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Cultivation, Harvesting and Processing to Produce Top Quality Coffee in *Coffea Robusta* L. Linden And Their Value Added Products-A Review

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ABSTRACT

Coffee is grown in various geological and climatic adversities in India. The top coffee producing countries include Brazil, Columbia, Indonesia, India and Ethiopia. Coffee, one of the world's most important trade products. Two species are economically important for the production of the beverage coffee, *Coffea arabica* L. (Arabica coffee) and *Coffea canephora* A. Froehner (Robusta coffee). Coffee is not merely a beverage, it also has medicinal, cosmetics uses too. Certain research studies shows that coffee is a source of antioxidants and regular consumption of coffee may lower chances of heart diseases and stroke. It can prevent certain type of cancers such as colorectal cancer. *Coffea robusta* is the variety that is chosen as the study material. It is a woody perennial evergreen plant. It's the second most commercially important coffee species in India is Robusta. The cost of Robusta cultivation is relatively lower compared to Arabica. Coffee in India is mainly propagated through seeds. Use of quality seed plays an important role in establishing a productive plantation. Coffee harvesting and processing is both an art and a science. The present study deals with the cultivation, harvesting and processing to produce top quality coffee in *Coffea robusta* and their value added product.

Keywords: *Coffea robusta*, cultivation, harvesting, processing

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INTRODUCTION

Coffee is one of the well known beverage all over the world. Their species are grown in almost all countries along the equators. The coffee products have great role in the economic levels. Coffee bean is the seed obtained from the berry of a plant belonging to Rubiaceae family of the coffea species. There are hundreds of varieties available under Arabica and Robusta. Most of the species are native to tropical Africa, Comoros, Madagascar, Mauritius and Reunion islands. The genus was first described in 18th century by the Swedish Botanist Carolus Linnaeus in his Species Plantarum in 1753. Coffee beans are roasted, ground and brewed with near boiling water or milk so as to produce a beverage called coffee. Coffee, one of the world's most important trade products, is cultivated in more than 50 tropical developing countries and represents an important source of income and employment for at least 100 million people (Vega. *et al.* , 2003).

Coffee production in India accounts for almost 4.5% of the total coffee production in the world. Coffee exports from India earn a foreign exchange of 4000 crore rupees and have gained high importance in the international market. Karnataka, Kerala, Tamil Nadu are the states which chiefly produces coffee in India. Coffee cultivation in India is done under a multi-layered canopy of forest trees or other crops and these coffee plantations are a home to varied forms of flora and fauna. There are difficulties in production and marketing of coffee, since this crop is very important to the economy of its producing states, there are efforts being made to increase the area under coffee cultivation, provide financial support to the farmers, bring up new channels for marketing their produce and help them solve other farm related issues.

According to history the first coffee plant was found in the mountains of Yemen. Then by 1500, it was exported to the rest of the world through the port of Mocha, Yemen. The coffee plant was first cultivated in India in 1600 at Chikmagalur. South America is now responsible for about 45% of the worlds total coffee exports and most of this coffee is grown in Brazil. Coffee plants grown within a defined area between the Tropics of Cancer and Capricorn, termed the bean belt or coffee belt. From 1966 to 1987, living coffee plants were collected from Madagascar, Comoros and Mascarene islands and for eight African countries (Guinea, Ivory Coast, Ethiopia, Cameroon, Central Africa, Congo, Kenya and Tranzania) by the Institute of Research for Development (IRD, Montpellier, France) in collaboration with Biodiversity International (ex IPGRI), the Paris Museum of Natural History (MHNP) and the French Agricultural Research Center for International Development (CIRAD) (Anthony *et al.* , 2007).

Two species are economically important for the production of the beverage coffee, *Coffea arabica* L. (Arabica coffee) and *Coffea canephora* A. Froehner (Robust coffee). The first botanical description of the coffee tree was in 1713, under the name of *Jasminum arabicanum*, by Antonie de Jussieu, who studied a single plant grown at the botanic garden of Amsterdam. The species was later classified under the genus coffeea as *Coffea arabica* by Linnaeus in 1737 (Charrier and Berthaud, 1985).

A coffee plant need specific conditions to flourish. They are grown in rows several feet apart. Some farmers plant fruit trees around them or plant the coffee on the sides of hills. A coffee tree averages from 5-10m (16-33ft) in height. As the tree gets older, its branches become less and bears more leaves and fruits. Heavy rain is needed in the beginning of the season when the fruit is developing and less later in the seasons as it ripens.

