Disruptive Technologies of CTRI

Commemorating 75 years of Impact

M. Sheshu Madhav, S. Kasturi Krishna, Anindita Paul and B. Hema

भाकृअनुप – केन्द्रीय तम्बाकू अनुसंधान संस्थान
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CONTENTS


CTRI
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PREFACE

Tobacco (Golden Leaf), the mandate crop of ICAR- Central Tobacco Research Institute (CTRI), is one of the important commercial crops in India. Tobacco makes a significant contribution to national economy by way of export earnings of about Rs. 9740 crores and excise revenue of Rs. 23357 crores besides providing employment and livelihood security to an estimated 46 million people engaged in its cultivation, curing, grading, manufacturing and marketing. The ICAR-CTRI, established in 1947, is one of the oldest and premier research institutes functioning under the aegis of the Indian Council of Agricultural Research (ICAR) and has an exclusive mandate of conducting basic, strategic and applied research on myriad aspects of different tobacco types grown in India. Since its inception, the CTRI has been making impressive contribution to the development of tobacco sector as a whole in the country.Through its long voyage of 75 years, the institute has evolved into a tobacco research network system with six research stations, two KVKs and All India Network project on Tobacco catering to the research needs of different tobacco types grown in the country.

The Institute has immensely benefitted the tobacco farming community by developing a number of improved varieties with premium leaf quality, economically viable and eco-friendly agro-technologies, drudgery reducing technologies and technologies for the dissemination for enhancing the tobacco production efficiency and product quality. The milestone varieties and technologies that have a significant impact are presented in a crisp manner in this book titled "Disruptive Technologies of CTRI".

The efforts of the CTRI fraternity under the indomitable leadership of the former Directors involved in development of these high impact technologies that have significant effect on tobacco farming are suitably acknowledged. I appreciate the efforts made by the publication committee in bringing out this book which will be a ready reckoner for not only to the tobacco farming community and also give status of impact of CTRI in the tobacco farming.

(M. SHESHU MADHAV)
DIRECTOR

Date : 08.12.2023


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Varietal Technologies

Sl. No	Popular Variety	Developed by	Year of release
	Flue-cured tobacco		
1.	Delcrest	N.R. Bhat *et al.*	1960
2.	CTRI Special	K.V. Krishnamurthy *et al.*	1976
3.	Hema	T. Sitaramachari *et al.*	1987
4.	VT 1158	K.V. Satyanarayana *et al.*	1993
5.	Kanchan	K. Nagarajan *et al.*	1998
6.	Rathna	K.N. Subrahmanya *et al.*	2001
7.	Siri	A.I. Narayanan *et al.*	2006
8.	FCH 222	K.N. Subrahmanya *et al.*	2012
9.	CH-3	T.G.K. Murthy *et al.*	2016
10.	CTRI Naveena	K. Sarala *et al.*	2023
11.	CTRI Sreshta	P.V. Venugopala Rao *et al.*	2023
	Chewing tobacco		
12.	Podali	G. C. Patel *et al.*	1956
13.	PT-76	S. Amarnath *et al.*	1990
14.	Meenakshi	J.S.L.Moses *et al.*	1992
15.	Abirami	R. Lakshminarayana *et al.*	2006
	Hookah and Chewing (*Rustica*) tobacco		
16.	Dharla	V. K. Dobhal *et al.*	2001
	***Motihari*tobacco (West Bengal)**		
17.	Torsa	S. Amarnath *et al.*	2008
	Natu tobacco		
18.	Gajapati	Y.N. Sarma *et al.*	2002
19.	Bhairavi	T. Sitaramachari *et al.*	2006
	Cheroot tobacco		
20.	Lanka Special	T. Sitaramachari *et al.*	1981
21.	Sangami	K. Palanichamy *et al.*	2008
	Burley tobacco		
22.	Banket A1	M.S. Chari *et al.*	1994
23.	Vijetha	P. V. Venugopala Rao *et al.*	2023

