CONILON
Coffee

3rd Edition

Updated and expanded

The Coffea canephora produced in Brazil

Romário Gava Ferrão

Aymbiré Francisco Almeida da Fonseca

Maria Amélia Gava Ferrão

Lúcio Herzog De Muner

TECHNICAL EDITORS

Capixaba Institute for Research, Technical Assistance and Rural Extension
Rua Afonso Sarlo, 160 - Bento Ferreira - CEP: 29052-010 - Vitória-ES - Brasil - Caixa Postal: 391
Telephone: 55 27 3636 9888; 55 27 3636 9846 - coordenacaoeditorial@incaper.es.gov.br | www.incaper.es.gov.br

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GRAPHIC DESIGN, ELECTRONIC EDITING, FINAL ARTWORK AND COVER
Laudeci Maria Maia Bravin

ENGLISH TRANSLATION
Marcelle Gualda Pasolini

CATALOGING
Merielem Frasson da Silva

PHOTO CREDIT
Augusto Barraque, Incaper and authors' collection

EDITORIAL COORDINATION AND PROOFREADING OF STANDARDIZATION
Liliâm Maria Ventorim Ferrão

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Cultivars of Conilon Coffee

Romário Gava Ferrão, Maria Amélia Gava Ferrão, Aymbiré Francisco Almeida da Fonseca, Paulo Sérgio Volpi, Abraão Carlos Verdin Filho, José Luiz Tóffano, Paulo Henrique Tragino and Scheilla Marina Bragança

1 INTRODUCTION

The coffee genetic improvement is one of the research areas that has been providing great contributions to increase productivity and quality and reduce the production cost of the crop, that is because the main goal of most breeding programs is the development of superior cultivars, since these are technologies of relatively low costs and of easy adoption by the producers.

Since the coffee tree is a perennial plant, its genetic improvement for productivity and other agronomic characteristics of interest demand a long experimental period, constituting a series of difficulties for breeders, due to the biotic, abiotic, resource problems, among others, that occur during the coffee trees evaluations for several consecutive years.

In the development of coffee cultivars, deep knowledge about the species, the environment and cultivation technologies, processing, marketing and consumer demands is of fundamental importance.

Breeding programs in coffee are mainly aimed at increasing productivity, profitability and the coffee grower economic stability, through the productive efficiency in the property. Productive efficiency can be achieved by improving yield or plant production components, reducing production costs, improving product quality and production stability (SERA; ALTEIA; PETEK, 2002).

In the genetic improvement of quantitative traits, such as grains production, it is more difficult to work with coffee comparatively than with annual plants. This is due to the existence of a long juvenile period, the need to evaluate, at least, for four consecutive harvests to know the long-term productive capacity and the existence of a sharp annual production oscillation. Nevertheless, breeding programs carried out in several research centers have provided great genetic advances.

In Espírito Santo, the species *Coffea canephora* was introduced around 1912, with the first seeds planted in the municipality of Cachoeiro de Itapemirim, and later taken to the northern region of the State (MERLO, 2012). Its commercial exploitation, however, started having more expression from the 1960s, with an initial objective of use in areas considered marginal to arabica coffee. Except for some crops existing in the State of Rondônia, the Conilon variety

(FONSECA, 1996), introduced from selections of the Kouillou group (CHARRIER; BERTHAUD, 1988) is cultivated. Since 1985, due to its social and economic importance and the main problems found in the Conilon production, the Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - Incaper (Capixaba Institute for Research, Technical Assistance and Rural Extension), then Instituto Capixaba de Pesquisa Agropecuária - Emcapa (Capixaba Institute for Agricultural and Livestock Research) a breeding program of the species, aiming, above all, to make the genotypes more suitable to their needs available to the Capixaba coffee grower, since until that time, the varieties used by the producers were propagated by seeds, with great plants heterogeneity, production and in other characteristics, with poor management, low general production potential and inferior quality of beverage.

The breeding strategies have been formulated, initially, prioritizing, in the short and medium term, the development of cultivars with traits superior to the existing ones, besides maintenance, conservation and taxonomic characterization of the species. Within this concept, the methodologies for the development of clonal cultivars and synthetic hybrids cultivars propagated by seed and the genetic variability evaluation were established. The main characteristics evaluated in these investigations are the productivity, adaptability to different environments, production stability, tolerance to biotic and abiotic stresses, maturation uniformity, beans size, percentage of "mocha" and wilted beans, yield in processing, vigor and plant architecture and those related to the final product quality.

As a result of the first thirty years of work, several basic studies that have actually contributed in increasing knowledge of genetic species (FONSECA, 1999; FERRÃO, R.; FONSECA; FERRÃO, M., 2000; FERRÃO, R. et al., 2000a, 2003a, 2003b; FERREIRA, 2003; FONSECA et al., 2003a, 2003b; FERRÃO, 2004; FONSECA et al., 2004a, 2004b; FERREIRA et al., 2004; FERRAO, et al., 2007a, 2007b; FERRAO et al., 2009; NASCIMENTO et al., 2010; ROGRIGUES et al., 2012, 2013; CARIAS et al., 2014) have been developed, and the studies that led to the development and the launching of ten cultivars, which are of direct application to the producers (BRAGANÇA et al., 1993; 2001; FERRÃO et al., 1999; 2000a, 2000b; FONSECA et al., 2001a, 2001b; FONSECA et al., 2004c; 2005; FERRÃO et al., 2007a, 2007b, 2012, 2014, 2015a, 2015b, 2015c, 2015d, 2015e), and that have helped mainly in the cultivation productivity improvement. As a record, in the 80's, it can be highlighted that the cultivars used by the producers, when planted and managed using the best technology of the time, did not exceed 60 processed bags per hectare (proces. bags/ha). Currently, many producers, when using the improved clonal cultivars and following the technical recommendations of planting, conduction and harvesting, have reached productivity higher than 120 bags/ha and obtained good quality product (FONSECA et al., 2005; FERRÃO et al., 2007a, 2014, 2017).

Within this context, an approach will be presented in this chapter on the fundamental information for the cultivars development, as well as the description of the main agro-morphological traits of each of them.

2 BASIC INFORMATION FOR THE CONILON COFFEE CULTIVARS DEVELOPMENT

Conilon coffee originates from plants that reproduce as a result of allogamy, with 100% cross fertilization, caused by gametophytic self-incompatibility, which hampers the self-fertilization or cross between plants that have the same genetic constitution in the reproductive gametes.

Due to this natural way of fertilization, the natural genotypic populations of this species, as well as those developed from seeds, even if collected in a single parent plant, are characterized by the high frequency of heterozygosis, a fact that imposes great variability among these populations plants. Thus, the natural method of reproduction of the species, via sexual propagation, leads to the development of very heterogeneous crops, with plants showing a great deal of unevenness in the characteristics: architecture, vigor, fruit maturation time and uniformity, beans size and weight, susceptibility to pests and diseases, drought tolerance and, especially, productive potential (VAN DER VOSSEN, 1985; CARVALHO et al., 1991). These factors have constituted important obstacles in the improvement of the final quality of the product obtained (FONSECA, 1995). The crops developed from clonal varieties are more uniform, with greater production potential and with the possibility of obtaining a better quality final production (FONSECA, 1996, 1999; FERRÃO, 2004; FERRÃO et al., 1999; 2007a, 2007b, 2008, 2012, 2014, 2015a, 2015b, 2017).

Therefore, due to the species allogamy and the botanical materials to be improved present high heterozygosity in the total of loci (sites) of genes in the chromosomes, causing great genetic variability in most of the plants characteristics, and easily propagated sexually (seeds) and asexually (vegetative), the methodological strategies traditionally used in coffee breeding programs for the Conilon variety are clonal selection and the obtainment of hybrids and synthetic varieties.

The main breeding methods used aim to explore the natural genetic variability of the species through the selection of parent plants, to form populations and to continue their breeding by recurrent selection, to develop clonal cultivars and to develop cultivars and synthetic hybrids propagated by seeds.

2.1 REPRODUCTION AND PROPAGATION

The conilon coffee, generally known in the world as "robusta coffee", is a species of mandatory cross-fertilization (CONAGIN; MENDES, 1961; CARVALHO et al., 1991). Thus, fruits harvested in a plant are necessarily derived from crosses of this parent plant with other plants that are near it, which, in this case, act as male[1] genitors. The mechanism that hampers self-fertilization[2], that is, the eggs fertilization by pollen from the same flower, or from different flowers of the same plant, or even from flowers of different plants with the same alleles[3], is a mechanism ruled by

[1]Genitor: the one who begets, the begetter, the father, the ascendant.
[2]Self-fertilization: method of sexual reproduction in which male and female gametes come from flowers of the same individual, or from flowers of different plants with the same alleles.
[3]Alleles: gene alternative form.

the genetic constitution of the plant called genetic self-incompatibility (CARVALHO, 1988). In this process, known as self-incompatibility system[4] of the gametophytic type, it is a single gene, called "S", which has a number of different alleles (BERTHAUD, 1980; CARVALHO et al., 1969; LASHERMES et al., 1996),that are found always in pairs and in heterozygosis[5] in each individual. Thus, a plant will always show different allelic forms of this gene. Thus, in order to occur a cross between two of them, it is necessary that in their genetic constitutions there is, at least, one of the two different alleles.