Coffea robusta or Robusta coffee is the synonym of *Coffea canephora* plant, a sturdy species of coffee bean with low acidity and high bitterness. *C.canephora* beans, widely known by the synonym *Coffea robusta*, are used primarily in instant coffee, espresso, and as a filler in ground coffee blends. It is seemed that the robusta is originated from the central and western sub-Saharan Africa. Roasted robusta beans produce a strong, full-bodied coffee with a distinctive, earthy flavour, but usually with more bitterness than arabica due to their high pyrazine content.

Around 60 countries are producing coffee in the world. It needs plenty of rain to grow and also need the optimum temperature. Its habitat is at high altitudes. The higher altitude, the more aromatic the beans are when they ripen. Soil and the environment have also a very great influence on the flavour characteristics. Coffee plants can either be propagated through seeds or cutting. The land should be prepared for planting. The spacing between the plants is decided depending on various factors such as variety, topography, the fertility of the soil and management practices. Pruning of dried branches or unwanted twigs facilitates the supply of air and sunlight to all the parts of the bushes. Proper pruning can help the plant achieve a desired shape. Shade trees like Indian fig, atti, bili, basari, mallegargatti, rosewood, jack and gandagarige can be planted within the coffee farm. Weeding in the coffee farm after the post monsoon period tend to use up all the soil moisture and nutrients from the soil. Therefore, it is highly important to control the weeds in the farm area with young plantations.

Coffee is not merely a beverage, it also has medicinal, cosmetical uses too. Coffee has medicinal properties, it is also used as the ingredient in cosmetics. It includes in lipbalm, lipstick, perfumes, face and body mask etc.

Health benefits of coffee include many aspects, it can reduce depression. Coffee is a source of antioxidants. It has the ability to reduce the risk of diabetes. Good for heart health and regular consumption of coffee may lower chances of heart diseases and stroke. It's an excellent drink for liver health, regular consumption of coffee can reduce the chances of liver damage. Coffee is good at protecting against Parkinson's disease. It can prevent certain type of cancers such as colorectal cancer. Coffee may guard against the gout problem.

METHODOLOGY

Soil and Climatic Requirements

The cultivation of coffee in India belong to the red and laterite soil groups. They differ in texture from sandy loam to clayey loam with colour varying from light grey to deep red. The soils are usually rich in organic matter and acidic to neutral in reaction (pH). The total soluble salts are well below the sensitivity limits. They are well supplied with potassium but are generally low in available phosphorus. They are also poor in calcium and magnesium. They respond well to liming, manuring and other soil management practices. For the growth of coffee, the soil should be deep (75 cm), well drained, slightly acidic in reaction and rich in organic matter content. Geographic parameters like elevation, aspect and environmental factors like rainfall, that ranges from 1000 to 2000 mm per annum. Temperature which ranges from 20°C to 30°C ideal, hot, humid. The atmospheric humidity can influence economic production of coffee much more than soil factors. Under South Indian conditions, high summer temperature combined with poor sub soil moisture can be severe limiting factor whereas at Northern latitudes cold winter temperature can be usually limiting.

NURSERY PRACTICES

The success of new planting in perennial crops like coffee depends primarily on planting of vigorous, disease free seedlings in the field. Therefore, utmost attention is required to raise desirable planting material in the nursery.

Site for nursery

A gentle sloping land without big shade trees, and a nearby water source is preferable for the nursery site. Water should not stagnate in the nursery site. The soil should be light to medium loamy and free from soil-borne pathogens like nematodes. The nursery site should be fenced off from cattle and other grazing animals and should be provided with overhead pendal for shade.

Mother bed

For sowing the seeds, germination beds of 1 width and 6m length raised to a height of 15 cm from ground level should be prepared. For this, incorporate four baskets (10kg) of well rotted cattle manure or compost, 2 kg of finely sieved agricultural lime and 400g of rock phosphate in each bed. The beds should be spaced 30 to 45 cm apart and provided with a gentle slope between two beds to avoid water stagnation. If the nursery soil is a heavy loam, it may be necessary to add coarse sand that will facilitate drainage and aeration. If one is using clay soil, then it should be mixed with coarse sand properly to enable easy air circulation. A deficit in air circulation leads to stunted seedling growth or can even result in the death of plants.