FLUE-CURED TOBACCO

Name of the technology : **Delcrest**

Year (s) of development : 1960

Technology details

Delcrest is an introduction from Canada, with high yielding potentiality in the black soils of East and West Godavari districts of Andhra Pradesh, later released as Flue-Cured Virginia (FCV) variety and it has yield potential of 1100 kg/ha. Plant is short (120 - 140 cm) with semi - open habit. Leaves are lanceolate with wide auricle, prominent veins, and thick mid-rib with 6 - 20 curable leaves. Early flowering (60 days after planting) and amenable to topping.

Impact of the technology

This line was introduced in the early years of institute establishment before the breeding efforts started giving results. In view of its higher yielding capacity (9%) than the existing variety, Chatam and amenability to topping resulted in higher bright grades and it became quickly popular among the farmers of black Soils of East and West Godavari districts, Andhra Pradesh during 1960s occupied around 70% of the area. Majority of the modern-day cultivars are having Delcrest in their parental lineage. Thus, the genome of Delcrest is one of the high impacting even today.

Publications/commercialization

- Murthy, GS., P. Ramanadharao, M. Srinivasa Rao and IVG. Krishnamurthy. 1962. Performance of Delcrest– A variety of flue-cured tobacco introduced and acclimatized by the Central Tobacco ResearchInstitute, Rajahmundry. Indian Tobacco 12:23-52.

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

N.R. Bhat, G.C. Patel, W.G. Walunjkar and J.S.L. Moses

Name of the technology : CTRI Special (MR)

Year (s) of development : 1980

Technology details

CTRI Special (MR) TMV resistant light cast FCV variety. It was developed by backcross method from TMVRR-1 x CTRI Special and recommended for cultivation in the black Soils, Southern Light Soils (SLS) of Prakasam, Nellore districts and river side lankas of Andhra Pradesh. The Plants of CTRI Special (MR) are tall, semi-open in habit with horizontally inserted leaves. Leaves are bright green, fast maturing. It Produces 23 - 24 curable leaves with high bright grade in all the primings with desirable quality and it has yield potential of 1200 kg/ha.

Impact of the technology

CTRI Special (MR) is the first TMV resistant variety developed in India. With its high yield potential (1200 kg/ha), TMV resistance and higher bright grade out turn it occupied 40% of the black Soils, Southern Light Soils of Prakasam, Nellore districts and river side lankas of Andhra Pradesh during 1980s and created huge impact among FCV farmers.

Publications/commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

K.V. Krishnamurthy, A. Bhima Sastry, K. Nagarajan, V.V. Ramana Rao, K.S.N. Murthy, P.V. Prasada Rao and M. Mohan

Name of the technology : **Hema**

Year (s) of development : 1987

Technology details

Hema is a high yielding (1560 kg/ha) FCV variety developed by pedigree method from cross between two vigorous plants collected from farmers fields. It was developed and released in 1987 by ICAR-CTRI-RS, Guntur to vertisols of Andhra Pradesh. Plant of Hema grows to a height of about 158 cm with open habit and 21 curable leaves. Leaves are lanceolate, puckered with entire margin and medium auricle and Inflorescence is open and medium in size. It yields more bright grades than other varieties in vogue. Cured tobacco quality are in the desirable ranges.

Impact of the technology

Hema is one of the highly plastic variety growing in both rainfed black Soils and light soils of Andhra Pradesh occupying more than 75% of the area during 1990s and early 2000s. It gives 200 kg/ha higher yield than the variety cultivated before its release.