As reproduction by cloning ensures that the offspring has the same genetic constitution as the mothers, all the seedlings originating from the same parent plant, as well as all those originating from different parent plants of a same clone, will present the same allelic compositions of said gene, and, as a consequence, will be self-incompatible. In order to occur the flowers fertilization and consequent fruit formation in plants of a particular clone, it is necessary the presence of others from parent plants with different alleles of the gene in question, which will be the pollen suppliers (FERWERDA, 1969; BERTHAUD, 1980).

To ensure that there is appropriate genetic compatibility between two or more clones, it is necessary to perform controlled crosses between them. With this purpose, the breeding program of Incaper uses proper methodologies, aiming to group compatible clones for the development of new clonal cultivars.

In genetic improvement of crossbred species[6] via sexual propagation, there are difficulties in establishing characteristics of interest in the offspring originated from cross between plants considered superior. The ease of asexual propagation (vegetative) in the conilon coffee allows the maintenance of characteristics present in the parent plants, constituting, therefore, an important tool to obtain faster genetic gains and with lower costs.

There are different methods of conilon coffee vegetative propagation, and for multiplication on a commercial scale, cuttings in Brazil prevail so far, mainly for being a technique with great operational ease.

2.2 CLONAL CULTIVARS

Improved clonal cultivars are constituted by grouping of clones that stood out for the desired characteristics and were defined after a series of experimental procedures and biometric analyzes used in scientific research. Therefore, these cultivars must be planted and managed under certain cultivation techniques and conditions to express their potential (FONSECA, 1995, 1999; FERRÃO et al., 2007a, 2007b, 2012, 2014, 2015a, 2015b, 2017).

The clonal cultivars use for planting the species *Coffea canephora* did not start in Brazil. There are many works cited in the specialized literature on the subject, which have been conducted for decades in several other countries. In many of these countries, clonal cultivars have been

[4]Self-incompatibility: genetic mechanism that prevents the occurrence of self-fertilization and crosses between individuals possessing the same alleles of incompatibility.
[5]Heterozygote: individual showing different alleles of the same gene.
[6]Crossbred species: species that originate the offspring through cross fertilization.

the base of all economic exploitation of the species (DUBLIN, 1967; FERWERDA, 1969; CAPOT, 1977; VAN DER VOSSEN, 1985; BERTHAUD, 1985; BOUHARMONT et al., 1986; CHARMENTANT et al., 1990).

The obtainment of clonal cultivars consists in the election through a phenotypic evaluation of individuals considered superior in open pollinated fields. Many of these fields are areas within well-conducted coffee crops, where there is a representative conilon coffee cultivation, being it asexual multiplication via cutting (cloning); in the following, these phenotypically selected individuals are evaluated in competition trials for, at least, four harvests, with data collected and studied about the different characteristics of interest of the breeding program. After the evaluations and the genetic compatibility test, the selected clones are grouped according to the research objectives for the development of a new clonal cultivar or to be kept in the Active Germplasm Bank and/or to be used for intra and/or interpopulation.

In order to select conilon coffee parent plants under agricultural properties conditions, the following criteria were used: selection based on potential and production stability, unstripped fruits, tolerance to water stress, tolerance to pests and diseases, cycle, size, plant architecture, fruit maturation uniformity and beans size and type.

In spite of a number of advantages, the use of clonal cultivars for crop development requires, however, that special precautions are taken in order not to make them more vulnerable to adverse environmental conditions, which means that it must be avoided the rusticity reduction, that is one of the most important and remarkable characteristics of the species. This rusticity is mainly due to the great genetic variability, result of its natural method of cross-fertilization (VAN DER VOSSEN, 1985; CARVALHO et al., 1991; MONTAGNON; LEROY; YAPO, 1992).

In order to provide greater security to the producer regarding the pollination and also to the drastic non reduction of the plant population genetic base, which would cause the cultivar vulnerability to the diseases and other factors, it is recommended to constitute the clonal cultivar with, at least, eight clones. These should be grouped after the genetic compatibility test and according to the established goals. The nine clonal cultivars already developed, launched and released for planting by Incaper were constituted by the grouping of, at least, 9 clones and a maximum of 14 clones.

The substitution of crops of genetic material propagated by seeds for clonal cultivars when carried out indiscriminately, that is, inadequate, and sometimes without its characteristics by the exclusion of clones, might lead to the narrowing of the species genetic base and result in crop failures and, also, occur the factor called "genetic erosion". Genetic erosion in conilon coffee consists of reducing genetic variability in natural populations as a consequence of the random recombination of a limited number of clones (CHARRIER; BERTHAUD, 1988).

2.3 CULTIVARS PROPAGATED BY SEEDS

Phenotypic selection of individuals has been widely used successfully in open pollinated fields for high heritability traits. Through the estimates of the General Combination Capacity (GCC) and Specific Combination Capacity (SCC), obtained by controlled crosses, *top crosses* or dialleles, it is possible to efficiently select genotypes based on phenotypic performance. By the recombination of the parents with better GCC values, the synthetic cultivars are developed. These can be multiplied in isolated fields of free pollination. By the clones parental crosses with higher SCC values, the hybrid cultivars are developed.

With the recombination of the interest groups, the basic populations are formed that can be used in the inter and intrapopulation breeding through the recurrent selection method.

The cultivars propagated by seeds are, in general, more rustic, present higher production stability and are recommended for crops in regions that are more susceptible to stress. However, they show a great heterogeneity, with very different plants regarding the architecture aspects of the aerial part, beans size and shape, time and uniformity of fruit maturation, susceptibility to pests and diseases, tolerance to drought, vegetative vigor, productive capacity, among others.

Despite the superiority of productive clonal cultivars and final quality of production compared to the cultivars propagated by seeds (DUBLIN, 1967; CHARRIER; BERTHAUD, 1988; BRAGANÇA et al., 1993; 2001; FERRÃO, 2004; FONSECA, 1999; FONSECA et al., 2004c), Charmetant et al. (1990) and Ferrão et al. (2000d) stated that it is possible to obtain synthetic hybrids varieties, sexually propagated, with productivity compatible with that of clonal cultivars.

2.4 GENETIC IMPROVEMENT AND DEVELOPMENT OF CONILON COFFEE CULTIVARS BY INCAPER

The main objective of Incaper's conilon coffee breeding program is the development of superior, clonal and seed propagated cultivars that gather a series of characteristics of interest, which concurrently provide the obtainment of high values in productivity with lower unit cost, adaptability to different environments, production stability and product quality compatible with the consumer market demands. Such conditions are essential for the coffee, in case, to become increasingly competitive, providing greater economic stability and improving the life of coffee grower, most of them in the State, conduct this activity in a family-based system.

In order to achieve the conilon coffee tree improvement, several strategies have been used, as follows: 1) identification and phenotypic selection of individuals with characteristics of interest in segregating natural populations; 2) asexual multiplication of the individuals selected in the previous stage and their evaluation in competition trials, with selection of superiors through the characteristics of interest, for the composition and development of the clonal cultivars; 3) intraspecific hybridization for the development of synthetic hybrid varieties, besides obtaining important basic information about the genetic structure of the species; 4) recurrent intrapopulation selection, aiming at the increase of the favorable alleles frequency in future generations; 5) maintenance and characterization of genetic variability in Active Germplasm Bank; and 6) characterization of genetic variability by molecular markers. The flowchart of the *Coffea canephora* breeding program, Conilon variety, of Incaper is shown in Figure 1.

Based on this flowchart of the clonal cultivar development process, the superior plants selected in producers crops or in isolated recombination fields are cloned, multiplied by the cutting process in nurseries and evaluated in field experiments for, at least, four harvests in sites where the coffee cultivation is representative in the State. Parallel to this evaluation, the superior genetic materials are identified, which are tested for genetic compatibility and evaluated for the quality of the beverage. Then the outstanding clones are grouped by time of maturation, tolerance to drought, resistance to pests and diseases, are multiplied in parent plants production areas, being programmed to its future use, if chosen as an important clone in the clonal cultivar constitution. Finally they are protected and/or registered in the Ministério da Agricultura, Pecuária e Abastecimento - Mapa (Ministry of Agriculture, Livestock and Supply) waiting for the launch. Other important information about these strategies is more detailed and commented in Chapter 6 of this book, with the denomination of "*Coffea canephora* Breeding".

