Training Manual
on
BASICS OF FCV TOBACCO PRODUCTION

भाकृअनुप - केन्द्रीय तम्बाकू अनुसंधान संस्थान

ICAR - CENTRAL TOBACCO RESEARCH INSTITUTE

(An ISO 9001: 2015 Certified Institute)

RAJAHMUNDRY - 533 105, ANDHRA PRADESH, INDIA

Training Manual
on
BASICS OF FCV TOBACCO PRODUCTION

Conducted to

Newly Recruited Field Officers of Tobacco Board, Guntur

During

30th September to 5th October, 2019

भाकृअनुप
ICAR

ICAR-CENTRAL TOBACCO RESEARCH INSTITUTE
(An ISO 9001:2015 Certified Institute)
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ICAR-CTRI

Training Manual on
BASICS OF FCV TOBACCO PRODUCTION

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Schedule of Training Programme on Basics of FCV Tobacco Production

Programme Organizers

Course Director : Dr. D. Damodar Reddy

Course Coordinator : Dr. C. Chandrasekhara Rao

Course Co-Coordinators : Mr. K. Viswanatha Reddy and Dr. B. Hema

Date	Topic	Resource Persons
30-09-2019	**Inaugural Session**	
	Theme-1: FCV Tobacco: Introduction, Significance and Resource Requirement	
	FCV Tobacco in India : An Overview	Dr. D. Damodar Reddy Director, ICAR-CTRI
	Functional Competency of Field Officers: Needs and Requirements	Dr. Y. Subbaiah
	FCV Tobacco Varieties for Different Zones	Dr. K. Sarala
	Resource Requirement of FCV Tobacco	Dr. C. Chandrasekhara Rao
	Visit to CTRI Museum	
1-10-2019	**Theme-2: FCV Tobacco Nursery: Standard Methods and Protocols**	
	Best Management Practices for Healthy Seedling Production	Dr. K. Prabhakara Rao & Dr. C. Chandrasekhara Rao
	Hands on Training in FCV Tobacco Nurseries	
	Theme-3: Resource Management in FCV Tobacco	
	Soil Fertility and Plant Nutrition of FCV Tobacco	Dr. L.K. Prasad
	Water Conservation and Water Management	Dr. M. Anuradha
02-10-2019 : Participation in 150th Gandhi Jayanthi celebrations and Swachha Bharat Programmes		
03-10-2019	**Theme-4: Agronomic Practices for FCV Tobacco Field Crop**	
	Non-Monetary Input Management in FCV Tobacco & Fertilizer Calculations	Dr. T. Kiran Kumar
	Agronomic Practices for FCV Tobacco Field Crop in Northern Light Soils	Dr. S. Kasturi Krishna
	Agronomic Practices for FCV Tobacco Field Crop Grown in SLS and SBS	Dr. M. Anuradha
	Agronomic Practices for FCV Tobacco Field Crop in Karnataka Light Soils	Dr. S. Kasturi Krishna
	Visit to Laboratories	
04-10-2019	**Theme-5: Biotic Stress Management**	
	Major Insect Pests and Diseases in FCV Tobacco and their Management	Dr. U. Sreedhar
	Nematodes and their Management in FCV Tobacco	Dr. M. Venkatesan
	Pesticide Formulations, Compatibility and their Efficient use	Mrs. B. Sailaja Jayasekharan & Dr. V. Venkateswarlu
	Orobanche (Broomrape) Menace in Crop Production: Impacts and Management Strategies	Dr. V.S.G.R. Naidu
	Theme-6: Post-Harvest Product Management	
	Harvesting and Curing of Flue Cured Virginia Tobacco	Dr. L.K. Prasad
	Bulking, Grading, Baling, NTRM and Leaf Quality	Dr. C. Chandrasekhara Rao
	Visit to ICAR-CTRI, BSR Katheru Farm	
05-10-2019	**Theme-7: Socio-Economic & Extension Related Issues in FCV Tobacco**	
	FCV Tobacco as a Commercial Crop: Economic Significance	K. Viswanatha Reddy
	ICT Applications in Tobacco	Dr. H. Ravisankar
	Methods and Approaches for Effective Transfer of Technology in FCV Tobacco	Dr. B. Hema
	Evaluation & Feed back	Course Co-Coordinators
	Valedictory Programme	All Speakers & Participants

FCV TOBACCO IN INDIA: AN OVERVIEW*

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Global Scenario of Tobacco

Tobacco is a commercial crop grown in more than 120 countries across the world, the top 10 tobacco producers are the China, India, Brazil, United States, Indonesia, Malawi, Zimbabwe, Argentina, Pakistan and Turkey. The global tobacco production was around 6,502 million kg grown in an area of 3.43 million hectares during 2017. It is grown on less than one percent of the world's agricultural land, and on a wide variety of soils and climates. The productivity of tobacco in India (1711 kg /ha) is lower than the global average (1843 kg/ha) and much below the productivity recorded by Brazil (2203 kg/ha), China (2215 kg/ha) and USA (2476 kg/ha) during 2017.

Tobacco Scenario in India

Tobacco is one of the important high value cash crops in India with a production of 800 million kg, India ranks third in the world in production after China and Brazil during 2017. Presently, tobacco is being cultivated in an area of about 4.67 lakh hectares, accounting to 0.32% of the total arable land in the country, covering 15 states. Out of 800 million kg, around 240 million kg is Flue-cured Virginia [FCV] tobacco, which is produced in an area of 1.51 lakh hectares, mainly in the states of Andhra Pradesh and Karnataka. Indian tobacco has an edge over the leading tobacco producing countries in terms of availability of different styles produced with relatively low production costs. Different tobacco types *viz*. FCV, *bidi*, chewing, hookah, cheroot, cigar wrapper, cigar filler, oriental and dark fire cured tobacco etc. are being cultivated in India (Table 1). The comparison between FCV and non-FCV tobaccos are given in Table 2 and production pattern of tobacco in India is given in Table 3.

Table 1: Major tobacco producing states in India

State	Tobacco types
Andhra Pradesh	FCV, Burley, Oriental, *Bidi, Natu*
Karnataka	FCV, *Bidi*
Gujarat	*Bidi*, Chewing, Rustica
Uttar Pradesh	*Bidi*, Chewing
Tamil Nadu	Chewing, Cigar
West Bengal	Hookah, Rustica
Bihar	Chewing
Other States	Pikka, Chewing, *Rustica*, *Hookah*

* This lecture note is not prepared to stand alone and needs interaction with the speaker for clear understanding of the content.

Table 2: Comparative status of FCV and non -FCV tobacco

FCV	Non-FCV
Area & Production under regulation of Tobacco Board	No regulation
AP, Karnataka	Mostly in Gujarat, UP, WB, Bihar, TN
0.2 m ha ; 300 m kg	0.26 m ha ; 500 m kg
Deforestation	-
Organised and transparent market facility	Unorganised market facility
Assured input supply	No
TB extends welfare measures	No

Table 3: Production Pattern of Tobacco in India during 2017

Tobacco Type	FCV Tobacco	Non-FCV Tobacco
Production (m kg)	240 (30%)	560 (70%)

- FCV tobacco share : About 30% in India Vs. 72% in world
- India's FCV tobacco production pattern is not aligned to world tobacco production
- The disparity is due to a unique pattern of tobacco consumption in India dominated by non-FCV products

Niche Areas of FCV Tobacco Cultivation in India

Flue-Cured Virginia tobacco is mainly grown in the states of Andhra Pradesh, Karnataka, and Telangana. The details of main soil domains along with districts covered are furnished in Table 4. In Andhra Pradesh, FCV tobacco is grown during *rabi* season by making use of conserved soil moisture in TBS, SBS and SLS domains, while 25 percent of tobacco area is under irrigated conditions of NLS domain. In Karnataka, FCV tobacco is predominantly grown as a rain-fed crop during *Kharif* season.

Table 4: Major Production Domains of FCV Tobacco in India

Domains	States/Districts covered	Major soil group	Soil order	Rainfall (mm)	Crop growing conditions
Northern Light Soils (NLS)	AP: East and West Godavari Telangana: Khammam	Red Sandy and sandy loams Soils	Alfsols	1100 - 1200	Irrigated (15th Oct-15th March)
Traditional Black Soils (TBS)	AP: Krishna, Guntur East & West Godavari	Heavy Black Soils	Vertisols	1000 – 1200	Dry (15th Oct-15th March)
Southern Light Soils (SLS)	AP: Prakasam and Nellore	Red Sandy Loams and Sandy Clay Loams	Alfisols/ Oxisols	750 - 800	Semi -monsoon (15th Oct-15th March)
Southern Black Soils (SBS)	AP: Prakasam and Nellore	Medium Black Soils (silt loams)	Inceptisols/ Entisols	750 - 800	Semi -monsoon (15th Oct-15th March)
Karnataka Light Soils (KLS)	Karnataka: Mysore, Hasan	Red Sandy Loams	Alfisols	800-850	Monsoon (May-Sep)

Table 5: Soil domain wise resource constraints and their management options

Soil Domain	Constraints	Management Options
NLS	● Light textured sandy or loamy sand soils with low SOC, CEC and water holding capacity ● Poor native soil fertility and low fertilizer use efficiency owing to leaching losses of N and K	● Addition of organic manures, incorporation of *insitu* green manure. ● Soil test based balanced fertilization ● INM ● Seasonal correction for N & K to compensate leaching losses ● Taking care of micro and secondary nutrient needs
TBS	● Low infiltration and poor drainage ● Loss of nutrients through surface runoff.	● Addition of organics ● Provide proper drainage i.e. creation of field channels along the plots ● Balanced Fertilization / INM
SLS	● Surface crusting and low soil depth· Low SOC stocks and poor soil fertility ● Poor nutrient use efficiency ● Soil moisture stress (excess/deficit) ● Poor ground water quality (Excess chlorides)	● Soil mulching and use of tine cultivator ● Green manuring and green leaf manuring and INM ● Soil test based balanced fertilizer use based on soil testing ● Water harvesting and recycling for life saving irrigation ● Use of ground water by mixing it with harvested rain water
SBS	● Poor drainage and root zone aeration ● Sub-soil hardening ● Phosphorus fixation	● Proper drainage i.e. creation of field channels along the plots ● Timely deep ploughing/chisel ploughing ● Organic manures / INM
KLS	● Moisture stress ● Low SOM and Soil Fertility	● Farm pond technology ● INM / Balanced Fertilization ● Taking care of micro and secondary nutrient needs

Employment Generation

Tobacco provides livelihood to millions of people in various components of tobacco sector including tobacco production, processing, manufacture and trade. Bidi sector employed millions of labour in bidi rolling, trade and retail activities and millions of tribals are involved in tendu leaf plucking. According to one estimate, the tobacco sector provides livelihood security to 45.7 million people in different categories, around 70 percent of whom are in the agriculture sector. The details are given in the below (Table 6).

Table 6: Number of people drawing livelihood from tobacco

Category	Million	Source
Farmers	6	22nd report of the parliamentary committee on sub-ordinate legislation (10th Lok Sabha)
Farm labour	20	
Bidi/factory workers	8.5	Reply to Lok Sabha Starred question No 180 dt. Aug.19th 2013, Industry Estimates
Tendu leaf collectors	4	M.P.Govt. Ad.(TOI, June 2000), Industry estimates
Trade/retailers	7.2	A.C. Nielson Retail Census-2014
Total	45.7	

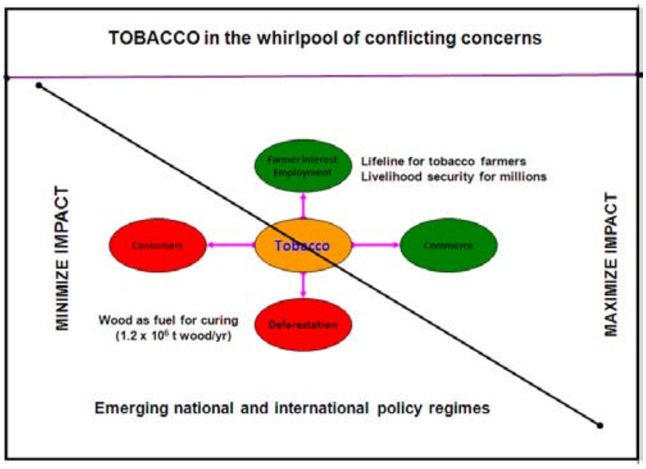
Source: Tobacco Institute of India, 2017

Key Developments in Tobacco Sector in India

- Indian Central Tobacco Committee, 1945: to look after technical and economic aspects of tobacco cultivation
- Central Tobacco Research Institute, 1947: to conduct research on different tobacco types grown in India (Under the aegis of ICAR since 1965)
- Tobacco Board, 1975: to regulate production and balance supply and demand (export promotion)
- COTPA, 2003: Prohibits advertisement and regulates the trade, production, supply and distribution of cigarettes and other tobacco products in India
- WHO-FCTC, 2005: Protects present and future generations from the devastating health, social, environmental and economic consequences of tobacco consumption and exposure to tobacco smoke
- Ban on E-cigarettes, 2019: Prohibits production, import, export, transport, sale, distribution, storage and advertisement

Present Concerns of Indian tobacco

Today tobacco sector is in the whirlpool of diametrically conflicting concerns relating to the livelihood security of those who are associated with tobacco production, processing and marketing on one hand and the serious health risks for those who consume it on the other. Another increasing concern about tobacco is deforestation resulting from the use of huge quantities of wood as source of energy for tobacco curing. Further, the emerging issues relating to climate change impacts, resource degradation, biotic and abiotic stresses, escalating production costs, pesticide residues, consumer preferences and regulatory policies are becoming increasingly complex and represent future challenges for tobacco researchers.



Tobacco in the Whirlpool of Conflicting Concerns

Operating Environment for Tobacco

Favorable

- Diverse climatic conditions favoring production of different FCV styles that meet trade requirements
- Price competitiveness and positive features of Indian tobacco
- Growing global market demand for Karnataka tobacco
- Availability of zone-specific high yielding varieties and best-bet agro-technologies

Unfavorable

- Changing consumer perceptions and preferences
- Increased health consciousness
- Stringent national policies on tobacco control
- WHO-FCTC : Seeking for demand and supply reduction measures (USA, Argentina, Indonesia - not ratified FCTC and may take advantage of export market)
- Environmental concerns stemming from consumption of huge quantities of fuel wood for curing

Field Level Functionaries: Focus Areas

- Seed – Source and quality
- Nursery raising – healthy seedlings
- Timely transplanting
- Soil fertility and fertilizer use
- Water management
- Intercultural operations
- Topping and sucker control
- Pest and disease management
- *Orobanche* management
- Harvesting and curing
- Post-harvest produce management (NTRM)
- Storage and marketing

Enhancing FCV Tobacco Farmers' Income in Andhra Pradesh

The strategies and action points specific to tobacco sector in Andhra Pradesh are furnished below:

Table 7. Action Plan for Enhancing FCV Tobacco Farmers' Income

S.No	Strategies	Action Plan
1	**Tobacco Productivity and Produce Quality Enhancement**	● Improved varieties/hybrids (CH-1 and Kanchan for light textured sols and Siri for Black Cotton Soils) ● Timely supply of pure seed and other inputs ● Soil health improvement/maintenance through sun hemp green manuring /organic manures ● Tray seedling production for crop uniformity and leaf quality ● Adoption of INM, IPM, timely topping and sucker management and other GAPs
2	**Cost Reduction Measures**	● Increased use of implements/machinery for land preparation, inter-culture and weeding, baling cured leaf etc. ● Increased input use efficiency (Soil test based nutrient use, micro-irrigation, fertigation, need based use of CPAs) ● Use of Agri-biomass briquettes and solar energy for tobacco curing to reduce dependency on wood fuel ● Increased fuel efficiency in curing
3	**Additional Income Generation**	● Improving cropping intensity (diversification of cropping system) ● Promoting allied enterprises- Dairy / Poultry /Goat farming etc. ● Rural non-farm income generation
4	**Institutional & Policy Support Measures**	● Transfer of crop and soil management interventions ● Bringing the Crop under MSP net and its upward revision, and creation of price stabilization fund and Market Intelligence ● Crop insurance-proofing weather and market fluctuations ● Effective implementation of PMKS Yojana in drought prone areas

FUNCTIONAL COMPETENCY OF FIELD OFFICERS - NEEDS AND REQUIREMENTS

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Field extension has the central role in informing, motivating and educating the tobacco farmers about the technologies and enabling the farmers for their effective adoption and to improve their farm productivity & income. Production / Financial / Environmental / Marketing and Man power risks are common in real farm situation. Factors like knowledge, resource & input management, price incentives, abilities & limitations of farmers and institutional support plays a significant role in the growth curve of tobacco yields and quality. For achieving the desired result, field officers should possess the necessary competencies to deliver quality programmes of relevance and importance.

Extension in FCV Tobacco

An empowering system of sharing information, knowledge, technology, skills, risk and farm management practices all along the value chain, so as to enable the farmers to realize higher net income on a sustainable basis. The uniqueness of extension efforts in Indian FCV is, private players converge and integrate with public extension into a single platform to benefit the farmers on addressing four elements viz:

- Enhance farm productivity
- Improve product quality & integrity to drive market price
- Reduce cost of cultivation
- Risk mitigation

Transformation of the Role of Field Extension

In the earlier period, focus was more on developing technical know-how. Later, it was recognised that the field extension lacked practical skills. Accordingly, due emphasis was given to the do how. Further, followed teaching principles such as seeing is believing and learning by doing. Though the technical know - how and do how are necessary, but found not sufficient to attain efficient and desired results. In the present scenario, field extension staff are judged on how they serve their targeted clientele, whether they listen to their clients, their rapport with their clients and how familiar they are with their clients contexts and issues. Therefore, Field extension staff should have and need to develop several functional competencies about “human-how” i.e., how to help people learn and change.

Hence, understanding of local situation, group dynamics, social relations, gender roles, communication patterns, leadership, team work and human motivation is essential to develop human-how skills. Therefore, extension staff must integrate technical skills with human-how skills (also referred as soft skills or process skills.) for effectively addressing the concerns.

Competency Requirements of Field Officers

- Technical skills
- Process skills

What process skills or functional competencies do the field officers need?

For Programme Planning

- Conduct need assessment
- Prioritize needs and problems
- Identify stakeholders and engage them in extension programs
- Resource mobilization
- Conduct community forums
- Develop a work plan

For Programme Implementation

- Conduct farm units
- Conduct method and result demonstration
- Organize farmer field schools
- Organize field days
- Establish a model village
- Conduct meeting effectively
- Manage conflict
- Manage time
- Manage group & team work and facilitate groups
- Write field reports

For Programme Evaluation

- Conduct surveys and personal interviews
- Conduct participant observations
- Conduct RRA and PRA
- Conduct focus group discussion
- Write extension evaluation reports and impacts

For Communication and Information

- Effective communication with leaders
- Organize extension campaigns
- Write for news paper or mass media
- Make good use of information and communicate technologies / access and use web based resources

Characteristics of Effective Extension Agent

- **Plan well:** should be able to plan a programme meticulously. Seeking participation by different groups and publicising their activity is very vital. While planning for the proposed extension activity, field officers should know who are the beneficiaries and stake holders, what are the available resources, farmers needs especially involving the poor, young and female farmers.
- **Coordinate and collaborate to implement:** Should be able to implement extension programme by coordinating several activities and collaborating with different stake holders and by building team work. Involving the members of different groups and use of participatory methods are the essential skills that the field officer should posses and practice.
- **Be humble**: Farmers already know a lot about their farming system, situation, resources and filed level problems. Greater need to respect this. The extension worker is meant to serve farmers interests and their aspirations. Hence, allow the farmers to express himself/herself about their situations/ concerns.
- **Communicate confidently**: Field officer has to be able to effectively communicate to persuade people to change their methods of cultivation or to adopt innovative technologies/ practices. In this connection, he should effectively listen to the farmers and use language and content that the farmers can understand.
- **Build public relations**: Development of good relations and rapport with the farmers will facilitate comfort among the farmers and move them to talk to extension agent and to believe extension agent. The stronger the relationship and feeling of trust, the quicker the adoption of recommended technology.
- **Value the diversity**: Field extension staff have to be sensitive towards the appeals of all the audience groups so as to avoid conflicts.
- **Acquire educational and information technology**: Information- communication technologies (ICT's) such as mobile phones, conference calls, e-mails, internet, whatsapp etc., are increasingly being used in extension services. Field officer should acquire knowledge and spread the technologies and the knowledge to use them among the farming community as the ICT's are effective in reaching a large number of users in a short time.
- **Evaluate to show results**: There is always a competition for resources. The Government tends to give priority to those programmes that show efficiency in reaching unreached farmers groups.
- **Update knowledge**: What one communicates depends on what he/she knows. Hence, field officer should be aware of relevant research happenings and innovative technologies so as to address the farmer's real needs.

Bias to be Avoided by the Field Officer

- **Middleman bias**: Using of middleman to reach out to local people is not good in the real farm situation as the middleman commonly brings in resource rich farmers who have access to well endowed situation and resources. In the process, we miss the actual target audience who are probably performing the actual farming and intensive work.

- **Hospitality bias**: If an extension agent gives emphasis on hospitality, they tend to spend time with the resource rich farmers who can provide good food and comfort. Resultantly, the resource poor farmers will be eliminated.

- **Innovator bias**: Extension staff has a tendency to start working with innovators or progressive farmers thinking that the technology/ innovative practice will trickle down quickly to the rest. However, the trickle down theory may not always hold true and the small farmers are left out.

- **Time bias**: When extension worker visits the village only during the day time when most workers are working in the field, there is every possibility that an incomplete picture of village and its people might be collected.

- **Spatial bias**: This bias arises when better-off households located near roads and service centres are visited and those located in the interior areas who are often poor be missed.

- **Project bias**: This bias arises when a particular model village or successful technology is repeatedly presented to outsiders and development workers. This does not reflect the reliable conditions and technology adoption status.

Criteria to Identify the Major Problems and Solutions

List the problems - rank the problem in terms of severity, importance, frequency and extent - identify the causes of problem - list possible solutions to resolve problem - screen possible solutions for feasibility. Making technology transfer more demand-driven, involving farmers and other stakeholders through participatory processes, orienting advisory services toward local, regional and international markets, strengthening networks and associations of farmers to increase their social capital are key principles which are to be incorporated in dissemination of information.

Technology Dissemination in FCV Tobacco

In the changing tobacco production scenario, farmer needs to have more information on: Which technology to use? How to manage this technology? How to use the capital, land and labour most optimally? How and when to change the cropping systems effectively? For which product is there a good demand in the market? How to find valid knowledge for making decisions? etc.

Technology transfer that is more demand-driven, decentralized, accountable to all stakeholders, efficient in reaching small farmers, and farmers of remote and marginal areas is the key element in achieving effective technology transfer and enhancing productivity of farms and income of farmers.

I. Innovative methodologies - Farmer as Resource Person

- Farm Schools
- Model Farms
- Farmer Field Schools (FFS)
- Progressive Farmer Circles

II. Information and Communication Technologies (ICTs)

Extension in FCV tobacco is now becoming more diversified, technology intensive, knowledge oriented and more demand driven. Use of ICT in extension enables the extension worker to be more effective in meeting the information needs of farmers. Effective use of ICTs helps in bridging knowledge deficiency among farmers at a faster rate. There are models through which the voice calls get transmitted at one go to all the registered farmers of the area.

III. Convergence of Extension Services

Many extension service providers in the field are providing different kinds of services and support to farmers. There is duplication of efforts and attending to extension work without convergence. Hence, a coordinated attempt to converge these efforts so as to improve the performance of various stakeholders is vital.

IV. Public Private Partnership (PPP)

The potential private extension providers could be identified and made partners in PP mode for effective management of services and for nurturing a plurality of institutions. In FCV tobacco, private sector is undertaking a range of functions related to transfer of technology.

V. Farming System Approach

The recommended technology should take into account components like soil, water, crops, livestock, labour, capital, energy and other resources, cropping system etc. The approach would emphasize the farmer's needs through an understanding of the existing farming systems rather than perceptions by scientists and extension functionaries.

VI. Documenting Farmers Knowledge

Many farmers have a scientific approach and practical knowledge but hardly document their experience. Farmers creativity and capacity for problem solving are to be recognized and documented as success stories.

FCV TOBACCO VARIETIES FOR DIFFERENT ZONES

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Introduction

Genetic purity and quality of seed used for raising the crop is one of the major factors influencing the crop yield that a farmer gets. Seed purity and viability ensures uniform crop growth thereby facilitates the ease of agricultural operations and consistent product quality. Leaf being the economic product in Flue-cured Virginia (FCV) tobacco, uniform crop growth is essentially required. The leaves at different positions of the tobacco plant differ from other positions morphologically and chemically and require slight modifications in curing schedules. Curing leaves of different positions in the same barn results in poor quality product as temperature for different flue-curing stages vary for leaves of various positions. Hence, uniform crop growth ensures harvesting of same position leaves in most of the plants in every pick thereby helping in proper curing. Further, agricultural operations viz., topping, harvesting, inter-cultures can be taken up at a time, when crop is uniform. For uniform crop growth in a field, use of quality and pure seed is a pre-requisite. Hence, farmers are advised to use pure seed of recommended high yielding varieties for realising higher profits.

Farm yields will be less, even if best practices are followed in crop cultivation, with the use of low yielding varieties. If the seeds of high yielding and stress resistant varieties are used, higher and stable yields can be obtained. In the endemic areas for pests and diseases, and under abiotic stresses, growing stress resistant/tolerant varieties reduces the crop losses and stabilises yields. Higher yield of quality product fetches good market price and higher returns to the farmers. Hence, use of high yielding and stress resistant tobacco varieties is necessary for realizing higher yields and net income under on-farm situations. In view of this, concerted efforts are being made to breed high and stress resistant tobacco varieties/hybrids through both conventional and modern plant breeding techniques at ICAR-CTRI, Rajahmundry.

Desirable Characters for FCV Varieties

Based on the production condition, quality of produce produced in the area and requirements of the exporting countries, the desirable characters of FCV tobacco cultivars differ. FCV cultivars should have the characteristics desired by growers and manufacturers of tobacco products. Tobacco is highly quality conscious and the market for each production area has been established largely on the basis of the varieties already in production, and drastic changes in varietal characteristics are not favoured by growers or manufacturers of tobacco products. In view of this, radical alteration in the characteristics of the variety already being grown cannot be made in order to achieve higher yields. This has necessitated development of varieties suitable to various FCV tobacco growing zones in India.

Some of the general characters required by FCV tobacco varieties are mentioned below. These include higher yield & quality, improved field and handling characteristics, resistance to diseases and pests, abiotic stress tolerance etc.

i. Higher Yield

Unlike the crops grown for their seeds, the economic value of tobacco depends both on quantity and quality of the leaf. In evaluating tobacco varieties, yield and quality (physical and chemical) of cured leaf are the main criteria. The number, size and the body of the leaves determine the leaf yield of the tobacco plant. Varieties with more number of good bodied bigger leaves are desirable for obtaining higher yields. Yield potential of FCV tobacco varieties grown in different agro-ecological conditions are given in Table 1.

Table 1: FCV tobacco Productivity (Kg/Ha) Potential- Present Levels and Targets

Type	Present Yield (kg/ha)	Targeted yield (kg /ha)
TBS	1600-3000	3500
NLS	1700-2900	3500
SLS	1600-2200	2800
KLS	1800-2700	3300

ii. Better Quality

Cured leaves are initially graded based on their size, colour, body, maturity, texture, blemish percentage etc., and accordingly given grade designation. Chemical quality of FCV tobacco is very complex and depends mainly on its chemical makeup which cannot be seen or measured easily. Chemical quality varies with kind and variety of tobacco, the environment in which it is grown, the process employed in ageing and curing the leaf, and specific use of the tobacco. Quality cannot be measured with finality by simple mechanical or chemical means; it depends upon the desires of the manufacturer and the taste of the consumer. Some of the components of quality that are given consideration by the breeder in developing varieties are leaf characteristics (size, shape, colour, thickness, puckering, oiliness, graininess of leaf surface, pliability and body of the leaf), burning qualities (fire holding properties; the rate, evenness and completeness of the burn; the characteristics of the residual ash), leaf aroma and taste, smoke flavour, sugar content and nicotine content. Manufacturers are giving greater attention to chemical composition of the leaf than they did in the past. FCV tobacco is highly quality conscious and acceptable limits prescribed for some of the physical and chemical properties of the cured leaf produced from NLS, SLS and KLS and the smoke quality parameters are furnished in Table 2. FCV varieties having these parameters in prescribed limits can only be suitable for cultivation.

Table 2: Physico-chemical and Smoke Characters of FCV Tobacco

Quality parameters	Acceptable limits	
	Minimum	Maximum
Northern Lights Soils (NLS) of Andhra Pradesh		
Nicotine (%)	1.5	3.5
Reducing Sugars (%)	5.0	21.0
Total Nitrogen (%)	2.0	3.0
Total Potassium (%)	2.0	3.5
Chlorides (%)	0.5	1.5
Starch (%)	0.7	5.0
Petroleum Ether Extractives (%)	4.3	13.6

Equilibrium Moisture Content (%) (at 60% RH, 20 ^{0}C)	13.0	15.0
Filling value (cc/g) (at 60% RH, 20 ^{0}C)	2.4	3.0
Southern Black Soils (SBS) of Andhra Pradesh		
Nicotine (%)	1.0	2.0
Reducing Sugars (%)	10.0	20.0
Total Nitrogen (%)	2.0	2.5
Total Potassium (%)	2.0	2.8
Chlorides (%)	0.5	1.0
Equilibrium Moisture Content (%) (at 60% RH, 20 ^{0}C)	12.5	15.0
Filling value (cc/g) (at 60% RH, 20 ^{0}C)	2.2	4.0
Southern Lights Soils (SLS) of Andhra Pradesh		
Nicotine (%)	1.2	2.5
Reducing Sugars (%)	10.0	25.0
Total Nitrogen (%)	1.5	2.5
Total Potassium (%)	2.5	3.0
Chlorides (%)	0.2	0.5
Starch (%)	0.4	4.0
Petroleum Ether Extractives (%)	3.5	7.4
Equilibrium Moisture Content (%) (at 60% RH, 20 ^{0}C)	14.0	15.0
Filling value (cc/g) (at 60% RH, 20 ^{0}C)	2.7	3.8
Levels of smoke constituents and TSNA in FCV tobacco		
Tar (mg/ cigarette)	18.2	29.5
Nicotine (mg/cigarette)	1.1	2.9
CO(mg/cigarette)	10.3	14.9
Tobacco Specific Nitrosamines (ppm)	ND	1.5

iii. Reduction of Harmful Substances

Smoke tar (nicotine free total particulate matter), carbon monoxide and tobacco specific nitrosamines (TSNA) are the chemical substances responsible for tobacco related health problems. In view of this, varieties with low level of TSNA (< 1ppm) and smoke tar (<12 mg/ cigarette) are essential.

iv. Improved Field and Handling Characteristics

The leaf features such as 1. toughness, so that the leaves will stand rough handling by men and machines, 2. fewer suckers, small suckers, or slower-growing suckers to reduce the labour cost of their removal and 3. even leaf maturity to harvest and cure the leaves at specified intervals for effective utilisation of barns are desirable in the improved varieties for easy handling. Dark cast varieties are suitable for irrigated and monsoon ecosystems, and light to medium cast varieties for rainfed systems as they mature evenly in these systems.

v. Resistance to Biotic and Abiotic Stresses

Diseases like root knot, blackshank, *Fusarium* wilt, TMV, brown spot, damping-off, leaf curl and leaf spot and insect pests like leaf eating caterpillar, aphid and whitefly (vector for leaf curl virus) cause considerable losses in FCV tobaccos. Control of disease/pests by chemicals, where such control is possible, interferes with quality in many cases and results in pesticide residues affecting FCV exports. Hence, development of resistant varieties offers the primary solution for the disease/pests problem. In order to get stable yields, FCV varieties need to be tolerant or resistant to prominent diseases/pests of the concerned FCV zones. For the FCV tobacco grown under rain-fed conditions, more often than not either the monsoon is delayed or precipitation is scanty which warrants the deployment of drought-tolerant varieties.

Varietal Requirement of FCV Tobacco Grown in Different Zones: The varietal characteristics required for FCV tobacco grown in different agro-climatic zones vary slightly and are mentioned soil zone-wise below.

(a) **Traditional Black Soils (TBS):** The leaf produced here is having demand in the international market as cheap neutral filler. Hence, varieties that give higher yield is necessary to overcome the increasing production costs. Varieties resistance to TMV, leaf eating caterpillar (*S. litura*) and aphid are essential in this area as these are major problems.

(b) **Northern Light Soils (NLS):** This area produces quality tobacco, and agro-climatic conditions are favourable for the production of good quality exportable types. The varieties that produce flavourful tobacco and resistant to TMV, black shank, root-knot and leaf eating caterpillar are essential here. Thick-bodied and green cast lines that respond to INM with maximum water-use-efficiency are necessary as the soils here are light textured and the crop is irrigated. Varieties with low TSNA and tar levels are required in order to meet the global demand.

(c) **Southern Light Sols (SLS):** Climatic conditions are highly unpredictable. Either long spells of drought or heavy rainfall due to cyclones are the common phenomena in this area. These climatic conditions affect the plants survival and growth and leaf expansion thereby influencing leaf yield. Most of the time, the varieties recommended for TBS region are cultivated by the farmers of SLS area. Medium to light cast variety with more number of leaves, good body, more leaf expansion and resistance/tolerance to drought/wet foot is essentially required for this area. Leaf curl, black shank, TMV and leaf eating caterpillar are main pest problems and needs development of resistant varieties to reduce the yield losses. In order to suit to different planting conditions, varieties that can perform well under early, middle and late-planting conditions need to be developed.

(d) **Karnataka Light Soils (KLS):** Highly plastic variety which can withstand drought spells and frequent rains are essential as this is a monsoon crop. Variety with high photosynthetic efficiency and neutral to photothermal variations are required for achieving higher yields in this area. Root- knot nematode, black shank, brown spot, *Fusarium* wilt and aphids are the major diseases and pests affecting KLS crop. High yielding variety with resistance to these diseases/pests including three species of *Meloidogyne*, root - knot nematode are needed for cultivation in this area.

Tobacco Cultivar Improvement

Although, occurring naturally as a perennial plant, tobacco is farmed as an annual crop. Out of the total 75 species in the genus *Nicotiana*, 20 are native to Australia, one to Africa and rest are indigenous to North /South America (Goodspeed, 1954; Burbridge, 1960). *N. tabacum* and *N. rustica* are the only cultivated species in the genus and several commercial varieties of them are being cultivated through out the world. *N. tabacum* is presumed to be a natural hybrid derivative of the cross *N. sylvestris* Speg and Comes x *N. tomentosiformis* Goodsp. Tobacco is one of the classic self-pollinated species because natural cross-pollination is relatively low (4-10%), significant levels of depression are seldom found following inbreeding and limited heterosis is expressed in hybrids between inbred lines. The predominance of additive genetic variance in populations and low levels of heterosis in most crosses made the breeders to focus largely on the development of pure line varieties. Also, for populations with large amounts of non-additive genetic variance and rare crosses exhibiting high heterosis, breeders developed hybrids to maximize genetic improvements. As transgenics are not accepted by traders, transgenic varieties are not bred in India.

Since 1950, a total of 29 FCV varieties and two hybrids are developed and recommended for cultivation in India. The details of FCV varieties/hybrids released/recommended for cultivation are given below (Table 3). As a result of breeding efforts and improved production technology, the cured leaf yield potential of FCV tobacco reached to around 3.3 tonnes/ha.

