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Technical competency and challenges in coffee production in Odisha, India

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Abstract
Coffee is a brewed drink prepared by processing of roasted coffee beans. It differentiated from other beverage in aroma, taste and quality drinks. Most of the countries have grown, processed and consumed as well as exports coffee products to get good income. In this race, India also takes part and has a great role in coffee production and export to international markets. Indian coffee fetched an international trade value for it's special characters like blending quality, mild and less acidic nature. India divided into two parts as traditional and non-traditional region of coffee production. Almost 97% of coffee produced from traditional area having Western Ghats and rest 3% from non-traditional area having Eastern Ghats and north-eastern states. South-western part of Odisha covered by Eastern Ghats has evidence of coffee production since 1930's. Coffee production started a long year ago but a number of constrains and challenges reduce quantity and quality of coffee in Odisha. Lack of education and awareness among tribal plays an important factor for lesser amount of cultivation. Unavailability of land, laborers, uncertainty in seasonal rainfall ceases production. Inappropriate market structure, large marketing channels and selling price is not satisfactory to attract new growers. Biological challenges like insect pest infestation, newly emerging diseases are harmful for quality coffee beans. Except all dearth of interest and government supports coffee cultivation is merely difficult in Odisha. This article aims to forecast a clear view of coffee production and challenges in Odisha region.

Keywords: Coffee production, beverage, challenges, biotic stress

Introduction
Coffee (*Coffea spp.*) belongs to the family Rubiaceae. More than 120 varieties of coffee existed from which mainly two varieties Arabica (*Coffea arabica*) and Robusta (*Coffea canephora*) are widely cultivated and well known for flavor and taste. It is a bushy shrub evergreen perennial plant well grown in tropical and sub-tropical region. Main vertical trunk along with plagiotropic growth habit resembles a tree like structure, so it needs regular pruning to attain a desirable plant height. Plant has dark to light green, waxy and shiny leaves. Axil of coffee leaves bear small white sweet smelled flowers in cluster. Fruits developed from fertilized flowers once in a year.

It is believed that coffee is native to Ethiopia. It has history of cultivated and used for drinks since ancient age. Coffee suffered a long journey to reach in Middle East and India by 16thcenturies. It introduced in India by a Sufi saint named 'Baba Budan' in 1670. He smuggled seven raw coffee beans from Yemen to India and planted on Chandragiri hills in Chikmagalur, Karnataka. Afterwards it extended to states Kerala and Tamil Nadu so called traditional area of coffee cultivation, which accounts 97% of production followed by Andhra Pradesh, Odisha and north-eastern states known for non-traditional area accounts rest 3% of coffee production. In the laps of time, coffee acquired a place in Odisha. During 1930s king of koraput, Rajbahadur Ram Chandra Deo planted a coffee estate near to Kolab basin Jeypore, Koraput. Since 30s cultivation of coffee increased dramatically and covers six districts Koraput, Kalahandi, Ganjam, Gajapati, Phulbani, Keonjhar of Odisha. Koraput is fascinating manifestation of creation as a part of Eastern Ghats. It has an average elevation of 870m along with highest hill peak Deomali situated an elevation about 1,672 m. High altitude, laterite soil and conducive climate has a good impact on coffee cultivation. Government of Odisha promoted cultivation of coffee since 1970. Most of private growers, tribal along with coffee board took part to increase the cultivable area and production. Currently in Koraput 3,200 hectares under coffee cultivation from which coffee board and private planters hold 10.54 and 943 ha respectively, where rest area belongs to tribal coffee growers. Coffee plantation and characterized plant morphology is represented through Figure 1. Now a day's Koraput being well-known for its tribal (Adivasi) coffee products. The district has capability of 10,000 ha area for coffee production, but more or less constrains remain minimize the production. Odisha holds fifth rank among the top coffee producing states in India.

Arabica variety of coffee mostly cultivated with a production of 550 Metric Tonnes per year. State earns huge foreign exchange by exporting coffee products. Seems it has enough opportunity for coffee production, day-by-day coffee losing its identity in many region.