Sowing

Selected and certified seeds are sown during December-January with their flat side facing the soil, at a distance of 2.5 to 3.0 cm in regular rows. They are covered with a thin layer of finely sieved soil. After sowing, the beds are mulched with a layer of paddy straw which ensures optimal temperatures for seed germination and protect the seeds from desiccation. The beds are watered daily in the morning with a rose can. Under optimal conditions, seeds will germinate in about 45 days and attain button or topee stage. At this point, remove the paddy straw cover. The seedlings are then transplanted into either a polybag nursery basket or into a secondary nursery beds.

Transplanting

Coffee seedlings are transplanted into nursery baskets at the button stage. Using a bamboo stick, seedlings are gently lifted from the germinating beds. This ensures the minimal injuries to the roots. Prior to transplanting, the nursery baskets are watered and a vertical whole about 5 cm deep is made in the soil at the center of the basket. Seedlings are planted in the hole after nipping off the tip of the tap root. Care should also be taken that the shoot system is placed at the same height above the soil as it was in the germination beds. Transplanting is done preferably in the cool hours of early morning or late afternoon. Seedlings uprooted from the primary beds should not be stored for a long time but transplanted immediately. It is preferable to dip the roots of seedlings in cow dung slurry or water to prevent desiccation. The basket plants are usually planted in the main field during late monsoon (August- September). These can withstand long distance transport.

PREPARATION OF LAND

Clean felling is not advocated when the forest land is cleared for planting coffee. Selective retention of desired species of wild shade trees, without too much overcrowding gives best results. The land should be divided into blocks of convenient size with foot paths and roads laid out in between.

PITS FOR PLANTING

Pits are usually opened after the first few summer shower during March/April. The size of the pits is usually determined by the texture and depth of soil. Pits of 45 cm x 45 cm x 45 cm are preferred. After opening, the pits should be exposed for weathering for 15 to 20 days. Later they are filled with the surrounding top soil. Adding well decomposed compost or FYM @ 1.5 to 2.0 kg/pit along with 20 to 30 g of rock phosphate is also recommended at the time of closing of pits. Bamboo sticks or wooden poles may be inserted at the centre of the pits to mark the location of the pits.

PLANTING IN THE FIELD

Disease-free and vigorous seedlings should be selected for planting in the field. Seedlings with stunted and twisted roots are to be discarded. Generally, seedlings raised in the secondary beds (about 16 to 18 months old) are planted at the commencement of monsoon (June) and poly bag nursery seedlings (6 to 8 months old) are planted during August-September. At the time of planting, a hole is made in the centre of the pit to plant the seedling. The pit has already been opened, soil exposed for weathering, and the pits closed again. In case of poly bag seedlings, the polythene bag is cut at the bottom and the tip of the tap root is nipped if it is found to be bending. In case of ball plants (secondary nursery seedlings), the tap root and lateral roots are to be spread out in proper position before packing with soil. Care should be taken that soil around the seedling is packed slightly above ground level (2 cm) to prevent stagnation of water around collar region. Avoid deep planting of the seedlings in the pit. The planted seedlings are to be provided with cross stakes to prevent wind damage and should be mulched with dry leaves. It may be necessary to water these plants if dry weather prevails with high temperatures, especially after monsoon planting.

PLANTING OF SHADE TREES

Silver oaks can be planted as shade belts in East-West direction to protect coffee from southern exposure at a spacing of 6m apart within a row and 12m between the two rows. Silver oak stands are best suited for training pepper vines also. Permanent shade trees are planted at wider spacing (9-10 m), wherever the forest tree cover is inadequate.

INTER PLANTING, REPLANTING AND UNDER PLANTING

Robusta coffee are usually planted at wider spacing of 3 m to 3.6 m and the bushes takes 6 to 7 years for the maiden crop and 10–12 years to give economic returns. In areas identified for replanting, two approaches could be made.

METHODS OF WEED CONTROL

MANUAL WEEDING

Typically new clearings are hand weeded 3 to 4 times and established coffee fields 2 to 3 times a year. During the monsoon season, weeds are slashed back (slash weeding) with the help of a machete. Clean weeding is generally done during post-monsoon period. It is a labour intensive and time consuming operation in coffee estates.

CULTURAL METHODS

In new clearings, the field is given a thorough digging (cover digging) to a depth of about 37 to 45 cm towards the end of monsoon. All weeds and vegetative debris are completely turned over and buried in the soil.