Table 3:FCV Tobacco Varieties/Hybrids Released/Recommended for Cultivation in India

S. No	Variety/ hybrid	Year of release	State (s)	Productivity (kg/ha)	Salient traits
	Varieties				
1.	Chatam	1950	Black soils of Andhra Pradesh (Developed atCTRI, Rajahmundry)	1100	—
2.	Delcrest	1960	Black soils of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1200	—
3.	Kanakaprabha	1971	Black soils of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1500	—
4.	Dhanadayi	1972	Black soils of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1520	—
5.	CTRI Special	1976	Black soils & SLS of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1365	—
6.	16/103	1976	NLS of Andhra Pradesh (Developed by M/s ITC ILTD Ltd.)	1717	—
7.	FCV Special	1976	KLS of Karnataka (Developed by M/s ITC ILTD Ltd.)	1118	—
8.	Jayasri	1979	Black soils of AndhraPradesh (Developed at CTRI, Rajahmundry)	1990	—
9.	CTRI Spl. (MR)	1980	Black soils & SLS of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1200	Resistant to TMV
10.	GodavariSpl.	1982	Black soils & SLS of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1525	Resistant to TMV
11.	Swarna	1984	KLS of Karnataka (Developed at CTRI RS, Hunsur)	1450	Resistant to powdery mildew
12.	Mc Nair 12	1986	NLS of Andhra Pradesh (Developed at CTRI RS, Jeelugumilli)	1880	Tolerant to black shank
13.	Jayasri (MR)	1986	Black soils & SLS of Andhra Pradesh (Developed at CTRI, Rajahmundry)	1503	Resistant to TMV
14.	Hema	1987	Black soils of Andhra Pradesh (Developed at CTRI RS, Guntur)	1560	—
15.	Bhavya	1988	KLS of Karnataka (Developed at CTRI RS, Hunsur)	2000	Resistant to black shank and root knot nematode
16.	Gauthami	1992	Black soils & SLS of Andhra Pradesh (Developed at CTRI, Rajahmundry)	2000	——-

17.	CM 12 (KA)	1993	NLS of Andhra Pradesh (Developed at CTRI RS, Jeelugumilli)	2000	Tolerant to black shank
18.	VT 1158	1993	Black soils of Andhra Pradesh (Developed at CTRI, Rajahmundry)	2000	Resistant to TMV
19.	Kanchan	1998	NLS of Andhra Pradesh and KLS of Karnataka (Developed at CTRI RS, Jeelugumilli)	2000	Tolerant to black shank and root-knot nematodes
20.	Thrupthi	1998	KLS of Karnataka (Developed at RARS, Shimoga)	1800	Tolerance to drought
21.	Rathna	2001	KLS of Karnataka (Developed at CTRI RS, Hunsur)	2000	———
22.	Kanthi	2006	SLS & SBS of Andhra Pradesh (Developed at CTRI RS, Kandukur)	1600-2000	Withstands moisture stress to some extent
23.	Hemadri	2006	Black soils of Andhra Pradesh (Developed at CTRI RS, Guntur)	2500	——-
24.	Siri	2006	Black soils of Andhra Pradesh (Developed at CTRI, Rajahmundry)	2900	———-
25.	Sahyadri	2009	AINPT Centre, Shimoga	2,000	Drought tolerant, mild drought situations
26.	FCH 222	2012	KLS of Karnataka (Developed at CTRI RS, Hunsur)	3,000	High degree of tolerance to *Fusarium* wilt disease
27.	N-98	2015	SLS of Andhra Pradesh (Developed at CTRI RS, Kandukur)	2,200	Rainfed conditions of Southern Light Soils
28.	LT Kanchan	2015	Andhra Pradesh (Developed at CTRI RS, Jeelugumilli)	2500	Low tar variety for Northern Light Soils
29.	CTRI Sulakhana	2018	SLS & BS of Andhra Pradesh (Developed at CTRI RS, Kandukur)	3300	Resistant to TMV and tolerance to aphid.
	Hybrids				
30.	CH-1	2015	Andhra Pradesh (Developed in collaboration with ITC ILTD Ltd. at CTRI RS, Jeelugumilli)	2900	High yielding and flavourful hybrid recommended for NLS
31.	CH-3	2016	KLS of Karnataka (Developed in collaboration with ITC ILTD Ltd. at CTRI RS, Hunsur)	2700	High yielding and flavourful hybrid recommended for release in KLS

FCV Varieties Recommended to Different Zones and their Characteristics

Varieties Recommended for Black Soils and SLS Areas

In the initial period, FCV tobacco cultivation centered around green cast varieties *viz.*, Harrison Special, Chatham, Delcrest, Virginia Gold in black soils which faced shortage of moisture, low fertilization and higher temperatures under rainfed conditions. These adverse conditions resulted in less plant vigour and poor leaf growth with improper maturity posing hardships to curing. This necessitated in developing light to medium cast varieties with easy curing, vigour and maturity. Also, to suit to the trade requirements breeding programmes were reoriented with emphasis on fast growth, early maturity with good ripe leaf, more of orange coloured leaf with good body and pliability, increased yield, response to application of higher doses of nitrogen without bad effects on curability and cured leaf colour.

From the base variety, Harrison Special in 1940-49 to the latest variety, CTRI Sulakshana in 2019, the cured leaf potential increased from 1,070 to 3,300 kg/ha. Most of the varieties developed for TBS are suitable for SLS and hence, recommended for that zone also. Siri, VT-1158 and Hema are the varieties currently cultivated in black soils and SLS area. N-98 is cultivated in parts of SLS and SBS areas. Siri is the variety occupying around 80% of the rainfed FCV tobacco growing areas of Andhra Pradesh. CTRI-Sulakshana is released for commercial cultivation from this crop season (2019-20) onwards.

Distinguishing Features of Black Soil/Southern Light Soil Varieties: Most of the time, the varieties recommended for black soils and SLS area are one and the same. Hence, the distinguishing features of recommended FCV varieties occupying major areas and newly recommended ones as on date for both the areas are listed here.

HEMA (1987): It is a cross between two vigorous plants found in black soils of West Godavari District and Light soils of Jeddangi area of East Godavari District released in 1987. It has an yield potential of 1,560 kg/ha. Tall, open habitat, lanceolate leaves, medium maturity, puckered surface, margin entire, medium auricle development, medium venation. It produces about 21 curable leaves per plant and the area of the leaf measuring about 622 sq.cm. It flowers at 70-80 days after planting. Inflorescence open and medium in size. Leaf maturity uniform, medium in nature. Nicotine 2.6%, Reducing Sugars 16.7%, EMC 15.4% and Filling value 3.5cc/g.

VIRGINIA TOBACCO-1158 (1993): Derived from a cross between L617 X CTRI Spl. (MR) released in 1993 for Northern and Central Black Soils of A.P. This has an yield potential of 2,000 kg/ha. It is a TMV resistant light cast variety with medium sized leaves. Plant habit open with horizontally inserted drooping leaves with medium puckering and good body. Colour of the mature leaves is light green and stem creamy green. Flowers in about 75-85 days after planting. Short internodes with less prominent auricle and 20 to 24 curable leaves per plant. Medium in maturity and cured leaves are lemon orange in colour. The average yield is about 2,000 kg/ha. Nicotine 2.4%, Reducing Sugars 16.7%, EMC 14.4% and Filling value 3.2cc/g. Plants grow to a height of 1.5 to 1.6 m. Cured leaves are lemon orange in colour.

SIRI (2006): Derived from the cross CM 16 X Gauthami. Plant grows to a height of 1.7 m with open plant habit, vigorous growth and short internodes. It gives 30-34 curable leaves. Leaf colour bright to light green and body medium. Leaf lanceolate, medium broad, medium puckered, semi drooping with medium auricle. Margin entire and with narrow tip. Cured leaves deep lemon to orange in colour and open grained. Flowers in 80 days after transplanting. It has an yield potential of about 2,900 kg/ha of cured leaf. Suitable for rainfed areas of Northern, Central and Southern Black Soils of Andhra Pradesh. It has acceptable physical and chemical characters.

N-98 (2015): It is a selection from local material isolated from bulk population. N-98 is a light to medium green cast variety with open habit. It grows to a height of around 2.5 m. The line gives more than 24 curable leaves. The leaves are long (60-65 cm) and slightly wider (30-35 cm) than Hema variety. Cured leaf is deep lemon to orange in colour, open grained, medium to thick bodied. The line has an yield potential of about 2200 kg/ha. The physical and chemical characteristics of the variety, N-98 are comparable with control, Hema and are in acceptable range.

CTRI SULAKSHANA (2018): It is an interspecific hybrid derivative involving VT-1158, Hema and *Nicotiana gossei*. Plant is semi erect, grows to above 2 m height, stem is light green to cream coloured and internode short to medium (~5.5 cm). The plant produces 30-38 leaves with 27-33 economic leaves. Leaves are broadly elliptic, sessile, light green cast with medium auricle. Leaf lamina is long (~80 cm), broad (~42 cm), margin wavy and tip medium pointed with medium puckering. The cured leaf is lemon yellow to lemon-orange colour in lower plant positions and lemon-yellow to light orange in higher positions. Cured leaf is medium bodied, oily with good ripeness characteristics and good aroma. This variety has an yield potential of about 3300 kg/ha and has resistance to TMV and tolerance to aphid.

Varieties Recommended for Northern Light Soils and Karnataka Light Soils

In view of increased preference for light bodied leaf with less nicotine/ tar content in international market during the sixties, cultivation of FCV tobacco was extended to light soil areas in Andhra Pradesh and Karnataka. The light soil grown tobacco was found to be ripe, open-grained, flavourful with good filling value. It had a more pleasant smoke in-terms of sugar-nicotine ratio compared to American tobacco. Thus, development of light soil tobacco cultivation got the boost.

Varietal Improvement in Northern Light Soils

FCV tobacco cultivation in NLS was started in 1970s. Initially exotic varieties and breeding lines were evaluated to find out suitable variety. Variety '16/103' was released by M/s. ILTD in 1972 which had yield potential of 1,600 kg/ha. Though it had given good quality leaf, it was found susceptible to black shank and TMV diseases. The exotic variety 'Mc. Nair 12', resistant to black shank was assessed and released in 1987. Though 'Mc. Nair 12' gives high yield, the cured leaf is of lemon yellow colour, with change in trade requirements for lemon-orange colour, further research efforts are geared in this direction. Through mutation breeding, variety 'CM 12 (KA)' was developed and released in 1993. 'CM 12 (KA)' produces 2,000 kg/ha cured leaf of desirable quality and possesses resistance to black-shank. Continuous efforts to have a better variety resulted in the identification of an exotic variety 'Kanchan' in 1998 with an yield of 2,500 kg/ha cured leaf of good quality with resistance to black-shank and tolerance to root- knot nematode. A low tar yielding variety LT Kanchan was released for NLS in 2015.

Collaborative efforts of CTRI and M/s ITC-ILTD resulted in development and release of two CMS hybrid varieties, CH-1 (2015) and CH-3 (2016). Both the hybrids are flavourful ones with good leaf quality characteristics and have a cured leaf potential of about 2,900 kg per hectare.

Also, two somaclones, Tobios-6 and FCJ-11 and a CMS hybrid NLSH-1 have been found promising for NLS area. The cured leaf potential of NLS cultivars increased from around 1900 kg/ha in 1980s to 2700 kg/ha with the release of CH-1 in 2015. Research is under progress to bring in varieties with still higher yields.

Varietal Improvement in Karnataka Light Soils

In KLS tobacco, the crop is raised as kharif crop. Numerous varieties were released for KLS to meet the requirement of this monsoon crop. First variety released for this region is FCV Special (1976). This was followed by release of number of high yielding varieties having tolerance/resistance to prominent biotic stresses (powdery mildew, black shank, frog eye spot, *Fusarium* wilt, root-knot etc.) of the region.

Distinguishing Features of NLS and KLS Varieties: As some of the varieties recommended for both NLS and SLS areas are common, the characteristics of recommended varieties occupying major areas and recently recommended ones as on date for both the areas are given below.

KANCHAN (1998): It is an exotic introduction from Zimbabwe to India released in 1998 for NLS area of A.P. and KLS of Karnataka. It is a green cast variety with semi-open habit and short internodes. Leaves are longer (60-66 cm), lanceolate with acute tip and wavy lamina. The variety produces 24 curable leaves with an yield potential of 2,400 kg/ha. The leaves mature slowly, cured leaves are deep lemon to orange in colour, open grained, medium to thick bodied, semi-flavourful rich in oil and fluffy. It is resistant to all the three races of *Phytophthora parasitica* var. *nicotianae* causing black shank and also less susceptible to root-knot nematode. The variety responds well to higher doses of nitrogen and it is best suited for assured rainfall zones.

FCH 222 (2012): Derived from a cross FCH 201 x Speight G 33 through pedigree method of breeding. The first *Fusarium* wilt resistant variety released for cultivation in light soils of southern transition zone of Karnataka under monsoonic conditions. It has open plant habit and grows to a height of 125cm. Stem colour green. Leaf shape lanceolate, surface moderately puckered, margin wavy, tip acute, sessile stalk and venation prominent. Leaf length 50 cm and width 26 cm. Total leaf No. 25 and economic leaf number 20. Number of days taken from planting to flowering is 70 to 75 days. Cured leaf mature, medium bodied, open grained, deep lemon to orange in color, oily and pliable with medium spots. The cured leaf is charecterised by neutral aroma with around 70% bright grades. Has a cured leaf yield potential of about 2400 kg/ha.

CH-1(2015): CH-1 is a cytoplasmic male sterile (CMS) flue-cured Virginia tobacco hybrid. CH-1 plant has semi erect habit; green coloured stem, short to medium internodal length (5.5 cm on an average) and grows to a height of 180 cm in untopped condition. Leaf is very long, medium broad with very good puckering and frills. The leaf is medium green cast in nature and has a wavy lamina with acute to acuminate tip. Leaf is sessile with high auricle development. The length of 5^{th}, 10^{th} and 15^{th} leaf are 65 cm, 70 cm, 68 cm respectively and the width is 28 cm, 30 cm and 26 cm respectively. The plant produces a total of 27 to 29 leaves with 25 economic leaves. The hybrid has a cured leaf yield potential of 2500 to 2900 kg/ha in Northern Light Soils. The plant and leaf type, colour, maturity and flowering behaviour of CMS hybrid CH-1 is close to the popular variety, Kanchan and suits the requirements of NLS farmers. The cured leaf produces lemon to lemon orange colour in lower plant positions and orange to deep orange colour in the higher plant positions. The leaf is medium bodied, oily with excellent ripeness characteristics and good flavour. The percentage of Nicotine, Total Sugars and Chlorides are 1.90 to 3.30, 9.5 to 20.2 and 0.04 to 0.45 respectively. Besides the high yield potential and good physical and chemical quality traits, the tobacco hybrid CH-1 possesses good manufacturability of cured leaf and highly desirable flavour profile as compared to Kanchan.

LT KANCHAN (2015): Developed through pedigree method of breeding involving Kanchan and low tar di-haploid line, D-1. Green cast variety with semi erect habit and short internodes. Plant shape resembles ruling variety Kanchan and grows to a height of 1.17 m. Produces more than 24 curable leaves. Leaves are long (65-72 cm) and broad (24-34 cm). Leaves lanceolate with acute to acuminate tip and wavy margin. Lamina thick with medium puckering.

Leaf maturity slower like Kanchan. Inflorescence medium and semi open. LT Kanchan has an yield potential of 2,500 kg/ha and delivers 11% less tar (mg/cig.) compared to control, Kanchan.

CH-3(2016): CH-3 is a cytoplasmic male sterile (CMS) flue-cured Virginia tobacco hybrid. The plant has semi erect habit and grows to a height of 185 cm in untopped condition. It has green colour stem, very long, medium broad leaves and short to medium internodal length (5.5 cm on an average). Leaf has very good puckering and frills. The leaf is medium green cast in nature and has a wavy lamina with acute to acuminate tip. Leaf is sessile with high auricle development. The length of 5^{th}, 10^{th} and 15^{th} leaf are 66 cm, 72 cm, 68 cm respectively and the width is 30 cm, 32 cm and 28 cm respectively. The plant produces a total of 28 to 32 leaves with 28 economic leaves. The hybrid has a potential of 2200 to 2700 kg/ha under Karnataka Light soils. The cured leaf produced is lemon to lemon orange colour in lower plant positions and orange to deep orange colour in the higher plant positions. The leaf is medium bodied, optimally spotted, oily with excellent ripeness characteristics and good flavour. The hybrid was rated higher to control in the sensory evaluation of cigarettes. The smoke test revealed that the hybrid, CH-3 possesses lower tar content than check, Kanchan which is a very important trait to meet the requirements of smoke deliveries. The analysis of flavor compounds also showed considerably higher neutral volatile compounds in the hybrid than check, Kanchan. Though, this hybrid was released for KLS, presently this variety is occupying majority area in NLS also.

Tobacco Pure Seed Production at ICAR-CTRI

One of the activities of ICAR-CTRI is the supply of pure and quality seed of released varieties to tobacco farmers. Tobacco seed requirements, though small in quantity, are of diverse nature and are met by CTRI and its research stations as well as the centers of All India Coordinated Research Project on Tobacco. While supplying the seed genetic purity (>95%), physical purity (>95%), germination percentage (>90%), moisture content (5-6%) etc. are to be ensured. Once a variety is released, the breeder concerned produces the nucleus and breeder seed and supplies the breeder seed to the Seed Production section. The Section multiplies the breeder seed in identified farmers fields under strict supervision. One hectare of tobacco nursery can supply seedlings to 100-150 hectares of field crop. About 100 kg of seed can be obtained per hectare from the crop raised for leaf purposes. This is sufficient to sow about 20 ha of nursery, which in turn gives enough seedlings to plant about 2000 to 3000 ha of crop. Thus, the seed obtained from one hectare is sufficient to cover about 2000 ha. This is a unique feature of tobacco in seed production and very few cultivated crops have such a high rate of coverage.

The pure seed of FCV tobacco produced by CTRI is being distributed to the farmers for commercial cultivation through the Auction platforms of the Tobacco Board stationed in different agro-climatic zones of Andhra Pradesh and Karnataka.

Conclusion

Varietal development is a continuous effort. Concerted efforts are being made to develop and release high yielding and stress tolerant FCV tobacco lines with commensurate quality including low levels of harmful substances for increasing the farm yields and returns to farmers. Farmers need to use pure quality seed of recommended varieties for realising higher yields. Farmers may be restrained from the use of seed imported from other countries to avoid the spread of new weeds and pests.

RESOURCE REQUIREMENT OF FCV TOBACCO

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Introduction

Tobacco is one of the important commercial crops cultivated in India. India is the third largest producer of tobacco in the world (721 M.kg) after China (2997 M.kg) and Brazil (862 M.kg) contributing to a tune of Rs 6,058 crores as foreign exchange and Rs. 23,318 crores as excise revenue to the national exchequer. Tobacco is a polymorphic crop, various tobacco types *viz.*, Flue-cured Virginia (FCV), Burley, *Bidi*, Chewing, *Natu*, Oriental, HDBRG, Lanka, Hookah, *Motihari* and *Jati* tobaccos are cultivated in different agro-ecological situations in the country. Unlike many other crops, tobacco is very sensitive to edaphic, climatic/ weather and management variations.

FCV Tobacco in India

Among the different types, FCV tobacco is an exportable type which occupies 32% of the total tobacco cultivation in India. FCV tobacco in India is cultivated mostly in Andhra Pradesh and Karnataka. Indian FCV tobacco has comparative advantage in supply due to the availability of varied agro-climatic conditions, diversified variety mix available all through at competitive price, free from pesticide residue and heavy metals. Soil and climate are the two very important factors which determine the suitability of a region for cultivation of FCV tobacco crop

Ideal Climatic Conditions for Tobacco

1. A frost free growing season of 100-120 days with a mean temperature of 26.7^{0}C and a liberal and well distributed rainfall from 88 to 125 mm rainfall per month are ideal requirements for tobacco crop (Garner, 1951).
2. Relative humidity may vary from 70-80% in the morning to 50-60% in the mid day.

In actual practice, when the ideal conditions of soil and climate are not available, a compromise is to be struck between them and suitable cultural practices are devised to make the differences in these requirements. Important climatic factors which influence the growth, flowering and metabolism of tobacco plant are

- Rainfall
- emperature
- Relative humidity
- Wind and
- Sunlight

Ideal distribution of rainfall for best yield and quality include cloudy weather with drizzling (soon after transplanting), light rainfall in early growth stage, bright sunshine with occasional moderate rain in grand growth period and no rains at all in ripening (maturity) of leaves because the rain will wash away the gums from the leave's surface resulting in poor curing. For maintaining the turgidity and expansion of leaf and to meet the transpiration losses of moisture from its enormous leaf area, tobacco plant needs considerable amount of water. On the other hand, tobacco plants are very sensitive to flooded or waterlogged condition of soil because of deprivation of oxygen in soil essential for the development of fibrous and vigorous root system. Hence heavy clayey soils are ruled out for tobacco cultivation in monsoon due to the inundation problem. Light soils can be used for taking up a rainfed tobacco crop provided the rains are well distributed during the growing season as in the case of Karnataka light soils.Tobacco crop can also be grown on light sandy soils under irrigated condition during dry months in winter as in the Northern light soils of Andhra Pradesh. In India, rains are heavy and uneven for a limited period during the South-West monsoons. Atmospheric temperatures are higher than the optimum level except in Hunsur and hence crop is grown in winter period of October to March when the temperatures are suitable to FCV tobacco in Andhra Pradesh.

Flue-Cured Tobacco Soils

Soils play an outstanding role in deciding the quality and commercial value of tobacco. The type, grade and quality of tobacco produced are, to a large extent influenced by the soil characteristics particularly the texture and colour of surface and subsoil. Flue-cured Virginia tobacco is grown on different types of soils ranging from sands to sandy loams of East Godavari, West Godavari and Khammam districts, the red loams of Prakasam and Nellore districts and heavy black cotton soils of Guntur, Krishna, Prakasam and East Godavari districts. These soils differ widely in texture and soil fertility. In an open, light textured soil, tobacco roots have been found at a depth of 120 cm utilising moisture and plant nutrients from such deep layers of soil. Three major soil conditions that contribute to maximum leaf expansion are adequate supply of oxygen, water and plant nutrients. Light soils produce thin and large bodied leaf, light in weight and color, mild in strength and weak in aroma whereas leaf produced in heavy soils is usually thick and heavy, dark colored, strong and aromatic. Natural resources *viz.*, soil and water are to be judiciously utilized for sustainable tobacco production. Soil constraints/limitations are to be studied comprehensively to find out suitable interventions for their successful management

Ideal Characteristics of Soils

- Sandy surface soil upto 15 to 25 cm depth.
- Sandy clay sub-soil extending upto a depth of 150 cm.
- Acidic soil reaction of pH 5.5 to 6.5.
- Low reserve of essential plant nutrients.
- Low organic matter content.
- Very low chloride content (less than 100 ppm).
- Soil should be free-draining and well-aerated throughout the season.
- The fertility status of the soils should not be high. In fact, nitrogen starvation condition should prevail at the time of leaf maturation.

Black Soils (Vertisols)

Tobacco is raised as a rainfed *rabi* crop with the conserved soil moisture of south west monsoon rains. Soils are alkaline, clayey texture (40-60% clay) with high water holding capacity (70%), high fertility and impeded drainage, rich in Ca and K (4.5 to 5% Ca) and hydraulic conductivity is very poor indicating easy water logging. These soils have high cation exchange capacity and soil absorption sites are fully saturated with exchangeable bases mainly calcium, magnesium, potassium and sodium. Buffering capacity of these soils is high. Swelling and sticky properties when wet and the shrinkage and hard cloddy nature of the soil when dry pose a great problem in the management. In these soils the infiltration rate is as low as

0.2cm/hr and hydraulic conductivity is as low as 0.15cm/hr, hence there is a possibility of submergence during the rainy season. The slow permeability is associated with black clay soils, creating oxygen stress in the root zone due to stagnation of water. Addition of organic manures, providing proper drainage i.e creation of field channels along the plots and balanced fertilization / integrated nutrient management practices are some of the management interventions required for cultivation of FCV tobacco

Light Soils

Northern Light Soils

These soils are derived from sand stones and are sandy to sandy loamy in texture, moderately acidic in soil reaction, well drained, low in CEC and water holding capacity, loose and highly porous, percent calcium saturation in these soils is 20-25%. As they are very poor in fertility they require adequate supplies of fertilizer elements *viz.*, nitrogen, phosphorus, potassium, calcium and magnesium for successful production of quality tobacco. In Andhra Pradesh these light soils are distributed in East Godavari, West Godavari and Khammam districts popularly called the Northern light soils (NLS). The crop in Northern light soil region is raised under assured irrigation sources and crop yields are high. Fertilizer and water use efficiency of these soils is very low and nutrient losses through leaching are high. Application of organic manures, pond sediments or mixing of clay decreases the bigger pores and increases the smaller pores, thus reduces the hydraulic conductivity and increases the water retention.

Southern Light Soils

In Prakasam and Nellore districts, FCV tobacco is grown on medium textured red soils and are popularly called as Southern light soils (SLS). These soils contain moderate quantities of clay, soils are neutral to slightly alkaline, low in organic matter, low in P and medium to high in available potassium contents. They are moderately well drained with moderate to slow permeability. Cation exchange capacity and percentage base saturation is also medium. FCV tobacco is grown on conserved soil moisture mainly from the rainfall of the North-East Monsoons. Soil crusting is one of the problems observed in some of the red soils in Prakasam and Nellore districts. Crusting tendency can be reduced by addition of farm yard manure, soil surface covers such as mulches, plant residue, close growing of the crops, grasses and legumes prevent the crust formation. Keeping the soil moist by irrigating the crops also helps in reducing the crust formation. Soil mulching, use of tine cultivator, green manuring and green leaf manuring, Soil test based balanced fertilizer use, water harvesting and recycling for life saving irrigation, use of ground water by mixing it with harvested rain water are some of the interventions suggested for cultivation of FCV tobacco.

Karnataka Light Soils

Karnataka light soils range from sandy loams to sandy clay loams, well drained, characterised by the dominance of 1:1 clay minerals unlike Andhra Pradesh black soils which are predominantly 2:1 clay minerals. Soils are slightly acidic, low in inherent fertility with fairly good water-holding capacity. FCV tobacco is grown as a monsoon crop during *Kharif* season.

Irrigation Water Quality

Chlorides in the irrigation water should be < 50 ppm. Irrigation with high chlorides lead to production of saline leaf. Chloride content in cured leaf should be < 1.5%, as high chlorides reduce the burning quality of the tobacco leaf.

BEST MANAGEMENT PRACTICES FOR HEALTHY TOBACCO SEEDLING PRODUCTION

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Introduction

Seeds are essentially an important delivery system of genetic information. Good quality seedlings continue to be the crucial determining factor of yield and quality in any crop including tobacco. ICAR- Central Tobacco Research Institute developed and standardized technologies to produce healthy tobacco seedlings.

Tobacco seeds are very small with thick seed-coat. They are about 0.75 mm long, 0.53 mm broad and 0.47 mm thick. Depending on the variety and the conditions under which the seed is produced, the size and the weight of the seed vary considerably. In *N. tabacum* the average weight of the seed is 0.08 to 0.09 mg and there are 11,000 - 12,000 seeds per gram. In *N. rustica*, the seed is larger and about three times heavier than *N. tabacum*. The emerging seedlings are tiny and delicate and therefore, the seeds are unsuitable for sowing directly in the field. Hence, they are sown in nurseries initially and raised carefully till the seedlings attain a particular size before transplanting in the main field. These nurseries can be a conventional raised seed bed nursery or tray seedling method. For successful raising of nurseries, proper location, good preparation and manuring, adequate facilities for watering and timely control of pests and diseases are essential.

Conventional Nursery

Selection of Nursery Site

- Generally tobacco nurseries are grown on sandy or sandy loam soils. These soils should not be subjected to inundation even during heavy rains and also capable of quick drainage. The nursery site should have a good internal as well as surface drainage and should be situated at an elevated place.

- To raise the nursery on heavy soils, it should be made porous by mixing about 200 cart loads (100 tonnes) of sand per hectare in the top layers. It helps in improving the drainage in heavy soils.

- It is desirable to change the nursery site every year as it would minimise incidence of pests and diseases and also eliminate contamination by other varieties. If it is not possible to change the site, old site can be used after sterilizing by rabbing, i.e. by burning any of the slow burning waste materials like, tobacco stalks, paddy husk, sugarcane-trash, etc. For the best results this operation should be done at the right moisture content, after the final preparation of the seed bed and a few days before sowing.

Preparatory Cultivation

Deep ploughing of the nursery site twice during summer months (April-May) will expose and desiccate the eggs and larvae of nematodes and other soil borne pathogens. It facilitates the exposure of pupae to high temperatures and thus destroyed. The nursery area should be periodically ploughed and weeded till it comes to a fine tilth and is free from weeds.

Seed Bed Preparation

- Systematic layout of nursery on raised beds with intervening channels helps in quick drainage of rain water. The beds of 1.0 m to 1.20 m width facilitate hand weeding and watering with rose cans. The beds can be of any convenient length along the slope but generally not more than 10 m. Channels should be 50 cm wide and 10 cm deep.

- Application of FYM or filter press cake @ 25 tonnes/ha i.e. 25 kg/10 m^2 by mixing well in the top layers at least 20 days before sowing is beneficial in obtaining more number of transplantable seedlings.

- Basal application of 50 g of ammonium sulphate, 50 g of potassium sulphate and 300 g of super phosphate and 100 g dolomite per 10 m^2 bed is recommended.

- Mixing fenvelerate dust 40 g per 10 m^2 bed with top soil along with basal fertilizer mixture before sowing prevents damage by soil pests like ants, termites, mole crickets, earthworms etc.

Seed Sowing

- Grow only tested and approved varieties.

- The optimum time of sowing the nursery is 15th August to 1st September in Andhra Pradesh.

- The sowing time of FCV tobacco in Karnataka is March-April. The first ten days of nursery period is most critical and if the afternoons are hot, missing even one watering inhibits germination of seed. Provision of covers and mulches over seed beds is found beneficial as they help in conserving moisture during germination and later protect the tender seedlings from scorching sunlight and beating rains.

- A seed rate of 3.5-4.0 kg/ha or 3.5-4.0 g/10 m^2 is quite sufficient. Higher seed rate results in over-crowding of seedlings which in turn lowers their quality and causes diseases like damping-off.

- The beds, after leveling are raked to form 0.25 cm deep furrows 5 cm apart along the length of the bed. As the size of the seed is very small, it is to be mixed with sufficient quantity of dry sand and evenly distributed over the bed.

- The seed is then sown and the furrows covered by drawing small brooms made of twigs across the furrows to cover and maintain the optimum depth of seeding at 0.25 cm.

- After seeding and covering, the bed is compacted by rolling a 22.5 cm diameter cement pipe.

Care of Nursery Beds after Sowing

- Mulching of seed beds with paddy straw after the seed is sown and pressed prevents erosion and washing-off of seedlings during heavy rains.
- The beds are watered 6-8 times per day to keep them moist but not wet, till the germination is completed.
- By supplying water through micro sprinklers healthy seedlings can be produced with low labour cost. In micro-sprinkler system the optimum spacing between laterals was found to be 2.5 m and the spacing between micro sprinklers was 2.5 m under the operating pressure of 1.25 to 1.5 kg/cm^2. Four micro-sprinklers are sufficient for two 10 m^2 seed beds.
- The cover is thinned out when the seedlings are about three weeks old and completely removed after one week.
- Weeding is to be done periodically for better growth of the seedlings.
- If the seedlings are over-crowded in some places, they can be thinned out at about three weeks age and transplanted in places where the stand is sparse.

Top Dressing of Fertilizers

After germination of seed, top dressing should be given as mentioned below.

Days after germination	Fertilser/10 m^2 seed bed in grams	
	Calcium Ammonium Nitrate (CAN)	Sulphate of Potash (SOP)
6	25	-
12	25	25
18	25	-
24	50	25
36	50	-
42	50	-

(Depending on the growth of seedlings top dressing should be done)

Seedlings of pencil thickness and of 10 to 15 cm length are normally preferred. Shorter seedlings may establish well under optimum conditions in heavy soils. In light soils longer seedlings are preferred for planting. Normally, the seedlings are ready for planting by the end of 7th or 8th week and in the first picking 30 to 40% of the total seedlings are available. The seed bed is top-dressed after each pulling to make the remaining seedlings grow to transplantable size. The recommended dose after each pulling is 100 g ammonium sulphate and 50 g sulphate of potash. When planting is delayed due to unfavourable field conditions, the overgrown seedlings in beds are clipped without damaging the growing point in order to retard the growth. Watering should be stopped 3 to 4 days before pulling to harden the seedlings. A bundle is to be prepared with 4000 to 5000 seedlings and seedlings are to be arranged in proper manner to facilitate proper aeration within the bundle. Over packing of seedlings should be avoided in the bundle. After the end of the nursery season, all the left over seedlings should be pulled out and the area ploughed and kept clean.

Nutritional Disorders and Corrective Measures

In tobacco nurseries, deficiencies of nitrogen, potassium and magnesium are generally seen. They have to be identified and corrected in time by applying recommended fertilizer.

a) Nitrogen

Nitrogen deficiency normally occurs due to heavy rains in nursery growing period due to leaching of nutrients. It causes stunting and yellowing of seedlings resulting in poor growth and an excess of nitrogen causes seedlings to become lanky and succulent which interferes with proper establishment of seedlings in the field. Excess nitrogen application in the form of ammonium sulphate than the recommended schedule will develop acidity in the soil and causes death of young seedlings

Nitrogen deficiency can be corrected by application of recommended dose of nitrogenous fertilizer.

b) Potassium

Due to K deficiency leaves become cup shaped from the underside. Lower leaves show typical mottling and chlorosis at tips and margins. The mottling appears to progress rapidly from the lower to the upper leaves.

Potassium deficiency symptoms can be corrected with soil application of sulphate of potash at recommended dose.

c) Magnesium

Magnesium deficiency symptoms appear first in the lowermost leaves of the plant. Leaves loose their normal color at the tips, margins and between the veins. The veins and the tissue close to them retain the normal color.

Magnesium deficiency can be corrected by spraying Epsom salt @ 50 g/10 L water two times at 10 days interval.

Resetting and Tray Nursery Seedlings

a) Resetting

At about 30 days age, young seedlings are taken out from overcrowded patches in the nursery beds and reset in fresh beds for allowing further growth. Resetted seedlings establish better in the main field in adverse conditions like scorching, hot weather and low humidity.

Tray seedlings give better establishment and facilitate uniform growth in the field.

Tray seedling Production Technique

A tray nursery technique has been developed and standardized to produce healthy tobacco seedlings to overcome disease problems and to preclude transplantation shock. The technique is simple and entails sowing tiny tobacco seeds on coconut coir pith compost and transferring the young seedlings of about 20-25 days to poly-trays for raising them on the growth media with standard nutrient and watering schedules. The tray nursery seedlings take about 60-65 days from sowing to transplanting. Tray nursery seedlings offer the unique advantage of ensuring crop uniformity with minimum gap fills and consequently increased cured leaf yield and quality as against the seedlings grown under conventional raised soil-bed nursery.

Composting of coir pith: Coir pith is the medium for seedling growth which is to be composted before its use. Composting of coir pith is done by pit method. In this method coir pith (100 kg) spread uniformly as a layer on the ground, on this 400 gm of *Plurotus* fungus is added uniformly. Again 100 kg coir pith is covered followed by addition of 1 kg urea. Spread again 100 kg coir pith. The process is repeated till the heap reaches above ground. The heap is moistend by sprinkling water daily.

Mother trays: In tray seedling production unlike in conventional method, seedlings are raised on composted coir pith medium (coir pith alone or coir pith + FYM (3:1)) in mother trays (cement bins/trays/brick beds) for about 25-30 days under protected condition. Coir pith medium is to be fortified with single super phosphate @ 300 g of single superphosphate, 250 g ammonium sulphate, 150g potassium sulphate/100kg. Spraying of blitox @ 2g/l on the medium is be done as a precautionary measure to avoid soil borne diseases. In these mother trays sand is added at the bottom and only top 4" is to be filled with the coir pith medium. Before sowing lines are to be made with broomstick on the media and the seed is sown @ 0.4 -0.6 g/sq mt. Water application is to be done in the initial stage with sprayer two times a day. Excess watering is to be avoided. Seeds start germinating from 5Th day onwards and the germination will be completed by 7-8 days. Fertiliser spray with 10g each of ammonium sulphate/CAN and potassium sulphate/10 litre is to be given two times @ 10 days interval after sowing. Seedlings will be ready for transplanting from the trays by 20-25 days.

Resetting in trays: Fortified coir pith is to filled tightly in the cells by periodical pressing in trays of 70/98 cells. Before filling, coirpith is to be moistened by applying required quantity of water so that filling is easy. After filling, the trays seedlings of 20-25 days are planted in the trays by making a suitable hole using a nail or small stick. After planting the media around the seedling is to be pressed. After resetting, the trays are to be kept in shade for 3-4 days. After that the trays are shifted to the raised beds in shade net (50%). Fertilisers are to be given three times at 5, 20 and 25-30 days @ 100 ml, 200ml and 300 ml of N and K (50g of CAN + 50 g of sulphate of potash in one litre) in 10 litres rosecan/ 40 trays. Washing of the seedlings is to be done after fertilizer application. Three days after third dose of fertilizer application seedlings are to be kept outside shade for about 7 days for hardening. Thus healthy seedlings will be ready after 60-65 days. At this stage when it is pulled seedlings will come easily from the tray because the coir pith is covered by the root mass. Clipping can be done if the field conditions are not ready for planting. Three to four days before transplanting ridomil @ 2.5 ml/10 litre and Flubendamide @ 20g/10 litres is to be sprayed to avoid subsequent mortality in the main field due to the incidence of leaf blight and stem borer. Tray seedlings enhance FCV tobacco yield by 10-25% depending on the growing conditions.