Publications/commercialization

- Sitaramachari, T., GSB. Prasannasimha Rao and VV. Ramana Rao. 1992. Performance of newly released FCV tobacco variety Hema in vertisols of Andhra Pradesh. Tobacco Research 18:73-83.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

T. Sitaramachari, N.C. Gopalachary, K. Balagopal, G.S.B. Prasannasimha Rao, S.N. Tripathi, V.V. Ramana Rao, M. Someswara Rao, B.V.V. Satyanarayana Murthy, T.K. Suryanarayana, J.V. Ramana Murthy and A.V. Sekhara Babu

Name of the technology : VT 1158

Year (s) of development : 1993

Technology details

VT 1158 is a high yielding (2000 kg/ha) TMV resistant FCV variety developed by Backcross method from the cross L-617 x CTRI Special MR (TMV resistant). It was released to Northern and Central Black Soil tobacco growing regions of Andhra Pradesh by ICAR-CTRI, Rajahmundry in 1993.VT 1158 is a light cast variety with short internodes and horizontally inserted drooping (60 x 30 cm size), medium puckered and good bodied leaves with prominent auricle. Plant height is about 150 - 160 cm with open habit and 20 - 24 curable leaves. It flowers about 75 - 80 days after transplanting. Leaf nicotine (2.4%) reducing sugars (16.7%) and chlorides (0.6%) of cured tobacco are in thedesirable ranges.

Impact of the technology

In view of its higher yield, bright grades and TMV resistance, it was cultivated in around 20% of the traditional black soils and light soils of Andhra Pradesh. It gives 500 kg/ha higher yield than popular variety Hema, thus it created a huge impact.

Publications/commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

K.V. Satyanarayana, R. Lakshminarayana, G.S.B. PrasannasimhaRao, Md. Elias Ahmed, K. Nagarajan, T.S.N. Reddy, R.B. Narayana Rao, B.S.N. Reddy, M. Veerraju, S. Krishnamurthy and J. Anjaneyulu

Name of the technology : Kanchan

Year (s) of development : 1998

Technology details

Kanchan is a high yielding dark cast FCV tobacco variety developed by pure line selection from an exotic cultivar. It is resistant to black shank and tolerant to root-knot nematode. It was released in 1998 for commercial cultivation to irrigated alfisols of Northern Light Soils (NLS) of AP and heavy rainfall areas of Karnataka Light Soils (KLS).

Kanchan is a green cast variety, with semi-open plant habit and short internode. Leaves are long and narrow with wavy lamina. Cured leaf is bright lemon to orange in colour, thick bodied, optimum spotted, pliable and has superior aroma. It yields more than 2000 kg/ha in KLS and 2400 kg/ha in NLS with around 70% bright grades while topping at 24 leaves level during the bud stage.Nicotine 2.6%, Reducing sugars 17.7%, Chlorides 0.6% of cured tobacco are in the desirable ranges.

Impact of the technology

Kanchan was a popular variety in both KLS and NLS areas mainly for its high yielding nature and its resistance/ tolerance to soil borne diseases like black shank and root-knot nematodes and also for producing good bright grade tobacco. During 2000s and early 2010, it occupied more than 90% of KLS and NLS areas. After the release of Kanchan, the traders are preferring cured leaf of Kanchan style, all the later bred cultivars invariably containing Kanchan or its derivatives as one of the parents.

Publications/commercialization

- Subrahmanya, K. N. and Shenoi, M. M. 2006. FCV tobacco varieties in KLS (Folder), Kasturi Krishna, S., S. V. Krishna Reddy, V. Krishnamurthy, C. ChandraSekhara Rao and M. Anuradha.2016. Effect of N and K on growth, yield and nutrient uptake of FCV tobacco cv. Kanchan. Indian Journal of Agricultural Sciences 86(5): 692-6.

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators /developers

K. Nagarajan, M.S. Chari, V.V. Ramana Rao, A.V.S.R. Swamy, G.S.B. PrasannaSimha Rao, S.S. Hussaini, K.N. Subrahmanya, M.M. Shenoi, K.Giridhar, S.M. Vishwanath, D. Ramachandram, M. SanniBabu, S. Sitaramaiah, C.V.N. Rao, A. Hanumantha Rao, C.V.K. Reddy and S. Ramesh

Name of the technology : Rathna

Year (s) of development : 2001

Technology details

The variety Rathna is a high yielding FCV variety developed by inducing mutation in FCV Special at CTRI RS, Hunsur. Ratna has an yield potential of around 1900 kg/ha with >75% brighter grade, of which over 60% are first grade. The variety has field resistance to black shank. It was released for commercial cultivation in 2001 for medium and low rainfall areas of KLS.