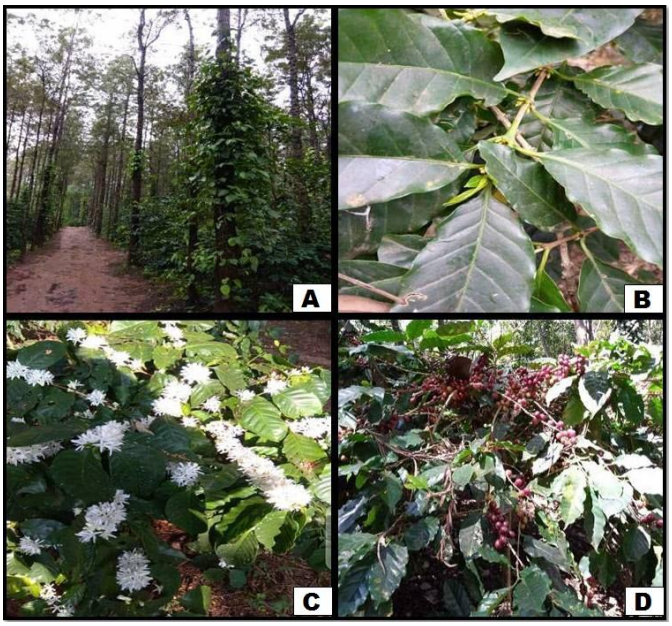

Fig 1: (A) Shady coffee garden canopy (B) Appearance of nodal blossom (C) Coffee flowers (D) Appearance of fruits

Varieties of Coffee

Coffee plant has a long life span of 70-80 years, but it produces quality fruit up to 50 years. To maintain proper frame and shape of plant, pruning is important operation in every year. Both Arabica and Robusta type of coffee cultivated in Odisha climatic condition. Arabica has cauvery, Chandragiri, Ruiru-ii, 4643 Sln-795 and Robusta has B-4, Sln-274, Sln-270 varieties. Harvesting of Arabica and Robusta coffee is shown through Figure 2.

Table 1: Characteristic of Arabica and Robusta coffee

Characteristic	Arabica	Robusta
Plant type	Bushy type plant with profuse branches.	Vigorous growth and more branches than Arabica.
Leaves type	Leaves are elliptical, small. Old leaves are dark green where new leaves are pale green in colour.	Leaves are wide and larger than Arabica, leaves are pale green colour.
Flower	Bunch of flowers arise in nodes. Minimum 25mm of rainfall required for full blossom of flowers after 7-8 days of rain.	More bunches arise in nodes of Robusta in compare with Arabica. It takes 7-8 days for blossom.
Fruit	It takes about 9 months to mature fruits. 10-20 deep red fruits on each node.	It takes about 10 months to mature fruits with light red color.
Resistance	It is less resistance to insect pest. Also highly susceptible to rust disease.	It is highly resistance to attack of insect pest and less susceptible to rust disease.
Berry Quality	Generally higher quality, sweet smell, aromatic in nature.	Less quality of beans produced in Robusta.

Fig 2: Harvesting of (A) Arabica coffee (B) Robusta coffee

Table 2: Soil and Climate

Characteristic	Arabica	Robusta
Soil	Deep, friable, Fertile, Irrigated, slightly acidic (pH 6-6.5)	Deep, friable, Fertile, Irrigated, slightly acidic (pH 6-6.5)
Elevation	1000m-1500 m	500m-1000m
Rainfall	1600-2500mm	1000-2000mm
Humidity	70-80%	80-90%
Temperature	15-25º C, cool	20-30ºc, Hot and humid
Blossom shower	March-April	February-March

Preparation of seeds

Especially plants are screened properly before for seed purpose. Fully ripped healthy and well-developed berries are collected, pulped and sieved. Seeds are mixed with sieved wood ash prior to dry in shade place. After discarding cut, triangular and elephant beans seeds are treated with fungicides like captan or thiram.

Nursery Practices

Light loamy soil of good drainage, high organic matter content with water and shade facilities place is important for nursery bed. Raised beds of 15 cm height, 1m width and convenient length required. Incorporate well-decomposed compost of 10 kg and 2 kg fine sieved agricultural lime. Lime helps to neutralized soil pH. Make nursery beds at a distance of 40-45 cm for better drainage. An overhead pandal should be present above nursery bed for appropriate shade.