Advantages of tray nursery

- 100% establishment, improves the yield by 10-25%
- Uniform crop growth due to less gap fillings (<1%), no transplantation shock, uniform field operations *viz*., topping and harvesting
- No weed problem in tray nursery
- Water and fertilizer use efficiency will be more. Hence, seedlings can be raised even under water scarcity
- Pests and diseases incidence very less
- Farmer friendly technology: Can be performed in back yards unlike conventional nursery
- Tray seedlings improve moisture and nutrient holding capacity and soil health
- Higher net returns and cost benefit ratio
- Total mandays for seedling production less
- Crop duration will be reduced by 10 days
- Reduces the pest and disease incidence in main field
- Total cost of cultivation reduced

SOIL FERTILITY AND PLANT NUTRITION OF FCV TOBACCO

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Soil fertility is an inherent ability to supply adequate available nutrients to plant or crop to produce desirable yield and quality. Tobacco is very sensitive to the physical and chemical properties of the soil. Hence, selection of suitable soils is essential.

Characteristics of soils best suited for the production of high-quality Flue-cured tobacco are

- Sandy surface soil up to 15 to 25 cm depth with sandy clay subsoil extending up to a depth of 150 cm
- An acidic soil reaction with pH 5.5 to 6.5
- A low reserve of Nitrogen
- Very low chloride content (less than 100 mg kg^{-1})

Soils that are not ideal and to be avoided are

- Inundated lands and low-lying basins
- Leaf exhibits very poor burning properties, due to absorption of moisture and deteriorates in colour during storage.
- Saline soils with soil chloride content > 100 mg kg^{-1}

FCV Tobacco Soil Regions

The soil characteristics, *the cultivation practices* and the *quality of the tobacco* produced are entirely different from one region to the other. Different styles of tobacco are produced in different zones to meet the demands of the customers of different countries.

Flue Cured Virginia tobacco is grown in India in four regions based on agroclimatic zones *viz.*,

- Traditional black soils (TBS)
- Northern light soils (NLS)
- Southern light soils (SLS)
- Karnataka light soils (KLS)

Traditional Black Soils: Clay loams, silty clay loams and clays, slightly calcareous, high in available soil moisture with very poor drainage. Tobacco is grown on conserved soil moisture during *rabi*.

TBS is divided into

- Northern black soils (*East and West Godavari* districts)
- Central black soils (*Khammam, Krishna & Guntur* districts)
- Southern black soils (*Prakasam and Nellore* districts)

Northern Light Soils (East Godavari, West Godavari and Khammam districts of A.P.): Sandy loams to loamy sands - low water holding capacity with very good drainage. Tobacco is grown under irrigated conditions during *rabi*.

Southern Light Soils (Prakasam and Nellore districts of A.P.): Red loamy soils - moderately well drained. Tobacco is grown in SLS during *rabi* on conserved soil moisture from North East monsoon rains.

Karnataka Light Soils (Southern Transitional Zone of Karnataka): Red loamy sands and sandy clay, well drained with fairly good water holding capacity. Tobacco is grown in KLS as *kharif* crop.

Table1: Soil Fertility in Different Zones Under FCV Tobacco

Soil fertility parameters	NLS	KLS	SLS	TBS
Soil reaction	Slightly acidic	Slightly acidic to neutral	Mildly alkaline	Slightly alkaline
Organic Carbon	Low	Low	Low	Low
Available Nitrogen	Low	Low	Low	Low
AvailablePhosphorus	High	Medium to High	Medium to High	Medium to High
Available Potassium	Medium to High	Medium to High	Medium to High	Medium to High

Note: Zinc is low in most of the light soil areas of FCV tobacco

Plant Nutrition

Fertilizers of FCV tobacco need to supply the nutrients required to produce a good yield of high-quality tobacco and sustain/maintain the nutrient levels of the soil. Nutrient requirements for FCV tobacco are higher than most of the other agronomic crops. Important nutrients for FCV tobacco production are nitrogen, potassium, calcium, magnesium, zinc, iron and boron.

Tab.2: Uptake of Major Nutrients by FCV Tobacco

Regions	Uptake of Major Nutrients (kg/ha)		
	NITROGEN(N)	PHOSPHORUS(P)	POTASSIUM(K)
KLS (Rainfed)	50 - 60	7- 8	70 - 80
NLS (Irrigated)	70 - 90	8-10	100 -120
SLS (Rainfed)	40 - 50	5-6	40 - 50

The above uptake values are for the yield ranges of cured leaf of 1200 - 2000 kg/ha of FCV tobacco of respective zones. The Nutrient Recovery Efficiency of FCV production generally varies from 30 - 40 % for N, 8 -10 % for P and 40 - 50 % for K.

Importance and Requirement of N, P And K for FCV Tobacco

Nitrogen

- Nitrogen usually affects the yield and cured leaf quality of FCV tobacco more than any other nutrient
- Failure to apply enough nitrogen will result in small plants, early firing, low yield and quality
- Excess nitrogen can cause plants to grow too large and become difficult to harvest and cure
- The studies indicate that a total of 120-150 kg N/ha (Irrigated) and 60-80 N kg/ha (Rainfed) is required to produce high yields of good quality FCV tobacco.

N deficiency symptoms in FCV tobacco

Phosphorus

- Phosphorus is probably the most excessively used nutrient in FCV tobacco
- Repeated applications of large quantities of phosphorus than plants can absorb with essentially no loss from leaching have resulted in a general buildup of this element
- Present research indicates that 40 to 60 kg per ha of P_2O_5 is adequate for tobacco if the soil test shows phosphorus to be Low – Medium

Potassium

- Potassium affects the quality of the cured leaf
- Potassium enhances the burning quality of tobacco
- Potassium promotes the spread of leaves and makes them light bodied
- A deficiency is noticed at the leaf tips and margins
- A bronze yellow appearance and tendency to turn down or curl under
- The tips of the leaves may deteriorate and fall off in the field, giving the tobacco a ragged appearance
- Tobacco deficient in potassium is more subject to leaf disease such as brown spot
- The application of potassium for FCV crop may vary from 60 kg per ha of K_2O to 150 kg/ha of K_2O or more in different soils

The imbalance in N and K, where low K and excessive N fertilization with low native K, resulted in poor yield and low - quality cured leaf.

Importance and Requirement of Secondary and Micronutrients for FCV Tobacco

Calcium

- FCV tobacco being grown under monsoon conditions, often suffers from severe drought which aggravates the calcium deficiency in the top 4 - 5 leaves
- Constricted tips on leaves. Symptoms are more common during late season drought
- Symptoms may be described as making the leaf heart shaped
- Inclusion of calcium containing N & P sources would mitigate the Ca deficiency

Calcium deficiency

Magnesium

Magnesium deficiency leads to yellow, weak and light weight leaves resulting in lower yields. Add Mg – 20 kg/ha during field preparation (150 kg/ha Dolomite - Ca Mg $(CO_3)_2$) to mitigate the deficiency.

Magnesium Deficiency in Nurseries

Magnesium deficiency at 20-25 days age. Yellowing of lower leaves starts from the tip of the leaf and spreads. It can be managed by using 50g $MgSO_4$ in 10 lt water spraying @ 2.5 l/bed, 2-3 times at 2-3 days interval.

Symptoms of magnesium deficiency in main crop (A) and nursery (B) Symptoms of Calcium deficiency

Boron: Boron deficiency is seen under drought / water stress conditions. Retarded growth with paling of leaves to white. Spraying of 10 g Borox powder/ 10 lt of water solution is recommended.

Symptoms of Boron deficiency in tobacco crop

Zinc

Zinc deficiency leads to narrow and thin leaves. Use zinc sulphate – 40 g / 10 lt of water and spray or soil application of zinc sulphate - 25 kg/ha to mitigate the deficiency.

Chloride

Chlorine is an essential minor element for plants. Small quantities of chloride help in improving yields and hygroscopicity of tobacco. High chlorides produce muddy and uneven colors in cured leaf with excessive moisture. Affects the burning quality of the cured leaf. Hence, soils with more than 100 ppm and water with more than 50 ppm chlorides should be avoided for raising nursery and main crop.

Manures and Fertilizers in FCV Tobacco

Manuring in FCV Tobacco

Manuring in FCV tobacco soils is required as most of the soils are low in organic matter content especially the light soils. Application of FYM @ 5 t/ha by mixing well in the top layers at least 20 days before transplanting is recommended. Growing of a green manure crop *Sunhemp* for 6 to 7 weeks and incorporation in soil is also an important activity to be practiced or advocated. *Gliricida spp* is also an important green leaf manure which can be used for incorporation in these light soil areas.

Fertilizer nutrient recommendation for important FCV tobacco regions: Fertilizer nutrient recommendations were given based on the type of soils, native soil fertility levels, crop requirement and type of cultivation i.e rainfed /irrigated.

Regions	**($N-P_2O_5-K_2O$ Kg/ha)**
Northern Light Soils	120 – 60 – 120/150
Southern Light Soils	60-60-60
Southern Black Soils	60-50-50
Karnataka Light Soils	60-40-120

Fertiliser Sources for Major Nutrients

Nitrogen sources generally recommended for FCV tobacco are: Ammonium sulfate, Calcium nitrate and Di Ammonium Phosphate.

Phosphorus sources generally recommended for FCV tobacco are: DAP and Single super phosphate and Ammophos: 20:20:0

Potassium source recommended for FCV tobacco is only Sulphate of Potash (SOP).

Fertilizer sources generally used for the supply of secondary nutrients i.e Ca, Mg and Sulfur are

- Calcium Nitrate: 15.5 % Nitrogen and 19 % Ca
- Dolomite: 13 % Mg and 21 % Ca
- SSP: 16 % $P_2 0_5$ and 11 -12 % Ca and 21 % S

Fertiliser Application: N and K fertilizer are applied in 2 - 3 splits by dollop method placed 3 inches away from the plant. Under conditions of heavy rains additional 50-60 kg ammonium sulphate /acre can be applied to adjust the leaching losses of nitrogen.

Soil Testing and Fertilizer Recommendation: Soil test-based fertilizer application is required to practice to

- Assess nutrient status
- Identify specific soil conditions like alkalinity, salinity and acidity
- Provide balanced nutrition to get higher yields & better quality
- Save nutrient fertilizers

Fertilizer recommendation is to be done based on soil test values by identifying the fertility class of the soil tested for respective major nutrients and based on the identified class adjust the nutrient recommendation for fertilizer recommendation i.e 25 % additional than the recommended dose for low category, recommended dose for optimum while 25 % lesser than the recommended dose for high category.

STCR based fertilizer recommendation with the help of fertilizer prescription equation is also an important approach for giving balanced nutrition to crop for achieving desired targeted yields.

WATER CONSERVATION AND WATER MANAGEMENT

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Introduction

Agriculture often places significant pressure on natural resources viz., soil, water and the environment. Sustainable agricultural practices are intended to protect the environment and improve the natural resource base. Efficient management of resources by sustainable practices helps to increase the productivity and quality of farm produce which in turn lead to profitable farm income. Water is one of the most precious natural resources on the earth. Even though three fourths of earth surface is covered with water, about 97.5% of water is sea water. Only 2.5% of fresh water from rivers and underground sources is fit for human consumption. Meeting the demands of very increasing plant population with 2.5% of available water is a serious challenge. In terms of usage volume, agriculture contributes to approximately 70% of global water demand, with industry and domestic demand at 20% and 10% respectively. It is very important to conserve and manage the water efficiently as the major share is used for agricultural purpose.

Tobacco is an important commercial crop cultivated under varied agro-climatic conditions. It occupies third position in the world with an annual production of about 800 million kg. Of the different types of tobaccos, flue-cured tobacco is one of the important types of tobacco grown in Andhra Pradesh and Karnataka. It is grown with conserved moisture on heavy black soils (Vertisols) and under irrigated conditions on light soils (Alfisols) of AP, and as a rainfed crop on southern light soils of Andhra Pradesh in *rabi* season and on light soils (Alfisols) of Karnataka in *kharif* season. Tobacco crop cannot tolerate water logging and at the same time it cannot withstand prolonged drought. Quality of tobacco is an important factor in FCV tobacco production. Irrigation water used for tobacco should have EC of <0.4dS/m. and a chloride concentration of 50 mg/l. Chloride concentration in irrigation water is critical because of its negative role on leaf quality. Hence water shed development in suitable areas and development of micro water structures for rain water harvesting is best water conservation strategy for FCV tobacco farming. Efficient management of conserved water is very important task in the changed climatic scenario.

Water Conservation: It contributes to sustainable intensification by allowing water to be used efficiently, resulting in higher agricultural production throughout the year and improved resilience to drought in turn improving farmers livelihood and food security. The major ways to conserve water in agriculture include soil compaction management (breaking the hard compacted layers in the soil which helps in increasing water holding capacity), adopting biological interventions such as vermicomposting and organic fertilizers which increases the soil organic carbon, soil structure and water holding capacity, use of mulching materials and cover crops, effective usage of water by micro irrigation, drip irrigation methods and establishment of rain water harvesting structures etc.

Water Management: Efficient utilization of water is a very important strategy in agriculture. Different methods of irrigation include flooding, furrow irrigation, alternate furrow irrigation and surge flow furrow irrigation. In general, farmers practice flooding method which causes lot of water loss. The improved methods of irrigation result in enhanced water use efficiency and increased productivity. Micro irrigation methods viz., sprinkler, micro sprinkler, drip and fertigation methods are very effective in not only water saving, it also enhances crop yields.

Government is also encouraging farmers to use improved methods of irrigation by providing subsidy. Agronomic practices like raised bed planting, ridge-furrow method of sowing, subsurface irrigation and precision farming help to economise water use.

There is scope for increasing income through crop diversification and integration of fish, poultry and other enterprises in the farming system. The multiple water use approach can generate more income benefits and decrease vulnerability by allowing more diversified livelihood strategies and increase the sustainability of ecosystems. Emphasis should be given on water resources conservation through watershed development in suitable areas and development of micro-water structures for rainwater harvesting. The promotion of water conservation efforts has direct implications on water resources availability, groundwater recharge and socio-economic conditions of the population.

Quality of irrigation water is an important factor in FCV tobacco production. The concentration and composition of dissolved constituents in water determines its quality. Irrigation water used for nursery and field crop of FCV tobacco should have EC of <0.4 dS m^{-1} and chloride concentration of 50 mg L^{-1}. Chloride concentration in irrigation water is of critical importance because of its negative role on leaf quality. With increasing level of chloride in irrigation water, the accumulation of chloride in leaf lamina increases. Therefore, water with high chloride should not be used for irrigation to produce quality tobacco leaf.

Micro Irrigation in Nursery

In the conventional method of nursery raising, watering to be given 4-5 times/day through rose cans manually. It is labour intensive and involves drudgery. The optimum spacing between laterals is 2.5-3.0 m and the spacing between micro sprinklers is 2.5–3.0 m and for this spacing four sprinklers are required for irrigating two tobacco nursery beds. The micro sprinkler system saves 24% and 35% of irrigation water at nursery bed level and at total system level respectively compared to rose can watering system. Micro sprinklers increase the N, P, K concentrations of the total plant to an extent of 14%, 10%, 11% and uptake per unit area to an extent of 50%, 45%, 47% respectively over the rose can watering. Micro sprinklers increase the weight, height, root volume and number of transplantable seedlings by 19%, 16%, 31%, 18% respectively over the rose can watering (Krishnarao *et al.*, 2014). Fertilizers also can be applied through the same system. This method saves the fertilizers to an extent of 20%. Micro sprinklers system is an economically viable strategy which saves labour and improves water and nutrient use efficiency.

In SLS, SBS and KLS regions, the crop is experiencing excess and deficit water stress in the same crop season.

Mitigation Measures for Deficit and Excess Water Stress Situation

Water deficit and excess influence the growth, yield and quality of tobacco. Water requirement of tobacco depends upon growth rate, availability of water in the soil and climatic conditions. Water use by the plant increases with the plant growth after transplanting and decreases as the plant matures. The possible measures to be advocated when water deficit condition prevails during the crop growth are a) Providing life saving irrigations with good quality of water (< 50 ppm chlorides), b) Shallow intercultural operations for weeding and loosening the soil around the plant, c) Foliar application of potassium nitrate @ 1% for sustaining the crop growth and increase drought tolerance and d) Timely harvesting of the leaves. When monsoon is delayed the best mitigation strategy is dense planting.

Tobacco is very sensitive to excess water stress. It stops gas exchange between the soil particles and atmosphere and seriously impedes the flow of oxygen to active root surfaces and to the microorganisms in the soil. Under excess moisture situations the measures to be taken are a) Excess water should be drained out of the field, b) Intercultural operations are to be taken up as soon as possible at optimum moisture conditions, c) Crop is to be supplemented with 10 kg N/ha and or foliar nutrition of potassium nitrate @ 1% to compensate leached nutrients, d) Timely topping and sucker control to avoid fast maturity, e) Timely harvesting of leaves to avoid over ripening, f) Removal of excess water from the harvested leaves and providing sufficient aeration in curing barn during yellowing and colour fixation to avoid barn rot.

FCV tobacco is grown under irrigated conditions in NLS region of Andhra Pradesh. Irrigation through furrow system is the general practice in NLS which consumes more irrigation water. Generally > 10 irrigations are given to tobacco crop in this region. Excess use of water is leading to depleted water table. There is need to advocate water use efficient irrigation systems for water conservation. Drip irrigation on alternate days for 15-30 minutes with drippers on all ridges improves the water and nutrient use efficiency. The consumptive use of irrigation water is only 172 ha mm in drip irrigation with higher water use efficiency of 11.2 kg/ha mm. Drip irrigation saves 50% of irrigation water over furrow irrigation. Fertigation with drip will save 20% of applied fertilizers besides significant improvement in yield compared to furrow irrigation. Sub surface irrigation with change in plant geometry will have further advantage in minimizing the water use. FCV tobacco grown as semi monsoon crop during *rabi* season in SLS region is to be given one or two irrigations depending on the north monsoon rains. The crop grown in SBS region with conserved soil moisture is not given any irrigation generally. Under transitional zone of Karnataka the crop is grown under monsoon and no irrigation is provided.

Success of tobacco farming depends on the rain water harvesting during excess rainfall and efficient recycling during deficit period. A micro water shed developed at CTRI Research Station, Kandukur and details of lined farm pond are given as examples for efficient utilization of cyclonic rain water in rainfed ecosystem.

Micro Water Shed – Rain Water Harvesting and Recycling Through Networking of Ponds at ICAR-CTRI Research Station, Kandukur

ICAR-CTRI Research station located at Kandukur in Prakasam district of Andhra Pradesh is prone to both drought and cyclones. The area receives rainfall from both South-West monsoon and North-East monsoon. The main crop is tobacco and the cropping period is October-February, which coincides with North-East monsoon. Although ground water is available in some pockets, it is not fit for irrigation as it contains high salts, particularly chlorides, which affect the quality of tobacco crop. The solution lies in the harvesting of rain water and its recycling, as there is good potential due to frequent depressions in Bay of Bengal resulting in heavy down pour.

The area was surveyed for delineating micro-watershed using “Total Station Survey Equipment” and different thematic maps were prepared. CTRI Micro watershed is covered in top sheet number 57M/16, Nellore and Prakasam districts, with North latitude $79^0$55’45" and East longitude of E 15^0 13’33" with a permanent bench mark at 16.53 m mean sea level (MSL). This micro-watershed falls under Mutteru basin, Index No 086/128. Catchment -4, Sub-Catchment -A and watershed code no 74 that drains in to Manneru River which in turn joins into Bay of Bengal. Waterways were designed based on catchment area of different fields, rainfall intensity and peak flow rate for safe disposal and harvest of rain water. A total length of 3926 m of waterways was dugout for networking of different structures.

Capacity and Catchment Area of Different Storage Structures

S. No.	Farm pond/ Percolation pond	Catchment area(ha)	DimensionsTop-Bottom-Depth (m)	Excavated Volume (m^3)	Storage capacity (m^3)
1	Farm pond-1	2.0	16 x 16 m8.4 x 8.4 ; 3.8 m	580	500
2	Farm pond-2	2.5	16.5 x 16.5 m8.5 x 8.5 ; 4.0 m	645	550
3	Farm pond-3	3.7	28.5 x 20.0 m20.1x11.4 ; 4.20m	1575	1275
4	Farm pond - 4	4.7	32.5 x 19.0 m + *23.5 x 8.0 ; 4.5 m	2300	1900
5	Farm pond - 5	2.0	16.5 x 16.5 m8.5 x 8.5 ; 4.0 m	645	580
6	Farm pond-6	2.7	16.5 x 16.5 m 8.5 x 8.5 ; 4.0 m	645	560
7	Percolation pond-1	3.0	18.5 x 18.5 m 8 x 8 ; 4.5 m	900	790
8	Percolation pond-2	2. 5	18.5 x 18.5 m 8 x 8 ; 7.0 m	1400	1065
9	Percolation pond-3	3.9	19.5 x 18.5 m 8.5 x 8.5 ; 6.5 m	1000	800
10	Roof rain water harvesting structure	400 m^2	8.0 x 5.0 m2.9 m	116	100

A total capacity of 8020 m^3 was harvested from catchment of 26 ha of farm land, which comes to an average of 308 m^3 ha^{-1}. The volume of water harvested was sufficient enough for irrigating 10 ha area by flood method (40 mm depth) after considering the losses due to evaporation and seepage.

Details of Lined Farm Pond: Tobacco nursery is being raised using harvested rain water at CTRI Research Station farm, Kandukur every year.

Water budgeting of lined farm pond (brick lining in cement mortar 1:6) having a dimension of 16 m X 16 m top, 8.4 m X 8.4 m bottom and 4 m depth

S.No	Particulars	Magnitude
1	Full capacity of farm pond by October end (m^3)	580
2	Catchment area (ha)	3.7
3	Water loss by evaporation from October to December (m^3)	123
4	Water available for irrigation (m^3)	457
5	Water requirement for one irrigation for one hectare at 25 mm depth for furrow method of irrigation (m^3)	250
6	Area irrigated with available water (ha)	1.83

This region receives rain during *rabi* season due to cyclones. The intensity of the rain is high during cyclonic period and the ponds get filled. Normally there is possibility of two filling in one season. One filling can be used for raising nursery and another for supplemental irrigation to field crop of tobacco.

NON-MONETARY INPUT MANAGEMENT IN FCV TOBACCO

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Introduction

Agriculture has always been the prominent sector playing a major role in determining the country's sustainability and economic growth. Tobacco is one of the most economically significant agricultural crops in India. Although, tobacco is grown in more than 100 countries, four countries viz., Brazil, China, India and the United States account for two thirds of total global production. Flue cured Virginia tobacco (FCV) is grown in India in four agro-climatic zones namely Traditional Black Soils (TBS), Northern light soils (NLS) and Southern Light Soils (SLS) in Andhra Pradesh and Karnataka light soils (KLS) in Karnataka. FCV is grown in different types of soils viz., sandy, sandy clay loam, clay loam, silty clay loam, red soils and red loamy. Non-monetary inputs are defined as those operations which help to achieve high yield at no extra cost and whose cost does not change with the level of output. Some of the non-monetary inputs in crop production are: choice of suitable varieties, tillage, time of sowing or planting, optimum plant population, timely inter-cultivation, fertilizer application based on soil test and timely weed management.

Selection of Suitable Variety: Number of tobacco varieties that are high yielders suitable to different soil types and resistant / tolerant to pest and disease have been developed.

Selection of Good Quality Certified Seed

Purchase of certified seed in time before commencement of the crop season in Andhra Pradesh and Karnataka through CTRI.

Desirable Qualities of Tobacco Seedlings for Planting in Main Field

- Pencil thick 50-60 days old
- Not too green or not too pale in color
- Devoid of ammonia effect
- Hardened seedlings
- Prefer reset seedlings
- Prefer disease and pest free seedlings
- Prefer tray seedlings for better establishment

Suitability of Soil and Water for FCV Cultivation

Tobacco is very sensitive to the physical and chemical properties of the soil. The best soils are light, well drained and properly aerated. Tobacco plant is highly susceptible to injury from flooding or water logging. Growers are advised to go for soil and water analysis and find out the suitability of soil for cultivating FCV tobacco and on usage of correct doses of fertilizer for improving quality and yields.

- The desirable pH is about 5.0-6.0
- Reasonable OM content in the soil
- Very low chloride content (<100 ppm)

Table: Cultural Practices Followed in FCV Tobacco Under Different Soil Domains

Cultural practices	NLS	SLS	KLS	TBS (NBS, SBS, CBS)
Varietal selection	Kanchan (tolerant to black shank and nematodes), McNair-12, Gold Streak	Gowtami, Hema (Resistant to TMV) VT1158 (TMV resistant) and Kanthi (withstands moisture stress)	Kanchan (K326 or NLS-4) & Thrupti (tolerant to black shank and nematodes), FCH-22, Swarna (resistant to powdery mildew), Ratna and Bhavya	Gowtami, Hema (Resistant to TMV) VT1158 (TMV resistant) Hemadri and Siri (HYV)
Optimum time of planting	September-October	September-October	April-May	October-November
Harvesting time	December-February	December-January	July-August	December-February
Preparatory cultivation	Discing with tractor with the onset of monsoon	Deep ploughing between July and September	Deep ploughing in March and April	Deep ploughing in summer
Organic manures	Sunhemp green manuring and application of FYM @ 10-12 t/ha or sheep/cattle penning	FYM @ 5 t/ha	FYM @ 8-10 t/ha	FYM @ 7.5 t/ha(NBS) and 8-10 t/ha (SBS)
Spacing	100 cm × 60 cm (16,666 plants/ha)	75 cm × 50 cm (28,571 plants/ha)	100 cm × 60 cm (16,666 plants/ha)	70 cm × 50 cm or 70 cm × 70 (28,571 or 20,408 plants/ha)
Method of planting	Flat planting followed by ridging on 40th day	Flat planting followed by ridging/earthing up	Flat planting followed by ridging	Flat planting
Fertilization dose (N: P_2O_5: K_2O kg/ha	115 : 60 : 120	60 : 60 : 60	60 : 40 : 120	60: 40: 40 (SBS) 50:50:50 (NBS)
Method of Fertilization	Dollop*	PRPF (Plant row plough furrow) Method	Dollop	PRPF
Intercultural operations	5 to 6 times	2 or 3 times	4 or 5 times	2 (one at 20 DAP and 50 DAP)

*10 cm to both sides and 10 cm in holes

Preparatory Cultivation

The cultural operations recommended for successful production of FCV tobacco depend on the agro-climatic conditions under which they are grown.Besides, they should also envisage the cost of such operations to make them economical and within easy reach of the average farmer and to achieve maximum benefits from the minimum necessary operations.Secondly, the nature and intensity of tillage operations vary from region to region and soil type to soil type. In most of the tobacco areas in Andhra Pradesh, the field is kept fallow till September even though monsoon rains are received by the middle of June.

In black soils where major portion of flue-cured tobacco is produced the soils crack deep in summer and become very sticky with the onset of rains. There is more of run-off than infiltration. In such soils summer ploughing resulted in substantial increase in both tobacco yield and quality. In irrigated northern light soils, digging the soil with tractor soon after harvest of tobacco or during summer with the onset of rain at proper moisture is essential as it helps in exposing and killing nematodes, soil borne pathogens, pests and weeds. In southern light soils, wherever possible the field should be ploughed by a tractor during summer to expose weed seeds, roots, soil pathogens and insect pests to scorching sun/heat of summer. Deep ploughing once with mould board plough between July and September at proper moisture followed by harrowing with tractor drawn/bullock drawn cultivator, 2-3 times is required to get proper tilth and keep the weeds under check.

Deep Summer Ploughing is recommended in all the tobacco growing soil types. In heavy clay soils mould board plough is used, where as in light soils disc ploughing is done.

Advantages

- Highly beneficial in minimizing the weeds and *Orobanche* menace
- Reducing insect-pest and disease problems
- Improving the water and nutrient conserving capacity of the soil. Increase in yield and quality of tobacco up to an extent of 15%

Overall, tillage operations includes one or two ploughings with mould board and disc plough followed by two cross ploughings with cultivator followed by planking for leveling of the field.

Optimum Time of Planting

The optimum time of planting is decided by taking into consideration the weather conditions prevailing in the particular region favorable for certain stages of crop growth. Sometimes early plantings are damaged by heavy rains and late plantings suffer from moisture deficiency.

Method of Planting

After field preparation position of plant is marked by running a marker in cross directions with bullock drawn marker or tractor. Planting is done manually on markings. Planting is done at the edge of the small furrows in NLS after giving a light irrigation.

Optimum Plant Population

- Broad leaf types are spaced wider than narrow leaf types.
- Wide spacing allows maximum expansion and thickness of leaves.
- Gap filling should be done within a week of planting to maintain the plant population. To ensure uniform growth of the main crop.
- Tray seedlings or polythene bag seedlings are preferable.

Improvement of Soil Health through Organic Manures and Green Manuring

Organic manures are essential for maintaining soil health, which increase the yields by 10-15% and imparts flavor and taste to tobacco. Application of organic and inorganic fertilizers in 25:75 ratio improved the yield and quality of tobacco in different zones. Addition of FYM will correct the micronutrient deficiency in nursery and main field. *In-situ* green manuring with green manure crops like Sunnhemp, Dhaincha, Pillipesara for improvement of soil health. FYM, groundnut cake and green leaf manuring on equal nutrient basis is also effective in FCV production.

Advantages of Green Manuring

- Reduces runoff
- Crop rotation
- Smothering of weeds
- All essential plant nutrients are returned to the top soil in a balanced ratio from deeper layers

Fertilizer Application Based on Soil Test

Based on soil type the fertilizer doses, time and method of application of fertilizers are recommended. Application of right type of fertilizers, right dose, right method and right time will enhance the fertilizer use efficiency. In heavy soil (vertisols and red clay loams) the fetilizers are applied before planting in plant row plough furrow (PRPF) method. In light soils (sandy to loamy sands) the fertilizers are applied in 2-3 splits in dollop method. Chloride containing fertilizers should not be applied to smoking tobacco as it impairs the burning properties of tobacco.

Intercultivation

Number of intercultural operations vary according to the need in different soil types in FCV tobacco. In case of vertisols, 2-3 intercultural operations are to be done at fortnightly intervals by working with a three tyned hoe in cross directions. First intercultivation is usually done about 10-15 days after planting when the plants are well established and final intercultivation is done deeply with country plough to prevent cracking of the soil. In souther light soils of A.P, the crop may benefit by periodic interculture of 2-3 times keeping the soil in a fit condition to absorb maximum precipitation. In KLS tobacco, about 4-5 intercultural operations at 8-10 days interval should be taken up during the crop growth period. Initially shallow intercultural using tyned harrows 2-3 times followed by passing country plough 2 times and final ridging the crop at 45-50 days using ridger. In NLS region during the initial stages, when the plants are small a light intercultivation is given with 4-tyned harrow. Thereafter, in subsequent intercultures 3 and 2 tyned harrows are used. Generally 5-6 intercultivations are needed, it depends upon the weed population, soil type and irrigation frequency and rains.

Advantages of Intercultivation and Ridging

- Control weeds
- Breaks the upper soil crust and loosens the soil to aid water penetration and soil aeration
- Builds up row ridges in light soils to reduce drowning, leaching and wind and cyclone damage

Timely Weed Management

Frequent intercultivations during crop growing period will take care of the weeds. However, the weeds have to be collected from the field and destroyed. As one way inter cultivation is only possible in light soils, after ridge formation, the row middles are generally weed free. Weeds are found to grow on the ridges within the space between plants. In KLS tobacco region, weeds should be removed manually at 15-20 days and at 35-40 days after planting to avoid competition for moisture and nutrients. *Orobanche* is menace in southern light soils and southern black soils. Integrated approach is the effective method for management of *Orobanche* combining following viable measures viz., deep summer ploughing, application of fully decomposed FYM, clean agricultural practices.

Crop Rotation

Mono-cropping in tobacco is always discouraged as it leads to development of pest and disease complex in addition to decreasing soil health. Crop rotations not only gives additional returns but also provides insurance against crop failures and improves soil health in the long run. Suitable crop rotations are worked out in tobacco growing regions without affecting the quality of tobacco.

Northern black soils	:	Maize – Tobacco, Sorghum-Tobacco
Central black soils	:	Sesamum –Tobacco
Sothern Black soils	:	Sesamum-Tobacco
Northern light soils	:	Sorghum/Sesamum-Tobacco
Southern light soils	:	Sesamum/Groundnut tobacco
Karnataka light soils	:	Tobacco –Ragi/Sesamum

Practical exercise on Fertilizer Dose Calculation in FCV Tobacco

Fertilizers like ammonium sulphate, Di ammonium phosphate and calcium ammonium nitrate as source of nitrogen, single super phosphate, Di ammonium phosphate as a source of phosphorus and potassium sulphate as source of potassium are used for tobacco.

Table: Nutrient contents of different fertilizers used in FCV tobacco

Fertilizer	N (%)	P_2O_5(%)	K_2O (%)	S (%)	Ca (%)
Ammonium Sulphate (AS)	20.6	-	-	24	-
DAP $(NH_4)_2HPO_4$	18	46	-	-	-
SSP Ca $(H_2PO_4)_2$ $CaSO_4$	-	16	-	11-12	20
SOP (K_2SO_4)	-	-	50	18	-

Practical exercises

1. **If a farmer in KLS region wishes to apply 60 kg of Nitrogen to his 1 ha tobacco main crop, how much amount of the ammonium sulphate (20% N) is required is required?**

Calculations

Amount of ammonium sulphate required = Rate of N application (kg/ha)/Content of N in AS (%) × 100

= 60/20 × 100 = 300 kg AS

AS required per acre

= 300 × 0.4 = 120 kg

2. If a farmer in NLS region of Andhra Pradesh wants to apply 115 kg of Nitrogen to his 10 acre tobacco main crop, how much amount of ammonium sulphate (20% N) is required ?

Calculations

Amount of ammonium sulphate required = Rate of N application (kg/ha)/Content of N in AS (%) × 100

= 115/20 × 100= 575 kg AS

AS required per 10 acre

= 575 × 4 = 2300 kg

3. Calculate the quantity of ammonium sulphate, single super phosphate and sulphate of potash required for 10 ha farm of tobacco crop. If the recommended doses of N, P_2O_5 and K_2SO_4 for tobacco crop in NLS region are 115, 60 and 120 kg/ha, respectively.

Amount of AS required = Rate of N application (kg/ha)/Content of N in AS (%) × 100 × Area

= 115/20 × 100 × 10

= 5750 kg AS

Amount of SSP required = Rate of P_2O_5 application (kg/ha)/Content of P_2O_5 in SSP (%) × 100 × Area

= 60/16 × 100 × 10

= 3750 kg SSP

Amount of SOP required = Rate of K_2SO_4 application (kg/ha)/Content of K in SOP (%) × 100 × Area

= 120/50 × 100 × 10

= 2400 kg SOP

4. Calculate the quantity of ammonium sulphate, single super phosphate and sulphate of potash required for 10 acres farm of tobacco crop. If the recommended doses of N, P_2O_5 and K_2SO_4 for tobacco crop in KLS region are 60, 40 and 120 kg/ha, respectively.

Amount of AS required = Rate of N application (kg/ha)/Content of N in AS (%) × 100 × Area

= 60/20 × 100 × 4

= 1200 kg AS

Amount of SSP required = Rate of P_2O_5 application (kg/ha)/Content of P_2O_5 in SSP (%) × 100 × Area

= 40/16 × 100 × 4

= 1000 kg SSP

Amount of SOP required = Rate of K_2SO_4 application (kg/ha)/Content of K in SOP (%) × 100 × Area

= 120/50 × 100 × 4

= 960 kg SOP

5. A farmer has to apply 60 kg N/ha, 60 kg P_2O_5/ha and 60 kg K_2SO_4 to tobacco crop of 1 ha area in SLS region. The available fertilizers are ammonium sulphate, Di ammonium phosphate and sulphate of potash. What quantity of each fertilizer is required to meet out his requirements?