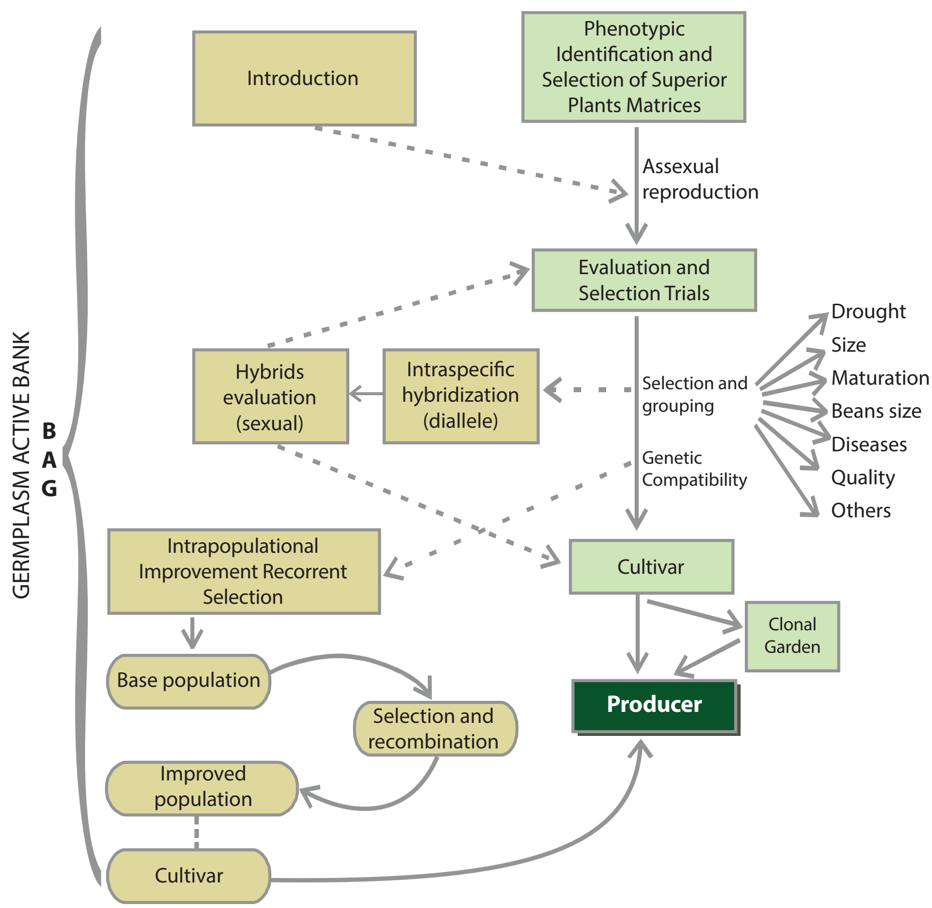

Figure 1. Flowchart of conilon coffee breeding program of Incaper.

Source: Ferrão et al. (2007).

Currently, experiments have been conducted in, at least, three edaphoclimatic climatic conditions: Fazenda Experimental de Marilândia - FEM (Experimental Farm of Marilândia), Fazenda Experimental de Sooretama - FES (Experimental Farm of Sooretama) and Fazenda Experimental de Bananal do Norte - FEBN (Experimental Farm of Bananal do Norte), which are Incaper research units, located in the municipalities of Marilândia, Sooretama and Cachoeiro de Itapemirim, respectively. According to the agroclimatic charter of Espírito Santo (FEITOSA, 1986), these sites present the following characteristics: 1) Sooretama- located at latitude 19º 24 'south, longitude 40º31' west, at an altitude of 40 meters; soil classified as sandy dystrophic Red-

Yellow Latosol (80% sand), with low fertility; annual rainfall of 1,200 mm and poorly distributed; average annual temperature of 24 ºC; average relative humidity of 80%; and flat topography with predominant south winds. 2) Marilândia- located at a latitude of 15º 47 'south, longitude of 43º 18' west and altitude of 70 meters; soil classified as crystalline, with low fertility; annual rainfall of 1,100 mm, average annual temperature of 24 ºC; relative humidity of 74%; and rugged wavy topography, characteristics of the region. 3) Cachoeiro de Itapemirim- located at latitude 20º 45 'south, longitude 41º 16' west, altitude 140 meters, average annual temperature 23 ºC, wavy topography, rainfall around 1,200 mm and better distributed, and soils of better fertility compared to those in the northern region of the state. In these places, the months of January, November and December are humid, while March, April and October are partly humid and May, June, July, August and September are dry.

The main characteristics experimentally determined to evaluate the genotypes are as follows: average plant height (cm), average crown diameter (cm), fruit maturation time (days from flowering to harvesting), fruit maturation uniformity, "mocha" beans (%), flat beans(%), average weight of 1,000 beans (kg), beans retained in the sieve 11, 13, 15 and greater than 15 (%), average sieve (%), ratio cherry coffee and coconut coffee, ratio cherry coffee and processed coffee, ratio coconut coffee and processed coffee, incidence and severity of the main pests (leaf miner, rosette cochineal, stem borer) and diseases, especially rust and blister spot, first harvest precocity, production variation due to the biennial effect of the coffee tree and finally biochemical and sensory characteristics associated with the final quality of the product.

3 CONILON COFFEE CULTIVARS DEVELOPED AND LAUNCHED BY INCAPER

Incaper developed, released and recommended for planting nine conilon coffee cultivars for the Capixaba coffee grower, known as Emcapa 8111', 'Emcapa 8121', 'Emcapa 8131', 'Emcapa 8141- Robustão Capixaba', 'Emcaper 8151- Robusta Tropical', 'Vitória Incaper 8142', 'Diamante ES 8112', 'ES 8122' - Jequitibá, 'Centenária ES 8132' and 'Marilândia ES 8143'. These cultivars are recommended for planting in the zoning region considered suitable for conilon coffee cultivation in the state of Espírito Santo (DADALTO, BARBOSA, 1997).

In Table 1 information regarding the launching year, number of clones and method of propagation of these varieties are found.

Table 1. Constitution, method of propagation and launching year of the nine conilon coffee cultivars developed and recommended by Incaper for the state of Espírito Santo

(to be continued)

Cultivar	Nº Clones	Method of Propagation	Launching Year
'Emcapa 8111'	9	Clonal	1993
'Emcapa 8121'	14	Clonal	1993
'Emcapa 8131'	9	Clonal	1993
'Emcapa 8141 - Robustão Capixaba'	10	Clonal	1999
'Emcaper 8151 - Robusta Tropical'	-	Seed	2000
'Vitória - Incaper 8142'	13	Clonal	2004

(conclusion)

Cultivar	Nº Clones	Method of Propagation	Launching Year
'Diamante ES8112'	9	Clonal	2013
'ES 8122' - Jequitibá	9	Clonal	2013
'Centenária ES8132'	9	Clonal	2013
'Marilândia ES 8143'	12	Clonal	2017

Source: Ferrão et al. (2007), Ferrão et al. (2015b, 2015c, 2015d).

3.1 'EMCAPA 8111', 'EMCAPA 8121' AND 'EMCAPA 8131'

The first three cultivars - 'Emcapa 8111', 'Emcapa 8121' and 'Emcapa 8131' - were launched in 1993 (BRAGANÇA et al., 1993; 2001). They are clonal cultivars formed by the grouping of clones genetically compatible with each other, possessing a series of common agronomic characteristics, distinguishing from one another, mainly, by the different maturation times of the fruits (Figure 2), that are, early, intermediate and late.

Figure 2. First improved clonal cultivars of Incaper. 'Emcapa 8111' (A), 'Emcapa 8121' (B) and 'Emcapa 8131' (C) respectively with early, intermediate and late maturation.

The clones that formed these three cultivars were selected from experiments carried out at the Fazenda Experimental do Incaper em Marilândia/ES (Incaper Experimental Farm in Marilândia/ES) from 1986 to 1992. In these trials, clones originated from selected parent plants in populations existing in the northern region of the state of Espírito Santo were studied by means of phenotypic selection, for which important characteristics of interest were considered, mainly related to productive capacity and grain quality.

3.1.1 'Emcapa 8111'

Clonal Cultivars constituted by the grouping of 9 clones, all compatible with each other, of early and uniform fruit maturation, with harvesting usually in the months of April and May.

It presented in the first four harvests without irrigation, average productivity of approximately 58 proces. bags/ha (29% higher than the control), with clones variation range between 49 and 64 proces. bags/ha, with an average yield in processing of 4.03 (kg of cherry coffee/kg of processed coffee) and an average sieve of 14.

3.1.2 'Emcapa 8121'

A clonal variety formed by the grouping of 14 clones, distinguished by intermediate maturation of the fruits, with the harvesting occurring normally in June.

It presented average productivity of the first four harvests without irrigation of approximately 60 proces. bags/ha (33% higher than the control), with clones variation range between 52 and 72proces.bags/ha, with an average yield in processing of 3.96 (kg of cherries/kg of processed coffee) and an average sieve of 15.

3.1.3 'Emcapa 8131'

Clonal cultivar composed of the grouping of 9 clones. It shows late maturation of fruits, with harvesting occurring normally in July and August.

It presented, in the first four harvests without irrigation, average productivity of 60 proces. bags/ha (33% higher than the control), with clones variation range from 51 to 72 proces. bags/ha, the average yield being 3.76 (kg of cherries/kg of processed coffee) and an average sieve of 14.

Table 2 shows the experimental data of these three clonal varieties main characteristics from 1989 to 1992. Their comparative advantages over seed propagated variety (control) are as follows: high productivity, higher productivity at first harvest as it shows faster plant development, better maturation uniformity, larger beans sizes, greater harvest homogeneity, improvement of production quality and possibility of harvesting scheduling.

The use of these three cultivars (Figure 2) in different planting plots allows harvesting scheduling, extended harvesting periods, and workforce optimization, especially for the family-based producer, during the harvesting period and of the physical structures for the fruits drying and the grains processing.

Table 2. Average productivity and other agronomic characteristics of the three conilon coffee clonal cultivars tested between 1989 and 1992 in relation to the control and the state average

Genetic Materials	Fruit Maturation	Time Harvesting	Productivity[2]					Relative Index (%)	Average Sieve	Mocha (%)
			1989	1990	1991	1992	Average			
'Emcapa 8111'	Early	until May	22	45	81	82	58	129	14	32
'Emcapa 8121'	Intermediate	June	20	50	89	79	60	133	15	34
'Emcapa 8131'	Late	Jul/Aug	21	48	90	82	60	133	14	33
Seeds var[1]	Uneven	May/Aug	10	38	77	57	45	100	Uneven <14	-
Conilon average in the State	Uneven	Apr/Jul	-	-	-	-	7	16	Uneven <14	-

Source: Bragança et al. (1993, 2001).