Sowing of seeds

January-February is the optimum time for seed sowing. Seeds sown 1.5-2.5 cm apart with the flat side down wards in rows of nursery bed. Cover the rows with a thin layer of fine soil and a layer of paddy straw. Regular irrigation and protection from direct sunlight by an over head pandal is essential. Seed starts germination about 45 days after planting which are moved to secondary nursery made with polybags.

Secondary Nursery

Polythene bags with numerous holes in the bottom filled with a mixture of forest soil, FYM, and coarse sand in the ratio 6:2:1 respectively. Sprinkle little amount of water and dig a hole of 5cm in middle of mixture with a stick. Remove seedling in capping stage, break little portion of the tap root and transplant to the polythene bag. Keep bags under shade in overhead pandal made before. Maintain regular irrigation in poly bags for 6 months. After coming six pair of leaves, plants are ready for transplantation to the main field.

Shade Management

Coffee grown under canopy of trees as it is a shade-loving tree. Approximately 60% shade and 40% sunlight are necessary for better growth of plants. A minimum time of 3 years time period required for shade before coffee plantation. Evergreen, perennial and profuse branches with fast growing plants meant for shade in main field. Silver oak and dadap trees are commonly used for shade in coffee estate. Silver oak trees are planted during June-July in beginning of south-west monsoon.

Main field preparation and planting

Well maintained field with shade trees important before planting of coffee. Pits size of 45cm x 45cm x 45cm are dug at appropriate distance according to varieties after summer showers. Generally, spacing of 2.1 x 2.1 m is appropriate for most of the varieties. The pits are open for weathering up to 15-20 days and marked middle of the pit with help of a stick. With commence of monsoon plants are ready to transplant in main field. Plants kept middle of the pit and heaped with soil. At the time of filling, apply 500 g of rock phosphate per pit along with top soil. In sloppy area follow the planting along with contour. After planting, tie two stakes in criss-cross position to keep plant straight and strong. Apply manures and maintain irrigation in newly planted trees.

Harvesting

Fruiting starts after third year of plantation. Flowers blossom in month of March and it take 8-9 months for fully developed fruits. Once in a year during December to January ripen coffee fruits ready for harvest with hand picking. 2-3 hand picking done of harvesting of berries. Perfect time for harvest coffee is when 3/4th portion of fruits ripen. Ripen fruits are used for parchment and unripen are used for cherry coffee.

Yield

Coffee yield depend up on various factors including biotic, abiotic and time of harvest. In average Arabica coffee yields about 800-1000 kg/ha where Robusta coffee yields about 500-800 kg/ha per year.

Post-harvest management

Pulping leads to extraction of two coffee beans inside a coffee cherry means separation of parchments from red skin. Ripen fruits need to pulp within 6 hours of harvesting to prevent fermentation. A mechanical or hand operated pulper is used for pulping of cherries. After pulping parchments washed and transfer to the drying yard.

For drying of parchments, a cemented drying yard require in an open place. Parchments spread in a layer of 3-4 cm depending on weather. In sunny days, it needs 7-8 days for proper drying. In evening parchment should be kept in a lump in drying days. After removing 30-40% moisture, it should be ready for packing.

Dried and cleaned gunny bags are best for storing dried parchments. Well-dried parchments are packed in bags, weigh and keep in dry place for long storage. Different coffee plant operations are represented through Figure 3.

Fig 3: Different coffee plant operations (A) Pulper machine (B) pulping operation (C) fruits feeding to pulper (D) collection of parchment

Table 3: Production details (per tons) of Coffee Board, Koraput

Year	2018-19	2017-18	2016-17	2015-16	2014-15
Quantity of clean coffee	4203	5272	4392	5383	5831
Grade-A	1853	1200	2749	3348	3997
Percentage	44%	22.76%	62.6%	62.19%	68.54%
Grade-B	1536	600	854	1116	907
Percentage	36.54%	11.38%	19.45%	20.73%	15.5%
Grade-C	385	85	133	141	140
Percentage	9.16%	1.61%	3.02%	2.11%	2.4%
Grade-PB	375	537	563	587	575
Percentage	8.9%	10.18%	12.81%	10.9%	9.86%