Amount of DAP required = Rate of P_2O_5 application (kg/ha)/Content of P_2O_5 in DA P (%) × 100

= 60/46 × 100 = 130.43 kg DAP

When we apply 130.43 kg DAP some amount of N is also applied

N supplied through DAP = Amount of DAP applied(kg/ha)/100× Content of N in DAP (%)

= 130.43 / 100 × 18 = 23.47 kg N

Requirement of N through AS (kg/ha) = Total N required (kg/ha) – N supplied through DAP

= 60-23.47 = 36.53 kg

Amount of AS required = N application rate(kg/ha)/Content of N in AS(%) × 100

= 36.53/20 × 100 = 182.65 kg AS

Amount of SOP required = Rate of K_2SO_4 application (kg/ha)/Content of K in SOP (%) × 100

= 60/50 × 100 = 120 kg SOP

6. A farmer has to apply 60 kg N/ha, 50 kg P_2O_5 /ha and 50 kg K_2SO_4 to tobacco crop of 1 ha area in SBS region. The available fertilizers are ammonium sulphate, Di ammonium phosphate and sulphate of potash. What quantity of each fertilizer is required to meet his requirements?

Amount of DAP required = Rate of P_2O_5 application (kg/ha)/Content of P_2O_5 in DA P (%) × 100

= 50/46 × 100 = 108.69 kg DAP

When we apply 108.69 kg DAP some amount of N is applied

N supplied through DAP = Amount of DAP applied(kg/ha)/100× Content of N in DAP (%)

= 108.69 / 100 × 18 = 19.56 kg N

Requirement of N through AS (kg/ha) = Total N required (kg/ha) – N supplied through DAP

= 60-19.56 = 40.44 kg

Amount of AS required = N application rate(kg/ha)/Content of N in AS(%) × 100

= 40.44/20 × 100 = 202.2 kg AS

Amount of SOP required = Rate of K_2SO_4 application (kg/ha)/Content of K in SOP (%) × 100

= 50/50 × 100 = 100 kg SOP

AGRONOMIC PRACTICES FOR FCV TOBACCO FIELD CROP IN NORTHERN LIGHT SOILS

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Introduction

Tobacco is grown in almost all parts of the world. Tobacco is one of the most economically significant agricultural crops in the world. It is a drought tolerant, hardy and short duration crop which can be grown on soils where other crops cannot be cultivated profitably. Tobacco crop is grown in more than 15 states, but major tobacco growing states are Andhra Pradesh, Gujarat, Karnataka, Uttar Pradesh, West Bengal and Bihar. Of the total tobacco production, the Flue-cured Virginia [FCV] tobacco is grown in 2.0 lakh hectares and accounts for about 40 %(300 mkg) of total tobacco production.

The term 'flue cured', first used to describe bright tobacco derived from the system of metal flues used to distribute the heat over the floor of the curing barn. The production of flue-cured Virginia (FCV) tobacco is about 300 million kg from an area of 0.20 M ha in India. India has the capacity to produce different styles of tobacco ranging from colour neutral filler to flavourful leaf catering to the needs of a wide variety of customers globally. In addition, production and processing costs of tobacco are also quite low in India, thus making the Indian tobacco price-competitive and value for money. Flue cured virginia tobacco is grown in India in four agro-climatic zones namely Traditional black soils (TBS), Northern light soils (NLS) and Southern light soils (SLS) in Andhra Pradesh and Karnataka light soils (KLS) in Karnataka.

FCV Tobacco Production Practices in NLS

The amount of cured tobacco suitable for various tobacco blends are determined by their physical and chemical properties which inturn are the products of interactions among genetic, soil, climatic and cultural factors. The cultural operations recommended for successful production of different types of tobacco depend on the agro-climatic conditions under which they are grown.

Climatic Factors

One of the important factor which affects tobacco growth is the climate. Rainfall, temperature, relative humidity, wind and sunlight exercise marked influence on growth, flowering and metabolism of tobacco plant. To maintain turgidity and expansion of its enormous leaf area, tobacco plant needs considerable amount of water.

Tobacco is tropical in origin, but it is grown successfully under tropical, sub-tropical and temperate climates. In India, tobacco is grown under a very wide range of conditions from the coast-line to an altitude of 3,000 feet. In the South, the crop is raised in winter from October to March when the temperatures are moderate.

Tobacco plant is remarkably sensitive to the environment. Ideal conditions required for successful production of high quality leaf are: 1) a liberal and well-distributed rainfall during active vegetative growth stage 2) long day lengths 3) a mean temperature of 80°F (26°C) during growing season and 4) a high relative humidity of 70-80%.

NLS Climatic Conditions

Rainfall	:	Range 800 - 1561 mm (Average =1100-1200 mm)
Mean temperature	:	23°C
Relative humidity	:	70-80 % morning; 50-60 % Mid day
Day length during peak growing period	:	11.2 hrs. in January

Soil

Tobacco is very sensitive to the physical and chemical properties of the soil. Soils which are open, well drained and properly aerated are best suited for tobacco cultivation. The plant is highly susceptible to injury from flooding or inundation of the soil. The desirable soil pH is 5.0 to 6.0.

Typical characteristics of soils best suited to the production of high quality Flue-cured tobacco are (1) sandy surface soil up to 15 to 25 cm depth (2) yellowish or a reddish sandy clay subsoil extending up to a depth of 150 cm (3) acidic soil reaction of pH 5.5 to 6.5 (4) low reserve of essential plant nutrients (5) reasonable organic matter content and (6) very low chloride content (less than 100 ppm).

Northern light soils (East Godavari and West Godavari of A.P. and Khammam district of Telangana) are sandy loams to loamy sands, slightly acidic, very low exchangeable cations, low water holding capacity, poor fertility status with very good drainage. Tobacco is grown in these soils under irrigated conditions during winter.

Nursery Management

Tobacco crop is raised by transplanting seedlings in the main field and so successful production of healthy transplantable seedlings is important and forms part of cultural practices. Seedlings should be produced from recommended varieties. Seedlings of pencil thickness and of 10 to 15 cm length are normally preferred from conventional nurseries beds. Tray seedlings are preferred for their uniformity in the field and also to avoid soil associated problems.

Preparatory Cultivation

In all the tobacco growing soils deep summer ploughing is invariably recommended. In light soils, disc ploughing is used for summer ploughings. The practice is found highly beneficial in minimizing weeds and *Orobanche* menace, reducing insect pest and disease problems and improving water and nutrient conserving capacity of the soil. With summer ploughing substantial increase of 15% in both yield and quality was observed

Pre-planting tillage operation includes one or two ploughings disc plough followed by two cross ploughings with cultivator followed by planking for levelling the field. Use of single planking helps in collection and removal of weeds and stubbles from the fields. The tillage operation must be completed before planting time.

Planting

The optimum time for planting is governed by taking into consideration either escaping certain periods of adverse weather or of taking advantage of periods of favourable weather conditions during certain stages of the crop. In Andhra Pradesh, the normal period of planting is from mid-October to mid-November. In the light soils of West Godavari district, planting early in the season, i.e., by the end of September or early October was found better than late plantings.

Generally, spacing is wider in soils of low fertility than in soils of high fertility. Wide-spacing allows maximum expansion and thickness of the leaf; narrow-spacing tends to produce small and thin leaves. In Northern light soils 100 x 60 cm is recommended with 16,666 plants per ha.

Planting is done manually. After final preparation of the land, position of the plant is marked by running a marker in cross directions. Planting is done at the edge of the small furrows in NLS after giving a light irrigation

Nutrient Management

Application of organic manures is essential for management of soil health. The organic manures in addition to improving the soil health and increasing the yields by 10-15%, impart the required flavour and taste to the tobacco as per the consumer's preference. The requirement of organic manures in addition to inorganic fertilizers has been worked out for FCV tobacco by Central Tobacco Research Institute and its Research Stations and recommended to the farmers. Application of organic and inorganic fertilizers in 25:75 ratio improved the yield and quality of tobacco in different zones. In a study on organic manures it was concluded that groundnut cake, FYM and GLM on equal nutrient basis are equally effective in the production of FCV tobacco.

In NLS 10-12 FYM/ FPC or *insitu* green manuring with sunnhemp is recommended as integrated nutrient management.

- Fertiliser recommendation is 115:60:120 kg NPK/ha in light soils (sands to loamy sands) and these fertilisers are applied in three splits in dollop method. In this method the fertilisers are applied 10 cm away from the plant on either side at 10 cm depth by making a hole with a stick and the holes are covered after application. Basal fertiliser should contain 100% P (as it is not subject to leaching), 25% N in ammoniacal form and 25% K (chloride free) because both N & K are subject to leaching in light (sandy) soils, to be applied at 10 days after planting.Top dressing of 1^{st} split contains 50% N (in nitrate form at least partially) and 50% K is applied at 25 days after planting. Top dressing of 2^{nd} split contains 25% N (in nitrate form at least partially) and 25% K.

Chloride containing fertilisers should not be applied to smoking tobaccos as it impairs the burning properties of tobacco. Fertilisers like ammonium sulphate, calcium nitrate, diammonium phosphate, urea, as sources of nitrogen, superphosphate and diammonium phosphate as sources of phosphorus and potassium sulphate as source of potassium are recommended for FCV tobacco cultivation.

Intercultivation

Generally 5-6 cultivations are needed and it depends on weed population, soil type, Irrigation frequency or rains. Intercultivation is done with a three-tyned hoe two or three times at fortnightly intervals by working the hoe in cross directions. The first cultivation usually commences about 10 to 15 days after planting when the plants are well established.

In the case of irrigated crop, the soil in the furrow which has a tendency to form hard crust is broken by harrow and the ridges reformed to increasing heights with each progressive irrigation. It reduces weed growth, improves soil aeration and water penetration and can be used to form a large row ridge which drives excess water to row middles and thus reduces the risks of drowning and loss of leachable nutrients when unwanted rains are received under irrigated Alfisol (NLS) conditions

In light soils, interculture from about 40 days after planting is done by ridger to throw up the soil beside the plants in the planting row and formation of high ridges progressively should completed by 60 days. Intercultivation between one irrigation and the next avoids surface run off and aids in percolation of water into the soil

Topping & Sucker Control

Tobacco plant has a determinate growth form with apical dominance. Once the flower head makes its appearance there will be no further meristematic growth on the main stalk. Removal of flower bud (Topping) takes away the apical dominance and the buds in the top 3 to 4 axils grow rapidly to replace the plants reproductive capabilities. In the case of light soil irrigated conditions, it is ideal to top the plant at the button stage.

Topping and the removal of subsequent suckers forms a composite operation. If suckers are not removed there is no use of topping. Tobacco plant normally has three axillary buds in the axils of each leaf. Growth pattern of the axillary buds show that suckers from the axils of top three leaves show determinate type of growth and may produce 6-7 internodes before ending as flower head. Suckers emerging from the axils of bottom leaves show indeterminate growth and have the capacity to produce 20-25 internodes before ending as flower head.

Sucker control can be done either manually or by chemical methods. Application of neem oil emulsion 15-20% in the top 5-6 axils controls the suckers considerably. C - C fatty alcohols in the form of emulsions (Decanol or Rayalten 4% or Suckerout) control the suckers effectively. All these are contact suckericides.

Irrigation Water Management

Water requirement of flue-cured and other tobaccos depend upon the growth, the availability of water in the soil and the climatic conditions. Water use by the plant increases to a maximum about 7 to 9 weeks after transplantation and then decreases as the plant matures. In Andhra Pradesh FCV tobacco grown in northern light soils (Alfisols) is given 12-13 irrigations while the same tobacco grown under southern light soils is given one life saving if good quality water is available.

Furrow Irrigation

Irrigation through all furrow system is a general practice in NLS crop, but it consumes more irrigation water and labour; and leaching losses of nitrogen and potassium are also more. The alternate skip furrow method of irrigation is more economical and checks the wastage of irrigation water and time. It improves the leaf quality and gives 10-20% higher yield than all furrow irrigation. Irrigation schedule for northern light soils growing FCV tobacco are given below.

Table 3: Irrigation schedule for northern light soils FCV tobacco

Irrigation	Days of planting	IW (ha mm)
	At the time of planting and 3rd day after planting in plough furrow	10+10
1st	15-20th day by plough furrow after basal dose of fertilizer	20
2nd	30-35th day after planting as surface irrigation	25
3rd	40-45th day by all furrow irrigation immediately after ridge formation	50
4th	50-55th day by all furrow irrigation	50
5th	65-70th day by all furrow irrigation	25
6th	80-85th day by alternate skip furrow method (ASFM)	20
7th	95-100th day by ASFM	20
8th	115-120th day by ASFM	20
9th	125-130th day by ASFM	20
10th	135-140th day by ASFM	20
11th	142-147th day by ASFM	20
12th	150-155th day by ASFM	20
	Total water requirement	340

In alternate skip furrow method, in the subsequent irrigations, first irrigated furrows are avoided and the un-irrigated furrows are irrigated. The same order is followed in consecutive irrigations.

Micro-sprinkler irrigation

In tobacco nurseries water is applied 3-6 times/day through rose-cans manually, which is labour intensive and involves high scale drudgery. To improve the water and nutrient use efficiency and also to reduce the labour cost in tobacco nursery raising, micro irrigation systems is the best method. The optimum spacing between laterals is 2.5-3.0 m and the spacing between micro sprinklers is 2.5–3.0 m and for this spacing 4 sprinklers are required for irrigating two tobacco nursery beds. The micro sprinkler system saves 24% and 35% of irrigation water at nursery bed level and at total system level respectively in comparison to rose can watering system. Micro sprinklers increases the N, P, K concentrations of the total plant to an extent of 14%, 10%, 11% and uptake per unit area to an extent of 50%, 45%, 47% respectively over the rose can watering. Micro sprinklers increases the weight, height, root volume and number of transplantable seedlings by 19%, 16%, 31%, 18% respectively over the rose can watering.

Drip Irrigation

In irrigated Alfisols (NLS) Drip irrigation on alternate days with drippers on all ridges gave significantly higher cured leaf yield and grade index with higher water use efficiency. The consumptive use of irrigation water is only 172 ha mm in drip irrigation with a high water use efficiency of 11.2 kg/ha mm. Fertigation at 80% RDF with soluble fertilizers through drip irrigation improved the yield and saved the fertilizers to an extent of 20%. As the water table is depleting we should go for drip irrigation to reduce the water requirement and also the to reduce leaching losses of nutrients in irrigated conditions.

Harvesting

Flue-cured tobacco is harvested by priming i.e. two or three leaves which have completed their growth and turning from green to yellowish green or slightly yellow in colour are detached from the plant in sequence as they ripen from the bottom to the top of the plant. Priming at the right maturity is essential. Immature leaves are gummy and on curing may turn out thick, close grained and poor in combustibility and filling power. On the other hand, over mature leaves may become the scrappy and less elastic. Greater porosity and graininess is achieved when tobacco is harvested only at right maturity. Ripe tobaccos give better grades and monetary returns than either unripe or over ripe tobaccos.

Ripe leaves per plant are removed by hand in each of several passes over the field during a period of 6 to 12 weeks after topping, and the number of primings varies depending on the leaf number (which may vary from 18 to 26 leaves) temperature, rainfall/ irrigation, soil productivity and N fertilization. After the commencement of the first priming, subsequent primings are taken in about 6 to 7 days intervals unless affected by rains.

Cropping Systems for Enhancing Farm Returns

As tobacco is grown during *rabi* October and November and with irrigation facilities available there is scope for crop intensification in this area. Development of sustainable tobacco-based copping systems for a particular zone plays a vital role in getting maximum monetary returns. It was possible to grow short duration *Kharif* crops successfully before *Rabi* tobacco taking the advantage from south-west monsoon rains and by giving one or two need based irrigations. From crop sequential studies it was observed that the cropping system blackgram - tobacco – maize recorded significantly higher net returns than other systems followed by greengram - tobacco - fodder sorghum. This was due to increased cropping intensity with inclusion of *Kharif* and summer crops in the system and which was found to be a sustainable cropping system.

In a study on alternative crops / cropping systems for low fertile, tobacco growing soils areas revealed that the net returns obtained were higher for tobacco followed by redgram + maize – greengram and redgram + groundnut – greengram system.

From the study it was concluded that net returns of not a single crop but only cropping systems are comparable with tobacco. However, redgram + maize – greengram and redgram + groundnut – greengram systems fetched the net returns nearer to that of tobacco .

Relay Cropping in Tobacco: Growing of bottle gourd/watermelon/ground nut as relay crop after 5-6 harvests of FCV tobacco planted with the recommended spacing of 100 X 60 cm on both sides of the tobacco ridge in Northern light soils of Andhra pradesh gives additional income to the farmers. Some of the farmers are following this practice for increased farm returns.

AGRONOMIC PRACTICES FOR FCV TOBACCO FIELD CROP GROWN IN SLS AND SBS

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Introduction

Tobacco is an important commercial crop cultivated under varied agro-climatic conditions. It occupies third position in the world with an annual production of about 800 million kg. Of the different types of tobaccos grown, flue-cured tobacco is one of the important types of tobacco grown in Andhra Pradesh and Karnataka. In Andhra Pradesh, FCV tobacco is grown during *rabi* season by making use of conserved soil moisture in Southern Black Soils (SBS), using north-east monsoon rains in Southern Light Soils (SLS) and under irrigated conditions in Northern Light Soils (NLS). In Karnataka FCV tobacco is predominantly grown as rainfed crop during *kharif* season. Tobacco is grown in red sandy soils in NLS, red sandy loams in SLS and KLS and medium black to heavy black soils in SBS and TBS. Soil, water and climatic conditions required for tobacco cultivation and agronomic practices to be followed for FCV tobacco cultivation in Southern Light and Southern Black soils are mentioned in this chapter.

Soils: The ideal soil conditions required for growing tobacco are i) Light textured sandy loam or loamy sand in surface with relatively heavy textured sub surface ii) Sufficiently deep with no barriers to root growth (25 to 35 cm) and located on a gently sloping side iii) Well drained, well aerated with adequate water holding capacity iv) Slightly acidic in reaction (pH 5.5 to 6.5) v) Soils with adequate soil organic carbon content iv) Low chloride content (<100 mg kg^{-1}). Water logged and saline affected soils should be avoided for tobacco cultivation.

Water: Quality of irrigation water is an important factor in FCV tobacco production. The concentration and composition of dissolved constituents in water determines its quality. Irrigation water used for FCV tobacco should have EC of <0.4 dS m^{-1} and a chloride concentration of 50 mg L^{-1}. Chloride concentration in irrigation water is critical because of its negative role on leaf quality. With increasing levels of chloride in irrigation water the accumulation of chloride in leaf increases. Therefore, water with high chloride should not be used for irrigation to produce quality tobacco leaf. However ground water with slightly more than desired quantity of chloride can be mixed with rain water harvested from farm pond.

Climate: Climate is also one of the important factors which determine the tobacco productivity and quality in addition to soil and water. Tobacco is tropical in origin, but it is grown successfully under tropical, subtropical and temperate climates. Ideal conditions required for successful production of high quality leaf are a) liberal and well distributed rainfall during active vegetative growth b) long day lengths c) a mean temperature of 80^0F during growth season and a high relative humidity of 70-80%.

Agronomic Practices for SLS Region

Southern Light Soils: Southern light soils (SLS) of Prakasam and Nellore districts are characterized with moderate quantities of clay, neutral to slightly alkaline, limited drainage, low in organic matter, low in P and medium to high in potash. Flue-cured tobacco is grown as rainfed crop with north-east monsoon rains. Usually the crop faces moisture stress during the season. Sometimes the crop also faces water logging situation. Soils having the problem of crusting and/or hardening on drying in sandy loams or coarse red soils can be overcome by maintaining adequate soil moisture through incorporating organic manures or by light & frequent irrigation with intercultural operations.

In general, FCV tobacco growing soils are low in organic carbon content. To improve the soil organic carbon status, there is a need to add organic inputs viz., farm yard manure/ vermicompost/green manures, agri-industrial wastes to improve organic carbon content. Tobacco crop requires relatively large amount of nutrients particularly N and K. Hence there is need to replenish the soil nutrients to maintain the soil fertility. Integrated nutrient management practices potentially increase yield and quality of tobacco in addition to soil health maintenance.

Preparatory Cultivation: Wherever possible, the field should be ploughed during summer to expose weed seeds, roots, soil pathogens and insect pests to scorching sun/heat of summer. Deep ploughing once with mould board plough between July and September at proper moisture followed by harrowing with tractor drawn/bullock drawn cultivator, 2-3 times is required to get proper tilth and keep the weeds under check.

Healthy Seedling Production: Production of sturdy and healthy transplantable seedlings is prerequisite for raising successful and uniform crop in the main field.

Nutrient Management: A balanced and desirable tobacco growth can only be achieved with an adequate and well-timed supply of nutrients. Well decomposed FYM @ 4000 kg should be applied in the preparatory cultivation. General fertilizer recommendation of N, P_2O_5, K_2O for SLS region is 60-60-60 kg/ha (24-24-24 kg/acre). However, use of recommended fertilizers based on soil tests and integrated nutrient management (INM) practices are the best option. Recommended fertilizers are di-ammonium phosphate, calcium sulphate, ammonium sulphate and potassium sulphate. Fertilizers are to be applied 15 days before planting in plant row plough furrow method. Application of manures and fertilizers and markings for planting should be completed preferably between the last week of September and 2nd week of October i.e., after the cessation of south west monsoon and before the onset of north east monsoon.

Planting: Healthy and vigorous seedlings of 50 to 60 days old should be planted between mid October and mid November at 65 X 65 cm spacing. Gap filling is to be completed within 10 days after planting. As the crop is grown as rainfed crop, time of planting is uncertain due to long temporal and spatial variation in the rainfall. Normally planting is planned based on the occurrence of rainfall. Planting tray nursery seedlings by pouring water in the planting hole is ideal than wet planting after rains. Delayed planting lowers the productivity considerably.

Interculture: The first interculture is to be done with tined harrow (*gorru*) nearly 20 days after planting or after the establishment of seedlings. Harrowing with tined harrow (*gorru*) may be repeated at least twice or thrice as per the requirement and should be followed by blade harrowing once or twice to create soil mulch and check the weed growth. It also helps to create small ridges along the planting row.

Irrigation: The crop is grown as semi monsoon crop during *rabi* season in SLS region. It requires one or two irrigations depending on the north east monsoon rains. Under rain fed conditions rain water harvesting during excess rainfall and its efficient utilization during critical crop growth period is effective strategy.

***Orobanche* Management:** *Orobanche* is a flowering parasite on tobacco roots and occurs in all tobacco growing zones. It is a holoparasite and draws its nourishment from tobacco by means of haustoria attached to the roots of tobacco. It was widely recognized that no single method of control proved to be consistent, satisfactory and economical for *orobanche* control. Therefore, the efforts are made to evolve an integrated strategy for effective control. The components of Integrated *Orobanche* management (IOM) include cultural, mechanical, and chemical methods *viz.,* i) Summer deep ploughing ii) Use of trap crops Sesame, Jowar, Black gram, Green gram for a minimum of two seasons iii) Crop rotation, iv) Application of Neem cake @ 10 g/plant, v) Removing *Orobanche* stems before flowering. One such IOM module developed at CTRI comprises: growing tobacco after sesame + application of neem cake @ 10 g/plant at 30 DAT + hand pulling of *orobanche* stems was found effective and promising for *Orobanche* management.

Integrated Pest Management: Integrated pest management modules consisting of cultural, mechanical and biological means developed for different agro-climatic zones should be adapted for efficient management of insects and diseases to maintain the Crop Protection Agents (CPA) residues in tobacco cured leaf within the limits (GRLs).

Topping and Sucker Control: Topping should be decided depending on the crop growth. Judicious topping is recommended in SLS region. It is beneficial to top the crop at button stage and apply decanol 4% or suckerout 3.5% on the top 4-5 leaf axils for effective control of suckers.

Harvesting: Tobacco leaf harvesting at right maturity is the most critical step in FCV tobacco production. Stage of harvest profoundly influences the leaf chemistry and yield. When leaves are ripe they turn yellow green in color with cream color midrib and leaf tip. It is desirable to pick 2-3 leaves per plant at each harvest. Bottom leaves are to be harvested slightly on greener side, middle leaves are to be harvested when they are ripe and top leaves when they are slightly over ripe. The most desirable physical and chemical characteristics of the leaf were found in the leaves harvested at the correct stage of maturity.

Crop Rotation: In tobacco cultivation, crop rotation is essential to produce good quality tobacco. Crop rotation not only enhances the productivity but also improves soil fertility and maintains soil health. Growing of short duration *kharif* crops such as groundnut, gingelly, black gram, green gram, *bajra*, cowpea, korra helps to get additional returns in addition to improvement in yield and quality of tobacco. Growing of *kharif* crops is based on south west monsoon rains. *In situ* green manuring helps to improve the soil before tobacco. Crop rotation should be followed in a systematic way, keeping in view the soil fertility and tobacco leaf quality.

Energy Saving Strategies during Curing: Adoption of energy saving methods for curing (Low profile barn, ventury furnace, glass wool insulation, use of alternative fuels, energy plantation etc.) minimizes the use of fuel material and will go a long way in conserving the natural resources. It also reduces the production expenditure for the farmers, as curing alone accounts for more than 30 % of the total cost of cultivation.

Agronomic Practices for SBS Region

Southern Black Soils: Black soils (Vertisols) under flue-cured tobacco cultivation are characterized by high clay content (40-50%), alkaline soil environment, high fertility and impeded drainage. These soils are rich in lime and potash. Tobacco is raised as a rainfed *rabi* crop with the conserved soil moisture of south-west monsoon rains. The crop in black soils experiences moisture stress in the later period of the crop growth. Soils having high compaction and hard pans in root zone can be tackled by deep ploughing or sub soiling during preparatory cultivation to break the pan and reduce the compaction.

Summer Deep Tillage: Summer deep tillage with heavy duty tractor & crow-barring is beneficial for increased absorption and retention of rain water and to expose the weed seeds, roots and soil pathogens to the scorching sun during summer.

Preparatory Cultivation: Two or three ploughings followed by one or two harrowings at proper moisture content during the months of August-September are sufficient.

Manuring and Fertilization: In black soils, fertilizers are to be applied 15-20 days before planting in the plant rows by opening furrows at 70 cm distance and covering by a plank. Later the planting is done on the rows where fertilizers were applied. This method of fertilization is known as plant row plough furrow (PRPF) method. By this method the applied fertilizer will be best utilized by the plant. Application of 3,000 kg well decomposed FYM per acre six weeks before planting is recommended once in two years. General recommendation for this region is N, P_20_5, K_2O @ 60-50-50 kg/ha (24-20-20 kg per acre), respectively. Recommended fertilizers are di-ammonium phosphate, ammonium sulphate and potassium sulphate. However, use of recommended fertilizers based on soil tests and integrated nutrient management (INM) practices is the best option.

Plant Population and Time of Planting: Healthy and vigorous seedlings of 50-60 days old should be planted between mid October to mid November at 70 x 50 cm (28,571 plants per hectare or 11,428 plants per acre) spacing. Gap filling must be completed within 10 days after planting.

Interculture: Two intercultures in-between 20th and 50th day after planting act as soil mulch, conserve soil moisture and check the weed growth. After 50 days, blade harrow should be run once.

Topping and Sucker Control: Removal of flower head (topping) at first flower opening stage was found to increase the yield and improve the quality. Judicious topping depending on the crop growth is recommended in the black soils. To achieve the full effect of topping, suckers are to be removed periodically. Depending on the need, application of decanol or royalten 4% or suckerout 3.5% @ 10 ml/plant in the top 5-6 axils gives good control of suckers.

Harvesting: Harvesting of 2-3 ripe leaves at each picking is advisable. It is better to pick leaves of yellow shade from bottom, fully ripe from middle and a little over ripe from the top portion of the plant.

Crop Rotation: In SBS region, growing of *kharif* crops is based on south-west monsoon rains. *In situ* green manuring helps to improve the soil before tobacco. Crop rotation should be followed in a systematic way, keeping in view the soil fertility and tobacco leaf quality.

Energy Saving Strategies during Curing: Adoption of energy saving methods for curing (Low profile barn, ventury furnace, glass wool insulation, use of alternative fuels, energy plantation etc.) minimizes the use of fuel material and will go a long way in conserving the natural resources. It also reduces the production expenditure for the farmers, as curing alone accounts for more than 30 % of the total cost of cultivation.

In addition to these strategies some of the practices which help to reduce the cost of curing include a) Rectification of air leaks by checking door gaskets and cracks on the walls of the barn structure, b) Enough ventilation to hold humidity down. The wider the vent opening, the more fuel is consumed, c) Periodic maintenance and adjustment of the burner for efficient operation, d) Harvesting only ripe leaf. Shorter curing time means less heat loss and more efficient curing and e) Uniform loading with no "tight spots" assures even drying and less energy use.

Strategies of Efficient Resource Management for Sustainable FCV Tobacco Production in SLS and SBS Regions

Zone	Strategies for Efficient Management of Resources
SLS	● Tray seedling production
	● Deep ploughing during summer to conserve moisture and to avoid compaction
	● Green manuring and green leaf manuring
	● Soil mulching to conserve moisture
	● Application of Soil test based recommended fertilizers
	● Adoption of INM and IPM practices
	● Water harvesting and recycling for life saving irrigation
	● Use of ground water by mixing it with harvested rain water
	● Ripe leaf harvest
	● Measures for increasing leaf moisture during drought years
	● Energy saving technologies and alternate fuels during flue-curing
SBS	● Tray seedling production
	● Proper drainage *i.e.* creation of field channels along the plots
	● Timely deep ploughing
	● Application of organic manures
	● Soil mulching to conserve moisture
	● Application of Soil test based recommended fertilizers
	● Adoption of INM and IPM practices
	● Timely interculture operations
	● Ripe leaf harvest
	● Energy saving technologies and alternate fuels during flue-curing

AGRONOMIC PRACTICES FOR FCV TOBACCO FIELD CROP IN KARNATAKA LIGHT SOILS

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Introduction

Flue Cured Virginia (FCV) tobacco is the main commercial crop grown in Southern transitional zone of Karnataka (STZ No. 7), which comes under Southern part of the state. The crop is grown during *kharif* season as rainfed crop in about 1.00 lakh ha each year in the light soil areas, popularly known as Karnataka Light Soils (KLS) with a production ranging from 100-120 M kg. The superior quality filler tobacco produced in KLS known as 'Mysore style' has great demand in the International market. Nearly 85% of the FCV tobacco area in Karnataka is mainly concentrated in four taluks (H.D.Kote, Hunsur, Periyapatna and K.R.Nagar) of Mysore district and remaining area of around 15% is in Arakalgud taluk of Hassan district and some scattered area in Chikmagalur, Shimoga as well as Davanagere districts.

Soils

In KLS region, majority of the soils are shallow to moderately deep, yellowish red to dark reddish brown in colour, sandy loam to sandy clay loam in texture, acidic to neutral in reaction, well drained and highly leached. The soils have low water holding capacity and cation exchange capacity. The clay content generally varies from 10 to 25% and Kaolinite and hydrous oxide of iron and aluminum dominate the clay complex. In general, the soils are low in nitrogen and medium to high in available phosphorous and medium to high in available potassium. The red sandy loam to sandy clay loam soil with slightly acidic to neutral pH and good drainage are quite conducive for quality FCV tobacco production. The length of the growing period (LGP) is around 190-200 days In general; the farmers are mostly small and marginal with a land holding of 1-2 ha.

Climate

The region has bimodal distribution of rainfall benefited by both south-west (May-September) and north-east (Oct-Dec) monsoons. The zone is under tropical monsoonic climate with an average annual rainfall varying from 650 -1000 mm and 80% received during the south-west monsoon period (May–October) which coincides with the FCV tobacco crop season. The Southern Transitional zone is endowed with ideal climatic conditions like lower diurnal temperature, higher relative humidity and monsoonal rains during the crop growth period conducive for production of high quality tobacco.

Nursery Management

Production of sturdy and healthy transplantable seedlings is the first major step contributing to the success of the crop in the main field. As the crop is raised as rainfed crop in *kharif* season which commences from March coincides with the pre-monsoonal period and hence the prevailing factors during the period influence the spread of several soil borne diseases affecting the quality of seedlings produced. Tray seedling production is recommended for this area to avoid soil problems and most of the farmers are following the practice.

Field Crop Management

Land Selection

Well drained, red loam to sandy loam soils with good water holding capacity having a pH of 5.5-7.5 is ideal for producing quality FCV tobacco. Avoid heavy/clay, waterlogged and saline affected soils.

Land Preparation

Field should be deep ploughed by tractor drawn disc plough in Nov.-Dec. followed by harrowing or ploughing twice in the month of April to May to achieve fine soil tilth for planting.

Transplanting

Early planting in the month of May is ideal for planting FCV tobacco in KLS. Select disease free and sturdy and hard seedlings from the resettled beds / tray nursery raised for planting for better establishment in the field. Recommended spacing of 100 x 55 cm with a population of 18,181 plants/ha has to be maintained. Form ridges at 1 m apart and pass the markers across the ridges at 55 cm. Depending upon the rainfall Ridge planting(in high rainfall area) and flat planting (medium to low rainfall situation) is preferred. Adopting dry planting by pouring water in the planting hole and using tray nursery system is ideal than the wet planting after rains.

Early planting in the season (during first fortnight of May) results in higher productivity, due to the prevailing rainfall pattern in southern transition zone. The crop is likely to escape late season drought as the field crop can utilize stored moisture from summer or pre monsoon showers. It facilitates good root growth & better establishment, resulting in higher productivity and quality. Tolerate drought/excess moisture conditions better than the late planted fields and always results in 35-40% higher productivity. Apart from the yield and quality advantages, the early planting also facilities the planting of the succession crop early in the season (late *kharif*/ early *rabi*), thereby increasing the overall productivity of the land in a given season.

Adopting higher plant density per unit area in medium to low fertile soils located in rain shadow or low rainfall regions will enable farmers to realize optimum and sustained tobacco productivity. Overall cured leaf productivity was enhanced to an extent of 13-15% by increasing the plant density to 22,222 plants/ha and 24,691 plants/ha from the recommended population of 18,181 plants/ha. Early canopy coverage in high density population will reduce evaporation losses from bare soil thereby enhancing the crop survival during drought like conditions and hot weather situations.

Nutrient Management

Integrated Nutrient Management (INM) practice involving application of organics and the recommended fertilizer nutrients is more ideal than application of chemical fertilizers alone to optimize the productivity level & desired leaf quality characteristics. Organic manures such as FYM @ 8-10t/ha, Press mud @ 6 t/ha or vermicompost @ 2 t/ha should be applied. FYM or Press mud should be well incorporated into the soil 2-3 weeks before planting. Vermicompost should be applied in the planting hole at the time of planting @ 100g/plant. The simple and most cost effective way of sustaining the soil health and farm productivity is by raising green mauring crops like Sunnhemp or Dhaincha. Farmers are advised to raise green manure crops like sunnhemp at least in one acre field each year so as to cover all tobacco fields once in 3-4 years.

Recommended dose of fertilizers is 60:40:120 NPK/ha. Application of 30 kg N in the form of (ammonium sulphate and DAP), 40 kg P_2O_5 (in the form of DAP) and 60 kg of K_2O (in the form of sulphate of potash) has to be applied as a basal dressing by adopting dollop method (4-5 cm deep and 5-8 cm away from the plant on both sides of the plant along the ridge) at 7-10 DAT. Top dress the crop with 30 kg N in the form of (ammonium sulphate), and 60 kg of K_2O (in the form of sulphate of potash) at 25-30 DAT. The recommended quantities of individual fertilizers have to be thoroughly mixed and applied.

In case of heavy rainfall after application of fertilizers, apply about 5-10 kg N (25-50 kg ammonium sulphate/ha) to compensate for the possible leaching losses depending on the soil type and the intensity of the rainfall received.

Interculture and Weeding

About 4-5 intercultural operations at 8-10 days interval should be taken up during the crop growth period. Initially shallow intercultural using tyned harrows 2-3 times followed by passing country plough 2 times and final ridging the crop at 45-50 days using ridger is to be done. Weeds should be removed manually at 15-20 days and at 35-40 days after planting to avoid completion for moisture and nutrients.

Topping & Desuckering

Topping and desuckering operations are essential for improving the yield and quality of FCV tobacco. The ideal time for topping is at the extended bud stage at 20-22 leaves depending upon the variety cultivated, soil type and condition of the crop. The desuckering can be done manually or using chemical suckericides like Decanol, Seeten, Suckerout etc. at 4% concentration (40 ml in 1 lit of water). Suckericide has to be applied 2-3 days after topping. Avoid the application of the suckericides during cloudy/ rainy/ drizzling conditions.