Ratna is a light cast variety with open plant habit and medium internodes. Leaves are broad and long with smooth surface. The lower leaf droop characteristically. It performs better with 60 kg N/ha and bud stage topping at 20-22 leaves level. Cured leaf is ripe, thin to medium bodied pliable, deep lemon to orange with optimum and uniform spots. Rathna is a better alternative to Bhavya in semi dry and dry zones, due to its ability to produce cured leaf having better spotting and pliability even under deficit moisture conditions. The cured leaf has Nicotine 1.8%, Reducing sugars 22.7% and Chlorides 0.5%, which are in the desirable range.

Impact of the technology

Rathna variety was adopted by majority of farmers as it was resistance/ tolerance to soil borne disease like black shank and for producing superior quality leaf with good bright grade out turn. Rathna replaced earlier cultivar Bhavya in semi dry and dry zones in view of its capacity to produce cured leaf having better spotting and pliability even under low moisture regimes.

Publications/commercialization

- Subrahmanya, K. N. and Shenoi, M. M. 2006. FCV tobacco varieties in KLS (Folder).
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators /developers

K.N. Subrahmanya and M.M. Shenoi. J.S.L. Moses, Md. Ilyas Ahmed and Abdul Wajid

Name of the technology : Siri

Year (s) of development : 2006

Technology details

"Siri" is a high yielding and superior quality FCV tobacco variety developed through pedigree method of breeding from a cross between CM-16 and Gauthami. It has a yield potential of 3500 kg/ha under favorable conditions. With the release of this variety, the yield potential of FCV tobacco for the first time crossed 3000 kg/ha mark. It was released for cultivation in the rainfed Vertisols of Andhra Pradesh in 2006.

Siri is a medium to light cast variety with open plant habit. The plant grows to a height of 1.7 m with short internodes. It possesses around 30-32 curable leaves with easy curing. Cured leaves are deep lemon to orange in colour with open graininess. It has nicotine (2.42 %), reducing sugars (17.1%), EMC (12.74%) and filling Value (3.06cc/g) of cured tobacco are in desirable ranges.

Impact of the technology

Since its release in 2006, for a period of nearly 15 years, Siri is continued to be cultivated in black soil/SLS areas. Popular and single largest variety occupying nearly 100% of the area (73,400 ha) in black soils and southern light soil region of AP (2020-21).Cultivation of SIRI variety resulted in increase of the average productivity of Black Soil and Southern Light Soil regions from 1187 kg/ha (2003-07) to 1475 kg/ha (2015-19).Generated an estimated additional revenue of Rs24,370 crores to the country and farm income of Rs. 3841 crores up to 2021 since release. Earned an amount of 11.04 crores to the ICAR-CTRI, Rajahmundry due to the sale of its seed to farmers.

Publications/Commercialization

- Naidu, S.K., K. Sarala, K. SumanKalyani and S. Nageswara Rao. 2010. Popularization of FCV tobacco variety Siri through FLDs in northern black soils of Andhra Pradesh. Tob. Res. 36(1&2):103-5.
- Narayanan, A.I., K. Deo Singh, K. Sarala, R.V.S. Rao, P. V. Venugopal Rao and A.V.S.R. Swami. 2006. Cy 135: A promising FCV tobacco line for rainfed vertisols of Andhra Pradesh. Tobacco Research 32(2): 50-55.
- Narayanan, A.I., K. Deo Singh, K. Sarala, R.V.S. Rao, P. V. Venugopal Rao, A.V.S.R. Swamy, V. Krishnamurthy and R. SubbaRao. 2007. Siri – A promising FCV tobaccovariety. ICAR News 13(3): 13-14.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