[1]Coming from selected plant seeds: control in the experiment. [2]Average productivity, in proces. bags/ha at 24, 36, 48 and 60 months after planting.

3.2 'EMCAPA 8141 - ROBUSTÃO CAPIXABA'

Considering the water deficit of 50 to 550 mm in most of the main coffee producing region of Espírito Santo, the most promising clones of the Incaper breeding program were selected from those with drought tolerance characteristics. Thus, in the period from 1994 to 1998, these clones were evaluated in two environments, FEM (Marilândia) and FES (Sooretama), in irrigated and drought conditions, and compared to T_1 controls (clones of Emcapa 8111, Emcapa 8121 and Coat 8131 cultivars) and T_2 (experimental cultivar sexually propagated).

The following variables were evaluated: VEI (visual evaluation index- grade from 1 to 5, considering the plant as a whole), leaf number, defoliation, productivity and physiological parameters such as: water potential, stomatal conductance, transpiration rate and net carbon assimilation. Thus, after four harvests, 10 clones of interest were identified. These clones grouping originated the variety 'Emcapa 8141 - Robustão Capixaba': Conilon coffee clonal variety tolerant to drought, whose main characteristics are found in Tables 3, 4 and 5.

Table 3. Average productivity of the clonal variety Emcapa 8141- Robustão Capixaba compared to the control varieties average

Varieties	Productivity			
	Average[1/]	Index (%)	Maximum	Index (%)
'Emcapa 8141 - Robustão Capixaba'	54,0	144,7	112,5	125,0
Control 1 (T_1)	44,7	100,00	90,0	100,0
Control 2 (T_2)	30,7	68,7	77,0	85,6

Source: Ferrão et al. (1999, 2000c).

[1/]Average productivity in proces.bags/ha obtained at 24, 36, 48 and 60 months in experiments without irrigation. T_1 - Control 1: Clonal cultivars Emcapa 8111, 8121 and 8131 average. T_2 - Control 2: Experimental cultivar sexually propagated.

Thus, 'Emcapa 8141- Robustão Capixaba' is a clonal cultivar launched in 1999 (FERRÃO et al., 2000a), formed by the grouping of 10 drought-tolerant clones compatible with each other. The component clones of this cultivar spotted out under conditions of water stress, evaluated in two environments from 1994 to 1998, standing out both in productivity and in the other physiological parameters considered. When compared to the controls, the average productivity of the first four harvests was 54.0 proces. bags/ha, while the control 1 average (clone cultivars Emcapa 8111, Emcapa 8121 and Emcapa 8131 average) was 44.7 proces. bags/ha and control 2 (sexual propagation), 30.7 proces. bags/ha.

Table 4. Visual evaluation index (VEI) average, average number of leaves per plagiotropic branches (NL/PB) and defoliation (%) of the cultivar Emcapa 8141- Robustão Capixaba compared to the average of the control varieties (T_1 and T_2)

Varieties	VEI[1/]	NL/PB		Defoliation (%)
		Without irrigation	With irrigation	
'Emcapa 8141 - Robustão Capixaba'	4,3	9,8	13,2	25,7
Control (T_1)	2,9	7,1	11,4	37,7
Control (T_2)	2,6	6,6	12,2	45,9

Source: Ferrão et al. (1999, 2000c).

[1/] - VEI: average of the grades from 1 to 5 regarding the aspects of leafing, vigor, diseases, leaf color, leaf thickness, maturation uniformity and architecture, after 4 months of water stress: 1 = worst index; 5 = best index. T_1- Control 1: Clonal cultivars Emcapa 8111, 8121 and 8131 average. T_2- Control 2: Experimental Cultivar sexually propagated.

Table 5. Summary of the clonal cultivar Emcapa 8141- Robustão Capixaba main characteristics

Cultivar Characteristics	Specifications
Cultivar type	Clonal
Number of clones involved	10
Fruits maturation	May/June, with uniformity
Plant architecture	Suitable for pruning and densification
Fruits size	Average sieve higher than 15
Foliar diseases	Tolerant
Water *deficit*	Tolerance to drought
Vegetative vigor	High
Defoliation	Low
Maximum productivity achieved	112.5 proces. bags./ha
Average productivity in water stress	54.0 proces. bags./ha (average of four harvests: 24, 36, 48 and 60 months)

Source: Ferrão et al. (1999, 2000c).

Although it is characterized as tolerant to drought, the cultivar Emcapa 8141 - Robustão Capixaba showed to be highly responsive to water supplementation, reaching, in such conditions, average productivity up to 112.5 proces. bags/ha in the first four harvests (Figure 3).

The main agronomic characteristics of this cultivar are the following: drought tolerant, high vegetative vigor, architecture and plants size, favorable to densification, fruit maturation between May and June, tolerance to major diseases, low defoliation index under water stress conditions and sieve superior to 15.

3.3 'EMCAPER 8151 - ROBUSTA TROPICAL'

Emcaper 8151 - Robusta Tropical 'was released for planting in 2000 and it is the first improved conilon coffee seed propagation cultivar for the state of Espírito Santo (FERRÃO et al., 2000d). It originates from the recombination of 53 elite clones of the Incaper conilon coffee breeding program. These clones come from superior parent plants selected from 1986 onwards from several regions of the State (Figure 4).

Figure 3. Cultivar Emcapa 8141 - Robustão Capixaba.

This cultivar, formed by seeds from open pollination in an isolated field of recombination, was evaluated in the municipalities of Linhares, Marilândia, São Gabriel da Palha and Cachoeiro de Itapemirim.

The general average productivity in these locations was 79.4 and 39.5 proces. bags/ha with and without irrigation, respectively, with production potential of 113.2 proces. bags/ha. It highlighted with average productivity of 19.2; 56.1; 64.8 and 70.9 proces. bags/ha at 24, 36, 48 and 60 months, respectively. The average productivity obtained in the environments, from the sum of 23 harvests, was of 50.3 proces. bags/ha (Figure 5).

Figure 4. Cultivar Emcaper 8151 - Robusta Tropical.

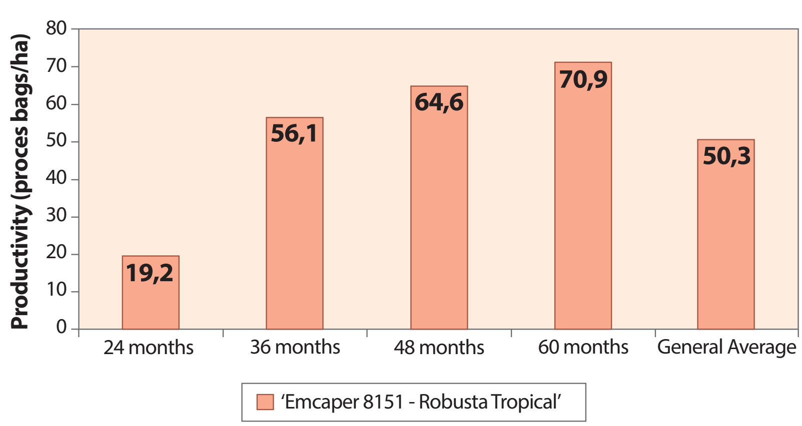

Figure 5. Cultivar Emcaper 8151 - Robusta Tropical productivity average at at 24, 36, 48 and 60 months and general average.

Source: Ferrão et al. (2000d).

Allied to the high productivity and the broad genetic base, it also presented some desirable characteristics of great importance, such as rusticity, high vegetative vigor, proper architecture for the densification, average sieve of 15 and adaptation to different regions of the State. Fruit maturation usually occurs between May and June (Table 6).

Table 6. Cultivar Emcaper 8151- Robusta Tropical main characteristics

Cultivar Characteristics	Specifications
Cultivar type	Seed propagated variety
Number of clones involved	53
Plant architecture	Average, proper to the density of 2.3 to 3.3 thousand plants/ha
Fruit Size	Average sieve of 15
Genetic Base	Wide
Rusticity	High
Adaptation	All regions suitable for conilon coffee cultivation in Espírito Santo
Maximum productivity achieved	113.2 bags./ha
Average productivity with irrigation	79.4 bags./ha
Average productivity without irrigation	39.5 bags./ha
Average Productivity - 23 harvests	50.3 bags./ha (average of the first four harvests)
Seedlings price (thousand)	25% of the clonal seedling value

Source: Ferrão et al. (2000d).

This cultivar aims to attend producers in regions with deficiencies of seedlings of the recommended clonal varieties and to small producers that use their own genetic materials as parent plants.

'Emcaper 8151 - Tropical Robusta' cultivation provides the coffee grower with a guarantee of greater stability in production due to its wide genetic base and lower cost in the crop implantation, due to the seedlings lower price and lower mortality rate after planting.