Inter-planting of green manure crops, cover crops and annual crops such as grain legumes, cassava, beans, pigeon pea, yam, sweet potatoes, vegetables, pineapple help suppress weeds to a large extent. Intercropping has been successful in Robusta coffee plantations in Wayanad region of Kerala.

CHEMICAL WEED CONTROL

Chemical weed control methods (weedicides) are employed where labour is scarce or expensive or when labour has to be diverted to other important cultural operations like manuring and spraying. Weedicides can be classified based on time of application (pre-emergent and post – emergent), mode of action (contact and systemic) etc.

- Paraquat -di- chloride 24% EC at 0.067% a.i.(Gramoxone at 500 ml per barrel).
- Glyphosate 41% EC at 0.27% a.i. (Round up or Glycel at 1200 ml per barrel).

IRRIGATION

SPRINKLER IRRIGATION

Sprinkler irrigation is the most versatile method of irrigation to supplement the natural rainfall for the growth and flowering of coffee. In sprinkler irrigation the water application resembles rainfall. Water is sprayed under pressure through small orifices or nozzles all over the plant and land surface. Systems are designed based on factors such as area to be irrigated, type of soil, location of water source, topography of land, wind velocity and infiltration rate.

For successful establishment of young plantations, coffee should be irrigated during the dry months to a depth well below the root zone and the intervals between irrigations should be long enough to allow the soil to dry out without causing serious wilting. This encourages deep rooting a protection against drought and also improves the anchorage of plants.

Robusta coffee being susceptible to drought, responds well to irrigation compared to Arabica. First winter irrigation must commence 20 to 25 days after the cessation of monsoon. Irrigation up to 25 mm once in 20 to 25 days till the end of December at 25 to 40 mm is to be given during the second

fortnight of February followed by backing irrigation of 25 mm water within a gap of 15 to 20 days after blossom.

DRIP IRRIGATION

The drip or trickle irrigation has assumed considerable importance in recent years in view of the greater need for economy in water use. In drip method, water is distributed by a network of tubing which brings water directly to each plant near the root system. Water is provided daily or on alternate days based on the water requirement of crops. Thus the water losses during conveyance and due to seepage, evaporation etc., are avoided. Besides, the water is not applied to the rows of plants. Thus drip irrigation system offers greater savings in water (up to 60%). The other advantages of drip irrigation system include saving in labour, increased yields, better quality of produce, less weed growth, increased fertilizer efficiency, possibility of fertilizer application through irrigation water and reduced incidence of foliar pests. However, the initial cost of drip equipment is a limitation for large scale adoption. Cost of the unit per hectare depends mainly on the spacing of the crop. The main item of expenditure is the lateral pipe line which is run all along the rows. The wider the row spacing lesser the cost.

- If the blocks are to be replanted with similar material, it is advisable to plant the young seedlings under the existing old blocks, in separate rows laid in between the old rows. The old bushes can be rejuvenated by collar pruning after one or two seasons of under planting, and can be exploited on multiple stems for two more seasons, before the newly planted bushes, start covering up the allocated space.
- If the old blocks are to be replanted with different variety whose spacing requirements are different from that of the old material, it is advisable to totally uproot the old stands and take up replanting in newly laid out lines. When the entire block is uprooted for replanting, manipulation in shade pattern is possible depending upon the requirement of the new variety being planted.

Harvesting and Sorting

Harvesting ripe fruits by selective picking is a pre-requisite for making good quality coffee. Two to three rounds of harvesting should be done by selective picking . In order to prevent berries from soil contact and to avoid from microbial contamination picking mat is used while harvesting. Strip picking is advisable for the plantation where 90% berries have ripened. Use clean bags for harvesting and keep the harvested fruits under the shade till it is transported for further processing. Sorting should be very meticulously carried out to separate ripe fruits from green, half-ripe,

partially dried and also extraneous matter. Each days harvest should be processed on the same day and maintained as separate lots.

Dry method or Natural method - Cherry Coffee

It is a process where entire harvested cherries are dried under the sun. The outer skin dries out to form the husk. Clean coffee is obtained by hulling the dry cherry.

