stems each, then one must conduct five shoots, sufficient to replace all the old five, even if two of them are kept to be eliminated only after the next harvest (FONSECA et al., 2013b).

The shoots kept for the reconstitution of the definitive stems number must be located in a distributed and equidistant way around the remaining trunks of the eliminated stems. By pruning and pinching, following the relevant technical recommendations, the crops will always be reinvigorated, with an appropriate number of stems for each particular situation.

4.4 PRUNING TIME

The pruning should be carried out preferably after the harvests and before the first flowering. This is the most appropriate time because the coffee tree is in a state of vegetative rest, which coincides with the driest season. It is important that pruning be done before flowering so that the farmer does not hesitate to remove the older and unproductive branches. These branches, although they present a small flowering, must be eliminated so that they do not harm the development of other more vigorous ones (SILVEIRA et al., 1993; SILVEIRA; ROCHA, 1995).

From 2006, an experimental work was conducted at the Experimental Farm of Marilândia, with the objective of evaluating the effect of different pruning times in conilon coffee clones of early, intermediate and late maturation. In a crop whose spacing was 2.5 x 1.0 m, the early clones were harvested in May and pruned in May, June, July and August; the intermediaries were harvested in June and pruned in June, July and August; the late ones were harvested in July and pruned in July and August. Immediately after pruning, the crop remained with 8,000 productive stems per hectare (two stems/plant) and without shoots. Two pinchings were made after pruning, one in October, 60 days after the last pruning season, and another in December, at 120 days after the last pruning season. At the first pinching, three more vigorous shoots were selected (left) in each plant for the renewal of the crop (RONCHI et al. 2007c; RONCHI, 2009).

Ronchi et al. (2007a) found that pruning, when carried out immediately after harvest (May/June), mainly for the early maturation clones, stimulated the appearance and early growth of the shoots so that, at the time of the first pinching, the shoots of these plants showed to be larger and more vigorous than those originating from plants whose pruning was late (July/August). However, during the growing season (October to January), they observed compensatory growth of the smaller shoots and, in January, there was no effect of the pruning season on shoot growth. They also verified that the pruning season did not affect the number of buds emitted per plant and that the time spent in the harvesting operation correlated directly with the number of shoots per plant and not with their size or vigor.

In 2007, on the occasion of the harvest of those remaining productive stems (8 thousand stems/ha), Ronchi et al. (2007b) did not observe effects of pruning on productivity, regardless of clone and variety (precocious, intermediate and late) evaluated. In 2007, 2008 and 2009, annual pruning was carried out, always at the same time, so that three consecutive harvests were collected in the following years (2008, 2009 and 2010), in those stems that were formed from the new shoots left in the beginning of work (three stems per plant totaling 12 thousand stems/ha).

In the 2008 harvest (first harvest of the new stems), significant effects of pruning season on productivity of early and late clones were observed. For example, clone 03 produced 17% more when pruned in May/June, compared to pruning done in July/August, although the harvest was performed on the same date. For clone 19 (late maturation clone), harvested in July, a 14% increase in yield was observed, when pruning was done in July, compared to August (RONCHI et al., 2008). Therefore, considering only this first harvest, the results pointed to higher yields when conilon pruning was performed immediately after the harvest. However, these results were not confirmed in the following harvests (2009 and 2010) for the several clones tested, nor when the average of the three harvests was considered (RONCHI et al., 2010). Taken together, the results indicate that there is no need to prune immediately after harvesting (RONCHI et al., 2010).

In fact, two years later, Morais et al. (2012), working in the same crop in Marilândia, Espírito Santo, and with the same treatments (clones, pruning season), found that the pruning of adult conilon coffee crops, immediately after harvesting or affects the physiology of the coffee tree, whether it be an early, intermediate or late maturation clone. These authors did not observe differences in the branches growth, photosynthesis, stomatal conductance, photochemical efficiency of FSII, leaf starch content and water use efficiency. Taken together, these results explain, at least in part, why crop yield, independently of the clone, was not affected by pruning times (RONCHI et al ., 2010; MORAIS et al ., 2012). Thus, considering all the information presented as well as the verification of the benefits achieved, it is recommended that it be performed preferably right after the harvest.

5 FINAL CONSIDERATIONS

The success of any enterprise requires that many decisions be taken in the planning phase of each step necessary for its consolidation. In coffee cultivation, it is no different. Deciding the business implementation, it is necessary to consider all the meanders that surround and influence it.

Thus, it is necessary for the coffee growers to focus on the economic aspects of the activity, the existing market, the demands of these markets, production costs and the possibility of economic return and, above all, the technological aspects that support the competitive development of the activity.

Define the area in which the planting will be carried out, the planting season, the production system to be adopted, the cultivar, the seedlings production or acquisition, the soil preparation; the needs of corrective and fertilizers, the spacing, the opening of pits; the definitive planting, the system of plants conduction, the cultivation treatment; the pruning systems, the harvesting, the processing system, the classification of beans, the storage and finally the commercialization are carried out.

In this chapter, aspects of conilon coffee crop management were approched, focusing mainly on planting, spacing and systems of plant conduction (pruning and pinching). These aspects are all essential for the crops to express their full productive potential.

There are many advances in activity that help in understanding the fact that conilon plantations have been experiencing such a development in their productive performance. It is possible to highlight here the aspects related to the new systems of plants conduction, as results of investments in research from the end of the 1980s, notably in Espírito Santo, the first Brazilian state to study alternative methods to conduct conilon coffee plants.

These systems have been evolving rapidly since the first pruning system proposed in 1993 with the development of new works to the present day with the association of pruning to the systems of initial conduction of the plants, the bending or the detachment of young plants with the programmed cycle pruning (PCP) and the elimination of already poor plagiotropic branches.

Incaper stands out in the year of 2016 with the consolidation of new technology: the recommendation of the programed cycle pruning system for arabica coffee (PPAC), an innovation that has called the producers of this species attention and for the development of which were used the same principles that grounded the practice for the conilon.

The practices related to the different systems of plant conduction are considered by many to be the ones that provide the greatest increase in coffee productivity and quality, since most of the other technologies fail to express the potential they have in preventing the early exhaustion of coffee plants and promote the constant renewal of crops.

Many other aspects related to plant conduction have been studied in Espírito Santo, Rondônia and Bahia; many of them have been carried out by research institutions present in these states in partnership with Incaper. It is expected that new limiting factors to the constant advances, such as those so far observed in the cultivation, will be elucidated and overcome through plant management, a rational, economic, environmentally non-aggressive practice that substantially reduces the demand for labor to the harvesting, which increases the uniformity of fruits maturation and the beans quality and that enables the family work, besides favoring the conditions of cultivation in general.

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