3.4 'VITÓRIA INCAPER 8142'

'Vitória Incaper 8142' is a clonal cultivar launched in 2004, developed by the grouping of 13 superior clones, selected among the genetic material considered as the "elite" of Incaper breeding program (FONSECA et al., 2004c). Those who combined the characteristics of interest that, taken together, distinguished them among the most appropriate ones, considering both the productive potential and other not less important aspects for the sustainability of the activity were chosen. These clones were selected in private properties and later evaluated under controlled experimental conditions and in different environments, the most representative of the species cultivation in the state.

This cultivar stood out compared to a series of criteria when compared to the other genetic materials used as control in the experimental work, specially highlighting its performance in relation to the high level of average productivity obtained over a period minimum of eight harvests. In this respect, the cultivar Vitória Incaper 8142 result, of 70.4 proces. bags/ha, exceeded by 21.05% the average of the other cultivars already recommended by Incaper (Figures 6). The most productive clones reached average productivity above 83 proces. bags/ha, and no clone of less than 62 proces. bags/ha was chosen. In Figure 6, there is a comparison of the average productivity of Vitória cultivar with Robusta Tropical and Robustão Capixaba.

The cultivar Vitória stands out because of its high productivity, production stability, tolerance to drought, tolerance to rust, maturation uniformity and large beans (Figure 7 e Table 7).

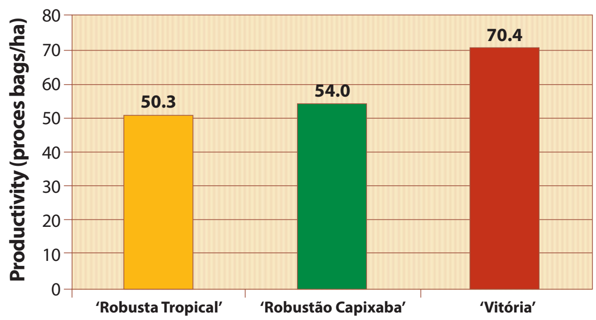

Figure 6. Average productivity, in eight harvests, of conilon coffee cultivars Robusta Tropical, Robustão Capixaba and Vitória, in non-irrigated crops, in different environments of Espírito Santo.

Source: Fonseca et al. (2004c).

Figure 7. Clonal cultivar Vitória - Incaper 8142.

Table 7. Clonal cultivar Vitória Incaper 8142 agronomic characteristics

(to be continued)

Method of propagation	**Asexual (Clonal)**
Number of clones	13
Method of planting	Each clone in a line
Visual Evaluation Index (VEI)	7.45 (Scale from 0 to 10)
Vegetative vigor	High
Average productivity (non irrigated)	70.40 proces. bags./ha
Plant height	2.32 m
Crown diameter	2.79 m
Plant architecture	Semi-culture cultivation
Fruits maturation	Uniform

(conclusion)

Method of propagation	Asexual (Clonal)
Maturation Time	May to July (depending on clone)
Ratio cherry/proces. (mass)	3.92
Ratio coconut/proces	1.80
Beans size	90.59% sieves 13 and larger
Mocha bean	21.40%
Reaction to rust	Tolerant
Water *deficit*	Tolerant
Adaptation	Zoned areas for conilon coffee in the ES

Source: Fonseca et al. (2004c).

3.5 'DIAMANTE ES8112', 'ES8122' - JEQUITIBÁ AND 'CENTENÁRIA ES8132'

The 'Diamante ES 8112' 'ES 8122' - Jequitibá and 'Centenária ES 8132' were obtained by different breeding strategies and a dataset of experiments conducted at the Incaper's Experimental Farms of Marilândia, Sooretama and Bananal do Norte, which constitute representative macroenvironments of conilon coffee cultivation in the Northwest, Northeast and Southern regions of Espírito Santo, respectively.

Taking advantage of the genetic variability of conilon coffee in commercial crops propagated by seeds of Espírito Santo, populations of recombinant fields and controlled crosses of Incaper, more than 2000 genetic materials were selected, which were evaluated in experiments for different characteristics and for at least four harvests for different characteristics associated with production and final quality of the product, without phytosanitary control, following Ferrão et al (2013a). Twenty seven clones were selected from the studied universe and grouped by maturation time of the fruits and the new cultivars were developed (Figure 8).

3.5.1 'Diamante ES8112'

Clonal cultivar, launched in 2013, constituted by the grouping of nine clones compatible with each other, of early and uniform maturation concentrated in May. It presents average productivity of 80.73 proces. bags/ha, which surpasses in 39.19% the Emcapa 8111 average and in 14.73% the average of 'Vitória Incaper 8142', which were launched in 1993 and 2004, respectively (FERRÃO et al., 2014, 2015a, 2015b, 2015c).

3.5.2 'ES8122' - Jequitibá

Clonal cultivar, launched in 2013, constituted by the grouping of nine compatible clones with each other, of intermediate maturation and harvesting concentrated in June. The average productivity of the cultivar of 88.75 80.73 proces. bags/ha surpasses in 47.96% and 26.07% the 'Emcapa 8121' (intermediate) and 'Vitória Incaper 8142' averages, launched in 1993 and 2004, respectively (FERRÃO et al., 2014, 2015a, 2015b, 2015d).

Figure 8. Illustration of the differentiated maturation times of clonal cultivars Diamante Incaper 8112 (maturation in May) (A), ES8122 - Jequitibá (maturation in June) (B), Centenária Incaper in 8132 (maturation in July) (C).

3.5.3 'Centenária ES8132'

Clonal cultivar, launched in 2013, constituted by the grouping of nine clones compatible with each other, of late maturation and harvesting concentrated in July. The average productivity of 82.36 80.73 proces. bags/ha, surpasses in 37.27% and 16.99% the 'Emcapa 8131'(late) and 'Vitória Incaper 8142' averages launched in 1993 and 2004, respectively (FERRÃO et al., 2014, 2015a, 2015b, 2015e).

The 'Diamante ES 8112', 'ES 8122' - Jequitibá and 'Centenária ES 8132' differ mainly by the maturation time of fruits: early (May), intermediate (June) and late (July), respectively. The average productivity in non-irrigated conditions of the three cultivars, of 83.95 proces. bags/ha, surpasses in 41.15% the average production of the first ones launched in 1993 ('Emcapa 8111', 'Emcapa 8121' and 'Emcapa 8131'), 19.25% of 'Vitória Incaper 8142', launched in 2004 (FERRÃO et al., 2013, 2014, 2015a, 2015b, 2015c, 2015d) and 140% the State average for 2014 which was 35.00 proces. bags/ha (CONAB, 2014) (Figures 8 and 9).

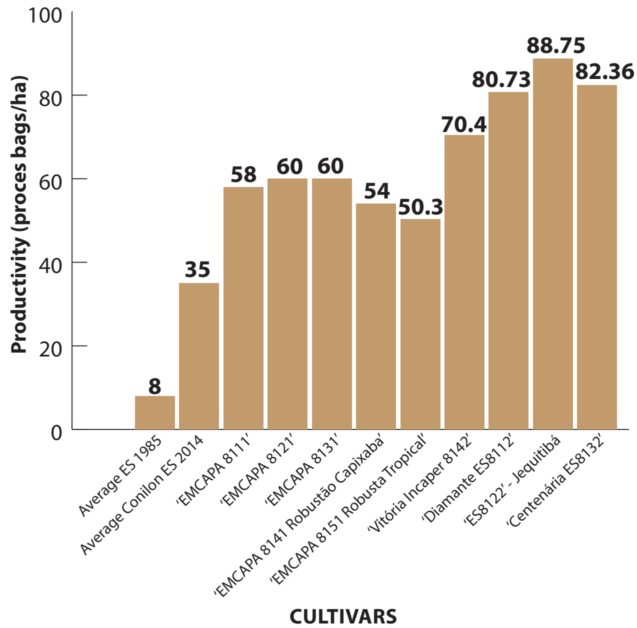

Figure 9. Average productivity without irrigation of cultivars Diamante ES8112, ES8122 - Jequitibá, Centenária ES8132 in relation to the other cultivars developed by Incaper and the Espírito Santo averages in 1985 (Incaper's breeding program start) and 2014.

Source: Elaborated by the authors.

These last three cultivars present genetic potential of yield greater than 120 proces. bags/ha in irrigated plantations and with the use of high technology. In addition to the high productivity in non- irrigated conditions, it also shows production stability, medium size, high vegetative vigor, low percentages of wilted and mocha beans, differentiated maturation time and uniformity of fruits, large beans, tolerance to drought and moderate resistance to rust and superior quality of beverage (Table 08, Figure 10).

Table 8. Cultivars Diamante ES8112, ES8122 - Jequitibá and Centenária ES8132 characteristics, Incaper, 2013

Characteristics	'Diamante ES8112'	'ES8122' - Jequitibá	'Centenária ES8132'
Number of clones	9	9	9
Maturation Time	May	June	July
Productivity (bags/ha)*	80.7	88.7	82.4
Vegetative vigor	7.9	7.9	8.2
Visual evaluation index	8.0	8.0	8.1
Beans WIL (%)	8.1	12.7	10.9
Mocha beans (%)	18.7	24.8	26.4
Ratio CH/PR coffee	4.3	4.2	4.2
Size beans (% > 13)	81.3	75.2	73.6
Weight of 100 beans (g)	14.9	17.2	16.9
Grade quality beverage	77.4	79.0	77.9
Fruits maturation	Uniform	Uniform	Uniform
Rust reaction	MR	MR	MR

Source: Incaper (2013b, 2013c, 2013d).