Harvesting

Time of harvest and degree of leaf ripeness influence greatly the chemical and physical properties of cured tobacco. Harvesting of well matured and ripe leaves each time is essential for getting good grade out turn and better cured leaf quality. Harvesting in tobacco is done by priming matured leaves and generally starts after 2 months of planting. At each harvest about 2-3 matured leaves are to be harvested according to the ripeness from the bottom and should be carried out in the morning hours. Harvesting should be done at 7-8 days interval depending upon the maturity and weather conditions. Harvested leaves should be transported to shade without damaging and spread on a clean tarpaulin. The green leaves are to be graded into immature, properly matured and over matured groups and tied to the sticks separately. Tie the leaves at the rate of 2-3 leaves / bunch and 16-18 bunches in a stick on either side and should not exceed 100-120 leaves per stick.

Cropping Systems for Enhancing Farm Returns

Flue Cured Virginia (FCV) tobacco is an important commercial crop grown in the rain fed conditions of the Southern Transitional Zone of Karnataka mostly by small and marginal farmers. The crop is mainly grown under rainfed farming situations in *kharif* season. Virginia tobacco cultivation has been highly successful and economical in this part of the Southern Transitional Zone. Being transition zone with congenial agro-climatic conditions, different crops such as cereals, pulses, oil seeds, vegetables and commercial crops are being cultivated in this region both under rainfed and irrigated farming situations.

As tobacco is grown during *kharif* sesason there is much scope for crop intensification both under irrigated and rainfed conditions.

Tobacco based cropping systems followed in KLS domain

H. D. Kote	:	Tobacco - Horse gram / Field bean / Cowpea
Hunsur	:	Tobacco - Finger millet/Cowpea/ Field bean
K.R.Nagar	:	Tobacco - Finger millet
Periyapatna	:	Tobacco - Hybrid maize/Finger millet/Cowpea/Field bean
Shimoga	:	Tobacco - Horse gram/Fallow

MAJOR INSECT PESTS AND DISEASES IN FCV TOBACCO AND THEIR MANAGEMENT

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Introduction

Insect pests and diseases are the major limiting factors in successful production of quality tobacco. Though the introduction of high yielding varieties, improved irrigation systems, large scale use of chemical fertilizers and pesticides helped in increasing the tobacco production, simultaneously the pest problems have also undergone quick changes and pests which were minor and manageable are reaching epidemic proportions in the recent past. Insect pests may attack tobacco at any time from emergence in the plant bed through and after harvest. Any part of the plant may be attacked, and damage can range from insignificant to total loss. Insects may also interact with diseases or agronomic problems. Beneficial insects act to keep pest insects in check and to reduce losses. Insect pests have a greater role to play especially during years when climate is favourable for their growth and development. In view of growing awareness and stringent regulations being enforced by tobacco importing countries, it is essential that the levels of pesticide residues in tobacco leaf be minimised. The residues in cured leaf should not exceed Guidance Residue Limits (GRL) of the few allowed pesticides and these limits are being reconsidered and lowered year after year. Hence, integrated management of pests with minimum reliance on chemical pesticides has assumed greater importance in the present day context.

For pest insects, an important clue to presence and identification is crop damage. Damage may include stunting or wilting of plants, destruction of the leaf, or indirect damage such as the build-up of sooty mold or leaf distortion. The time of year or crop stage at which damage occurs and the pattern in the field are also important clues. Form and color as well as color variation and habits of the insect (how it moves, reaction to being disturbed, where it hides) are helpful in making identifications.

The problem of pesticide residues has of late become one of the limiting factors in the export of tobacco. Sole dependence on synthetic insecticides for pest control is beset with adverse effects such as irreversible damage to the public health, development of insecticide resistance in insect pests, annihilation of beneficial organisms, insect pest resurgence and environmental pollution. These problems force us to resort to integrated pest management (IPM) to achieve long term sustainable systems of crop protection and production.

The major insect pests that infest tobacco are leaf eating caterpillar, *Spodoptera litura*; whitefly, *Bemisia tabaci*; stem borer, *Scrobipalpa heliopa* in the nursery and field crop; ground beetles, *Mesomorphus villiger*; tobacco bud worm, *Helicoverpa armigera* and tobacco aphid, *Myzus nicotianae* in the field crop, while cigarette beetle, *Lasioderma serricorne* is a pest of stored tobacco. Apart from these, minor pests like ants, mole crickets and rove beetles, earthworms and grasshoppers occur in the nursery and stink bug, *Nazara viridula* occurs in the field crop. It is roughly estimated that about 34% loss of cured leaf can be avoided by adopting appropriate pest management practices.

Pests in Tobacco Nursery

1. Caterpillars and Cutworms

Four species of caterpillars viz., *Spodoptera litura* F., *Spodoptera exigua* Hb., *Agrotis ypsilon* Rott. and *Plusia signata* F. are known to infest tobacco nurseries. Of these four species, *Spodoptera litura* F., commonly known as tobacco caterpillar, is the most important pest.

Tobacco Caterpillar : *Spodoptera litura*

Young caterpillars are light green with black head or black spots and mine on the leaf tissue. Well grown caterpillars are grey or dark brown with 'V' shaped white mark on the front portion of the black head. They feed voraciously along the veins of leaves and also cut the stems of small and tender seedlings. Hence, they are also known as cutworms. There will be about 80 to 100% loss due to this pest during severe infestation.

Management

1. Deep ploughing of nursery area during April-May will facilitate the exposure of pupae to high temperature and thus destroy them.

2. Sow castor around tobacco nursery 10 days before sowing of tobacco so that the castor puts up sufficient foliage by the time *Spodoptera* infestation builds up. Castor seedlings attract female moths of *Spodoptera* for egg laying. Clip the leaves having egg masses and tiny caterpillars and destroy them.

3. Egg parasitoid *Telenomus remus* @ 40,000/ha at 3-week interval commencing the 1st release at 3-weeks after sowing will reduce the egg population of *S. litura*. *Apanteles africanus* larval parasitoid, *Chelonus formosanus* egg-larval parasitoid, hemipteran bug *Harpactor costalis* are found abundant on castor and regulate *S. litura* population, conserve them by avoiding indiscriminate pesticide use.

4. Install four 'litlure' pheromone traps (loaded with 2.5 mg pheromone per vial) per acre two weeks after germination. Spray one per cent neem seed kernel suspension (NSKS) in water on 3-week old seedlings and 2% NSKS on 4-week old seedlings.

For preparing 10 litres of 1% NSKS, take 100 g of neem seed kernel powder and put in a small muslin cloth bag. Dip the bag in a bucket (or any vessel) containing 10 litres of water and squeeze the bag for 15 minutes to get a light brownish liquid. This suspension can be directly sprayed on tobacco seedlings.

For preparing 2% NSKS of 10 litres, 200 g of neem seed kernel powder is to be taken and processed as above.

Use 50 litres of 1% NSKS on 3-week old seedlings and 60 litres of 2% NSKS on 4-week old seedlings. Or spray 1000 litres of nuclear polyhedrosis virus (NPV) solution per hectare prepared by 250 NPV infected larvae by mixing with 250 g rice powder or starch powder during evening times or spray *Bacillus thuringiensis* var. Kurstaki @ 1.0 kg in 1000 litres of water per hectare.

If the number of seedlings damaged by *Spodoptera* exceeds 6 per sq.m. area, spray the following insecticides from fourth week onwards.

(a) Emamectin benzoate 5 SG.@ 5 g in 10 litres of water

or

(b) Novaluron 10 EC @ 10 ml in 10 litres of water

The other three species of caterpillars viz., (1) green caterpillar, *S. exigua* (2) green semi looper *P. signata* and (3) black cutworms, *A. ypsilon* that sometimes infest the tobacco nurseries can also be controlled by spraying the above insecticide.

2. Stem Borer

Stem borer is the larva of a tiny brown moth called *Scrobipalpa heliopa*. Tiny caterpillars bore inside the stem and midribs and feed on internal tissues. As a result, swelling appears where the borer stays. It causes stunting and unusual branching of the seedlings thus affecting the nursery and at times, the planted crop is also affected.

Management

1. Stem borer affected seedlings should be removed and destroyed.

2. In tobacco nurseries where stem borer is a serious problem, spray flubendiamide 48 SC @ 2.5 ml or Chlorantranaliprole 18.5 SC @ 3ml in 10 litres of water at 30 and 40 days after germination. Final spray should be given before pulling seedlings.

3. In planted crop, spray above insecticide twice at 15 days interval starting from 10 days after planting. After completion of harvests, the stem borer affected plants should be uprooted and destroyed to prevent carry over of the pest to the next season.

3. Whitefly: *Bemisia tabaci*

Whiteflies are small fly like insects seen on the underside of leaves. They will fly immediately when the plant is disturbed. The adult fly sucks the sap from the infected leaves and transmits the leaf curl virus disease to the healthy seedlings.

Management

1. Remove alternate weed hosts around nursery area and destroy.

2. Install yellow-sticky traps (20 cm x 15 cm size galvanized iron sheet painted with yellow colour coated with castor oil) @ 5 per acre.

3. If the population of whitefly is 100 per each sticky trap, give the following spray schedule of insecticides

1st spray	-	Imidacloprid 200 SL @ 2.5 ml **or** Thiamethoxam 25 WG @ 2 g **or** Pymetrozine 50 WG @ 4g **or** Flonicamid 50 SG @ 4 g in 10 litres of water
2nd spray -15 days after 1st spray	-	With any one of the above insecticide
3rd spray -15 days after 2nd spray	-	With any one of the above insecticides

Pests in the Field

The major pests that affect tobacco crop in the field are ground beetles, whitefly, leaf eating caterpillars, tobacco aphid/ green peach aphid and capsule borer. Control measures for these pests are given below.

Ground Beetle

a. *Mesomorphus villiger*
b. *Seleron latipes*
c. *Opatroides frater*

These beetles are dirty grey or black, hard bodied insects. They cut the stem of newly transplanted seedlings. This damage is usually noticed more in dry years and during prolonged hot spells immediately after planting.

Management

1. In the newly planted field, keeping the grass heaps 6-7 m distance apart between rows on a moist soil and dusting next day with fenvalerate 4% dust @ 10 kg.

Or

2. Apply 5 g of pongamia cake or neem cake powder (mixed in handful of sand) at the base of the seedling immediately after transplanting.

Leaf Eating Caterpillar: *Spodoptera litura*

In the field crop, pest incidence is generally confined to few border rows. The female moth lays about 2000 eggs on the under side of the leaves in bunches. After 2-3 days of incubation, light green tiny caterpillars with black head emerge in hundreds. They eat the green matter of the leaf and turn to grey or dark grey or black in colour. The grown up larvae feed voraciously on the tobacco leaf making lot of holes on the leaf, causing 10 to 15% damage.

Management

Install 10 pheromone traps per ha 20 days after planting. Critically examine the leaf for egg masses and tiny caterpillars, collect and destroy. If the infestation is severe, spray the hot spots thoroughly with 0.5% neem seed kernel suspension or nuclear polyhedrosis virus 250 LE in 1000- litres of water per ha by mixing with 250 g rice flour or starch powder or with the following insecticides.

(a) Emamectin benzoate 5 SG.@ 5 g in 10 litres of water

or

(b) Novaluron 10 EC @ 10 ml in 10 litres of water

Whitefly: *Bemisia tabaci*

Tiny whiteflies cause leaf curl disease. Leaves of the curled plants are twisted, puckered and thickened with abnormally prominent veins. Plants show stunted growth and the yield is reduced.

Management

1. Do not use leaf curl affected seedlings for transplanting in the field.

2. Remove and destroy alternate weed hosts.

3. Crops like brinjal and sunflower should not be grown in the vicinity of tobacco fields.

4. Remove the leaf curl infested plants if they are less than 2% within one month after planting and destroy them.

5. Install 12 yellow sticky (castor oil coated) traps per hectare to monitor the whitefly population.

6. If the whitefly population reaches 100 per trap, the spray schedule recommended for the nursery has to be adopted in the field crop also commencing from 10 days after planting.

Spraying has to be done preferably in the evening hours (4 to 6 pm) with high volume sprayers and it should be ensured that both sides of the leaf are covered. Further, the spray schedule has to be adopted by all the tobacco farmers in the endemic area.

Tobacco aphid: *Myzus nicotianae*

Aphids are louse like insects, which are green or pinkish to brown in colour. In case of heavy infestation, hundreds of them can be seen on the underside of the leaf. By constantly sucking the sap from the leaf they make the plant pale and sickly and thereby retard the growth. They secrete sugary juice known as 'honey dew' on the leaf due to which sooty mould develops rendering the leaf unfit for curing. In addition, they also transmit virus diseases like rosette or bushy top.

Management

During early winter, for control of aphids one spray has to be given when 2% of the plants are infected, with any one of the following insecticides.

a. Imidacloprid 200 SL @ 2.5 ml
or
b. Thiamethoxam 25 WG @ 2 g
or
c. Flonicamid 50 SG @ 4 g
or
d. Pymetrozine 50 WG @ 4 g in 10 litres of water

If the infestation is observed later, spray the infested plants only. Subsequently spray only aphid infested plants once in 8-10 days. Leave two weeks between spray and harvesting of leaf to avoid excess pesticide residues in cured leaf. If more than one spray is required, change the insecticide. Spraying should be done preferably in the evening hours.

Lady bird beetle *Chielomenes sexmaculata* and aphid lion *Chrysoperla carnea* regulate aphid populations in tobacco and tobacco based cropping systems respectively. Avoid indiscriminate pesticide use and encourage natural control.

Budworm/Capsule Borer: *Heliothis armigera*

The larvae of this species are greenish or pale brown with broken dark-brown stripes along the body. They bore the capsules and feed on the seeds inside. They feed on top leaves also when the infestation is heavy.

The incidence of capsule borer is observed after December under favourable conditions, preferably after heavy rains in untopped fields. The incidence is seen from 30 days after planting. Generally, one larva is seen on the terminal bud. From 30-50 days, it feeds on the terminal bud and then on the young leaves and causes loss to the crop. More than one borer per plant are seen after flowering and they feed on the developing seed of the capsules.

Management

1. Hand picking of the budworm/capsule borers in the tobacco crop once in three to four days and destroying. Care should be taken to avoid touching the TMV infected plants.
2. Top or trim flower heads to bring down the incidence of capsule borer considerably.
3. In untopped fields spray nuclear polyhedrosis virus (NPV) of *Heliothis* @ 250 L.E. or *Bacillus thuringiensis* var. Kurstaki @ 10 in10 litres of water. For NPV solution add starch powder @ 250 g/ha and spray in the evening hours.
4. If the infestation is severe spray Flubendiamide 48 SC @ 2.5 ml.

Care to be Taken while Using Pesticides

There are strict regulations regarding the pesticide residues on tobacco throughout the world. The residues must be within the prescribed limit. In all the tobacco growing countries, DDT and other chlorinated hydrocarbon pesticides are banned for use on tobacco. Pesticides should not be used indiscriminately. In recent times it was observed that the residues of profenophos and chlorpyriphos are observed above the GRLs and also the GRL for acephate has been further lowered to 0.2 ppm. Hence, use of the above insecticides is to be discouraged on tobacco.

In order to minimize pesticide residues in tobacco following measures should be adopted

1. Recommended pesticides should only be used on tobacco. The banned pesticides should not be used under any circumstances.
2. Pesticides should be used as per the recommended doses judiciously. Using more than the required times should be avoided.
3. Pesticides in dust form should not be used on tobacco.

4. When number of pesticides are recommended for controlling a single pest and when there is need to spray more number of times, the pesticide should be changed each time.
5. Banned pesticides on tobacco should not be sprayed even on the rotation crops or other crops in the surrounding area.
6. Sikar sprayers with duromist nozzles or high-tech sprayers should be used for better efficiency.
7. Interval between last spray and harvesting should be minimum one week for)

Guidance Residue Levels of Insecticides in tobacco

Insecticide	GRL (ppm)
Acephate	0.10
Acetamiprid	2.50
Carbaryl	0.50
Carbofuran	0.50
Chlorpyrifos	0.50
Cypermethrin	1.00
DDT	0.20
Deltamethrin	1.00
Demeton-S-methyl	0.10
Diflubenzuron	0.10
Dichlorvos	0.10
Dimethoate	0.50
Endosulfan	1.00
Fenvalerate	1.00
HCH (áâä)	0.07
HCH (ã)	0.50
Imidacloprid	5.00
Malathion	0.50
Methomyl	1.00
Monocrotophos	0.30
Phorate	0.10
Phosphamidon	0.10
Profenofos	0.10
Chlorantaraniliprole	10.00
Thiamethoxam	5.00

Tips for Pest Management of Tobacco

1. Visit the field periodically, look for the insect damage, identify the insect pest, decide whether the damage warrants control, choose the best method of control and apply at the right time. If the control is delayed damage will be more if it is too early the desired result can not be obtained. Chemical control should be resorted to when unavoidable and as a last resort.

2. Choose selective pesticide to control the right pest and spare bio-control agents and apply insecticides on the basis of economic threshold levels.

3. Pesticides approved for use on tobacco should only be used and they should be used at recommended doses only.

4. The recommended pesticides should be used in correct dose with right equipment. Pesticides should not be used more than the recommended number of times. Indiscriminate use of pesticides will kill the beneficial natural enemies of the pests, leads to unwanted residues in the leaf, insect pests may develop resistance to pesticides, and also leads to environmental pollution.

5. Where more than one insecticide is recommended on a single pest, and where such a pest needs many sprays for effective control, spray recommended insecticides one after another. This helps to minimise the residues of any one insecticide beyond permissible level and also delays resistance development.

6. Pesticides not recommended for tobacco pests should not be used for control of pests on the crops grown in rotation with tobacco and on non-tobacco crops in near by fields.

7. Sole dependence on chemical control is undesirable and as far as possible alternate methods of control should be adopted.

8. Adapting proper management practices, deep ploughing in summer, trap crops, use of neem based pesticides (in nurseries), nuclear polyhedrosis virus (NPV), B.t. insecticides etc. is desirable.

9. Use of recommended seed rate in nursery, following recommended plant to plant and row to row spacing in field, avoiding use of excess doses of chemical fertilizers is important to keep the pest problems under control.

10. Castor grown around tobacco nurseries acts as an ovipositional trap crop for *S.litura*. Eggs and neonate larvae should be collected every day from the trap crop and destroyed.

11. In planted tobacco *Tagetes* can be grown around the field as *Tagetes* attracts *Heliothis* moths. Eggs and larvae on *Tagetes* flowers should be collected and destroyed periodically. Bird perches @ 20/ha should be arranged at crop canopy level 30 days after planting to encourage bird predation of insects.

12. Left over seedlings in the nursery and tobacco stalks after harvesting in the field should be pulled out and destroyed. These when left out serve as reservoirs of pests and the pest problems will be increased.

13. Following recommended pest management practices in the nursery, planting healthy seedlings in the field is highly desirable. When planting in the field, seedlings infected with diseases and infested by pests like stemborer should be removed and destroyed.

14. Monocropping of tobacco years together may help in pest buildup. To avoid this crop rotation should be followed.
15. Healthy plants withstand pest attack. To keep the plants healthy, balanced nutrient and water management is important.
16. Selecting proper pesticide is key to the success of pest control. Use systemic insecticides for sucking pests like aphid and whitefly, contact and stomach insecticides for leaf caterpillar and budworm is desirable. When spraying uniform coverage of the crop should be ensured. Under any circumstances more than one insecticide should not be mixed for spraying.
17. To save time and money some times insecticides and fungicides are mixed and sprayed. Ensure compatibility of the pesticides otherwise mixing is not desirable. If the pesticides in use are incompatible they will not give the desired results and some times damage the crop also. Organophosphate and carbamate pesticides should not be mixed with pesticides with alkaline properties. eg. Copper based fungicides should not be mixed with insecticide.
18. For effective control of insect pests use Sikar or Hi-tech sprayer fitted with duromist nozzle with right pressure.
19. Dust formulations should not be used on tobacco.
20. Do not open the pesticide container with bare hands or teeth. Use knife, blade or scissors.
21. Do not mix the pesticide with bare hands, use a stick for mixing and mix pesticide in an open or well ventilated area.
22. Use protective clothing and devices.
23. Never eat, drink, smoke or rub your eyes or face while spraying. Wash thoroughly after spray and take a thorough bath.

Tobacco Diseases

Tobacco is susceptible to several fungal, bacterial, viral and nematode diseases. These diseases not only reduce the yield of tobacco but also impair the quality parameters of the cured leaf. In normal years average crop loss due to diseases is estimated to be 5 to 10 percent.

Fungal Diseases

Damping off

Characteristic Symptoms

In nursery, disease appears any time upto 35 days after sowing. It may appear soon after seedling emergence (pre-emergence damping off) and may be confused with poor germination. In early stage, tiny seedlings seem to disappear due to rotting causing daily reduction in seedling stand. Older seedlings show shriveling and dark brown discoloration of stem at the base and ultimately collapse and topple over. The wet rotting and collapse of seedlings start in circular patches and may extend to the entire bed, if unchecked.

White cottony growth of the pathogen appears on the infected seedlings and gradually dry off and become papery white in colour and responsible for as much as 90% death of seedlings.

Predisposing Factors for Disease Epidemic

Over-crowding of seedlings and presence of excessive organic matter predispose the seedlings to damping off disease. Such extreme weather leads to mass multiplication of pathogen. High relative humidity of > 85%, high soil moisture, cloudiness, temperatures below 24^{o}C, soil pH 5.5 to 7.5, continuous wet weather and low lying areas are optimum conditions for disease development.

Management Strategies

Cultural and Preventive

i. Deep ploughing in summer, **ii.** Raising of seed beds 15 cm high, **iii.** Rabbing the seed bed before sowing, **iv.** Use of recommended seed rate, **v.** Regulation of watering and **vi.** Use of Tray nursery seedlings.

Chemical

- Apply copper fungicide (Bordeaux mixture @ 0.4 % or copper oxychloride @ 0.2 %) with rose can at 3-4 day intervals depending on disease incidence and conditions.

- Spray either Metalaxyl - M + Chlorothalonil 440 SC or Metalaxyl - M + Mancozeb 68 WP @ 0.2% or Fenamidone + Mancozeb 60 WG @ 0.3% or azoxystrobin 23 SC @ 0.1% at 21 and 31 DAS were found effective against damping off disease in tobacco nursery.

Leaf Blight and Black shank

Characteristic Symptoms

Under continuous wet weather conditions, large circular to irregular water soaked patches appear on the leaf surface causing leaf blight. Seedlings show blackening of roots and stem at ground level. Symptoms of black shank on the transplanted tobacco are seen in the form of blackening of roots and stalk. Blackening of the stalk starts at the base near the soil gradually extending upwards upto 30 cm or more. The leaves turn yellow and the whole plants wilt and die. When the stem is split open, the pith is found dry, brown to black in colour and separated into plate like discs.

Predisposing Factors for Disease Epidemic

Heavy rainfall after planting, continuous wet weather, temperature below 22^{0}C and high moisture lead to severe incidence. The fungus remains viable in soil for several years and possibly over winters, as mycelia in dead tobacco stalks and roots. It spreads through irrigated water or through the air-borne sporangia, splashed during the rain.

Management Strategies

Cultural and Preventive

i. Deep ploughing in summer, **ii.** Raising of seed beds, **iii.** Rabbing the seed bed before sowing, **iv.** Use recommended seed rate, **v.** Regulation of watering and **vi.** Use of tray nursery seedlings.

Chemical

- Drench nursery beds with 0.2% of any copper fungicide or 0.4 % Bordeaux mixture at 2 to 3 days interval.
- Spray Metalaxyl + Mancozeb @ 0.2 % (2g / l of water) or Fenamidone + Mancozeb @ 0.3% (3g/l of water) or Azoxystrobin @ 0.1% (1ml/l of water) - need based (1 or 2 times after 21 and 31 days of sowing).
- If the leaf infection is severe, give 3rd spray 1 or 2 days before pulling seedlings for planting.

Anthracnose

Small, light green to white or water soaked lesions develop on young leaves and tender stems. These lesions enlarge in wet weather to form oily circular spots of 3 mm diameter on the leaves or girdle the young stems. The spots dry up, become papery thin, gray-white surrounded by brown border. Elongated, black or brown lesions on the midrib and petiole are seen in severe cases. Several elongated or oblong sunken brown lesions develop on the stem making the seedlings unfit for transplanting.

Management Strategies

Cultural and preventive

i. Deep ploughing in summer, **ii.** Raising of seed beds, **iii.** Rabbing the seed bed before sowing, **iv.** Use recommended seed rate, **v.** Regulation of watering and **vi.** Use of tray nursery seedlings.

Chemical

- Spray Carbendazim @ 0.05% (5 g / 10 l of water) at 15 days interval.

Frog Eye Leaf Spot

Characteristic Symptoms

Brown, round spots resembling frog eye form appear on the lower leaves of the seedlings. Spots appear first on basal leaves and gradually spread to upper leaves. Spots are small, circular, 5-8 cm diameter in size, brown or tan with dingy gray centers. Under hot, dry weather frog eye lesions may be pinpoint in size and would not be recognized. The pathogen is regarded as weak parasite which normally attacks only physiologically declining tissue.

Predisposing Factors for Disease Epidemics

Frequent watering and wet weather leading to high humidity and temperature around 27^0C are favourable for the development of the disease.

Management Strategies

Cultural

i. Use recommended fertilizer dose only, **ii.** Avoid excess nitrogen fertilizer, **iii.** Collect and destroy the crop debris after harvest, **iv.** Use healthy transplantable seedlings and **v.** Regulate watering.

Chemical

- Two sprays either with Pyraclostrobin + Metiram @ 0.2% or Carbendazim @ 0.05% immediately after appearance of the disease followed by another spray at 10-15 days was interval found effective in reducing disease incidence.

Sore shin

- Disease appears both in tobacco nursery as well as in the main field.

Characteristic Symptoms

Sore shin lesions appear as reddish-brown, sunken cankers that range from narrow to completely girdling the stem near the soil line. Injury is more common during warm weather. As soil temperature rises later in the season, affected plants may show partial recovery due to new root growth. On transplants, the dark brown discoloration of the stalk at or near the soil line extending upwards to several centimeters is a characteristic symptom of sore shin.

Predisposing Factors for Disease Epidemics

Disease is severe in the plant bed when cool temperature (20^0C and below) prevails, and it often occurs in the field when temperatures are high.

Management Strategies

Chemical

- Spray Propiconazole @ 0.1%, a triazole compound at 21 days after sowing to control the disease.

Fusarium wilt

Characteristic Symptoms

Fusarium wilt usually appears in clusters of plants in the field. Yellowing and drying of the leaves on one side of a tobacco plant are typical symptoms. If a strip of the outer stem tissue (bark) is removed from the side of the stalk with yellowed leaves, a brown discoloration of the wood or vascular tissue is present rather than the normal white color. This discoloration usually can be traced from the affected part of the stalk down into the roots. The midribs of leaves on the affected side of the plant are often curved to one side with half of the leaf yellowed and the other half remaining green. In a young plant, the bud may bend toward the side of the plant with the yellowed leaves. Wilting, although implied by the name of this fungal disease, is not typical of diseased plants.

Predisposing factors for disease epidemics

It is a warm weather disease, high temp. 28-30^{0}C is favorable for the disease. Moisture deficiency retards the vegetative vigor of the host and keeps the fungus under control.

Management strategies

- Crop rotation with non host crops like sorghum, maize etc.
- Spray Carbendazim 0.05% on infected and surrounding plants.

Brown Spot

Characteristic Symptoms

Older leaves show small water-soaked lesions which enlarge quickly. As the spots enlarge, the centers die and become brown, leaving a sharp line of demarcation between diseased and healthy tissue. On the lower leaves, the brown spot lesions with concentric rings are mostly circular and usually range from 1-3 cm or more in diameter. On the upper leaves, the spots are usually smaller and range up to 1.5 cm in diameter. In severe infection spots enlarge, coalesce and damage large areas making leaf dark brown, aged and worthless.

Predisposing Factors for Disease Epidemic

The disease appears during first week of February and gradually increases its intensity towards the maturity of the crop. Temperatures between 13.4 to 25.1^{0}C, relative humidity% 54 to 96, total rainfall 9.3 mm and bright sunshine 7.4 hours are favorable for rapid build-up and spread of the disease.

Management Strategies

Cultural

- Avoid use of excess nitrogen fertilizers and planting of tobacco on severely infected fields.

Chemical

- Two sprays, one at disease appearance and another after 15 days with Propiconazole @ 0.1% or Dithane M-45 @ 0.2% was found effective in the management of brown spot disease.

VIRAL DISEASES

Tobacco Mosaic Virus (TMV)

Characteristic Symptoms

An irregular pattern of dark green and light green leaf areas intermingled, stunted plant growth, leaf malformation, and mosaic burn. Young leaves of infected plants are often malformed and may show leaf puckering, or wrinkling of the leaf tissue. Nearly mature leaves that are infected may show "mosaic burn". Mosaic burn is characterized by large, irregular, burned or necrotic areas on the foliage that can cause extensive damage to the tobacco crop.

Predisposing Factors for Disease Epidemics

Plant age, amount of inoculum and growth conditions in general determine whether symptom expression is acute or chronic. Usually the time required for symptom appearance is shortened by increase in temperature and light intensity. Above 38-40^{0}C temperature infection is inhibited and above 27^{0}C or below 10^{0}C temperature symptoms disappear.

Management Strategies

Prevention and Eradication

i. Grow resistant varieties, **ii.** Remove infected plants, **iii.** Adopt phytosanitory measures, **iv.** Prophylactic sprays of 0.5% skimmed milk on 30th, 40th and 50th DAP prevents spread of the disease.

Tobacco Leaf Curl Virus (TLCV)

Characteristic Symptoms

Diseased leaves show vein clearing, puckering of leaves, downward curling of leaf margins; leaves become brittle; thickening of veins, ear-like out-growths on the under surface of leaves resulting in stunted growth of the plant.

Predisposing Factors for Disease Epidemics

Whiteflies are more abundant and active in relatively dry season and as a result, leaf curl is more prevalent during dry weather.

Management Strategies

As TLCV is a virus, no direct method for control is as yet available. The incidence of TLCV can be decreased by vector control.

Cultural Management

- Leaf curl infected seedlings should be discarded while planting.
- Diseased tobacco plants should be removed and destroyed within one month after planting, if the infected plants are less than 2%.
- Alternate weed hosts for whitefly should be removed and destroyed, in and around tobacco fields.
- Soon after harvesting, the tobacco crop should be destroyed to prevent overwintering.
- Crops like brinjal and sunflower grown in the vicinity of tobacco fields will aggravate the problem.
- 12 yellow sticky traps (castor oil coated) per hectare should be installed to monitor the whitefly population. If 100 whiteflies stick to the trap, the following insecticide spray schedule has to be adopted.

Chemical

- Spray insecticides as recommended for control of whitefly.

Cucumber Mosaic Virus (CMV)

Characteristic Symptoms

Typical mottling and mosaic patterns appear, sometimes accompanied by stunting and narrowing and distortion of the leaves. Severe strains may cause interveinal discoloration and oak-leaf pattern of necrosis on lower leaves. 'Mosaic-burn' or sun-scald frequently appears on the upper leaves of infected plants. Mild strains cause only a faint mottling of the leaves.

Management Strategies

- The virus is readily transferred by aphids and survives on a wide variety of plants. Varietal resistance is the primary management tool, and eliminating weeds and infected perennial ornamentals that may harbor the virus is critical.

- Viral diseases cannot be controlled once the plant is infected. Therefore, every effort should be made to prevent introduction of viral diseases into the field. Sanitation is the primary means of controlling viral diseases. Infected plants should be removed immediately to prevent spread of the pathogens. Perennial weeds, which may serve as alternate hosts, should be controlled in and adjacent to the field.

Chemical

- Spray insecticides as recommended for control of aphids.

NEMATODES AND THEIR MANAGEMENT IN FCV TOBACCO

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Root-knot nematodes *(Meloidogyne* spp.) are ubiquitous parasites with an amazing capacity to interact with a very large variety of plant species. Being a polyphagous pest it occupies a vast array of ecological niches, wide host range, have many different lifestyles and prevalent in tropical and subtropical climates. It causes economic damage to many annual and perennial crops and in tobacco the average yield loss of 25% is caused by these nematodes alone. The most distinctive symptom of *Meloidogyne* infestation is the appearance of galls on primary and secondary roots, which become swollen and distorted with heavy infestations. Because of their microscopic size the nematodes go unnoticed until serious symptoms appear. The pathogenic nematodes can provide avenue for entry of soil borne pathogens into infected parts of the roots causing *Fusarium* wilt and root rot diseases. They can also transmit viral diseases. Plants infected with RKN often mimic the same signs of nutrient deficiency. The appearance of the galls on the roots can be confused with nitrogen-fixing nodules common in the legume family. Above ground symptoms are wilting during the hottest part of the day even with adequate soil moisture, loss of vigour, yellowing leaves.

Once the root knot nematodes are established in the field, it is virtually impossible to eradicate. For effective management in infested field, it is imperative to disturb the harmonious relationship between nematode and host plant through altering the soil ecosystem. However, individual techniques used for nematode management is not free from limitations. These methods are highly influenced by several biotic and abiotic factors. Hence, the concept of Integrated Nematode Management (INM) is gaining importance compared to individual approach. Cultural methods such as summer ploughing, crop rotations, antagonistic crops, trap crops, destruction of crop residues, and application of organic amendments, use of resistant varieties/hybrids/genotypes (host plant resistance) are effective mechanisms for managing *Meloidogyne* spp. Physical methods such as Soil sterilization and steam sterilization are promising. However, these methods are expensive to practice in open field condition. Biological control of root knot nematodes under field condition can be achieved by inoculation with effective fungal antagonists such as nematode trapping fungi, *Arthrobotrys* spp. and *Monacrosporium* spp. and egg parasites, *Paecilomyces lilacinus*, *Pochonia chlamydosporia*, bacterial antagonists nematode parasites (*Pasteuria penetrans*) and nematode antagonistic rhizobacteria (PGPR, *Pseudomonas fluorescens* and *Bacillus spp*.). These antagonists feed or parasitize the nematodes or release secondary metabolites which are having nematicidal activity. Judicious or need based application of nematicides is recommended for early protection of tender stages of the plant such as seed or seedling treatments in nursery bed applications. Carbofuran 3G, a carbamate group chemical is utilized as nematicide. Novel approaches like RNA interference (RNAi), targeted gene silencing, anti-nematode-based resistance such as anti-nematode effectors, inactivation of parasitism genes, anti-feeding site-based resistance, molecular transfer of resistant genes against economically important nematodes, testing molecules of novel chemistry etc. are frontier areas of research.

PESTICIDE FORMULATIONS, COMPATIBILITY AND THEIR EFFICIENT USE

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Introduction

Insect pests account for ten to thirty per cent loss of the potential yield of crops. Pesticides offer practical control measure for insect pest populations approaching or at the economic threshold. Pesticides or Crop Protection Agents (CPAs) have rapid curative action in preventing economic damage and indispensable in attaining better yields. They work better and faster than alternatives in maintaining higher C: B (cost: benefit) ratio i.e., higher returns to the farmer.

But their indiscriminate and injudicious application may pose risks to crop as well as humans in the form of poisoning and residues. However, health risks may be insignificant compared to their benefits. The pesticides evolved into the present form with major changes in their chemical form and modes of action.

- In ancient times: lime sulphur, arsenicals, nicotine sulphate,...
- DDT, BHC
- *Organophosphates and Organocarbamates*: chlorpyriphos, carbofuran
- *Synthetic pyrethroids*: permethrin, lambda cyfluthrin
- *Neo-nicotinoids*: imidacloprid
- *Microbial derivatives*: **emamectin benzoate**, spinosad
- *Pyridine azomethines:* **pymetrozine**
- Indoxacarb, fipronil, **flubendiamide, flonicamid, chlorantraniliprole,..........**

New pesticides are turning safer as they are used at lower doses with higher LD_{50} implying less mammalian toxicity (Lesser the LD_{50}, higher the toxicity). However, they should be the last resort after maintaining sanitation and other Integrated Pest Management (IPM) tactics. The application techniques play a vital role in the success of the insecticide formulations.

Terminology

- **Active ingredient (a.i):** Toxic part of a pesticide formulation that kills the pest.
- **Inert ingredient/ Carrier:** Non-toxic part that make a formulation better for storage, handling or application. Eg: talc, clay, alcohol,..