A.I. Narayanan, K. Deo Singh, K. Sarala, R.V.S. Rao, R. Lakshminaryana, K. Palanichamy, P.V. Venugopala Rao, A.V.S.R. Swamy, T.G.K. Murthy, R. Subba Rao, J.A.V. Prasada Rao, C.V. Narasimha Rao, Y. Subbaiah, B.S.N. Reddy, K. Sesha Sai, J. Siva Sai, S. Rajeswara Rao, K. Santhi Nandivelu, J.V.R. Satyavani, T. Krishna Reddy, T. Lakshman Rao, D. Balakrishna, M. Trinadh, V.V. Ramana, M. Mohanacharyulu, K.P.S.N. Murthy and B.V.V. Satyanarayana Murthy

Name of the technology : FCH 222

Year (s) of development : 2012

Technology details

FCH 222 is a high yielding (3000 kg/ha) and *Fusarium* wilt tolerant FCV tobacco variety developed at ICAR-CTRI RS, Hunsur for cultivation in the Karnataka light soil areas.This variety was developed through pedigree method of breeding from a cross between FCH-201xSpeightG-33.

The plant of FCH-222 contains around 25 leaves with 20-22 curable leaves with plant height of 110-125cm under un-topped conditions. Leaves are wavy with acute tip, prominent auricle with a sessile stalk, medium spangling at maturity, moderately puckered and light green in color. Cured leaf is ripe, medium bodied, pliable, lemon to orange with optimum spots. Cured leaf has Nicotine 1.76%, Reducing sugars 18.11 %, Chloride 0.18% which are in the desirable ranges.

Impact of the technology

Currently, FCH-222 is a popular variety in wilt affected areas covering around 35 % of the area. FCH-222 gives 50% higher yield than other varieties in wilt sick fields.

Publications/Commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

K.N. Subrahmanya, C. Panduranga Rao, T.G.K. Murthy, C. Mahadeva, P. Nagesh, S.S.Srinivas, M.M. Swamy, S. Ramesh, M.M. shenoi, P. Venkateswarlu, S. Ramakrishnan, V. Krishnamurthy and C.V.N. Rao

Name of the technology : CH-3

Year (s) of development : 2016

Technology details

CH-3 is a flavourful FCV F_1 hybrid developed through hybrid breeding though a cross, CMS Kanchan x P18-1. It has a yield potential of 2700 kg/ha under favorable conditions. It was released for commercial cultivation to KLS in 2016.

The plant of CH-3 has semi erect habit and grows to a height of 185 cm under un-topped condition. It has green colour stem, very long, leaves were medium bodied, oily with excellent ripeness characteristics with good aroma. It has short to medium intermodal length (5.5. cm on an average). The plant produces a total of 28 to 32 leaves with 28 curable leaves. Leaf has very good puckering and frills. Semi erect and plant height is 1.85 m under un-topped condition features with short to medium internode length (5.5 cm). Leaves are medium green cast, sessile with high auricle development, wavy lamina with acute to acuminate tip, very long, medium broad, very good puckering and frills. The percentage of Nicotine 1.0 - 2.89%, Reducing sugars 14 - 20%, Chlorides 0.1 - 0.33%, respectively, which are within the acceptable range.

Impact of the technology

CH-3 covered a maximum of 95% of NLS area during 2015-16 and 49% of KLS during 2020-21. According to an estimate, due to CH-3 cultivation, the productivity increased from 1870 kg/ha (2006-11) to 2187 kg/ha (2015-2020) in NLS and 1039 kg/ha (2009-13) to 1233 kg/ha (2016-2020) in KLS. An additional farm income of Rs. 1, 170 crores and excise/forex revenue of Rs. 8, 160 crores to National economy was generated.