* = average productivity without irrigation; WIL = Wilted beans; MR: Moderate resistance to rust; CH/PR = ratio cherry coffee and processed coffee.

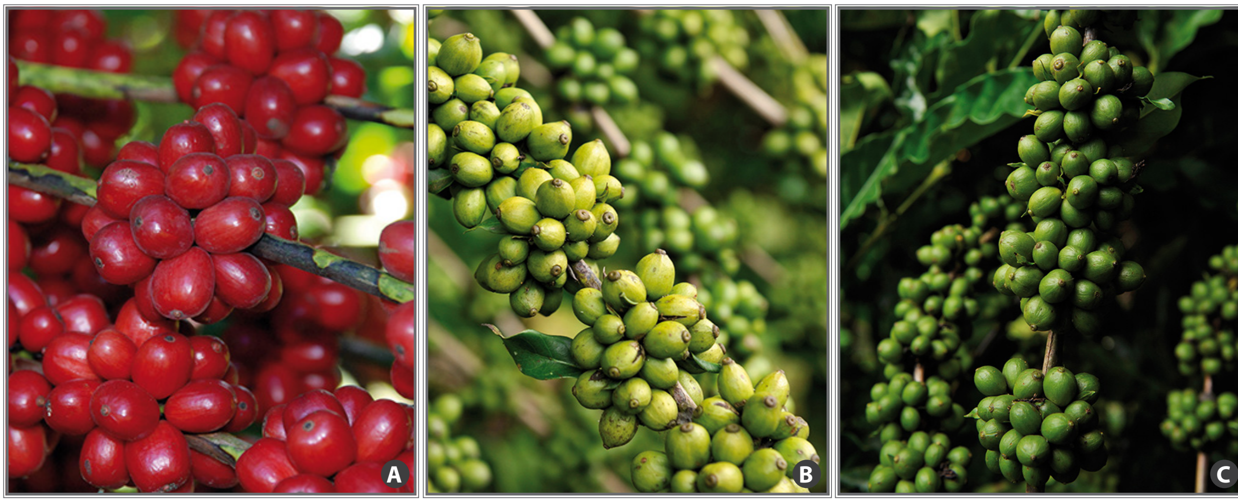

Figure 10. Illutation of the maturation season of cultivars Diamante ES8112 (A); ES8122 - Jequitibá (B) and Centenária ES8132, early, intermediate and late, respectively.

Another great highlight of the cultivars Diamante ES 8112, ES 8122 - Jequitibá and Centenária ES 8132 is the superior quality of the beverage. In sensory analyzes of beans samples from the three experimental sites prepared through the natural process using the quality scale of the Coffee Quality Institute (CQI) fine coffee tasting protocol, the selected clones obtained, on average, 77.20, 79.01 and 77.97 points, respectively, classifying them as cultivars of higher quality coffee. They presented the aroma and flavor characteristics that bring them to chocolate, caramel, sweet, touch of red fruits and cocoa.

3.5.4 'Marilândia ES 8143'

The cultivar 'Marilândia ES8143' is formed by the grouping of twelve compatible clones of the Incaper conilon coffee breeding program, which presents the main characteristic of tolerance to drought (FERRAO et al., 2017).

During the development of the research, different breeding strategies were used, foccusing on the identification and selection of clones with tolerance to drought. For this, we used data from different agronomic characteristics and experimental observations of about 1.000 genetic materials of Incaper.

The following characteristics of the plants and fruits were evaluated as a priority: productivity, vigor, unstripped fruit, defoliation, maturation uniformity, beans wilting and size, processing yield, mainly the rust disease and the quality of the beverage.

Data and information were obtained under conditions of water deficiency in the Incaper's Experimental Farms of Bananal do Norte, Marilândia and Sooretama, located in representative environments of the South, Northwest and Northeast regions of Espírito Santo, respectively. It is recorded that this condition, associated with temperature elevation, was the most severe one ever referenced in the last 50 years in Espírito Santo (Figure 11). As a consequence, such situation was characterized as a favorable condition for the clones selection of the new cultivar 'Marilândia ES8143'.

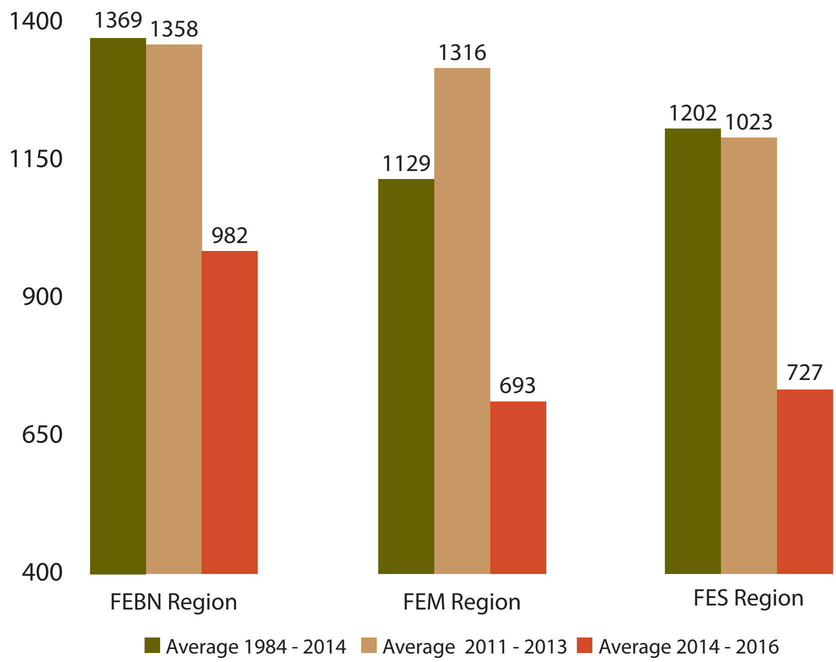

Figure 11. Average rainfall data (mm) at the Incaper's Experimental Farms of the Bananal do Norte (FEBN), Marilândia (FEM) and Sooretama (FES).

Source: htpp//www.meteorologia.incaper.es.gov.br

The main results of 'Marilândia ES 8143' cultivar are shown in Table 9. The average productivity of 'Marilândia ES8143' was 80.98 proces. bags./ha in normal conditions (NC) and 63.62 proces. bags./ha in drought conditions (DC), which exceeds in about 17.00% the cultivar Emcapa 8141- Robustão Capixaba (control), launched in 1999.

Table 9. Average productivity and beans wilting of 'cultivar Marilândia ES8143' and Emcapa 8141 Robustão Capixaba (T), in experiments conducted under normal rainfall conditions, with additional irrigation (NC), under drought conditions (DC), potential productivity without water restrictions (PP), Incaper. 2017

Cultivars	Productivity (proces. bags/ha)						Beans wilting (%)	
	NC	%	DC	%	PP	%	NC	DC
Marilândia ES8143	80.98	117.02	63.32	117.26	135.00	120.00	9,27	22,83
Robustão Capixaba (T)*	69.20	100.00	54.00	100.00	112.50	100.00	-	-

*(T) = Emcapa 8141 - Robustão Capixaba (Control): conilon coffee cultivar, tolerant to drought launched by Incaper in 1999.

The new cultivar also presented productive potential (PP) of 135.00 proces. bags./ha in plantations conducted using high technology and correct use of irrigation, low beans wilting, 9.27%, 22.83% in normal (NC) and drought (DC) conditions, respectively.

The cultivar 'Marilândia ES8143' stands out for its high productivity, production stability, rusticity, suitable plant architecture, maturation uniformity of fruits, moderate resistance to rust, superior quality of the beverage and tolerance to drought (Table 10).

Table 10. Cultivar 'Marilândia ES 8143' agronomic characteristics

Cultivar characteristics	Specifications
Cultivar type	Cultivar tolerant to drought
Method of propagation	Clonal (asexual)
Number of clones	12
Maturation time[1]	Intermediate (May/June)
Size	Medium
Vegetative Vigor	High (8.00 on a scale of 0 to 10)
Visual Evaluation Index (VEI)	High (8.12 on a scale of 0 to 10)
Resistance to rust	Moderate Resistance
Defoliation index in water deficit condition (DC)	Low
Behavior regarding the water deficit	Tolerant
Fruit maturation	Uniform
Fruit size	Medium to large
Average productivity[2] in water deficit condition (DC)	63.62 proces. bags/ha
Average productivity in normal condition (NC)	80.98 proces. bags/ha
Beans wilting under water deficit conditions (DC)	Medium (22.83%)
Beans wilting in normal condition (NC)	Low (9.27%)
Average percentage of mocha beans (DC and NC)	19.91 %
Cherry/processed coffee ratio	4.26
Weight of 100 beans	14.56 grams
Quality of the beverage (DC)[3]	Superior (78.52 points)
Adaptation	Zoned areas for conilon coffee in the ES

Source: Ferrao et al. (2017).

(1) fruits maturation between 250 and 290 days, with an average of 272 days after the main flowering.

(2) average of at least four harvests, eight environments, without irrigation.

(3) sensory evaluation of the beans under drought conditions (DC), using the Coffee Quality Institute (SCQ)/SCCA (Specialty Coffee Association of America) of fine robusta coffee tasting protocol.