Drying

The ripe fruits contain 62-65% moisture which has to be brought down to 11% while drying for safe storage. Some care should be taken to avoid mould/mycotoxin contamination at the farm level. The coffee fruits is to be spread for drying immediately after sorting the fruits. Heaping of fruits should be avoided as it provides congenial atmosphere for mould growth which may lead to mouldy taste and mycotoxin contamination. The fruits are to be spread to a thickness of 7 to 8 cm on clean drying yard constructed out of cement or tiles or stone slabs. The coffee mass is to be stirred at least 4 to 5 times a day for uniform drying. Protect the cherry coffee from re-hydration at night due to mist and dew or rain at night by covering. Drying takes 12 to 15 days during bright sunny weather and depends on the spread thickness. The properly dried cherry makes rattling sound when fistful of it is shaken. The standard moisture level of dried coffee is 11% for safe storage.

Wet method or Wash method – Parchment Coffee

Plantation/washed/parchment coffee is prepared by wet method of processing using pulper machine to separate fruits skin from the coffee bean. The pulped beans with mucilage are either fermented or treated with enzymes and washed using machine in the presence of water.

Pulping Coffee Fruits

Pulping is done by using disc, drum or vertical pulping machines. Coffee fruits should be pulped on the same day after sorting. Disc pulper is more suited for pulping robust coffee. Shaking/roller sieve for spreading pulp coming pulped beans and re-passer pulper could increase efficiency of pulping. The pulper should be adjusted properly and fruits to be fed uniformly through siphon system to avoid cuts and bits. Pulper should be maintained in good condition by replacing worn out parts such as bearings, knives, bars and discs. Single, double and four disc pulpers are available and can be used depending on the quantum of fruits to be processed. Small growers may opt for single disc pulper.

Removal of Mucilage

The pulper beans are covered with a mucilage layer which should be removed completely to obtain good quality coffee. The mucilage is removed by adopting the following methods.

- a) Natural fermentation
- b) Enzymatic method**

Natural Fermentation

Fermentation process takes place in the presence of natural enzymes and microorganisms like Yeast and bacteria existing on the coffee fruits. Fermentation takes 36 to 72 hours for robusta coffee. The fermentation tanks should have smooth surface and sloping floor (5%) towards the discharge end. The tank should not be deeper than 1.2 meter for better handling of the fermenting mass. The tank size and number will depend on the quantum of fruits to be processed every day and also the fermentation period. Shift the pulped beans into fermentation tank with minimum water. After removal of the fruit skin and floats drain out the water completely.

Enzymatic Method

Commercial Pectinolytic enzymes available in the market could be used for hastening the fermentation of mucilage present on the wet parchment. The duration of fermentation would depend upon the concentration of the enzymes used and the ambient temperature.

VALUE ADDED PRODUCTS IN COFFEE

Coffee is not merely a beverage product but also it has many properties too. Coffee is an inevitable ingredient in cosmetics like body scrub , face wash , lipstick, lip balm, perfume etc. And also coffee merely as a liquid consumption it is taken as solid food also like coffee flour, which can be blend with normal flour for baking cakes, and syrups etc.

SUMMARY

Coffee traces its origin to a genus of plants known as *Coffea*. Within the genus there are over 500 genera and 6,000 species of tropical trees and shrubs. Experts estimate that there are anywhere from 25 to 100 species of coffee plants. Most of the world's Robusta is grown in Central and Western Africa, parts of Southeast Asia, including Indonesia, Vietnam and in Brazil. Production of Robusta is increasing, though it accounts for only about 30% of the world market. Robusta is primarily used in blends and for instant coffees. The Robusta bean itself tends to be slightly rounder and smaller than an Arabica bean. The Robusta tree is heartier and more resistant to disease and parasites, which makes it easier and cheaper to cultivate. It also has the advantage of being able to withstand warmer climates, preferring constant temperatures between 75 and 85 degrees Fahrenheit, which enables it to grow at far lower altitudes than Arabica.

It requires about 60 inches of rainfall a year, and cannot withstand frost. Compared with Arabica, Robusta beans produce a coffee which has a distinctive taste and about 50-60% more caffeine.

Cultivation of coffee in India is primarily an agro-based rural enterprise earning substantial foreign exchange to the country. Today, coffee occupies a place of pride among plantation crops grown in India. Also continuous research have resulted in the development of new technology for the benefit of the growers.

Coffee is economically important cash crop and different products are made from it. In the global coffee market, the differentiated/ specialty coffee are emerging as one of the fastest growing segment with increased demand for such coffees from the consumers. It also has medicinal properties , that is been proven by scientific researches.

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