Importance of Formulations

- Handling (with sprayer, duster, hand broadcasting,..)
- Storage
- Purpose (seed dressing, foliar spray, drenching,..)
- Quantity of spray fluid required (based on HV, LV, ULV)
- Solubility of active ingredient

It is important to understand the properties of various liquid, solid and other pesticide formulations to utilize them in an efficient and proper manner. Certain organizations regulating pesticide formulations and their analysis are CIPAC (Collaborative International Pesticides Analytical Council), CORESTA (Cooperation Centre for Scientific Research Relative to Tobacco) and IPFT (Institute of Pesticide Formulation Technology). CIPAC two letter formulation codes of international coding system were adapted to notate various formulations in this chapter. Based on the readiness to use, pesticides are of two types *viz.*, concentrates and ready –to-use (RTU) formulations. RTU type formulations are safe to handle, saves time and water but are costly and less available. Whereas concentrates are generally available in the market; that are diluted with water and sprayed in the field.

I. Liquid A.I. Formulations

Soluble Liquid concentrate (SL)

- Dissolved active ingredient (salt)
- SLs have lower viscosities than SCs
- They mix easily in water and require minimal agitation
- Similar to salt water
- Eg: Imidacloprid 17.8 SL

Suspension Concentrate (SC)

- Solid particles dispersed in liquid- not soluble completely
- Contains emulsifier
- Needs agitation
- Similar to Beet root juice
- Eg: Flubendiamide 48 SC

Emulsifiable Concentrate (EC)

- Liquid dispersed in another liquid (oil) - do not mix up
- Turns milky when added to water
- Phytotoxicity chances
- Strong odour due to solvents used (petroleum products)
- Absorbed by skin of humans
- Eg: Novaluron 10 EC, Hexaconazole 5 EC, Spinosad 2.5 EC

Flowable Concentrate for Seed Treatment (FS)

- Fine powder a.i. suspended in liquid
- Does not dissolve in water or liquid
- For mixing with seed
- If sprayed, agitation needed and abrades the nozzles
- Eg: Imidachloprid 48 FS

Ultra Low Volume

- Hundred percent active ingredient (a.i.)
- Spray fluid not more than 2.5 l / acre
- No agitation and no abrasion of tank
- Drift prone
- Absorbed by skin of humans

II . Solid A.I. Formulations

Dust (DP)

- Used under water scarce conditions or when plant should not be sprayed
- a.i. less than 10 % is mixed with filler (carrier)
- Seed dressing and spot application
- Drifts to non target areas also
- Uneven distribution
- Inhalation hazard
- Eg: Malathion 5 DP, Chlorpyriphos 1.5 DP

Granules (G)

- a.i. less than 15 % coated on carrier
- Soil application and in whorls of crops
- No drift issue and slow release of a.i.
- Uneven distribution
- Not effective on unlevelled surfaces
- Eg: Emamectin benzoate 5 SG (soluble granules), carbofuran 3 G, Cartap 4 GR

Pellets

- Same as granules
- But all particles are of same size, shape and weight

Wettable Powders (WP)

- Same as dust but a.i. range is 5-95 %
- Do not form a true solution
- Constant agitation is needed
- Abrades sprayers
- Long exposure for pests
- Powder visible on plants after drying
- Inhalation hazard
- Difficult to mix in very hard or alkaline water
- Eg: Thiodicarb 75 WP, Copper oxychloride 50 WP

Soluble Powder (SP)

- Forms a true solution
- a.i. is 15-95 %
- Inhalation hazard
- Eg: Diafenthiuron 50 SP

Water Dispersible Granules/ Dry Flowables (WG/ DF)

- a.i. is 90 % and coated on granules
- Constant agitation needed
- Eg: Pymetrozine 50 WG

III. OTHER FORMULATIONS

Microencapsulation

- Highly toxic and slow release
- Liquid/ solid pesticide in plastic coating
- Safe to applicator
- But hazardous to bees- they get confused with pollen

Water Soluble Packets (WSP)

- Highly toxic a.i.
- Pre-weighed pesticide in small plastic bags

Fumigants

- May be any of the following types:
  a) Non-volatile liquids under pressure
  b) Volatile liquids
  c) Solids that are sublime
- Penetrate cracks and crevices
- Single treatment is effective
- Target site should be completely covered
- Toxic to humans
- Eg: Celphos tablets

Impregnates

- Pesticides impregnated on fertilizers

The Biggest Problem In Pest Control: "How to apply" and "How much to apply"

Pesticide Measurement

$$\text{Quantity of Insecticide} = \frac{\text{Quantity of spray solution} \times \text{Strength of spray solution}}{\text{Strength of Insecticide}}$$

(*OR simply*)

$$V_1N_1 = V_2N_2$$

V- *Volume* or *Quantity* or *Amount*.....ml or g (litre or kg)

N- *Concentration* or *Strength*....%

Pesticide Computations

Ex 1: How much volume of Flonicamid 50 WG is required to spray @ 0.012 % to control whitefly, *Bemisia tabaci* and spray fluid required per hectare is 1000 litres?

Sol: $V_1 N_1 = V_2 N_2$

V_1 = 'x' g ; V_2 = 1000 lt

N_1 = 50 % ; N_2 = 0.012 %

$$V_1 = \frac{1000 \times 0.012}{50} = 0.24 \text{ lt } (= 240 \text{ ml})$$

- Mix 240 ml of flonicamid in 1000 lt of water and spray one hectare

Ex 2: How much quantity of Proclaim 5 SG is required to spray @ 0.0025 % to control *Spodoptera litura* when final volume is 1 lt (1000 ml)?

Sol: V_1= '*x*' g ; V_2= 1000 lt

N_1= 5 % ; N_2= 0.0025 %

$V_1 N_1 = V_2 N_2$

$$\text{Hence, } V_1 = \frac{1000 \times 0.0025}{5}$$

= 0.5 g in 1000 lt

Ex 3: What is the strength of the spray fluid prepared when 0.4 g of Flubendiamide 48 SC is mixed in 1 lt of water (spray fluid)?

Sol: $V_1 N_1 = V_2 N_2$

$$\frac{0.4 \times 48}{1000} = N_2$$

So, N_2 = 0.019 %

Ex 4: What is the quantity of Pymetrozine 50 WP needed when spray fluid of 1000 lt of 2 % concentration is needed?

Sol: $V_1 N_1 = V_2 N_2$

$$V_1 = \frac{1000 \times 2}{50}$$

Hence, V_1 = 40 g

Ex 5: Quantity of Lufenuron 10 EC needed to spray is 10 ml in 10 litres. How many tanks of 10 litre capacity are needed when spray fluid / ha is 1000 litres?

Sol: **1 tank at a time carries 10 lt à 1 tank 100 times carries 1000 lt**

So, 100 tanks of 10 lt capacity are needed to spray 1000 lt in 1 ha

Ex 6: If the tank capacity is 15 lt, how many tanks are needed to spray 1000 lt/ ha and how much insecticide per tank (similar to above Eg 5)?

Sol: **Insecticide per tank :-**

10 ml in 10 lt

'*x*' ml in 15 lt

$$= \frac{10 \times 15}{10} = 15 \text{ ml}$$

No. of tanks:-

1000 / 15 = 66.66 tanks

SUMMARY

- Pesticides or Crop Protection Agents (CPAs) have rapid curative action in preventing economic damage and indispensable in attaining better yields.
- Pesticide formulations are necessary for safe handling, storage of the toxic substance or active ingredient (a.i.).
- They are basically divided based on the state of the active ingredient as solid and liquid formulations.
- Pesticides should be applied at the optimum level…not high, not less.
- Dry formulations should be pre-slurried before mixing in the mixing container.
- Pesticide spray fluid should not be stored for long time.
- Wind speed and direction and slope of the field are important for spraying properly.

Formulations with Combinations of Pesticides

When two or more chemicals can be mixed safely, or used in combination, they are said to be **compatible.** These combinations can be a pesticide mixed with another non-pesticide chemical, or can be two or more pesticides that are combined in the same tank mix. The reasons for combining pesticides are:

1. To increase the effectiveness of one of the chemicals. As mentioned above, this is called synergism. The material added to increase the effectiveness of the primary chemical is called a **synergist**. The synergist may not necessarily be pesticidal by itself, but increases the effectiveness of the pesticide with which it is combined. The best-known example of the use of a synergist is the addition of piperonyl butoxide (PBO) to pyrethrum, pyrethrins, or some synthetic pyrethroids. Without the addition of PBO, flying insects may be knocked down by these insecticides, but will later recover and fly away.

2. To provide better control than that obtained from one pesticide. Applicators sometimes combine active pesticides to kill a pest that has not been effectively controlled by either chemical alone. Many combinations are quite effective, but in most cases it is not known if the improved control is a result of a **synergistic** action or an **additive** effect of the combined chemicals on different segments of the pest population. One should always check the label to verify the safety and legality prior to mixing of pesticides.

3. To control different types of pests with a single application. Frequently, several types of pests need to be controlled at the same time. It is usually more economical to combine the pesticides needed and make a single application.

When two or more pesticides cannot be used in combination, they are said to be **incompatible.** Some pesticides are incompatible because they will not mix, others because even though they mix, they do not produce the desired results. Some combinations of chemicals result in mixtures that produce an effect which is the opposite of synergism. This effect is called **antagonism** and may result in chemical reactions which cause the formation of new compounds. In other cases incompatibility may result in separation of the pesticide from the water or other carrying agent. If one of these reactions occurs, one of the following may result:

- Effectiveness of one or both compounds may be reduced.
- Precipitation may occur and clog the screen and **nozzles** of application equipment.
- Various types of **phytotoxicity** may occur.
- Excessive **residues** may **result.**
- Excessive **run-off** may occur.

Another less familiar, but extremely important, undesirable effect of combining certain pesticides is **potentiation.** Some of the organophosphorous pesticides potentiate (or activate) each other as far as animal toxicity is concerned. In some cases, the combination increases the toxicity of a compound that is normally of very low toxicity, so that the result is a compound that is highly toxic to people, other animals or plants.

Some pesticide labels indicate known **compatibility** problems. Some pesticide **formulation**s are prepared for mixing with other materials and are registered for pre-mixes or for tank mixes. If this is true, it will be indicated so on the label. Prior to tank mixing a combination of chemicals, refer to the compatibility charts that are available through the pesticide dealer or from various other sources are to be referred. Organophosphates and some herbicides are more **persistent** in the environment and multiple applications several days apart may result in excessive residue, phytotoxicity, or livestock poisoning.

Pesticides Efficient Usage and its Safety

Do's:

While Purchasing

- Purchase pesticides/biopesticides only from registered pesticide dealers having valid licence.
- Purchase only the required quantity of pesticides for single operation in a specified area.
- Check the approved labels on the containers/packets of pesticides.
- Check the Batch No., Registration Number, and Date of Manufacture / Expiry on the labels.
- Purchase pesticides well packed in containers.

During Storage

- Store the pesticides away from house premises.
- Keep pesticides in original containers.
- Pesticides/weedicides must be stored separately.
- Area where the pesticides have been stored should be marked with warning signs.
- Pesticides are to be kept away from the reach of children and live stocks.
- Storage place should be well protected from direct sunlight and rain.

While Handling

- Keep pesticides separate during transportation.
- Bulk pesticides should be carried tactfully to the site of application.

While Preparing Spray Solution

- Always use clean water.
- Use protective clothing *viz.*, hand gloves, face masks, cap, apron, full trouser, etc. to cover whole body.
- Always protect the nose, eyes, ears, hands, etc. from spill of spray solution.
- Read instructions on pesticide container label carefully before use.
- Prepare the solution as per requirement.
- Granular pesticides should be used as such.
- Avoid spilling of pesticides solutions while filling the spray tank.
- Always use recommended dosage of pesticide.
- No activities should be carried out which may affect one's health.

Selection of Equipments

- Select right kind of equipments.
- Select right sized nozzles.
- Use separate sprayer for insecticides and weedicides.

While Applying Spray Solutions

- Apply only recommended dose and dilution.
- Spray operation should be conducted on cool and calm day.
- Spray operation should be conducted on sunny day in general.
- Recommended sprayer should be used for each spray.
- Spray operation should be conducted in the wind direction.
- After spray operation, sprayer and buckets should be washed with clean water using detergent/soap.
- The entry of animals/workers in the field immediately after spray should be avoided.

After Spray Operation

- Left over spray solutions should be disposed off at safer place *viz.* barren isolated area.
- The used/empty containers should be crushed after triple rinse with water with stone/stick and buried deep in soil away from water sources.
- Hands and face should be washed with clean water and soap before eating/smoking.
- On observing poisoning symptoms first aid should be given and the patient must be shown to a doctor. Also the empty container should be shown to doctor.

DONT'S

While Purchasing

- Do not purchase pesticides from foot path dealers or from un-licensed person.
- Do not purchase pesticide in bulk for whole season.
- Do not purchase pesticides without approved label on the containers.
- Never purchase expired pesticide.
- Do not purchase pesticides whose containers are leaking/loose/ unsealed.

During Storage

- Never store pesticide in house premises.
- Never transfer pesticides from original to another container.
- Do not store insecticides with weedicides.
- Do not allow children to enter the storage place.
- Pesticides should not be exposed to sunlight or rain water.

While Handling

- Never carry/transport pesticides along with food/fodder/other eatable articles.
- Never carry bulk pesticides on head, shoulder or on the back.

While Preparing Spray Solution

- Do not use muddy or stagnant water. Never prepare spray solution without wearing protective clothing.
- Do not allow the pesticide/its solution to fall on any body parts. Never avoid reading instructions on container's label for use.
- Never use left out spray solution after 24 hours of its preparation.
- Do not mix granules with water.
- Do not smell the spray tank.
- Do not use overdose which may affect plant health and environment.
- Do not eat, drink, smoke or chew until the completion of the whole operation of pesticide usage.

Selection of Equipments

- Do not use leaky or defective equipments.
- Do not use defective/non- recommended nozzles. Do not blow/clean clogged nozzles. with mouth. Instead use tooth brush tied with sprayer.
- Never use the same sprayer for both weedicides and insecticides.

While Applying Spray Solutions

- Never apply over-dose and high concentrations than recommended.
- Do not spray on hot sunny day or strong windy conditions.
- Do not spray just before rains and immediately after the rains.
- Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer.
- Do not spray against the wind direction.
- Containers and buckets used for mixing pesticides should never be used for domestic purpose even after thorough washing.
- Never enter into the treated field immediate after spray without wearing protective clothing.

After Spray Operation

- Left over spray solution should not be drained in or near ponds or water lines etc.
- Empty containers of pesticides should not be re-used for storing other articles.
- Never eat/smoke before washing clothes and taking bath.
- Do not take the risk by not showing the poisoning symptoms to doctor as it may endanger the life of the patient.

In case of accidents the following symptoms occur: if Over exposed to pesticides

- Headache, Dizziness, Sweating, Salivation, Chest pain, Difficulty in Breathing, Nausea, Vomiting, Muscle /Stomach cramps, Skin irritation.

What is to be done After Exposure?

- If skin contaminated, remove the cloths, wash the skin with soap water.
- If eyes contaminated, wash the eye with clear running water for 15 min.
- In case of inhalation of poison, take victim into fresh air, loose any tight clothing, and give artificial respiration.
- To induce vomiting use saline water/don't induce vomiting if victim is unconscious.
- Don't waste time and take the victim to the hospital as early as possible.
- Take the container with label and leaflet also to show to the doctor.

Protective Equipment to Avoid Exposure

- Full sleeved shirt and pants
- Boots or shoes
- Dust/face glass mask
- Goggles/spectacles
- Hat/turban
- Gloves (full)

OROBANCHE (BROOMRAPE) MENACE IN CROP PRODUCTION: IMPACTS AND MANAGEMENT STRATEGIES

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Head, CTRI-KVK, Kalavacharla

Introduction

Orobanche, commonly known as Broomrape is an obligate phanerogamic root parasite that attacks many dicotyledonous crops. *Orobanche* is a genus of over 200 species of parasitic herbaceous plants in the family *Orobancheaceae,* native to the Mediterranean region (North Africa, the Middle East and Southern Europe) and Western Asia. They lack chlorophyll and obtain carbon, nutrients, and water through haustoria which connect the parasites with the host vascular system affecting the yield and quality of important crops like tobacco, mustard, sunflower, tomato, brinjal, faba bean etc., with the average yield loss of as high as 50%. Some species are relatively specific in their host selection, while other species have a very wide host range. The most important species and their hosts are given here.

Orobanche **species**	**Common name**	**Host range**
O. aegyptiaca **Pers.**	Egyptian broomrape	Tomato, potato, tobacco, brinjal, pea, faba bean, cabbage, cauliflower, rape, mustard, turnip, hemp, sunflower, spinach
O. ramosa **L.**	Branched broomrape or Hemp broomrape	Hemp, potato, tobacco and tomato; also on groundnut, cowpea and chilli pepper.
O. crenata **Forsk.**	Bean broomrape	Faba bean, pea, lentil, chickpea, vetch and clover.
O. cernua **Loefl.**	Nodding broomrape	Solanaceous crops: tomato, potato, tobacco and brinjal.
O. cumana **Wallr.**	Sunflower broomrape	Sunflower and sometimes tomato.
O. minor **Sm.**	Common broomrape	It attacks red and white clover, lucerne, tobacco, carrot, lettuce, sunflower and many other crops and ornamentals.
O. solmsii **Clarke**	Changbao broomrape	Causes significant damage in mustard and tobacco in Nepal.

Biology

The broomrape plant is small, measuring 10-60 cm tall depending on species. The leaves are triangular scales, dark prurple without any chlorophyll. It is best recognized by its yellow-to-straw coloured stems completely lacking chlorophyll, bearing yellow, white or blue, snapdragon-like flowers. These plants generally flower when weather conditions are cool to moderately warm. When they are not flowering, no part of these plants is visible above the surface of the soil. The flower shoots are scaly, with a dense terminal inflorescence (spike) of 10-20 flowers in most species.

Seed

A single plant in the field can produce 2,50,000 seeds (about 1,84,000 seeds per gram) and a single *Orobanche* plant is therefore capable of heavily infesting the field, rapidly increasing the seed bank in the soil. Seeds are usually dark brown, oval shaped, measure 0.35 x 0.25 mm and weigh 3 to 6 ìg (Parker and Riches, 1993) and blacken with age. Testa is hard, surrounding a fatty endosperm that has an undifferentiated embryo at one end.

Seed Dispersal Mechanism

Broomrape seeds are widely disseminated by the winds and also through contaminated crop seeds. However, animals and farm machinery could be the other sources of seed dissemination. The seeds remain viable even after passing through the alimentary system of animals; therefore even the farm yard manure may be contaminated with viable *Orobanche* seed.

Seed Dormancy and Conditioning

Though minute, the seeds are capable of lying dormant for several years and germinating in succession. Immediately after shedding the seeds are dormant and require a period of after-ripening. At the start of the rainy season the seed will absorb water, but it is still unable to germinate. However, a moist environment is required (for several days) together with suitable temperatures in order to render the mature seed responsive to germination stimulants. This preparatory period is known as conditioning or preconditioning. This "conditioning" period lasts for 5 to 21 days at a suitable temperature (15 to 20°C). Preconditioning at a suitable temperature increases the sensitivity with several orders of magnitude, and prolonged preconditioning can decrease sensitivity again (Matusova *et al*. 2004).

The dormancy of the seeds is broken during preconditioning and the seeds, therefore, begin to be sensitive to increasingly lower concentrations of the germination stimulant. With prolonged preconditioning, seeds enter secondary dormancy and become less sensitive to the germination stimulant. These substantial changes in sensitivity suggest that this is a safety mechanism that restricts the period in which the seeds can respond to the germination stimulants produced by host plants (Matusova *et al*. 2004).

The release of dormancy and re-induction of dormancy are highly dependent on the preconditioning temperature and preconditioning period. However as an obligate parasite, to ensure its highest chances of survival, broomrape can adopt different strategies to persist as dormant seed in the soil. The impermeable seed coat, requirement of a proximate host root within a maximum distance of 1cm from the seed, requirement of optimum soil moisture and temperature and finally the strict requirement of host root signals (germination stimulants) are the main strategies deployed by the parasite to proceed for germination or to enter into dormancy (Lopez-Granados and Garcia-Torres, 1996). It has been reported that the optimal preconditioning temperature and period vary between different species or different seed populations of the same species (Logan and Stewart, 1992).

Seed Germination

Conditioned seeds are capable of geminating but a chemical stimulus is needed to trigger the germination. This stimulus normally comes from host roots. The stability of the chemical stimulant is very short-lived in the soil (Sauerborn, 1991). Therefore *Orobanche* normally germinates only when a host root is nearby. This ensures that most of the germinated seeds get their host because the limited resources of the very minute seeds do not permit the germinated seedlings to travel for long distances in search of the host. A few host plants like chilli and bell peppers (*Capsicum annuum* L.), coat buttons (*Tridax procumbens* L.), and hairy beggar-ticks (*Bidens pilosa* L.) stimulate the germination of broomrape seeds without themselves being parasitized (King, 1966).

Growth

Upon germination, broomrape seed develops a small radicle which penetrates a fine rootlet of the host and becomes firmly connected with it. The radicle elongates by cell division and extension (Parker and Riches, 1993). It attaches to host roots mainly in the region of root elongation and absorption (Foy *et al.*, 1989). The tip of the radicle enlarges as soon as it attaches to the host root and forms a 'haustorium'. Subsequently, the haustorial tissue penetrates the host root by enzymatic degradation, rather than mechanical destruction and establishes connections with the host vascular system.

The haustorium has three functions: attachment, penetration into the host root, and nutrient acquisition from the host. When a successful connection has been made with the host, the parasite can grow rapidly using water and nutrients taken from the host, causing yellowing of leaves, stunting and wilting of the host plant. The part of the broomrape seedling outside the root of the host swells to form a tubercle. After 1 to 2 weeks of growth, a shoot bud develops on the tubercle producing a flowering spike which elongates, and emerges above the soil. After emergence the parasite will grow until it flowers, produces seed and dies. The complete cycle takes 10 to 15 weeks. High soil moisture due to irrigation or rain after planting, low soil temperature during winter months encourage heavy incidence of *Orobanche*.

Economic Importance

Broomrapes cause extensive damage by reducing the yield of parasitized crops. Besides causing yield loss and reduction in cultivated area of crops, broomrapes also reduce crop quality. The presence of broomrape plant material in harvested crop produce may reduce the value of the crop or make it unmarketable. Broomrapes reduce the number of crop alternatives available to farmers. The presence of broomrape in a field may force farmers to plant a less economical, non-host crop or to leave the field fallow.

Management Strategies

I. Eradication

Eradication of of *Orobanche* is extremely difficult owing to factors like prolific seed production, higher longevity of seeds, seed emergence only when suitable host is present, shoot emergence above soil surface at 30-45 days after infestation, and vigorous growth. Several methods of control have been tried against broomrapes, but most have proved ineffective because *Orobanche* seeds in the soil remain viable for long periods. Due to the genetic variability that occurs within and between *Orobanche* species (Román et al., 2001 & 2002), these parasites are well equipped to adapt to individual control strategies such as host plant resistance and herbicides.

II. Preventive Methods

Preventing the parasite from spreading to parasite-free areas is the most crucial step in broomrape management. Avoidance should therefore be considered the prime method of protection, and containment and eradication the second line of defence against the parasitic weed

- Prevent the spread of seeds by restricting the movement of infested soil by farm machinery and vehicles. Clean all the tools and implements after their use in the infested fields.
- Prevent grazing on infested plant material.
- Avoid the use of infested plants for composting or for making hay.
- Use certified crop seeds collected from non infested fields and avoid using seeds obtained from infested fields.
- In *Orobanche* sick fields, growing specific host crops for one or two seasons is to be skipped off.
- Burning of residue from infested crops can reduce carry over of broomrape seeds back to the soil.

III. Mechanical Methods

Controlling broomrapes by means of mechanized cultivation is also not feasible because most of the parasite plants appear within crop rows and emerges so close to the crop. Moreover, these practices are followed only after the emergence of the parasite and by that time it has already damaged the crop. Cutting down the *Orobanche* shoots either upto or 2-3 cm below the soil level, well before flowering or seed setting, will prevent the seed production.

IV. Cultural Practices

- **Summer Ploughing:** Summer ploughing at soil depth of more than 20 cm for several years in areas of heavy infestation will reduce *Orobanche* seed bank.
- **Soil Solarization:** Mulching the soil with transparent polyethylene sheets for several weeks under solar irradiation kills *Orobanche* seeds in the upper soil layers. The temperatures of 45-60 °C kill *Orobanche* seeds that are in the imbibed state; therefore soil must be wet at the time of treatment. Seeds of *O. ramosa* can survive for 35 days at 50°C in dry air, but are quickly killed by temperatures of 40°C when wet (**Habimana *et al* 2014)**. This is effective only where sunshine is sufficient. The biggest limitation to this method however, is the high cost of the polyethylene.
- **Flooding:** It has been observed that broomrape problem is more severe under rainfed than irrigated conditions. Flooding the field suppresses the broomrape as the seeds of the parasite do not survive an extended period of inundation (more than one month).
- **Fertilization:** The nutrient status of soil has been observed to affect the infestation of broomrape and its parasitism on host plants. *Orobanche* tends to be associated with less fertile soil conditions. Broomrape infestation of tomato decreased with increases of soil nitrogen (Mariam and Rungsit, 2004). Ammonium form of nitrogen has been found to reduce broomrape parasitism to a greater extent than that caused by either urea or nitrate form. Van Hezewijk and Verkleig (1996) have shown that application of ammonium sulfate at 8 mM in combination with a nitrification inhibitor during the conditioning phase reduced germination of *O. crenata*. This effect was more pronounced with 4 mM ammonium sulfate applied with a nitrification inhibitor during the germination

phase. Reduced germination and radicle length were observed in *O. ramosa*, grown in association with host crop seedlings in response to application of ammonium nitrate (Abu-Irmaileh 1994). Application of neem cake at 400 kg/ha has been found beneficial in reducing the infestation.

- **Intercropping and Crop Rotations:** It has been demonstrated that intercrops with cereals or with fenugreek or berseem clover can reduce *O. crenata* infection on faba bean and pea due to allelopathic interactions (Fernandez-Aparicio *et al.*, 2010). Rotation with non-host crops is usually suggested. Broomrape infestation in tobacco was significantly lower (1.75%) succeeding maize but higher in sole tobacco (21.54%) (Kasturi Krishna *et al.*, 2007). The use of trap crops offers the advantage of preferentially stimulating broomrape suicidal germination. Growing of trap crops such as jowar, gingelly, blackgram and greengram in kharif facilitates *Orobanche* germination but will not allow it to grow. Catch crops like berseem (*Trifolium alexandrinum* L.) and sweet pepper (*Capsicum frutescens* L.) which are susceptible to attack by broomrapes can be used.
- **Sowing date:** The degree of infestation by broomrapes is closely related to the date of sowing of the host crop. Delay of the sowing date has resulted in reduced parasitism of broad bean and lentil by *O. aegyptiaca* (Sauerborn, 1991). Shifting sowing from October to November, December or January reduces numbers and dry weight of attached and emerged broomrapes; both *O. crenata* and *O. foetida* in faba bean (Grenz *et al.*, 2005).
- **Resistant Genotypes:** Breeding resistant genotypes of host plants is one of the most promising approaches to reduce losses due to infestation by *Orobanche*. In legumes, resistance to *O. crenata* associated with low induction of parasitic seed germination has been reported in several species (Abbes *et al.* 2010), although it is not known whether this is based on production of germination inhibitors or on reduced production of stimulants.
- **Hand Weeding:** Hand pulling of broomrape shoots before seed set has been the most commonly used method of control and is still practiced where labour is inexpensive. Hand weeding limits only seed production and is recommended only under conditions of light infestations. However, this method is labour intensive and injurious to crop plants.

V. Chemical Methods

- **Germination Stimulants:** Germination stimulants, both natural and synthetic, have good potential as effective tools of management of broomrape, but much remains to be learned about their structure, activity and stability in the soil. Their ability to respond to germination stimuli fades gradually when the seeds dry and they then remain dormant until re-conditioned. Initial attempts to deplete broomrape seed banks using synthetic Strigolactone were made by using the synthetic Strigolactone analogue GR7 (Fernández-Aparicio *et al.* 2011). However, field application of these GR type Strigolactones provided only partial control of *Orobanche* owing to the instability of the compound, particularly at pH >7.5 which is common in *Orobanche*-infested soils.
- **Post-emergence Herbicides**

  Any herbicide that can translocate, without being metabolized, through a host plant into broomrape attached to the host roots has potential for use in broomrape control.

i. Promising results with post emergence application of glyphosate 25-50 g/ha twice at 30 and 55 days after sowing have been obtained in mustard crop (Punia, 2014).

ii. Selective control of broomrape by glyphosate in some of the host crops is due to rapid translocation of the herbicide away from the crop foliage to the parasitic attachments on the host roots (Foy et al. 1989). ^{14}C-glyphosate was shown to translocate from tomato leaves to *O. aegyptiaca* shoots (Jain and Foy 1997).

Use of Transgenics in Broomrape Management

Using the modern techniques of biotechnology, it is now possible to develop herbicide tolerant crops. Glyphosate resistance has been engineered into tobacco, tomato, rape and soybeans, all species affected by broomrapes. Preliminary observations with transgenic oilseeds rape possessing target site glyphosate tolerance are that excellent control of broomrape is achieved with a 250-750 g/ha glyphosate treatment 5 weeks after transplanting seedlings into broomrape-infested pots (Gressel *et al*. 1994; Joel *et al*. 1995). Chlorsulfuron affected excellent control of *Orobanche aegyptiaca* in preliminary pot tests, with transgenic tobacco having a modified ALS. Foliar application of 15 g/ha chlorsulfuron 10, 20 or 30 days after transplanting prevented the development of parasite without reducing tobacco yield (Joel *et al*. 1995). The transgenic sulfonylurea-resistant flax already available (Mc Sheffrey *et al*. 1992) might make flax an interesting trap/catch crop for controlling broomrape beyond its present use.

For *Orobanche*, high concentrations of the stimulant also inhibit seed germination and over-expression of the appropriate genes could be an effective control strategy.

Biological Control

Biological control through inundation with locally occurring pests and pathogens may be feasible and has been pursued vigorously; however, it has never been integrated with other options (Amsellem *et al.,* 2001; Kroschel and Klein, 2004).

- The broomrape fly (*Phytomyza orobanchia*) is a widely occurring insect pest of several *Orobanche* species. The efficacy of the broomrape fly *Phytomyza orobanchia* as biological control agent of *Orobanche* is reported from Eastern Europe. The insect bores into the bulb and stem of *Orobanche*, attacks the capsules, and eats most of the seeds. Natural reduction of *Orobanche* seed production of 11–79% has been reported from several countries (Klein and Kroschel, 2002). Mass rearing of *Phytomyza* and the yearly release could be a possible approach in *Orobanche*. The use of *Phytomyza orobanchia* in combination with mycoherbicides and other control measures in an integrated and participatory approach could yield better results. As the use of this insect often conflicts with the use of insecticides to control aphids, this option has been quite unpopular (Gressel *et al*., 2004).

- *Orobanche*-specific *Fusarium oxysporum* was used to control the parasite in tobacco and in sunflower. *Fusarium oxysporum* var. *orthoceras* gave some control of *Orobanche aegyptiaca* (Panchenko, 1981) and *Orobanche cernua* (Bedi and Donchev, 1991).This agent is still to be developed for worldwide biological control of the different *Orobanche* species.

Conclusion

None of the control methods reported to provide effective and economic control of broomrape. Combination of different methods of control into an integrated system is the best approach for effectively controlling broomrape thereby preventing damage and yield loss in field crops.

HARVESTING AND CURING OF FLUE CURED VIRGINIA TOBACCO

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Leaf Harvesting

The uniform and well matured ripe leaves should be harvested. Ripe leaves have greenish yellow colour, a velvety feel and lost much of their stickiness. These leaves lie horizontally or bend slightly down with slightly dry leaf tips. Bottom primings are harvested slightly on the green side, while the middle leaves when they are ripe and the top leaves when they are fully ripe. On an average, not more than three leaves should be harvested at a time. Harvesting must be done on a clear weather day. The crop should not be harvested immediately after rains or irrigation and it should be postponed by 2 - 3 days.

Priming is done once in a week under normal conditions. The leaves should be plucked against the direction of the sun for better judgment of ripeness of leaf. While picking, the midribs should be bent sideways. A well matured leaf will snap crisply with a characteristic sound. The leaves are to be carried carefully without pressing to one end of the field and placed carefully in a wide basket the tips upward. The basket must be taken to the tying shed as early as possible to minimize wilting in the field.

Green Leaf Grading

Despite utmost carefulness, on a field scale harvest, it is sure to harvest some immature tobacco. They must be sorted out before tying. Similarly, over ripe leaves are to be separated if any. These over ripe and under ripe leaves must be tied separately so that each stick contains leaves of uniform colour. Over ripe leaves are usually yellowish white and under ripe leaves are relatively dark green.

Tying the Leaves

The leaves are to be tied to sticks by handling gently in a shaded place, avoiding wilting and bruising. A bruised leaf (physically damaged) does not cure well in the barn. About three leaves are tied in a bunch, back to back, with a jute twine loop on a stick. About 90-100 such leaves are tied in separate bunches with a series of loops on a stick approximately 130 cm long. The leaves are distributed uniformly all over the length of the stick to avoid overcrowding.

Loading of Green Leaf into the Barn

For a satisfactory curing, the whole barn should be loaded with the freshly harvested leaves from a single priming. The unripe leaves (green) are placed on the top tiers, the over ripe (yellowish white) leaves on the bottom tier and well-matured leaves (greenish yellow) in the bulk of the intermediate tiers. The sticks are placed on the tiers approximately at 20-25 cm so that the leaves from the adjacent sticks slightly touch each other without pressing.

An ordinary barn of 4.88 m x 4.88 m x 4.88 m (16 ft x 16 ft x16 ft) size will usually be loaded with 700-750 sticks with such spacing. Low profile barn of 7.32 m x 4.88 m x 3.2 m (24 ft x 16 ft x 10.6 ft) can accommodate 810 sticks.

The barn should never be overloaded while curing the bottom and middle leaves since they spoil easily if drying rate is slow. Leaves from the top of the plant may be crowded slightly more by closer spacing without much detriment to grade return. Loading of the barn should be completed by late afternoon.

Flue Curing

Flue curing is a process of removing moisture and achieving desirable bio-chemical changes *(chlorophyll degradation, conversion of starch to sugars, unmasking of yellow xanthophylls and carotenoid pigments etc)* in the harvested leaf in a phased manner. Curing of tobacco leaf is an art of making leaf best in its physical and chemical characteristics according to the preferences of the market. The process essentially influences the quality of a cured leaf.

Factors be taken care before going for the curing process which influence the quality of cured leaf are (i) Selection of curable leaf (ii) Number of bunches/leaves per stick (iii) Number of sticks per barn (iv) Loading of the sticks in the barn.

Curing Process

Details of Curing Schedule

Typically, the curing schedule is divided into three phases defined as yellowing, leaf drying, and stem drying. Although each phase (fig -1) is divided into 48-hour intervals, the actual time required may vary. It is im-portant to note that the curing schedule is a general guide, and the actual schedule followed may deviate due to factors such as tobacco ripeness and maturity, weather conditions during the growing and harvest seasons, airflow, and other influences. Tobacco harvested from different fields on the same farm may cure differently when exposed to the same curing environment. Each cure is different; as a result, tobacco can be cured successfully with a temperature schedule that deviates from the general schedule. A temperature sched-ule is selected based on curing experience and the tobacco's response to the curing environment.

Stages	Temperature		Time
	Dry bulb	*Wet Bulb*	
Yellowing	85 to 105 °F	82 to 94°F	36-48 hrs
Colour fixing	105 to 120°F	94 to 98°F	5-10 hrs
Leaf drying	120 to 145°F	98 to 110°F	36-48 hrs
Midrib drying	145 to 160°F	110 to 114°F	24-36 hrs

Furnace is charged after loading the leaf and temperature raised by 5 to 6°F above outside temperature. Top ventilator is left very slightly open, especially during the cooler hours of the night, bottom ventilators are left open with slight gaps so that upward movement of air continues in the barn.