In addition to the nine cultivars developed and launched by Incaper, the 'G30/G35 Verdebras' (MUDAS VERDEBRAS, sd; VERDEBRAS, 1995), 'Ipiranga 501', 'SV 2010', 'Colatina PR 6' and Tributum are also planted in Espírito Santo. This set of genetic materials has been multiplied in about 200 clonal gardens implanted in educational and research institutions, cooperatives, municipal governments, producer associations and nursery professionals. This network of clonal gardens has been the production base of about 60 million seedlings per year for the renewal of 8% of the Capixaba conilon coffee cultivation per year.

It is recorded that the Incaper project 'Sustainable breeding of conilon coffee' won the 10th Inoves Award in 2014 in the category Results for Society' (INOVES, 2014).

4 *Coffea canephora* CULTIVAR DEVELOPED BY IAC

The Instituto Agronômico de Campinas - IAC (Agronomic Institution of Campinas) has been working on its *Coffea canephora* genetic breeding program with clonal selection of progenies and recurrent selection. As more applied results, different cultivars and progenies that have been planted in some regions of Brazil were developed and recommended. As a strategy oh asexual improvement, it was selected and has been evaluated in experiments, a set of clones aiming at the development and recommendation of clonal cultivars as a cultivation option for the low altitude and hot regions of the State of São Paulo (MISTRO, 2013).

4.1 'APOATÃ IAC 2258'

The cultivar Apoatã IAC 2258 was introduced from the Centro Agronômico Tropical de Investigação e Educação Superior - CATIE (Tropical Agricultural Research and Higher Education Center), Costa Rica in 1974, evaluated and used by IAC as a scion for resistance to nematodes since 1987. The cultivar is characterized by being multicaulis, very vigorous and having a wonderful root system. It shows high resistance to the rust causal agent and *Meloidogyne exígua* (SALGADO; RESENDE; CAMPOS, 2005), *M. incógnita* and *M. paranaensis* (SARA et al., 2006; FONSECA et al., 2008; FERRÃO et al., 2015a) nematode resistance. It is recommended in plantations in the regions of the Upper Paulista, Center-West and Northwest of the State of São Paulo, as well, as a rootstock for any of the recommended arabica coffee cultivars (CARVALHO; FAZUOLI, 1993; IVOGLO, 2007).

In experiments carried out by Embrapa Rondônia, in municipalities of the state of Rondônia, Apoatã, besides the adaptation and high productivity for that State, showed late maturation (July, August); ratio ripe coffee (cherry) and the processed equal to 5.0; weight of 1,000 flat type seeds of 141 grams; average sieve of 16.7; 89.5% of flat type seeds, soluble solids content of 31.2% caffeine content in the seeds of 1.7% (FONSECA et al., 2008; FERRÃO et al., 2015a).

4.2 'GUARINI IAC 1598'

The cultivar Guarini IAC 1598 comes from a set of superior plants selected from a germplasm of a parent plant in the Tree Farm of the Paulista Company of Rio Claro/SP Railway in 1945. One of the introductions of *C. canephora* in Campinas, stood out for having high production and, as a main characteristic, fruits and seeds much larger than those of conilon cultivar, besides a higher level of resistance to *H. vastatrix* compared to this cultivar. This group of coffee trees, which has been very productive, received the name Guarini (CARVALHO; FAZUOLI, 1993; FERRÃO et al., 2015a).

In experiments carried out in Rondônia, 'Guarini', besides adaptation and high productivity for that state, presented late maturation (July, August); ratio ripe (cherry) and processed coffee equal to 5.0; weight of 1,000 flat type seeds of 131 grams; average sieve of 16.6; 78.0% flat type seeds; soluble solids content of 28.3%; productivity in the fourth crop of 67.0 proces. bags/ha; resistance to the main breeds of rust; wonderful system; high resistance to the nematode *Meloidogyne exigua* and a certain degree of resistance to *M. incognita* (FONSECA et al., 2008; FERRÃO et al., 2015a).

4.3 BUKOBENSIS IAC 826 E 827

The origin of Bukobensis seems to be from Uganda, Africa (CHARRIER; ESKES, 2004). Its introduction in the IAC was by seeds from parent plants of the Tree Farm of the Paulista Company of Rio Claro/SP Railway in 1945. with subsequent selection of productive plants and with early or semi-early and more uniform maturation. The best IAC selections received the acronyms Bukobensis IAC 826 and IAC 827 (CARVALHO; FAZUOLI, 1993).

These are medium size cultivars, similar to conilon coffee with larger seeds; early or semi-early maturation; good productivity; resistant to rust and nematode *Meloidogyne exigua*; with high soluble solids contents in the seeds (FONSECA et al., 2008; FERRÃO et al., 2015a).

5 CULTIVAR DEVELOPED BY EMBRAPA RONDÔNIA

Embrapa Rondônia, in partnership with other Brazilian research institutions, has been working with the genetic improvement of *Coffea canephora* since 1978, at the Estação Experimental da Embrapa Rondônia (Experimental Station of Embrapa Rondônia) in the municipality of Ouro Preto do Oeste. The general objective of this work is the development of cultivars with adaptation and stability of production to the edaphoclimatic conditions of the Legal Amazon (VENEZIANO; SOUZA; SANTOS, 2003; SOUZA; SANTO; CARNEIRO, 2007).

Taking advantage of the species variability in the three main producing regions of Rondônia (Cacoal, Rolim de Moura and Ji-Paraná), *C. canephora* plant parents were identified, cloned and tested in experiments. After the evaluations of the genetic material, for four harvests for different characteristics, following the technical recommendations (VENEZIANO; PEQUENO, 2002), the superior clones were selected and grouped, obtaining the cultivar BRS Ouro Preto.

5.1 'BRS OURO PRETO'

The cultivar BRS Ouro Preto is a clonal cultivar launched in 2012, formed by the grouping of 15 superior clones that are compatible, intermediate maturation and tolerant to the main climatic stresses (high temperature, high air humidity and moderate water deficit) observed in the poles of coffee cultivation in Rondônia (EMBRAPA, 2012).

The cultivar presents productivity potential of 70.00 proces. bags/ha, maturation cycle of 270 days after the main flowering, high production stability, high vegetative vigor, good maturation uniformity, large beans with average sieve of 15.36, average of 36% of mocha beans, moderate resistance to rust and cercospora, neutral quality of beverage with higher soluble solids and caffeine contents than the commercial arabica coffee cultivars (EMBRAPA, 2012).

5.2 OTHER RECOMMENDED CULTIVARS FOR RONDÔNIA

Veneziano (1996), indicated for cultivation in the state of Rondônia, the following progenies from the Instituto Agronômico de Campinas - IAC (Agronomic Institute of Campinas): IAC

1647, IAC 2258, IAC 2259, IAC 2293, Kuoillou 66-3,Kuoillou 68, Kuoillou 69-5, 'Guarani IAC 1675', 'Apoatã IAC 2258'. It further indicates the following promising materials Kouillou 70-1, Guarini IAC 1598, IAC 10, IAC 37, IAC 640, IAC 1645, IAC 1650, IAC 1655, IAC 1657, IAC 2259, IAC 2286, IAC 2290, IAC 2291 and IAC 2292.

6 PROTECTION AND REGISTRATION OF CULTIVARS

Intellectual property law is the legal expression of privilege granted by the State for the appropriation of economic benefits of an invention or creation in exchange for its availability for the society benefit. It covers a number of laws, notably the Law of Cultivars Protection, which ensures the breeder of a cultivar the rights over it, as long as duly protected in the Serviço Nacional de Proteção de Cultivares - SNPC (National Service of Cultivars Protection)/ Ministério da Agricultura, Pecuária e Abastecimento - Mapa (Ministry of Agriculture, Livestock and Supply). The granting of protection happens through the Cultivars Protection Certificate. However, so the protected cultivar might be marketed in the country, it is necessary the register in the Registro Nacional de Cultivares - RNC (National Register of Cultivars) (MOURA, 2008).

6.1 COFFEE CULTIVARS PROTECTION

From Law nº 9.456 of April 25, 1997, regulated by Decree nº 2366 of November 5, 1997, coffee is included in the official MAPA list, as it may be protected in Brazil (BRASIL, 1998).

The Law on cultivars protection aims to strengthen and standardize intellectual property rights.

According to the legislation, cultivar is a genotype, obtained from any genus or higher plant species, resulting from work using breeding strategies, that is clearly distinguishable from other cultivars known by the minimum descriptor margin, designated by an own generic denomination, described in a specialist publication available and accessible to the public in conditions of being grown.

The development process of a new cultivar is long and involves the use of different methods of breeding, field trials, laboratory tests, use of statistical methods, knowledge on the reproductive biology and species genetics. In the final phase of the protection process, the results of specific experiments conducted by a plant breeder, called DHS tests (Distinguishability, Homogeneity and Stability) are used.

Thus, in addition to being innovative- it has not been offered for sale in the country, less than 12 months in relation to the protection request or it has not been marketed abroad for more than 4 years, the new cultivar must have the following characteristics:

- Distinguishability: it must be clearly distinguished from any other cultivar by an important characteristic or by several characteristics which the combination give it the quality of "new cultivar".

- Homogeneity: it must present low variability when planted, that is, the individuals of the same cultivar must have identical or very similar characteristics.

- Stability: the cultivar characteristics should be maintained in successive reproduction generations.

The right to protection of coffee cultivars is valid for 18 years and guarantees the institution holding the technology, a competitive advantage through the exclusive right of production, reproduction, marketing, import/export and ownership of protected cultivars. After the period of validity of the right, the protection can not be renewed, and thus, the cultivar falls into the public domain and no other right may stop its free use.