Publications/Commercialization

- Suman Kalyani, K., T.G.K. Murthy and M. Mani. 2012. On-farm testing of FV tobacco hybrids (CH-1 & CH-3) in Northern Light Soil (NLS) area of Andhra Pradesh. An Analysis. The Journal of Research ANGRAUXL(4):98-100.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

T.G.K. Murthy, K.N. Subrahmanya, M.M. Shenoi, M. Mahadevaswamy,S. Rangaiah, P.V.V. Venugopala Rao, K. Sarala, S.V. Krishna Reddy, A.R. Panda,A.V.S.R. Swamy, S. Amarnath, C.V. Narasimha Rao, P.R.S. Reddy, M. Mani,Sushmita Bhattacharjee, P. Srinivas, B.S.R. Reddy, C. Jacob Jem, P. UmaMahesh, P. Venkateswara Rao, K.C. Biddappa, H.N. Ramprasad, M.I. David,G. Krishna Kumar, H.G. Ravish, R. Rajasekhar, K.N. Suresh, Mrigban Ray, K. Srinivas, Pavan Kumar, D.V.R. Rajiv Mohan, Vipin Thomas, N. Palani, S. Mukherjee and N. Vishwanath

Name of the technology : **CTRI Naveena (FCJ 11)**

Year (s) of development : 2023

Technology details

CTRI Naveenais a somaclones having a yield potential of more than 3300 kg/ ha and can even yield up to 3900 kg/ha under favorable conditions. It can withstand rain damage to certain extent during crop growth compared to other varieties grown in this region. Recommended for cultivation into Northern Light Soils of Andhra Pradesh.

Plants of FCJ-11 are open conical in shape and grows to about 180 cm height. The leaves long (-84 cm), broad (~39 cm), sessile, broad elliptic in shape and strongly recurved with strongly pointed tip. The leaves are dark green in colour with strong puckering. The cultivar produces around 35 total leaves with around 32 good bodied curable leaves. Cured leaf is bright lemon to arrange in colour with good aroma.The cured leaf has acceptable range of physical, chemical and smoke parameters.CTRI Naveena shows lower incidence of *Spodoptera*, budworm and aphids under field condition. The contents of nicotine (1.9-2.29%), reducing sugars (13.9-17.85 %) and chlorides (0.16-1.65 %) are within the acceptable range.

Impact of the technology

CTRI Naveena found to be remunerative (B:C ratio 1.57) to farmers with an additional revenue of ~Rs. 50,000/- per ha than existing varieties. It occupied 15% (6,375 ac) of NLS area (42,500 ac) during 2022-23. It gives nearly 900 kg additional yield than existing variety, Kanchan.

Publications/Commercialization

- Sarala, K., P. Venkateswarlu, T.G.K. Murthy, K. PrabhakaraRao, A.V.S.R. Swamy, Y. Subbaiah and D. Damodar Reddy. 2021. FCJ-11: An FCV somaclone suitable for cultivation under NLS of Andhra Pradesh. Tob. Res. 47(2): 85-93.
- Sarala. K., K. Prabhakara Rao and D. Damodar Reddy. 2020. FCJ 11: A high yielding FCV tobacco cultivar for Northern Light Soils of Andhra Pradesh. ICAR-CTRI, Rajahmundry.
- Indian Tobacco – Compendium of Varieties - 2019

Investigators/ Developers

K. Sarala, P. Venkateswarlu, T.G.K. Murthy, K. Prabhakara Rao, A.V.S.R. Swamy, Y. Subbaiah, C. C. S. Rao, D. Damodar Reddy, M. SheshuMadhav, S. Kasturi Krishna, S. V. Krishna Reddy and U. Sreedhar