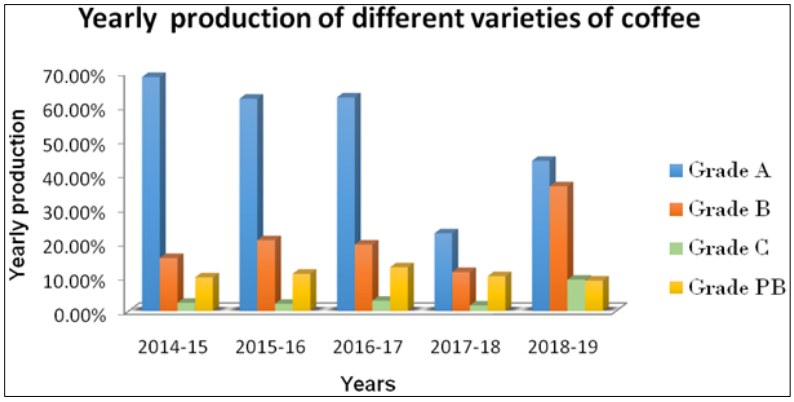

Fig 4: Comparative analysis of different varieties of coffee production from 2014-15 to 2018-19

Tough coffee production gains such an important position but if we follow 2014-15 to 2018-19 production rates, then we get consecutive years havoc yield or production loss. To find out the exact cause of such types of production loss we get major biotic stresses takes an important role for this cause. Production loss is represented through Figure 4. Major challenges of coffee production describe below.

Major challenges in coffee production

Coffee is known as cash crop. Cultivars can get a long-term benefit up to 50 years from coffee estate for doing one time investment. It helps in strengthening economic condition of farmer as well as known for GDP grower of the state. Coffee estate maintains and conserves bio diversity of forest, prevents soil erosion, forest fire and reduces podu cultivation. It also creates a better livelihood for human being and a safe place for different animals. However, many benefits from coffee cultivation still growers are not interested. Biotic, abiotic and social stress plays a major role for diminution of the coffee production.

Being a producer one has to live in uncertainty until coffee is processed, bagged and the actual price has been paid. Unpredictable weather causes damage to coffee production. Currently, change in climate leading to raise in temperature and diversified rainfall patterns creates threat to coffee cultivation. Sudden and heavy rainfall during harvesting and processing period have a negative impact on quality coffee production. Rise in diurnal temperature reduce growth and flowering ability as plants are sensitive. Landslides destroy hectares of cultivable area and soil become unfertile and large sloppy area become unfit for cultivation.

Coming to social stress education is an important factor. Illiterate farmers are not aware about package of practices for cultivation. Over 90% of farmers are small and medium. Economic condition of tribal does not support for initial investment without any production up to three years. Due to less price of parchments, problem in marketing and lack of government support farmers are not interested for coffee cultivation.

Biotic stress like insect pest (Le Pelley, 1968) [5] and disease incidence causes huge loss in coffee plantation. Management of coffee disease pests were characterized and estimated by Venkatesha, 1998 [8]. Some important insect pests are cited below.

Coffee berry borer

Berry borer (*Hypothenemus hampei*) is one of the harmful pests among all pests seen in coffee cultivated area. After eight week of flowering borer attacks near the apex region of coffee berry. Adult female made about 1mm diameter perforation on upper surface of berry. Holes filled with debris are clearly visible on naked eye, which deposit over the berry. It may be brown or grey in color. Female found in the mesoderm of two seeds. Sometimes un ripen berry rotten by borer.

Management

Cultural practices and phytosanitary measures are important to check attacks of berry borer. After harvest left over berries are main source of borers that infect new berries, so harvest healthy along with infected berries reduces borers attack from 70% to <6% (https://dx.doi.org/10.3390%2Finsects7010006). *Cephalonomia stephanoderis* and *Proropsnasuta* have parasitoid effect whereas *C. stephanoderis* reduces 16-45% attack of borers. Quinalphos 25 EC @ 1.7ml/L or lamdacyhalothrin 5 EC 0.6-0.8ml/L effective against berry borer.