Following the current rules, a cultivar can be protected with the right to charge "*royalties*" or not, which are fees charged by the holders of protected cultivars on the value of its reproductive material. These values are negotiable and have varied between 3% and 5% on the seeds and seedlings sale value. Only small producers (defined in law) and those who use seeds for their own use can multiply, exchange, donate seeds and seedlings of protected cultivars among themselves, without the holder's authorization. However, they will never be able to sell them (MOURA, 2008; TEIXEIRA; ROCHA; RAMALHO, 2011).

Conilon coffee cultivars, previously protected, in Brazil were developed through breeding programs using public resources. Thus, the "royalties" not charged of producers for their use in plantations in the country.

The protection of a cultivar is carried out by submitting a series of documents to the Serviço Nacional de Proteção de Cultivares - SNPC (National Service for the Protection of Cultivars) by responsible breeders, as a fee payment, technical report and descriptor form containing data from the evaluation of 42 agronomic morphological characteristics, including from leaf shape, width and length, to seed thickness, flowering, genetic compatibility, maturation uniformity, reaction to diseases, production and quality. Descriptors for the protection of conilon coffee cultivars are found in Chapter 4 of this publication.

The holder of a protected cultivar loses the right under it in the following situations: expiring protection period of validity, waiver or cancellation of the protection certificate if the cultivar loses the homogeneity or stability of its characteristics, non payment of the annuity installment, absence of a living sample if the cultivar shows unfavorable impacts on the environment and human health (MOURA, 2008).

6.2 COFFEE CULTIVARS REGISTRATION

With the objective of establishing mechanisms for the production and sale of seeds and seedlings organization, systematization and control the Ministério da Agricultura, Pecuária e Abastecimento - Mapa (Ministry of Agriculture, Livestock and Supply) established, through Decree Nº 527, of December 30, 1997, the Registro Nacional de Cultivares - RNC (National Register of Cultivars).

According to the Brazilian Legislation of Seeds and Seedlings, Law Nº 10.711, dated August 5, 2003 and Decree Nº 5.153, July 23, 2004 (BRASIL, 2004), only the production, processing and marketing in the country of seeds and seedlings of cultivars registered in the National Register of Cultivars (RNC) is allowed. However, this qualification does not guarantee the right to the registered cultivar (MOURA, 2008).

For the proper use of a cultivar there is a need for its registration in the RNC, which is done, using a proper form available on MAPA, accompanied by a certificate of tax payment, technical report with the tests results to determine the Value of Cultivation and Use (VCU) and a statement of the existence of minimum stock of basic material (CAMPOS et al., 2006).

VCU is understood as the intrinsic value of the combination of the cultivar agronomic characteristics with its properties of use in agricultural, industrial, commercial and/or natural consumption activities. For the installation of the VCU trials there is a need for communication to MAPA, defining the time and place for checking and supervision. The tests must be installed following the MAPA criteria, obeying the planning and the statistical design that allow the collection and analysis of the different characteristics data, associated to the production and quality of the cultivars evaluated. Thus, the basic information of the main morphological, biological and/or physiological characteristics that make possible the cultivar identification, referring to productivity, reaction to pests and diseases, region of adaptation and other important data for the domestic and international market. The VCU trials results are of exclusive responsibility of the applicant for registration, and can be obtained directly by any natural or legal person of public or private right, of proven capability and qualification (BRASIL, 2011).

For the production of seeds and seedlings the nurseryman must register in the Registro Nacional de Sementes e Mudas - Renasem (National Register of Seeds and Seedlings); choose cultivars that are recommended and registered in MAPA; define the technical responsible that accompanies all stages of production, quality and identity of the seed and seedlings (certificate of origin).

Fields intended for seed production and nurseries of seedlings must be registered with the supervisory board (MAPA) in the federation unit in which the producer is registered in Renasem. The application request must be made through own forms and certificate of tax payment The registration period for coffee must be made every year, by December 31 of the year prior to the harvest.

In Brazil, the base of planting and renewal of conilon and robusta coffee crops are made by fifteen cultivars. These genetic materials are protected and/or registered with the Ministério da Agricultura, Pecuária e Abastecimento - Mapa (Ministry of Agriculture, Livestock and Supply) as shown in Table 11.

Table 11. *Coffea canephora* cultivars registered in the Ministério da Agricultura, Pecuária e Abastecimento - Mapa (Ministry of Agriculture, Livestock and Supply), 2017

(to be continued)

Name	Register Type	Holder	Registration Nº* Protection**
Conilon	Cultivar	Incaper	05381*
EMCAPA 8111	Cultivar	Incaper	05384*
EMCAPA 8121	Cultivar	Incaper	05383*
EMCAPA 8131	Cultivar	Incaper	05382*
EMCAPA 8141- Robustão Capixaba	Cultivar	Incaper	05385*
EMCAPER 8151 Robusta Tropical	Cultivar	Incaper	05386*

(conclusion)

Name	Register Type	Holder	Registration No.* Protection**
Vitória Incaper 8142	Cultivar	Incaper	20471*
Diamante ES8112	Cultivar	Incaper	31002*, 21806.000118/2013**
ES8122 - Jequitibá	Cultivar	Incaper	31003*, 21806.000119/2013**
Centenária ES8132	Cultivar	Incaper	31001*, 21806.000117/2013**
Marilândia ES8143	Cultivar	Incaper	37678*
Apoatã IAC 2258	Cultivar	IAC	02958
BRS Ouro Preto*	Cultivar	Embrapa	29486*, 21806.000058/2012**
Ipiranga 501	Cultivar	Francisco Luís Silva Felner	26043*
SV 2010	Cultivar	José Jânio Bizi	27053*
Verdebrás G30/G35	Cultivar	Wanderlino M. Basto	06380*
Colatina PR6	Cultivar	Fundação Procafé	34015*
Tributum	Cultivar	UFES	37808*

Source: Mapa (2015).

Clonal cultivars registered* and protected** in Brazil with the Serviço Nacional de Proteção de Cultivares - SNPC (National Service of Cultivars Protection), MAPA.

7 FINAL CONSIDERATIONS

The conilon coffee breeding program has been increasing the productivity and improving final product quality. Special registration has been taking place in Espírito Santo: until the first varieties were introduced (1993), the average productivity in the State was 9.2 proces. bags./ha, and the well-managed crops did not exceed 60 bags/ha. The state average productivity of 2014 of 35.14 proces. bags./ha , shows that in just over 20 years, the use of improved cultivars associated with other technologies, provided an increase of more than 280% in average productivity, with many producers obtaining more than 120 proces. bags./ha. Likewise, there was a 312% increase in production, with a significant improvement in the final quality of the product.

The cultivars obtained by the different breeding programs developed in Brazil have been promoting changes in the Brazilian conilon coffee, with emphasis on Espírito Santo, Rondônia and Bahia. In addition to their superiority over genetic materials planted in the past decade, they are precursors to other technologies, such as the use of superior seedlings, in-line planting, soil repair and increased use of fertilization, denser plantings, irrigation use and management, pruning, among other important ones that aim at the improvement of the coffee cultivation of Espírito Santo.

Special attention is given to the strategy of implementation and conduction of a network of more than 200 clonal gardens in the State, to make available seedlings of the varieties recommended to the producers in the crops renew. These clonal gardens have the potential to produce approximately 60 million seedlings per year, which is sufficient for the renewal of

8% of the coffee conilon cultivation area per year, with superior genetic material.

In order to obtain superior cultivars, it is necessary that the selected materials gather, simultaneously, a series of favorable characteristics and show genetic compatibility. Therefore, improved clonal cultivars have a defined number of clones, which only guarantee the expression of productive potential, stability, longevity and contributes to the maintenance of the genetic base. Conducting clonal crops with a reduced number of clones could lead to disastrous results for the producer and, for the future of Conilon coffee production, by reducing the available genetic base, which is the raw material in the evolution of genetic improvement and in the development of cultivars with characteristics of interest to society. In view of the above, it is essential that producers follow the technical recommendations and do not exclude clones that they consider inferior from an improved cultivar, since this attitude deprives the genetic material. Such attitude compromises the stability of the species' crops in Brazil.

It is estimated that the improved cultivars are present in about 50% of the conilon coffee producing properties, around 20 thousand rural properties in Espírito Santo. They occupy about 50% of the areas cultivated with this species of coffee in the State and have caused changes in coffee cultivation, in rural and urban environments. It is also estimated that more than 150 thousand hectares have been renewed with these genetic materials, which are responsible for the production of about 7.5 million proces. bags/year, which represents around 75% of the State production.

In addition to the productivity increase, improvement the production final quality, improvement of yeld and quality of life of those involved in the activity, the higher cultivars have been leading to a greater movement in the market, especially of inputs and equipment, and also have helped in the market stabilization; as a consequence, the creation of new jobs and greater movement and effective integration of the different links in the coffee chain.

In view of the problem of lack, high labor cost for harvesting and global warming, it has been worked on breeding strategies aiming at the development of cultivars for mechanical harvesting, for association of coffee with trees (shading) and for higher altitudes.

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CEP: 29052-010 - Vitória, ES - Brasil
Telephone: 55 27 3636 9846 - biblioteca@incaper.es.gov.br
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