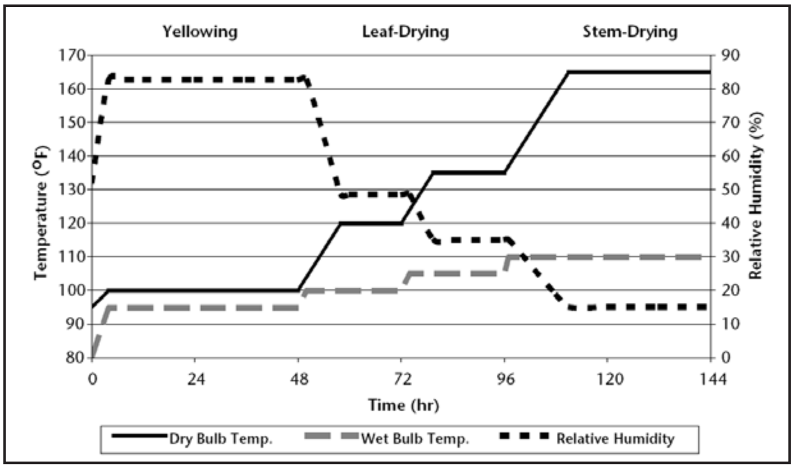


Fig. 1: Typical curing schedule of FCV tobacco

Curing Phases

Yellowing: Temperature is raised by not more than 1 to 2°F per hour reaching 105°F by the time the leaf becomes yellow and is ready for fixing. Temperature should be raised in such a way that yellowing is nearly completed by the time it reaches 105°F. Top and bottom ventilators are gradually opened to 3" or so.

Fixing colour: Great care is required in raising the temperature during this stage. It is raised by not more than 1 to 2°F every hour. Bottom ventilators are opened to 3 – 5" at the base. Top ventilator is raised to a height of 3- 5" from the roof. It is not necessary to raise the top ventilator completely.

Leaf drying: After getting 130°F the top ventilators are gradually closed and later the bottom ventilators are closed. At 140°F, all the ventilators are kept closed.

Midrib drying: Temperature is raised and maintained at a maximum of 160°F until the stem is dry. The ventilators which have been closed during the later part of the leaf-drying stage continue in the closed position.

Temperature and Relative Humidity Management

Proper control of temperature and relative humidity are essential for efficient tobacco curing. For most growers, the relative humid-ity is indirectly monitored by measuring both the dry and wet bulb temperatures.

The dry bulb temperature, which is the actual air temperature, is measured with a conventional thermometer or thermostat. The dry bulb temperature is controlled by the thermostat, which cycles the heat input on and off. A wet bulb thermometer is simply a dry bulb thermometer connected to a water reservoir by a wick that is wrapped around the thermometer bulb.

As a result of the evaporative cooling process, the wet-bulb tem-perature will be lower than the dry-bulb temperature. The amount of cooling depends on the relative humidity. The relative humidity is a ratio: the actual weight of the water vapor in the air relative to the maximum weight of water vapor the air can hold for a given dry bulb temperature. The higher the relative humidity is, slower the evaporation rate, and vice versa. The difference between the dry bulb and wet-bulb temperatures determines the relative humidity of the air. Thus, the difference between the two temperatures indicates the amount of moisture in the air and is often referred to as the drying potential or wet bulb depression.

As the difference between the dry-bulb and wet-bulb temperatures increases, the relative humidity of the air decreases, resulting in an increase in the drying potential. A smaller difference in temperature indicates an increase in the relative humidity and a decrease in the drying potential. If the air were completely saturated, which means the relative humidity would be 100 percent, the dry bulb and wet bulb temperatures would be the same.

Bio-chemical Processes in Curing

The early stage of flue-curing should permit continuing biological activity in the leaf permitting destruction of chlorophyll, conversion of starch to simple sugars and leaf proteins to soluble nitrogenous constituents. These cellular reactions take place in fully turgid leaf cells in aqueous medium and for complete enzymatic reactions, thermal inactivation of these enzymes must be prevented. This means maintaining high humidity and low temperature in the barn for these favourable reaction sequences. During this period leaf turns yellow containing high percentages of soluble sugars.

Further breaking up of sugars by respiratory enzymes have to be prevented since cured leaf must contain high sugars, browning reaction caused by another set of enzymes *poly phenol oxidase* turning the yellow leaf to brown has to be avoided and possibly bio chemical conversion of soluble nitrogen to ammonia has to be arrested since some of these soluble nitrogenous constituents transform into aroma bearing constituents at a later stage. These are achieved by thermal desiccation at the subsequent stage of curing by progressively raising the temperature of the barn and lowering relative humidity by ventilation adjustments. However, since all these biological reactions are a sort of continuous process, changing the temperature and humidity of the barn must necessarily be slow and progressive, abrupt change in temperature and humidity should never be made in the barn while curing is in progress.

Different Physical and Biochemical Changes that Occur during Curing

1. Colour change from green to yellow or orange
2. Chlorophyll degradation occurs up to 1% of original content
3. Unmasking of yellow xanthophylls and carotenoid pigments happens
4. Starch hydrolysis to free sugars
   a. Initial starch - 20-40%
   b. Yellowed leaf -12%
   c. Final cured leaf - 5%
5. Sugars formation will be between 10- 25%
6. Free sugars to CO_2
7. Hydrolysis of proteins to free amino acids (partial respiration)
8. Formation of *Amadori* and *Maillard* compounds
9. Oxidative browning of poly phenols

Improper Curing in the Barn Results in

- Sponging: Improper ventilation leads to developing of light brown spots
- Barn scald: Raising temperature to 130 ^{0}F before leaf drying results in dark *wheatish* coloured leaf
- Carmalised leaf: Raising temperature > 160 ^{0}F and leaf near to flue pipes lead to carmalisation
- Runback: Sudden drop in temp during mid rib drying would result in dark brown spots around the mid rib
- Greens: Increasing the temperature > 105 ^{0}F before yellowing & loading green leaf results in more greens

Unloading the Barn

The barn is allowed to cool down keeping the ventilators closed after the curing is over, the fire is put off. The leaf must attain proper condition for handling. For this, all doors and ventilators are wide open at night so that leaf will absorb moisture from the atmosphere and become soft. In dry weather, wet gunny bags are put on the flue pipe with very slow fire in the furnace to build up humidity inside the barn for few hours just enough for leaf handling. The sticks are removed from the barn and kept in the racks. The leaf is untied from the sticks when there is proper condition preferably in early morning hours and bulked.

Importance of Fuel/Energy Saving

Firewood is the predominantly used source of fuel for flue curing barns, with coal and agro-biomass residues like coffee husks making small contribution to total energy requirement. Some conservative estimates on wood fuel requirement suggest that on an average 5 kg wood is needed for each kg of cured leaf. If 80% FCV tobacco produced is cured using wood as source of energy, the quantity of wood consumed annually for tobacco curing comes to 1.2 million tons. The fuel use efficiency in traditional curing barns is also often very low, contributing to large requirement of fuel wood. A brand new, well-insulated barn uses only about 60 % the heat value of the fuel to cure the tobacco and remaining 40 percent of the heat is lost through the walls of the barn by conduction and radiation, through the exhaust, or through air leaks. Quality of cured tobacco as well as the cost of curing depends on condition of the barn. Poorly maintained barns waste as much as 60 percent of the fuel. Curing in KLS coincides with S-W monsoon exposing the barns to continuous rains, cold gusty winds and low night temperatures. Hence the requirement of heat energy for curing tends to be high to compensate the loss of heat due to dissipation. Flue curing alone accounts for > 30% of the cost of production. Such large-scale use of wood fuel for tobacco curing can result in deforestation and represents a serious environmental issue. Hence, adoption of energy saving methods and exploring alternative green energy sources to minimize the use of valuable wood besides reducing overall cost of cultivation.

Fuel or fuel wood productivity: Enhancing the fuel wood productivity will not only save the wood fuel which helps in sustaining our natural wood resources but also increase or improve efficiency of costly fuel source while tobacco curing. Fuel wood productivity with reference to FCV tobacco curing is: a unit cured leaf (kg) produced per kg of fuel wood.

Enhancing Fuel Wood Productivity

Energy /fuel wood saving techniques and methods:

Barn maintenance: Proper use of top and bottom ventilators according to the curing stages reduces the heat loss and ensures uniform distribution of the heat inside the chamber. Arresting the leakage of hot air from the barn by plugging and proper sealing will reduce the wood consumption. Technical training to the curers regarding the curing process and precautions help in curtailing the energy loss.

Use of alternative sources of energy/fuel: Use of agri bio-mass for briquettes is one of the alternative sources of energy where crop residues and agri wastes can be made in to compressed briquettes and used as fuel for curing in place of wood. Use of solar energy and natural gas are possible options being explored for supplementing/replacing wood fuel during the FCV tobacco curing.

Fuel wood propagation: Popularizing ‘Grow Your Own Fuel’ concept where the FCV tobacco farmer himself ear markssome land to raise fast growing wood fuel trees which not only caters to his fuel need at the time of curing but also reduces the dependency on natural wood reserves. Raising community based social forestry in village waste lands is also another option which alleviates burden on the natural reserves.

Improving energy efficiency during curing process

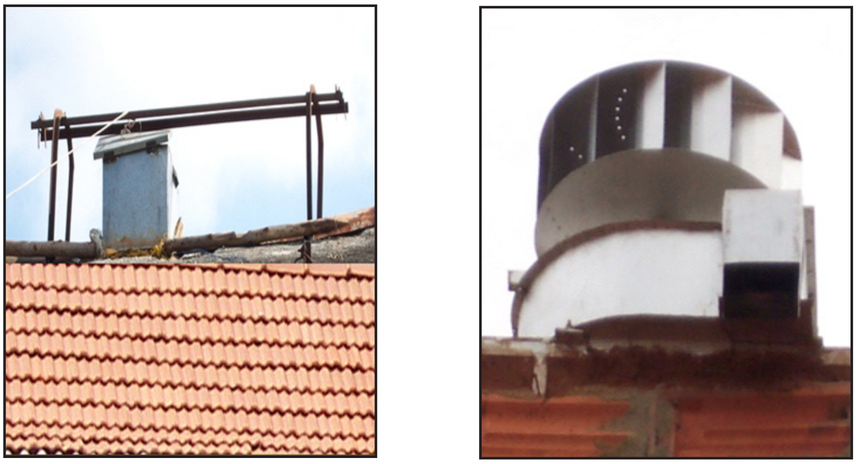
Energy efficiency can be enhanced during the leaf curing process by improving heat movement by convection within the barn, minimizing heat loss from barn, improving burning efficiency, improving heat transfer, ensuring better utilization of heat generated, facilitating uniform distribution of fresh air and removing humid air with the help of ventilators.

Technologies developed and tested for improving energy efficiency by ICAR-CTRI, Tobacco Board and ITC

Low profile barn, barn insulation with thermocole, rock wool/glass wool and paddy straw, Furnace modification – Venturi, flue pipe modification (TIDE), turbo fan (CTRI, RJY model), turbo fan (ITC model), flue pipe modification (Tobacco Board) and Integrated barn (Low profile barn, Venturi furnace and paddy straw insulation & flue pipe modification).

Low profile barn

Venturi furnace



Turbo fan on barn roof

Fig.2: Different techniques tested for enhancing energy efficiency during the curing process.

These techniques helped in saving wood / conserving energy up to 30 %. Some of the above concepts are being widely used in the curing process.

Recent advances in Promoting Alternative Energy Sources

The concept of promoting alternative fuels to wood is gaining momentum and has become a national agenda because of environmental concerns and climate change issues. It is a concern in FCV tobacco production since fuel wood use for curing is a major production activity. The natural no cost renewable source i.e solar heat energy can very well be used for supplementing the wood partly or fully.

Fig.3: Polycarbonate roof barn designed and used for testing

Studies are being conducted using solar energy for FCV tobacco leaf curing to reduce the wood consumption during the curing process. At ICAR -CTRI, Rajahmundry different solar heat conducting/trapping materials like white polyethene, black alkathene, galvanized iron and Polycarbonate sheets were tested to find out the best suitable material that can be used to design the solar heat energy-based barn. Among the materials tested the polycarbonate sheet was found to be the best suitable for curing FCV tobacco by solar heat trapping. Temporary poly carbonate + black alkathene chamber attained the temperature up to 138 ^{0}F during daytime.

Trails were conducted with the polycarbonate roof top chamber (600 cubic feet) in the existing barn and compared with the traditional barn curing. A consistent raise in temperature was recorded in upper tiers in case of polycarbonate barn during evening hours compared to normal barn. About 29 % fuel wood was saved with polycarbonate roof barn in comparison to traditional barn. Studies indicated that temperature could be increased or maintained with less fuel during daytime which would help in saving the fuel during daytime.

Use of solar energy and agri- biomass as an alternative to the wood fuel for curing will save the wood fuel and help in reducing the cost of cultivation of FCV tobacco. Promoting research in this area would help in developing better technologies to avoid wood as fuel for curing FCV tobacco as far as possible.

BULKING, GRADING, BALING, NTRM AND LEAF QUALITY

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I. Bulking

Bulking is to be done for efficient grading. Leaves of different varieties must be bulked separately. Leaves from different stalk position must also be kept separate. The bulk must be about one meter high on a raised platform. A close watch should be kept on moisture condition. Dryness causes shattering of leaf. Leaf which is over conditioned will loose colour and develop molds. The bulk should never be on the floor or near any material likely to give offensive odour like insecticides, fungicides or fertilizers. When leaf is being bulked, the bulks have to be covered with polythene sheets (or some other suitable covering e.g., tarpaulin). The bulk is turned for approximately 2-3 times prior to grading depending on the moisture content.

II. Leaf Grading

Grading is the sorting of cured leaves into lots which are homogeneous and is one of the important production practices in flue-cured Virginia tobacco production. The main purpose of farm grades in black soil tobacco and plant position grades for light soil tobacco is to realize more income for farmer's produce and save time for the exporters and render the fixation of minimum support prices and minimum export prices for each grade easier.

Grading of FCV Tobacco in Traditional Black and Southern Light Soils

Factors to be considered include leaf position/length, ripeness and texture, overall colour, blemish damage. These are to be applied at various degrees, depending on the tobacco type and market requirements, to each plant position style category. In black soils, farm grades and in light soils plant position grading is practiced.

Table.1: Grade specifications for the 10 farm grades for black soil tobacco

S. No.	Grade	Color	Body	Texture	Blemish not to exceed	Corresponding Agmark grade
1	Farm-I	Bright lemon or orange	Thin to Medium	Soft	25%	1 to 4
2	Farm-II	Light brownish yellowor or brownish lemon	Medium	Good	25% (White to yellow blemish allowed)	LBY 1
3	Farm-III	Light brown	Good to Medium	Medium	50%	LBY 2
4	Farm-IV	Brown	Heavy Body	Medium to Coarse	50% (brown blemish allowed)	Brown
5	Farm-V	Dark brown	Heavy Body	Medium to Coarse	50%	Dark Brown
6	Farm-VI	Light greenish orange	Good	Soft to Medium	10%	LG
7	Farm-VII	Light medium green	Heavy	Medium to Coarse	25%	LMG
8	Farm-VIII	Medium green	Heavy	Medium to Coarse	35%	MG
9	Farm-IX	Dark green	Coarse	Coarse	-	DG
10	Farm-X	Colour may range from orange,yellow green and/or brown	Variable	-	-	Pl & Bits

Grading for FCV Tobacco in NLS and KLS

The chemical and physical characters of leaf depend on the position of leaf on the plant in flue-cured Virginia tobacco. These chemical and physical characters influence the leaf quality. If the grading is done to group leaves having similar physical and chemical characters into one lot, it will be very easy for the manufacturer to use the tobacco. It will also attract the attention of the foreign buyers in addition to the domestic buyers. Physical and chemical characters vary depending on the position of leaf on the plant. Grading according to the leaf position on the plant and its colour, blemish and maturity is called plant position grading.

Table 2: Physical characters of leaf depend on the position of leaf on the plant

Character	Leaf position on the plant		
	Bottom	Middle	Top
Physical			
Colour	Lemon/yellow	Orange/yellow	Orange/yellow/Mahogany/Red
Leaf thickness/ Body	Thin	Medium	Heavy
Texture	Soft	Medium	Coarse
Injury	High	Low	Nil
Leaf width	Normal	Spready	Narrow, elongated tips
Chemical			
Nicotine	Low	Medium	High
Sugars	Medium	High	Low
Chlorides	High	Medium	Low

This is more pronounced in light soils and hence Northern light soil tobacco and Karnataka light soil tobacco are essentially to be graded as per plant position grading system.

The sub-committee constituted by the Tobacco Board in 1982 felt that the grading system recommended by Mr. Been, EEC expert on grading, does not suit the Indian conditions. The committee after detailed discussions evolved a plant position grading system consisting of 33 grades for the tobacco of Northern light soils and Karnataka light soils. Later the 33 grades system was found to be inadequate to accommodate different styles and qualities of tobacco produced. Too much reduction in number of grades would lead to mixed grading and would be disadvantageous to the growers. The issue was further discussed and finally a system was evolved consisting of 63 grades in all.

The main features of this grading system were

1. Division of the leaves on the plant into four positions *viz.*, Primings (P), Lugs and Cutters (X), Leaf (L) and Tips (T).

2. Seggregation of leaf in each plant position, into different grades based on the quality and colour factors.

3. Division of the plant into two positions for the purpose of green colour grades- Bottom (P & X) and Top (L &T).

4. Provision of a grade called No Grade (NOG) to accommodate PL, Scrap, bits etc.,

Government of India notified these finalized plant position grade specifications in 1984. The Tobacco Board has recommended this plant position grading at the farm level to Northern light soil and Karnataka light soil tobacco and the specifications for the 63 grades are given in Table.3.

In the plant position grading system a grade is defined as a sub division of a type according to plant position or group, quality and colour.

a. Group

Groups in flue-cured Virginia tobacco are Primings (P), Lugs and Cutters (X), Leaf (L) and Tips (T). The P- group consists of primings i.e., the bottom two to three leaves, X-group consists of Lugs and Cutters, i.e., the next five to six leaves over the primings, L group consists of Leaf, i.e., the next six to eight leaves and the T group consists of the top three to four leaves. General characteristics of these groups are

1. **Primings:** Dusty and sandy, high injury, thin bodied, lean in oil, prematurely ripe, short leaf, weak colour, open face, round ends, earthy odour and small midribs.

2. **Lugs and Cutters:** Less dusty and sandy, blunt tips, comparatively less ground injury, thin to medium body, lean in oil except in 1 and 2 quality leaf, better colour intensity, midrib more prominent than in primings, open faced, spready and broad leaves and grainy leaf.

3. **Leaf:** No dust or sand, pointed tips, no ground injury, bodied leaf, rich to lean in oil, ripe tobacco, large and prominent midrib, close face, naked butts and dark colour.

4. **Tips:** No dust or sand, no ground injury, narrow and pointed tips, bodied leaf, dark colour, closed face, very large and prominent midrib.

Table.3: Grade Designation and definition of quality of unmanufactured flue cured Virginia tobacco grown in Northern Light Soils of Andhra Pradesh and Karnataka state (plant position)

Group (plant position)	Grade colour	Spot / blemish / injury / waste in terms of percentage	Maturity / grain / texture	Body	Description of leaf
Primings(P)	P1 Bright lemon or orange P2 lemon or orange P3 lemon or orange P4 lemon or orange P5 lemon or orange	Up to 20% 20 to 30% 30 to 55% Up to 80% more than 80%	More ripe & Grainy	Very thin	Being sand leaf shows a material amount of injury and subject to disease to a large extent compared to other groups. Comparatively short leaf having open face and an earthy nose
Lugs and Cutters (X)	X1 Bright lemon or orange X2 lemon or orange X3 lemon or orange X4 lemon or orange X5 lemon or orange	Up to 20% 20 to 30% 30 to 55% Up to 80% more than 80%	Ripe & very grainy	Thin to medium	Comparatively broader leaves with wider spread from butt end. Elastic fine texture with natural luster, characterized by small midribs and veins
Leaf (L)	L1 Bright lemon or orange L2 lemon or orange L3 lemon or orange L4 lemon or orange L5 lemon/orange or Mahogany	Up to 20% 20 to 30% 30 to 55% Up to 80% more than 80%	Ripe to medium grain	Medium to heavy	Usually long, but not as broad as cutters, Gummy but not very elastic. Generally having pronounced midrib and veins. They tend to fold along the midrib.
Tips(T)	T2 lemon or orange T3 lemon or orange T4 orange or mahogany T5 orange or mahogany	Up to 30% 30 to 55% Up to 80% more than 80%	Under ripe Medium to close grained	Medium to heavy	Pointed tips with narrow blade coarse texture having deep colour intensity. Leaf having prominent midribs and veins.
"P" & "X" BG (Bottom Green)	Bright yellow or Lemon or Orange to light brownish yellow or orange or lemon with greenish tinge.	Up to 25%	Ripe, Grainy, Fine to Medium	Light to Medium	Nil
"L" &"T" TG (Top Green)	Deep yellow or Lemon or orange to light brownish yellow with greenish tinge	Up to 25%	Ripe to under ripe, less grainy, medium to coarse	Medium to heavy	Nil
"P" & "X" BMG (Bottom Medium Green)	Bright yellow or lemon or orange to light brownish yellow or orange or lemon with green cast on	Up to 50%	Ripe, grainy, fine to medium	Medium	Nil
"L" & "T" TMG	Deep lemon yellow or orange to light brownish yellow with green cast on	-do-	Ripe to under ripe, less grainy to close grained, medium to coarse	Medium to heavy	Nil
"L" & "T" "P" & "X" NOG (no grade)	-	-	-	-	Leaf or part of the leaf (except stems) including perished and trashy leaf, scrap and bits from all positions not falling into any of the above grades.

Table 4: Grades in plant position grading system in Northern light soil and Karnataka light soil areas

Sl.No	Priming (P)	Lugs & Cutters (X)	Leaf (L)	Tips (T)
1	P 1 L P 1 0 P 1 J	X 1 L X 1 0 X 1 J	L 1 L L 1 0 L 1 J	
2	P 2 L P 2 0 P 2 J	X 2 L X 2 0 X 2 J	L 2 L L 2 0 L 2 J	T 2 L T 2 0 T 2 J
3	P 3 L P 3 0 P 3 J	X 3 L X 3 0 X 3 J	L 3 L L 3 0 L 3 J	T 3 L T 3 0 T 3 J
4	P 4 L P 4 0 P 4 J	X 4 L X 4 0 X 4 J	L 4 L L 4 0 L 4 J	T 4 0 T 4 J
5	P 5 L P 5 0 P 5 J	X 5 L X 5 0 X 5 J	L 5 L L 5 0 L 5 J	T 5 0 T 5 J
6	BG	NDB	TG	T 4 R
7	BMG	NDD	TMG	T 5 R
8		NoG		

Note:

a. P, X, L & T are plant positions
b. 1, 2, 3, 4, 5 are quality nos. based on the spots and blemish on the leaves.
c. L: Lemon colour; O: Orange colour; R: Mahogany/Red colour
d. G: Green colour; J: J- style indicating immature tobacco
e. BG: The leaf from P & X positions and spot less than 20%
f. TG: The leaf from L & T positions and spot less than 20%
g. BMG: The leaf from P & X positions and spot more than 20%
h. TMG: The leaf from L & T positions and spot more than 20%
i. NDB: The leaf bits with good colour and without midrib
j. NDD: The leaf bits without good colour and without midrib
k. NoG: The leaf which does not fall into any grade.

b. Quality

It is the second factor of the grade where quality is identified based on the percent of spot/blemish/injury/waste. Each group has five quality numbers except in T group where the first quality number does not exist. The five quality numbers and the criterion used for classification into quality numbers are as follows:

Table 5. Classification of leaf Quality

Quality No.	Limits of Blemish/spots/waste/injury	
1.	Up to 20%	spots/blemish/waste/injury
2.	20-30%	,,
3.	30-55%	,,
4.	55-80%	,,
5.	Above 80%	,,

c. Colour

It is the third factor of grade based on the colour intensity of the leaf. The symbols used to denote the colour in the classification are: Lemon (L), Orange (O), Mahogany (R) and Green (G). In case of immature tobacco, the colour symbol in the grade shall be substituted by the letter J. Two grades NDB and NDD were added to the plant position grades list (Table 4).

Precautions in Grading of FCV Tobacco

1) Grading pandals should be spacious and permit sufficient light for grading. The light source should be preferably from north.
2) The labour entrusted with grading work should be thoroughly trained to do grading according to the specifications.
3) Grading should be done for each pick separately after bulking them separately.
4) Tobacco having the same style and colour only should be mixed. Short leaves and scrap should not be mixed with normal leaf.
5) Greens when bulked for a long time till the end of the season may turn to yellow or orange. If not, these greens should be graded before baling.
6) The leaf of different grades should be baled separately. Grades should not be mixed under any circumstances.
7) Tobacco graded as per the specifications will immediately attract the buyers. To make it more attractive, baling should be done with good bale boxes. As far as possible, baling should be done before marketing. Fertilizer bags or torn rags should not be used for baling.
8) Bale should not be too tight, as the quality will go down due to heat generation. At the same time bale should also not be too loose to lose moisture resulting in weight loss.
9) Optimum moisture in the bale is to be maintained. Excess moisture results in development of molds and continuation of chemical reactions at greater speed leading to colour loss. Low moisture in bales will lead to shattering of leaf resulting in reduced prices. Water should not be sprinkled on the bales.
10) The bales should not be kept one over the other. The bales should be covered with tarpaulin or polythene sheet until they are transported to auction platform for marketing.

III. Leaf Quality: Tobacco quality is the balance of visible, physical, chemical and biochemical properties of the leaf. Visual characters *viz*. colour, body, ripeness, size; physical characters *viz*. filling value, equilibrium moisture content, burning rate, porosity, elasticity, shatterability, strip yield and porosity; Chemical characters *viz*. total nitrogen, potassium and chlorides, biochemical characters like nicotine, reducing sugars, starch, and their ratios are important in governing the quality of FCV tobacco. Quality management depends on several factors like soils and climate, cultural practices, fertilizers, irrigation, diseases and pests, air pollutants, maturity of leaf, curing and ageing of cured leaf.

I. Visual Characters

Leaves with undesirable colors particularly green and brown are of poor quality and they are removed by farmers before offering the tobacco for sale. The lemon/orange color is the desirable quality. The relationship between leaf quality and plant position of leaf is given (Table 6).

Table. 6: Relationship between leaf position and leaf quality

S.No.	Visual Characters	Lugs	Cutters/leaf	Tips
1.	Colour	Lemon/ orange	Lemon/ orange	Orange/Mahogany/ green
2.	Finish	Dull	Lustrous	Dull
3.	Ripeness	Over ripe/ ripe	Ripe	Under ripe
4.	Size	Medium	Large	Small/ medium
5.	Texture	Dry	Soft	Dry/woody
6.	Grain	Very grainy	Grainy/ medium	Medium /close
7.	Thickness	Thin	Medium to thin	Medium to thick
8.	Physical damage	High	None	None
9.	Aroma	Low	Medium	High

II. Physical Quality Characteristics

Tobacco buyers evaluate tobacco by its visual characteristics. Such a system of subjective quality evaluation varies with personal fancies and hence cannot be considered as precise. The necessity of objective laboratory tests to evaluate physical qualities has become essential particularly in newly evolved varieties and agronomic practices in order to build up the desirable traits in the crop. The important physical properties of leaf are filling value, equilibrium moisture, shatter resistance, porosity and burn rate.

Filling Value

It is an index for the number of cigarettes that can be produced from a given weight of raw material. Good filling value enables the manufacturer to ensure that cigarettes are made as well filled rigid rods. Poor filling results in poorly made soft cigarettes from the ends of which tobacco shreds fall out easily or else cigarette weight has to be increased in order to restore cigarette firmness. Heavy filling on the other hand can result in too much draw resistance and in sharply altered burn characteristics.

Equilibrium Moisture Content

A hygroscopic property of cured leaf as judged by equilibrium moisture content is an important technological criterion for judging quality. It is the moisture absorbing capacity of leaf which depends on the relative humidity of the surrounding environment. Cured leaf low in hygroscopicity is very difficult to get to 'order' or 'condition' with the result the leaf handling is impeded which gives harsh taste and smoke. High hygroscopicity on the other hand, entails operational difficulty in the cutting and filling machine. Storage of heavily hygroscopic leaf is also a problem. It impairs combustibility. The hygroscopicity of leaf is increased with chloride content of the leaf. Reducing sugars also increase the leaf moisture content. Therefore, it is apparent that cured leaf of acceptable quality should have its equilibrium moisture content within the optimum range i.e. 11 to 15% at 60% relative humidity. Lipophilic colloidal constituents of leaf materials and tissue density (porosity) have direct influence on the water absorption and retention capacities. The water holding capacity of cured leaf increased with potassium content.

Combustibility or Burning Quality

Combustibility or burning quality of tobacco involves several criteria like fire holding capacity, rate of burn, evenness or completeness of burn and character of residual ash. Leaf burn is very commonly used to determine the burning quality of cured leaf. This test is done by touching a piece of manually stretched pre-conditioned leaf to glowing nichrome wire and noting number of seconds the glow continues. Usually 3-5 seconds burn is considered to be satisfactory. Rates of burn vary with different types of tobacco. Factors affecting combustibility are both physical and chemical in nature. Among the physical characteristics, micro structure of leaf is more important. Thick heavy leaf with fine texture due to a close cell packing would have a poor burn since there would be less air space between the cells and consequently poor aeration during burning. Good burning leaf has a loose open structure having high porosity which likely promotes burn by better aeration. Good burn is always exhibited by leaf containing high potassium and low chloride. Calcium and magnesium control completion of burning process and production of white ash.

Shatterability

Another important economic factor in tobacco quality is its resistance to breakage during handling. Tobacco is a fragile material that tends to shatter to a great or less degree with each handling. Breakage becomes accentuated under the stress of mechanical processes in the factory. Tobaccos do differ in their relative brittleness due to various factors. Strength in tobacco leaf is dependent on calcium pectate, the cementing material in the cell wall.

Porosity

Leaf structure or texture is an important physical property of flue-cured tobacco. Texture and grain are synonyms for cigarette tobacco. Graininess in flue cured tobacco is a measure of porosity of leaf which regulates its capacity to absorb and retain additives in the intercellular air chamber. Leaf structure is also defined as degree of cell development of leaf as indicated by its porosity.

Strip Yield

Strip yield in flue-cured tobacco is important to manufacturers since it is the lamina portion of leaf that is normally used in cigarette making. Midribs differ substantially from leaf lamina in chemical composition and its inclusion in blends affect smoking flavour unless ground or otherwise reconstituted. Because of this low utility of midrib, a large bulk of exportable flue-cured leaf is despatched only in the form of strips. This makes strip yield an important criterion in developing varieties as higher the strip yield, greater is the economic return. The strip constitutes, on an overage, about 75% of leaf by weight, usually ranging from approximately 70-80%. Within this range, the higher the strip yield, the better the usability of tobacco.

Elasticity

Elasticity is considered to be a major quality factor in tobacco. Elasticity is the ability of the leaf, when moist, to undergo stretching without breaking. Such tobaccos after being compressed, during cutting in the manufacture of cigarettes, will spring back immediately. Springiness in flue-cured tobacco is thus due to its elasticity. Elasticity is dependent upon water soluble constituents, and stands in direct correlation with the moisture content in tobacco.

Chemical and Biochemical Quality Characteristics

Total Nitrogen

It is generally considered that flavour and taste of smoke is correlated with the nitrogenous constituents and flue-cured tobacco containing 1.6 to 2.3% total nitrogen gives the most satisfying smoke. Higher nitrogen content of tobacco would result in, apart from curing difficulty, deep brown coloured trashy leaf, which shatters readily, and it has the strong – pungent smoke. Generally high level of nitrogen is associated with high level of nicotine. Lower nitrogen content would result in 'washed out', pale coloured leaf, lacking in rich colour characteristics of good tobacco, and it gets flat insipid smoke.

Phosphorus

Phosphorus deficiency results in dark brown cured leaf, because they do not mature normally and appear greenish in color, lack of luster of normal leaves.

Potassium

Leaf color, texture, combustibility and hygroscopic properties are believed to be enhanced by potash fertilizer. Increased potassium application leads to thin, more elastic and pliable tobacco. Potassium content in the cured leaf was found to improve the burning quality of tobacco. An adequate level of potassium in cured leaf tends to off-set the deleterious effects of high chlorine on burning quality. Potassium acts as a mineral catalyst and oxygen carrier in promoting burn of tobacco leaf. Cured leaf lacking in potassium content would result in poor coloured trashy leaf and loses its luster, which may not have any commercial value.

Chlorides

Chlorine is one of the essential nutrients in the production of tobacco. It plays an important role in influencing leaf quality and burn. It is absorbed with ease from the soil solution. One of the principal effects of chloride in growing leaf is to increase water content and turgor, which in turn, tends to produce a larger and thinner leaf. When present in small quantities it improves yield and certain quality factors like colour, moisture content and keeping quality. Larger amounts of chlorides produce muddy and uneven colour in the cured leaf with excessive hygroscopicity and poor burn. Regulation of chlorides in the leaf is therefore essential in the production of leaf of good quality. Leaf having more chlorides (greater than 2%), was found to have poor burn and keeping quality. Rate of deterioration in the colour of the leaf is positively correlated with its chloride content. High chloride content of the leaf is known to increase the hygroscopicity of the leaf which in turn induces certain chemical reactions leading to the deterioration of colour during storage. Rate of deterioration increases with increase in relative humidity and both oxygen and moisture were necessary to bring about the degradation in the colour of the leaf. Leaching technique is best suitable for reclaiming soils containing marginally more chlorides.

Biochemical compounds play an important role in the quality of tobacco. Many of the constituents originally present in the green leaf undergo enzymatic and oxidative reactions during curing. During the curing process there are losses of volatile constituents, changes in the structure of compounds by oxidation, hydrolysis, degradation and polymerization of chemical components leading to the formation of aromatic and flavorful compounds. Each compound produced in smoke is a potential contributor to organoleptic properties.

Nicotine: Nicotine content of tobacco by virtue of its stimulatory effect on the smoker is next important constituent. Nicotine is synthesized in the root. It is considered that a nicotine level of 1.75 to 2.0% in FCV tobacco is most satisfactory. The nornicotine in acceptable tobacco should not exceed 5% of total alkaloids. High proportion of nornicotine in cigarette leaf leads to abnormal and objectionable smoke flavour due to pyrolysis of nornicotine into myosmine.

Carbohydrates: carbohydrates account for 40-50% of tobacco weight and contribute significantly to the smoking quality.

Starch and Sugars: During early stage of curing, enzymatic hydrolysis of starch results in reducing sugars.

Reducing Sugars: Higher content of reducing sugars in flue cured tobacco is undesirable as it imparts an acidic character to the smoke. Lower content imparts alkalinity to smoke due to high nitrogenous constituents. During smoking, sugars are burnt out as CO_2 and water, thus helping to neutralise free base and increase moisture content in smoke and so act as an emollient, if present in excessive quality.

Lignin: High mol. wt. polymer with 100 or more aromatic units with more methyl groups. Lignin is source for flavour compounds like vanillin, benzyl alcohol which are distilled into main stream smoke. Benzyl alcohol contribute to fruity and smoothness to smoke.

Cellulose: High cellulose content in tobacco blend is a negative to smoking quality. It tends to impart a sharp stinging harshness and a burnt paper odor to the smoke.

Pectin: pectins contributes to the structural stability of the leaf and pyrolysis products that contributes to the smoke chemistry. Tobacco leaf contains several biochemical components as listed in Table: 2

Proteins and Aminoacids: During curing, storage and ageing many changes occur in proteins and thus some of the proteins will give quality to smoke.

Phenols: Chlorogenic acid, rutin and scopoletin are major phenols in tobacco. FCV has more phenols than burley tobacco. Pyrolisis of chlorogenic acid, rutin and scopoletin produces simple phenols and compounds which produce smoky like aroma. Some phenols found in smoke derived from other than these phenols have been implicated in bitter, smokey and medicinal taste of smoke.

Organic acids: Malic, citric, oxalic and malonic acids are 90% of organic acids produced in leaf. They are found in the form of salts. Quality of tobacco smoke is inversely proportional to citric acid. Aromatic acid, phenyl acetic acid gives honey like taste to smoke.

Total alcohols: Pyrolisis of nicotine at high temperature produce substituted pyridine in tobacco smoke which gives residual tobacco aroma following smoking

Nitrogen/Nicotine ratio

The ratio of nitrogen to nicotine is assumed to give some chemical balance within the leaf. The higher the ratio, the less desirable the tobacco because it tends to be light bodied. A ratio in the neighborhood of 1.35 gives way to paleness of colour, slickness of texture and a general lack of desirable physical characters and deficiency in aroma. In fact, a value exceeding 1.0 has been ascribed as imbalanced. Too low a value (below 0.5), on the other hand, frequently may be considered undesirable because the tobacco is heavy bodied and associated with high nicotine content and low level of reducing sugars. A range of 0.6 - 0.7 ratio has been adjudged as most desirable in medium to light bodied matured tobacco.