White stem borer

White stem borer (Xylotrechus *quadripes*) severely attacks on Arabica variety grown without shade. Primarily larvae enter into hardwood by making tunnels and filed with excreta of the grubs. Ridges around stem showed symptoms with yellowing and wilting of leaves. Young plants may die within a year of infection. Symptomatic characterization is exactly similar as described by Venkatesha, 2001 [7].

Management

Optimum shade management in coffee estate controls stem borer. Regular pruning of branches with uprooting and burning of infected plants ceases pest infestation. Severity of stem borer on Arabica coffee and it's management described by Venkatesha in 1999 [9]. Spraying of neem kernel extract around stem region found to be effective. Natural predators *Apenesia spp*. has effective against the pest in field condition.

Mealybugs

Planococcus lilacinus is important sucking pest of coffee. Both nymphs and adults suck sap from young leaves. Mealybugs infect nodes, branches, spikes and berries. In sever stage honeydew excretion develops sooty mould which affects photosynthesis.

Management

Proper shade management in coffee estate controls pest infestation. Removal and destruction of ants is important in field condition. Dusting of Malathion 5% or quinalphos 1.5% is effective predators like lady bird beetle controls pests.

Coffee bean beetle
Araecerus fasciculatus is pest of both in field and storage of coffee beans. It severely attacks on storage by absorption of moisture from beans. Large sized holes are visible on beans. In field condition fruits become shrink and black in color.

Management
Proper storage environment can check pest infestation. Maintain optimum relative humidity, temperature and moisture content of seeds is storage room. Disinfect gunny bags with malathion 50% EC + pyrethrum colloid @ 2g/l.

Green scale
Scale (*Coccus viridis*) is one the serious sucking pest of coffee. Both nymphs and adults sucks sap from under side of leaves, green shoots and spikes. Upward curling of leaves with honeydew excretion develops sooty mould.

Management
Removal and destruction of infected plant parts is important control measures. Control ants by spraying quinolphos 25 EC @ 0.6 ml/l.
Some major diseases are mentioned below.

Seedling blight
Causal organism: *Fusarium stilboides* Wollenw.

Symptoms
This is most common disease in nurseries and germination beds. Cotyledons fail to open, necrotic lesions appear on stem and seedling wilts. Later stage lesions are enlarging results the death of seedlings. Though the causal pathogen is seed borne but it also can spread by rain and insect. Frequent rainfall boost up severity of infection.

Management
Disease free seeds treated with Benomyl 50%WP (1g/kg seeds) are effective against disease.

Root Rot
Causal organism: *Rosellinia arcuate*

Symptoms
Fungus enters through injuries/wound on root either by insect or nematode or by mechanical tools. Symptoms are easily visible as the leaves wither and branches turn into dry rot.

Management
As disease spreads through root system, uproot the infected plants, cut trunk and twigs. Burning of infected plant debris immediately should do to prevent infection. The hole made after uprooting of plants can be treated with methyl bromide.

Wilt
Causal organism: *Gibberella xylarioides*

Symptoms
Discoloration of leaves to yellow, dry up and heavy fall of leaves are primary symptoms. On trunks, small cracks where bluish-black stain appears. Within few weeks or months entire plant withers and dies.

Management
Chemical treatment fails to prevent disease. Selection of resistance variety can protect from the disease.

Leaf rust
Causal organism: *Hemileia vastatrix*

Symptoms
It is found that leaf rust is most severe foliar disease found in coffee plantation. Arabica variety of coffee is susceptible to rust disease. Small sized discolored spots visible underside of the leaves as primary symptom. Later on spots enlarged with powdery spores from yellowish-orange to bright orange color while yellow to brown discoloration in upper surface of leaves. Orange lesions turn black color followed by necrosis. Heavy defoliation of leaves and plants remain stunted with low yields. Symptomatic characterization along with germination and penetration studies of coffee rust was described by Rayner in 1961. Symptomatic characterization is represented through Figure 5.

Management
Resistance varieties recommended for cultivation. Races of the pathogen and resistance to coffee rust were tested by Rodrigues *et al*. in 1975 [4]. Collection and destruction of infected leaves should done on regular basis. Spray Bordeaux mixture 0.5% prior to flowering during rainy season.

Fig 5: Coffee rust

***Cercospora* leaf spot**
Symptom
Small eye-like yellow spots appear on leaves that slowly increase up to 5 mm. Later it turns gray-white in center while brown color around spot. Characterization of American leaf spot is welly characterized by Rao and Tewari in 1987. Diseased berries dried, blackened and poor in quality. Symptomatic characterization is represented through Figure 6.

Management
Follow seed treatment with hot water. Use disease free and resistant variety of coffee. Remove and burn infected plant debris and clean working equipment frequently.

Fig 6: *Cercospora* leaf spot of coffee

Coffee berry disease
Causal organism: *Colletotricum kahawae*

Symptom
Dark brown lesions and slightly sunken spots are appeared on berry which ultimately turned to black. Pulp becomes hard and brittle. Berry mummification is common symptom visible later. Symptomatic characterization of coffee berry disease was explained previously by Waller *et al*. 1993 [10].

Management
Copper oxychloride is effective fungicide against the disease. Also, select resistance variety of coffee. Remove and destroy infected plant part along with mummified berries. Coffee berry disease resistance through breeding was tested by Van der Vossen and Walyaro in 1980 [6].

Black rot or Koleroga
Causal organism: *Corticium salmonicolor*

Symptom
Dark brown to black decaying of leaves and twigs are basic symptom of black rot. Sclerotia appears on the leaf surface and heavy defoliation of leaves cause damage to plants.

Management
Removal of infected plant parts from field helpful for control disease. Application of borax is effective against black rot.

Discussion
Coffee is an economically major important beverage crop in India. Every year coffee production faced a havoc loss due to environmental changes and rapidly adopted biotic stresses. Management of biotic stresses is now a day an important challenge with combining environmental sustainability impact. Coffee production through integrated pest and disease management techniques (IPM and IDM) are the consortia of all possible management approaches. Very recently Das and Pattanayak, in 2020 [1] explained IDM approaches on grapes production in India. Every time we needs to more responsible to our soil and environment. Avoiding hazardous, toxic agrochemical is the basic needs of sustainable agriculture. Recently Ministry of agriculture and farmers welfare, Govt. of India, notified through Govt. Gazette notification [S.O. 1512(E) dated 14 th May, 2020] of list of prohibited insecticides which enlisted acephate, atrazine, benfuracarb, butachlor, captan, carbendazim, carbofuran, chloropyriphos, 2,4 D, deltamethrin, dicofol, dimethoate, dinocap, diuron, malathion, mancozeb, methomyl, monocrotophos, oxyfluorfen, pendimethalin, quinaphos, sulfosulfuron, thiodicarb, thiophanat emethyl, thiram, zineb, ziram etc. So, marketing or business exposure or promotions of those agrochemicals are restricted. Some major biotic stresses in coffee production are coffee rust, *Cercospora* leaf spot, wilt, root rot, seedling blight, berry disease, white stem borer, mealy bug, leaf minor which affects largely and are the major constrains in coffee production. Along with the biotic stresses another problem important problem of coffee production is skilled labor, investment, loans etc. Tough Government initiated many schemes, micro to macro loans, skill based workshop and training programmes which is very much helpful for coffee production. Simultaneously Coffee board of India has works on multiple problems of coffee production since 1942. The future of Arabica type coffee industry has been mostly dependent on rust resistant, genetically edited hybrid vigour production with superior yield levels, bean standards and cup quality. First success came through the development of rust resistant varieties in India in 1940's, are pioneering ones in the history of coffee breeding. Another classical work revealed on the existence of physiological races in rust pathogen supplemented the breeding efforts in India and worldwide. Development of improved strains was first tested through conventional breeding technique in 1925. Production of disease resistant and pest resistant varieties is best strategy to combat biotic stresses through eco-friendly approach. As per the IDM strategy if it's not possible then selection of diverse biological agents against biotic stresses is found to be more ecofriendly management tool. Tough there are many barriers in coffee production but if we follow right IDM or IPM protocol, we can easily breaks those biotic stress related barriers. Coffee is consider to be an essential commodity for human consumption and its multiple nutraceutical properties, aside maintain its same static value year after year.

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