Reducing Sugars/Nicotine ratio

The ratio of sugar to nicotine would give balance of opposing effects and thus serve as a good smoking quality indicator. A high ratio may tend to indicate mildness and smoothness while a very low ratio may be indicative of harsh irritating smoke. If the ratio is too high, it may indicate that the tobacco is too mild to be acceptable to smoker. If cured leaf contains both low level of nicotine and sugars as generally is the case with Indian flue-cured tobaccos, the ratio appears to be comfortable. High sugar content consistent with nicotine level is the most desirable feature for smoking quality in flue-cured tobacco. The desirable ratio is 7-13.

Table 2: Acceptable limits for the important chemical constituents and quality indices in flue-cured tobacco

Constituent/Quality index	Acceptable limits
Total nitrogen %	1.0 - 3.0
Nicotine %	0.7 - 3.0
Total sugars %	10.0 - 26.0
Reducing sugars %	8.0 - 24.0
pH	4.6 - 5.5
Reducing sugars/ Total N	7 - 13
Reducing sugars/Nicotine	7 - 13
Total N/ Nicotine	< 1.2
Filling value at 60% R.H. & 20^0C	3.3 - 3.8 cc/g shreds
Equilibrium moisture content at 60% R.H. & 20^0C	11 - 15%
Pore volume	0.13 - 0.18 ml/g
Combustibility	2.5 - 3.5 mm/min
Leaf burn	3 - 6 sec.
Shatterbility index	> 3

Note: The individual chemical constituents alone should not be taken into consideration for quality evaluation. The ratios of the constituents are also very important and should be taken into consideration for quality appraisal of tobacco.

Quality Management

There are several factors which influence the quality of tobacco, hence the following management factors one should be kept in mind for getting good quality tobacco.

Soils and Climate

Soil and climatic factors have an over riding influence on the quality of the leaf. In India FCV tobacco is grown in four different agro-climatic zones i.e. Northern light soils (East Godavari, West Godavari and Khammam districts), Traditional black soils (East Godavari, West Godavari, Krishna, Guntur, Khammam and Prakasam districts) and Southern light soils (Prakasam and Nellore districts) in Andhra Pradesh and Karnataka light soils (Mysore, Hassan, Chitradurga and Shimoga districts) in Karnataka.

Attributes of an Ideal Soil for FCV Tobacco

- A light sandy surface soil (15 - 25 cm depth)
- Well drained and well aerated
- An acidic soil reaction of pH 5.5 to 6.5
- Fertile with adequate SOM level
- A low chloride content (<100 mg kg^{-1})

Tobacco produced in Traditional black soil is lemon yellow in colour, chemically balanced tobacco, viewed as a cheap, coloury filler, medium to heavy bodied tending to become flat, slightly dry natured with lower elasticity, close to medium grainy (low to medium pore volume), slightly immature and better filling value. It gives balanced smoke, its total effect in the blend considered to be neutral in character and lends itself very favourably for blending with other growths in fairly high proportions. It contains medium content of nitrogen, nicotine and sugars, and low chloride content.

Tobacco produced in Northern light soils is fully developed, orange in colour, fairly lustrous, good bodied, soft textured, elastic, ripe and open grained with excellent ageing properties. It contains medium nicotine content, medium nitrogen content, favourable total N/Nicotine ratio, reducing sugars range from 14 to 24%, reducing sugars/nicotine ratio -9 to 10 and chloride content is low (0.5 to 1%). The physical quality attributes of this leaf are in equally desirable levels from the point of manufacturer. Thus the chemical and physical characteristics of Northern light soil tobacco fully meet the export requirements and have an edge of superiority over black soil tobacco.

Tobacco produced from Southern light soils is medium in size, lemon to orange in colour, lustrous, ripe and open grained with very good smooth and pleasant smoking properties. It contains low nicotine content, medium nitrogen content resulting in high nitrogen/nicotine ratio that indicates light body, low to medium sugar content with a balanced sugar/nicotine ratio indicating a generally mild and non-irritating, smooth and pleasant smoke and low chloride content.

Karnataka light soil tobacco has the best quality attributes which are comparable to leaf from Zimbabwe. This tobacco is medium to large in size, rich lemon yellow to orange colour, ripe and open grained, more often with leaf spot indicative of good maturity, light bodied leaf with mild and smooth smoking properties, good combustibility and viewed internationally as quality filler. It contains medium nicotine content, medium nitrogen content, high sugar content and very low chloride content. Physical quality characteristics of this tobacco are ideally suited for efficient manufacture of cigarettes. By virtue of all these desirable chemical and physical quality attributes, it has got excellent export market and immensely liked by importing countries.

Cultural Practices

Studies on the effect of plant densities on yield and physical and chemical quality parameters showed that in light soils increasing plant population with appropriate supplementation of nutrients improved yields without any detriment to quality. Optimum plant population is often determined by leaf quality, rather than yield. If dry condition could be predicted then plant populations could be decreased in order to reduce water stress. Plants should be spaced and managed to obtain a complete canopy to make maximum use of sunlight, closer spacing of plants results in decrease in filling value. Hence optimum spacing is necessary to get good grade index.

Tray Seedlings: Transplanting with tray seedlings will overcome the problem of non-uniformity and helps in improving the yield and quality of tobacco.

Irrigation

Irrigation is generally not a recommended practice in black soils. But when the crop suffers very much for want of soil moisture, irrigation may be given preferably in the early phases of crop growth, when the soil moisture level is less than 60% of field capacity. When this practice is followed leaf quality has not been affected. It should, however, be remembered that the chloride content of irrigation water is within limits of acceptability. In NLS irrigation is quite essential to achieve good crop yields and quality. In flue cured tobacco, soil moisture tension was found to influence chemical composition of the leaves. If it is low tension, gives lower concentration in the cured leaf of nicotine, total nitrogen, calcium oxide and magnesium oxide, but higher concentration of sugars, as well as better burning characteristics. Moisture stress will give thicker and coarse textured tobacco. Irrigation water is another important source of chlorides in the leaf. The chloride build up in the soil depends upon the number of irrigations, the quantum of water given under each irrigation, the chloride concentration of the water and the soil characteristics. Studies taken up in black soils showed that with increasing number of irrigations, chloride content of leaf was found to increase. In the case of light soils it was established that waters containing chlorides not exceeding 50 ppm are suitable for irrigation as the leaf chlorides were within the limits of acceptability (2%).

Fertilizers

Studies carried out on fertilizer requirements of flue cured tobacco grown in different types of soils indicated that in black soils, 20 kg N/ha was the best, both from the angle of yield and quality. Nitrogen application @ 120 kg N/ha is necessary in NLS of Andhra Pradesh. Phosphorus and potassium application either in black soils or light soils had little effect on quality parameters. As the black soils contain higher levels of these nutrients, there is no need to apply P or K to these soils and hence omitted in the fertilizer schedule. In Northern light soils, there was a build up of phosphorus due to continuous application of DAP as a source of nitrogen, its application was reduced to half of the recommended dose i.e. 30 kg P_2O_5/ha. Potassium application @ 120 kg K_2O/ha is necessary in NLS of Andhra Pradesh. Application of FYM @ 2.5 tonnes/ha in alternate years would have beneficial effect in improving yield and quality. Similarly application of organic manures like FYM or filter press cake @ 7.5 tonnes/ha had no detrimental effect on quality. Sunhemp *in situ* green manuring was found to be beneficial in improving yield and quality of NLS tobacco.

Topping and Sucker Control

Topping increased the nitrogenous constituents particularly nicotine and nitrogen and decreased reducing sugars. In light soils, bud topping with specific number of leaves for a particular variety is recommended for getting good quality leaf. Leaves from topped plants have a higher concentration of starch than un topped plants, which results in an increased reducing sugar concentration in the cured leaves. Topping also increases nicotine content of leaves, increase in root volume and mass and enhancing the activities of enzymes involved in nicotine biosynthesis in roots. The nicotine content of cured leaf is usually increased more than that of reducing sugars and consequently the ratio of sugars:nicotine is decreased. Tobacco produced from topped plants has a decreased filling value, more total particulate matter in smoke stream. However it has an increased content of flavor precursors, which improve smoking quality.

Diseases and Pests

Severe infection and damage by pests such as insects, mites and nematodes can affect normal growth, which usually results in smaller yields and increased usage of pesticides and ends in pesticide residues, which is an undesirable quality. In a diseased plant the important components of tobacco quality like nitrogenous compounds, lipids, sugars, phenolics and terpenoids will increase and alter quantitatively and qualitatively.

Air Pollutants

Air pollutants in atmosphere also can have harmful effect on quality of tobacco. Herbicide contamination in neighbourhood fields will affect the quality of tobacco.

Maturity

Maturity of leaf at harvest is one of the most important factors affecting quality of the leaf. Fully matured tobacco will have higher leaf strength, better extensibility, enhanced hygroscopicity, better combustibility and more porosity than immature tobacco. Equilibrium moisture content will decrease and increase in pore volume with progress in maturity. Mature leaves contains good elasticity. For getting thinner leaves with maximum reducing sugars and minimum nitrogen, leaves should be harvested at fully mature stage. The most desirable physical and chemical characteristics of the leaf were found in the leaves harvested at the correct stage of maturity.

Curing

Extensive hydrolysis of starch (60-70%) into soluble sugars and their utilization for respiration of the leaf are dominant factors of flue curing. As reducing sugar level of the leaf depends directly on the starch content of the leaf, starch content of the leaf can be taken as an index of leaf quality. Proteolysis also takes place during flue curing, but it occurs to an extent of 7 to 20% only. The changes in the nitrogenous constituents of the leaf indicated that the differences in the formation of amides and ammonia in the leaf are due to differences in the availability of carbohydrates for respiratory purpose. Green leaves with fairly good amount of moisture (80 to 85%) and starch (about 13%) tend to produce higher grade on curing.

Ageing

During ageing the important changes that take place are decrease in equilibrium moisture content, reducing sugars, nicotine and petroleum ether extractives, and increase in sugar/nicotine ratio and the content of total volatile acids. Most of the transformations associated with ageing were found to take place better under ambient conditions and completed during an optimum period of 12 months. Continued ageing beyond this period causes deterioration of quality particularly the physical properties. Several physical characteristics like equilibrium moisture content, pore volume and leaf strength were found to improve under optimum ageing conditions. Filling value, pH and nicotine content showed continuous decrease throughout the period of ageing. Total nitrogen had not been affected due to ageing except in tobacco from northern belt where continuous reduction of this constituent was observed to certain extent. Irrespective of the mode of storage, a period of 12 to 16 months is optimum for ageing.

FCV TOBACCO AS A COMMERCIAL CROP: ECONOMIC SIGNIFICANCE

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Introduction

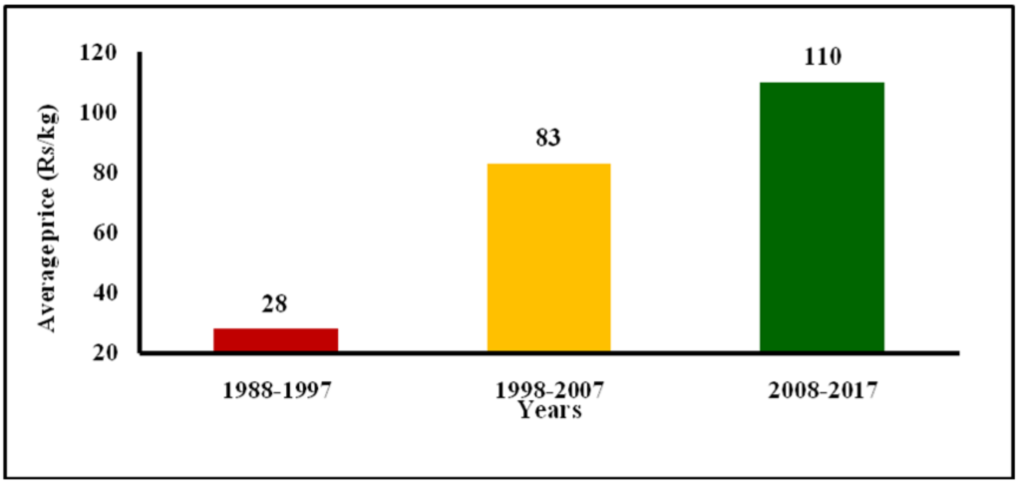
Tobacco is one of the important commercial crops grown in India. It occupies a predominant position in any dialogue related to agricultural exports and revenue generation to the national exchequer and its potential to generate income and employment to a sizable population in the country. Tobacco production is an important source of livelihood and provides direct and/or indirect employment to the millions of people in India. During 2016-17, tobacco made a significant contribution of Rs. 28,712 crore to the Indian economy in terms of excise revenue (Rs. 22,737 crores) and export earnings (Rs. 5539 crores) in 2017-18. India produces different styles of FCV tobacco, which vary in their physical and chemical characteristics under diverse climatic conditions and it is exported to over 114 countries across the globe. Tobacco production in the country is fairly diversified for exports and provides a one-stop shop for different styles, qualities and price ranges. The tobacco produced has a wide range of quality such as semi-flavourful to flavourful, quality neutral filler and good filler styles.

Tobacco in Indian Economy

The tobacco economy in India is quite complex with a multiple of stakeholders in the form of tobacco growers, farm labourers, leaf pluckers, processors, bidi workers, and retailers, across the tobacco value-chain. The government is also a stakeholder with the welfare of the different categories of stakeholders as its prime interest. The main beneficiaries of tobacco production are the small and marginal farmers, landless agricultural labourers, rural women and tribal youth. The growth of tobacco economy will be of immense benefit to the country by contributing to agricultural exports, foreign exchange earnings and revenue generation and livelihood option for millions of people in the country. Predominantly, FCV tobacco, an important commercial crop, which has got relatively high production facilities *viz*., supplying of seeds, fertilizers, insecticides, farm implements, crop loan and many extension activities to educate the tobacco farmers about the new technical know-how and good agricultural practices, there is no other commercial crop in this country that has got these kind of facilities.

Tobacco Prices

The annual average price of FCV tobacco has increased more than three folds from Rs. 28 /kg during 1988-97 to Rs. 110/kg during 2008-17 due to increase in demand for quality Indian tobacco characterized by balanced leaf chemistry, low pesticide residues, and heavy metals mainly due to the adoption of scientific management interventions suggested by the Institute.

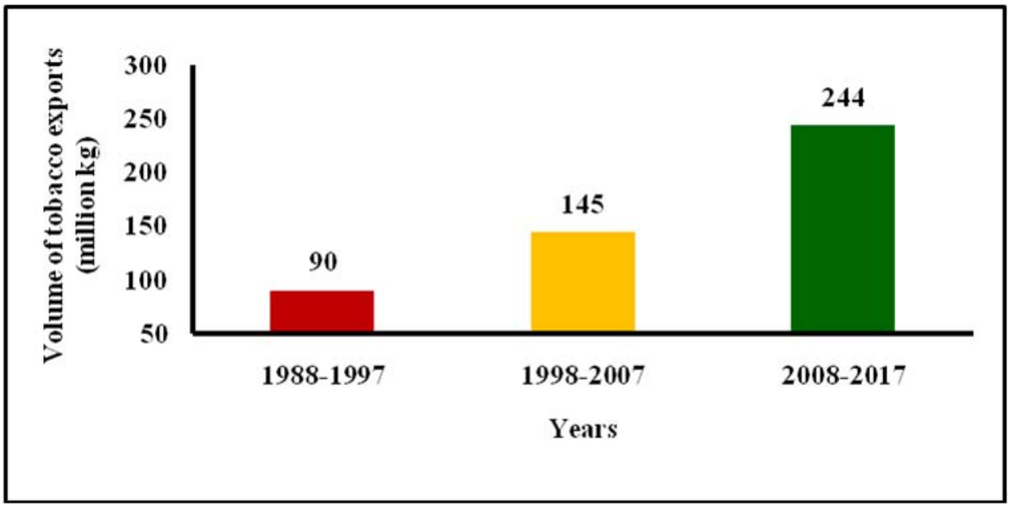


Source: Tobacco Board

Fig 1.Trends in Prices of FCV tobacco in India during past three decades

Tobacco Exports

Meticulous adoption of technology interventions has led to the production of quality leaf with low levels of pesticide residues and free from NTRMs. Accordingly, there has been a continuous demand for Indian tobacco in the global market as is evident from the increased tobacco exports in the past three decades. The annual average tobacco exports from the country increased by 2.7 times in volume and 10 times in value during past three decades i.e. from an average of 90 million kg and Rs.451 crore during 1988-97 to 244 million kg and Rs. 5030 crore during 2008-2017 respectively.

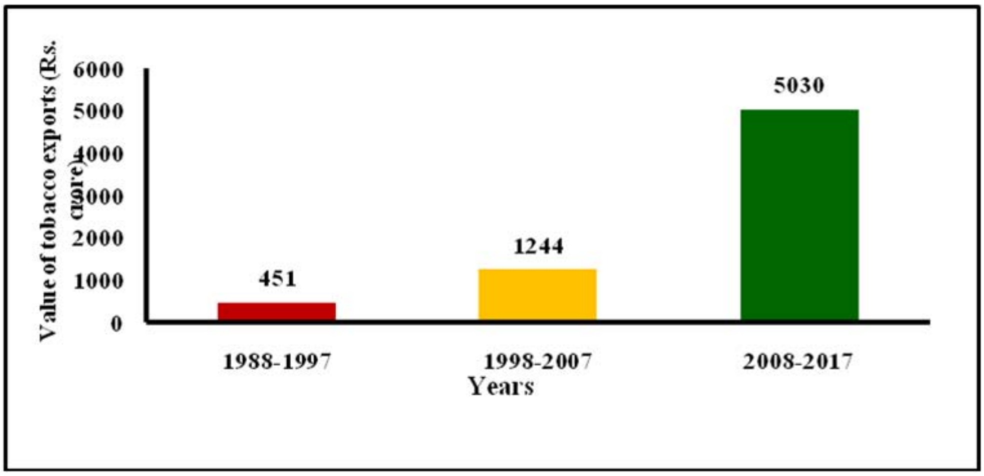


Source: Tobacco Board

Fig 2. Trends in volume of tobacco exports from India

Export Destinations of Indian Tobacco

During 2017-18, India's unmanufactured tobacco exports accounted for 85% of total exports of tobacco and tobacco products in terms of quantity and 70% in terms of value in rupees. In volume terms, Belgium continued to be the leading export destination for Indian unmanufactured tobacco during 2017-18 followed by other important markets *viz*. Egypt,



Source: Tobacco Board

Fig 3. Trends in value of tobacco exports from India

South Korea, UAE and Russia. Out of the top five destinations, exports to South Korea have improved on year-on-year basis whereas there was a decline in export of tobacco to the other countries *viz.*, Belgium, Egypt, UAE and Russia.

Productivity of FCV Tobacco vis-à-vis Other Predominant Crops in Prakasam district of Andhra Pradesh

In Andhra Pradesh, FCV tobacco is grown during *rabi* season by utilizing conserved soil moisture in Prakasam and Nellore districts, while 25% of tobacco area is under irrigated conditions in West and East Godavari districts. The productivity of FCV tobacco was 1034 kg/ha during 2012-13 to 1226 kg/ha in 2015-16 and subsequently increased to 1411 kg/ha during 2017-18. The productivity trends in other crops *viz.*, red gram, bengal gram, chilli and cotton has shown year-to-year fluctuations owing primarily to biotic and abiotic stress during the corresponding period. Despite the local biophysical constraints, FCV tobacco clearly outsmarted all other predominant crops with respect to productivity in Prakasam district of Andhra Pradesh during the same period.

Table 4. Productivity trends in major crops in Prakasam district of Andhra Pradesh

(kg/ha)

Year	Red Gram	Bengal Gram	Chilli	Cotton	Tobacco
2012-13	666	1868	3920	527	1034
2013-14	913	1945	4397	566	1102
2014-15	718	1889	4624	600	1163
2015-16	864	1932	3782	479	1226
2016-17	442	1490	3016	524	1206
2017-18	389	1294	4680	408	1411

Source: DES, Govt. of AP

Price Stability of FCV Tobacco vis-à-vis Other Agricultural Commodities

Recent experiences show that prices of agricultural commodities are more volatile than those of non-farm commodities in India. For instance, in Prakasam district of Andhra Pradesh (the major domain of FCV tobacco), the trends in farm harvest price (FHP) of major crops depict that chilli, chick pea, red gram and cotton seem to exhibit high price volatility among all agricultural commodities. The bengal gram and red gram exclusively grown in southern black soils and southern light soils of Andhra Pradesh, because of higher price fluctuations in pulses and lesser demand.

Table 5. Trends in Farm Harvest Price of Major Crops in Prakasam district of Andhra Pradesh (Rs/quintal)

Year	Chilli	Bengal Gram	Red Gram	Cotton	Tobacco
2011-12	5016	3579	4038	3483	9788
2012-13	6277	3329	3807	3497	11039
2013-14	6557	2724	4070	3950	10109
2014-15	6926	3648	5758	3737	10343
2015-16	11413	4724	7898	4035	12907
2016-17	7069	5313	3888	4498	14667

Source: DAC&FW

Net Income of FCV Tobacco Farmers in India

The technology-led growth in the productivity resulted in significant rise in net income of FCV tobacco farmers in the country. Productivity growth coupled with significant growth in prices of FCV tobacco in India has led to significant increase in farmers' income. The net income of FCV tobacco farmers has increased from Rs.78,009/ha during 2014-15 to Rs.1,24,954/ha during 2017-18, nearly a 60 percent increase. This is evident from the trends in net income during last 4-years.

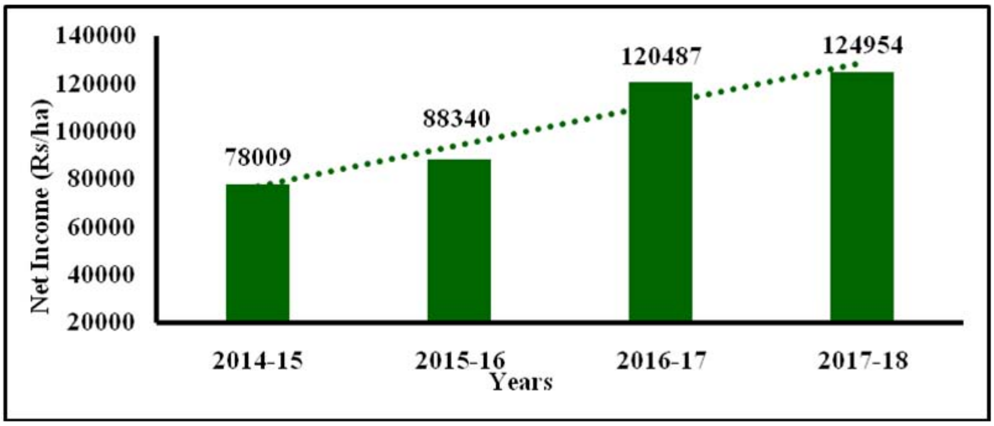


Fig 4. Trends in net income of FCV tobacco farmers in India

Sources of Growth in Farm Income in FCV Tobacco Production

Sources of growth in farm income are identified mainly from the experiences and trends in Andhra Pradesh and Karnataka.

The sources of growth in FCV tobacco production and income can be categorized as below.

- Agricultural R&D technology
- Policy intervention
- Market and price
- Crop diversification and
- Cost saving measures

ICT APPLICATIONS IN TOBACCO

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Introduction

ICT (Information and Communication Technologies) refers to technologies that provide access to information through telecommunications medium such as the radio, television, cell phone, computers, satellite technology; internet including email, instant messaging, video conferencing and social networking websites which have made it possible for users across the world to communicate with each other and to give users quick access to ideas and experiences from a wide range of people, communities and cultures. ICT consists of three main technologies *viz*. computer technology, communication technology and management technology. These technologies are applied in agriculture for processing, exchanging and managing data, information and knowledge.

Agriculture is an important sector with the majority of the rural population in developing countries depending on it. The sector faces major challenges of enhancing production in a situation of dwindling natural resources necessary for production. The growing demand for agricultural products, however, also offers opportunities for producers to sustain and improve their livelihoods. India has made a tremendous progress in the field of agriculture over the last few decades. The technological developments in agricultural sciences have changed the agricultural sector to a great extent. Information and communication technologies play an important role in addressing these challenges and uplifting the livelihoods of the rural poor. The agricultural extension mechanism is dependent on ICT to provide appropriate and location specific technologies for the farmers. The benefits of ICTs for increased agricultural productivity and strengthening the agricultural sector include timely and updated information on agriculture related issues such as release of new varieties, emergence of new threats such as diseases, weather forecast, pricing control, warning alerts etc.

The ICT in agriculture is an emerging field focusing on the enhancement of agricultural and rural development in India. It involves application of innovative ways to use ICTs in the rural domain. The achievements in ICT can be utilised for providing accurate, timely, relevant information and services to the farmers, thereby facilitating an environment for more remunerative agriculture. Given the development scenario of Indian Agriculture, ICT movement is still evolving. However, all the ICT initiatives are not uniform with disparities between regions in the level and quality of telecommunications, information and the effort of individuals, public and private organizations and differentiated nature of demand of the farmers in different areas. As a result, there have been many successes, failures, lessons learnt and experience gained, so far. While these initiatives are intended to address the needs of the farmers through ICT; their actual usage and their ability to bring significant impact on the farm productivity and socio-economic development of the intended beneficiaries is to be understood. The common problems in adoption of ICT in rural segments are ICT illiteracy, availability of relevant and localized contents in their own languages, easy and affordable accessibility and other issues such as awareness and willingness for adoption of new technologies among the rural people etc. The ICT enables vital information flows by linking rural agricultural communities to the internet, both in terms of accessing information and providing local content. New ICT technologies are generating possibilities to solve problems of rural poverty, inequality and giving an opportunity to bridge the gap between information rich and information poor and support sustainable development in rural and agricultural communities.

Use of ICT in Agriculture

- Increasing the efficiency, productivity and sustainability of small scale farms.
- Information about pest and disease control, especially early warning systems, new varieties, new ways to optimize production and regulations for quality control.
- Better of markets resulting from informed decisions about future crops and commodities and best time and place to sell and buy goods.
- Up-to-date market information on prices for commodities, inputs and consumer trends.
- Strengthen capacities and better representation of their constituencies when negotiating input and output prices, land claims, resource rights and infrastructure projects.
- Reduce social isolation, widen the perspective of local communities in terms of national or global developments, open up new business opportunities and allow easier contact with friends and relatives.

ICT Applications in Tobacco

ICAR-CTRI has developed various software systems for research namely Decision support systems for soil and water analysis, expert system for tobacco insect pest and disease management, tobacco germplasm information system,. Expert system for diagnosis of nutrient deficiencies in fcv tobacco and online expert system i.e. tobacco agridaksh.

We A mobile app on good agricultural practices for FCV Tobacco was developed and hosted.

The app consists of four main modules viz., 'TOBACCO', 'SHARE' 'CONTACT', and 'ABOUT'. The module 'Tobacco' provides technical information about 'Good Agricultural Practices of FCV Tobacco' which in turn consists of three main modules *viz*., Nursery, Field Crop and Post-Harvest Management. 'Nursery' consists of two sub modules viz., Conventional method and Tray Nursery embedded with information on 'agronomic practices' supported by good photographs. In 'Feld crop' module, information on 'Cultural operations, Irrigation and Fertilization' was provided based on soil type *viz*., Northern Light Soils (NLS), Southern Light Soils (SLS), Black soils and Karnataka Light Soils (SLS). Nutrient Management module is developed as a decision support system, which allows the user to view the visual deficiency symptoms along with Corrective Measures. 'Weed Management' module is a knowledge-based system which provides the information on Weed Description with good photographs and control. 'Post-Harvest Management' module provides the information on "Green leaf management, Curing, Bulking, Grading and Baling' of FCV tobacco with good photographs. The module 'SHARE' provides hyperlink to access CTRI website. 'CONTACT' module provides contact details for receiving suggestions given by the user, if any. The module 'ABOUT' gives a general information pertaining to CTRI.

The Link to download the app is:
https://play.google.com/store/apps/details?id=com.icar.ctri

METHODS AND APPROACHES FOR EFFECTIVE TRANSFER OF TECHNOLOGY IN FCV TOBACCO

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Introduction

Tremendous efforts have been made by ICAR-CTRI in generation and transfer of tobacco technologies. Besides research, the institute has been constantly involved in imparting hands on practical training on various aspects of tobacco cultivation. Similarly, the institute developed region specific agro-technologies have shown high degree of adoption in all tobacco zones. Extensive adoption and use of institute technologies, varieties and services created a huge economic impact on tobacco farms and farmers. Technology does not stand alone, but encompasses social, economic, and cultural factors that can impede the diffusion or transfer of technology. One of the major concerns in the transfer process is how to effectively disseminate new technology considering the viewpoint of farmers, particularly in addressing the questions of where, how, and what technologies are appropriate and available to them. While many farmers know the nature of their problems in the field, research and extension workers' absence of knowledge of their socio-economic conditions stop them from adopting technologies and pursuing technological solutions to their problems.

The institute has been involved in conducting On farm trials, Front line demonstrations, Field demonstrations, analysis of success stories, innovative methodologies like Model Project Area Approach, Field Friends, crop phase wise training programmes, advisory services and implementing them in convergence with Tobacco Board and other tobacco stakeholders. Need based training programmes are being conducted for tobacco farmers, field staff of Tobacco Board and other stakeholders of tobacco industry in order to bridge the technology adoption gap in the real farm situation. The farmers can access detailed information from the institute website.

Outreach Activities of the Institute

On Farm Trial

An On-Farm Trial aims at testing a new technology or an idea in farmer's fields, under farmers' conditions and management, by using farmer's own practice as control. It should help to develop innovations consistent with farmer's circumstances, compatible with the actual farming system and corresponding to farmer's goals and preferences. It is the evaluation of proven research results under farmer's conditions for knowing its suitability. ICAR-CTRI is conducting On farm trials in collaboration with Tobacco Board. The technologies which successfully come out of On Farm Trials are then recommended for Front Line Demonstrations (FLDs).

Front Line Demonstrations

Conducting demonstrations under the close supervision of scientists, because the technologies are demonstrated for the first time by the scientists themselves for knowing field level constraints and for getting direct feedback from the farmers. The main objective of Front-Line Demonstration is to demonstrate newly released crop production and protection technologies and its management practices in the farmers' field under different agro-climatic regions and farming situations. While demonstrating the technologies in the farmers' field, the scientists are required to study the factors contributing to higher crop production, field constraints of production and thereby generate production data and feedback information.

Field Demonstrations

Field demonstration is a long term educational activity conducted in a systematic manner in farmers' fields to show worth of a new practice/ technology. "Seeing is believing" is the basic philosophy of field demonstrations. Only proven technologies are therefore selected for field demonstrations. Field demonstrations educate farmers through results obtained in terms of varieties resistant to disease and pest, quality and overall higher yields. In addition, it also educates the farmers in terms of input-output ratio and economic gains in terms of net returns.

Field Day

In general the extension worker conducts various demonstrations and at times when it's more convincing, the extension worker organizes field day so that it can be shown to many of the farmers for convincing and motivate the farmers to adopt the recommended practices. Field day is a method of motivating the people to adopt a new practice by showing what has actually been achieved by applying the practice under field conditions. A field day may be held in a research farm or in a farmer's field or home. If the number of participants is large, they should be divided into small groups of about 20 to 25 persons each, who shall visit the spots in rotation.

Training

Need based training programmes are conducted for tobacco farmers, field staff of Tobacco Board & other stakeholders of tobacco industry in order to bridge the technology adoption gap in the real farm situation.

Analysis of Success Stories

An in-depth analysis of success stories of recognized farmers highlights the technologies which are found to be having high technical efficiency in determining the yields and quality under real farm situations. Further the success stories can be adopted by many farmers in similar situations elsewhere through different dissemination means.

Innovative Methodologies adopted by ICAR-CTRI

To attain much promise in sharpening of knowledge and skills of tobacco farmers, ICAR-CTRI has adopted the innovative methodologies like Model Project Area Approach, Field Friends programmes, crop phase wise training programmes, mobile based advisory services and implementing them in convergence with Tobacco Board and other tobacco stakeholders. The methodologies are intended to promote the adoption of innovative technologies for achieving increased yields, quality and farm returns.

Convergence Approach for Training and Creating Awareness on New Technologies

Many extension service providers in the field are providing different kinds of services and support to farmers. There is duplication of efforts and attending to extension work without convergence. A coordinated effort was taken up by ICAR-CTRI scientists, Tobacco Board officials, Trade members and progressive farmers in addressing the issues in a participatory mode: ICAR-CTRI : FARMERS: TOBACCO BOARD: TRADE. The approach is adopted every season in all the regions of tobacco cultivation falling under different auction platforms of Tobacco Board. Village level awareness and training campaigns are conducted during the crop season.

Model Project Area

Low productive areas are selected for implementation of model project area approach under different FCV tobacco micro-zones. Tobacco Board conducts demonstrations on latest technologies on FCV tobacco cultivation in collaboration with ICAR-CTRI in the selected villages. This provides an opportunity to implement recommended technological interventions and to evaluate technology performance. Model project area serves as nerve centre in assessing and demonstrating technology potential and also helps in up scaling the technology demonstrated.

Field Friends Programmes

The potential extension providers in tobacco are identified and made partners in field friends programmes. Together they visit tobacco fields, identify the major problems if any and advocate viable remedy if farmer is readily present. If farmer is not available, they display the remedy on suitable paper and keep it as a flag in the field.

Mobile Based Advisory Services

Extension in FCV tobacco is now becoming more diversified, technology intensive, knowledge oriented and more demand driven. Mobile phone penetration in rural areas has expanded rapidly. Hence, mobiles are being used to communicate tobacco technology directly to farmers at a faster rate. Effective use of mobile Apps helps in bridging knowledge deficiency among farmers. Developing Mobile Apps through which necessary information gets transmitted to all the registered farmers in a tobacco area is the need of the hour.

In the present context of utilizing ICT tools for timely and effective communication of needful agricultural information, ICAR-CTRI has developed a Mobile App for providing technological support to stake holders for improving the yield and quality of FCV tobacco. The app consists of four main modules viz., 'TOBACCO', 'SHARE' 'CONTACT', AND 'ABOUT'. The Mobile App is free to download for all the tobacco growers, trade and tobacco based officials through google play store. The key features of the Mobile App are

- It is a icon based user-friendly menu driven application for easy and instant accessing of the FCV tobacco information.
- It is very easy to understand as the information displayed is 'image based'.
- 'Share' option in the mobile app provides access to ICAR-CTRI website.

Progressive Farmer Circles

Farmers are the best educators of other farmers. So farmer to farmer extension visits can greatly help in information exchange and dissemination. The approach facilitates for effective action, observation and feedback. Identifying achiever farmers in different agro-climatic micro zones, two-three achiever farmers share their success/experience with other farmers during group meetings and field visits. Scientists act as facilitators. The topics covered can vary considerably *i.e* IPM, INM, PHPM etc.

Documenting Farmer's Knowledge

Many farmers have a scientific approach and practical knowledge but hardly document their experience. Farmer's creativity and capacity for problem solving are being recognized and documented as success stories.

Future Thrust

Much still needs to be done to promote better and more effective methods of technology transfer to facilitate the tobacco farmers to achieve increased output and higher incomes.

- **Cyber Extension Activities**
  Information and Communication Technology (ICT) initiatives in the lines of Web-based systems, interactive software and Mobile Apps can be further scaled up. Farmers and extension personnel can seek clarifications on queries through online query facility to be provided at the website. Kiosks, web based consultancies, e-mail and mobile based queries for technological clarification of farmers can be scaled up.
- **Mass Media**
  For the popularization of technologies developed by the institute, various activities like creating technological awareness week, interest and knowledge among the farmers/ clients through daily newspapers/ press media and other means of mass media can be encouraged.
- **Institutional and Off-Campus Training Programmes**
  Institutional and off-campus training programmes on various aspects of production, protection and postharvest product management of tobacco can be increased at the headquarters, regional stations of the Institute to benefit farmers and extension personnel. Besides, training programmes can also be conducted on selected topics on request from farmers and organizations.
- **Cluster Groups**
  The work on organization of Farmer's Interest Groups can be increased at different sites/ locations/ villages where front line demonstrations of improved varieties and their agro-techniques are conducted.
- Celebration / organization of farmers day, Farm Innovators Day, Agricultural Education Day, regularly every year to encourage farmers
- Interactive guest lectures are to be given on technologies to the visiting farmers / extension workers during different training programmes
- Visit to farmer's fields and interaction/meetings with the scientists
- Participatory approach of transfer of technology
- Organizing farmer's fair/ national seminars/ congress/ symposium and arranging technological exhibitions
- Technical folders and bulletins (technical literature) to the farmers /extension workers/ during their visit, farmer's fair, exhibitions, meetings, etc. both in english and local languages can be distributed.

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