Name of the Technology : **CTRI-Sreshta (FCR 15)**

Year (s) of development : 2023

Technology details

FCR-15 is a high yielding TMV resistant Flue Cured Virginia (FCV) tobacco line, developed through hybridization followed by pedigree selection (Siri x VT 1158). FCR-15 has a leaf yield potential of 3000 kg/ha under normal conditions at Southern Light Soils of Andhra Pradesh. It produces a total of 22-27 curable economic leaves, FCR-15 found to withstand heavy rainfall during grand growth period with even maturity, good quality leaves and longer colour retention. The variety CTRI – Sreshta showed consistently superior performance with higher yield (2400 kg/ha) over the control, Siri, possessing TMV resistance, The quality characteristics i.e.nicotine 2.37-2.62 %, reducing sugars 12.56-18.26 %, chlorides 0.21-0.43 % are in the acceptable range and are released to Southern light soils of Andhra Pradesh by Varietal Identification Committee.

Field crop of FCR 15

Impact of the Technology

CTRI Sreshta occupied 40% (30,000 ac) of SLS area (75,000 ac) during 2022-23. It gives around 300 kg/ha higher yield than previously grown Siri variety under farmers condition. The crop loss to farmers during heavy rains is being reduced due to cultivation of CTRI Shresta.

Publications/Commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

P.V. Venugopala Rao,T.G.K. Murthy, K. Sarala, A.V.S.R. Swamy, A.R. Panda, K. Prabhakara Rao, U. Sreedhar, K.C. Chenchiah, R.V.S. Rao, D. DamodarReddy, M. Anuradha, S. KasturiKrishna, P. Venkateswarlu, C.C.S. Rao, K. Gangadhara, Mohanacharyulu, T. Lakshmanarao, S. Rama Raju, S.K. Dam, A. Mutyam, M. Mohana Rao, Ch. Lakshman Rao, K.Vidya Sagar, N. Johnson and K. Padmaja

CHEWING TOBACCO

Name of the technology : **Podali**

Year (s) of development : 1956

Technology details

Podali is a high yielding (1600kg/ha)chewing tobacco (N. tabacum L.) variety developed through pure line selection from local cultivar at ICAR-CTRI-RS, Dinhata, West Bengal. Recommended for sandy soils of North Bengal region. Early maturing type and having leaves are petiolate, oblong, boat shaped and narrow with more spangling. Maturity at 90-100 days, 7-8 no. of leaves under topped condition and contain 3.0-4.0 % nicotine, reducing sugars (0.76 - 1.11%), and chlorides (0.89 - 1.11%) of cured tobacco are in desirable ranges.

Impact of the technology

Podali grown in 60% of *jati* tobacco area of North Bengal It gives 300 kg/ha additional yield than previous variety grown.

Publications/Commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

G.C. Patel, W.G. Walunjkar and J.S.L. Moses

Name of the technology : Pusa tobacco 76 (PT 76)

Year (s) of development : 1990

Technology details

Pusa tobacco 76 is a chewing tobacco varietydeveloped by pedigree method from the cross, (Sona x HP 66-1) x (B.K. Rajwa x GandakBahar) at ICAR-CTRI-RS, Pusa, Bihar. It yields about 2600 kg/ha. Released for commercial cultivation in 1990 to chewing tobacco growing areas of Samastipur and Muzafarpur districts of Bihar.

The plant of PT-76 is semi open, tall with longer internode length which favours increased photosynthesis, thereby registering higher yields and better leaf quality. Leaves are long and broad, light green with pointed tips. Flowers in 110 days and topped plant matures in 130 days. Cured leaves are elastic and dark brown in colour with heavy gumminess and white incrustation with excellent chewing taste. It gives pungent taste withgood aroma. Leaf quality parameters: nicotine 4.0 - 4.9%, reducing sugars 0.6 - 1.5% and chlorides 1.7 - 2.3%.

Impact of the technology

During 1990s, PT-76 occupied about 60% of the chewing tobacco growing areas of Samastipur and Muzafarpur districts of Bihar. It gives 400 kg/ha addition yield than its predecessor variety grown in the area.

Publications/commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

S. Amarnath, R. Sinha, R.G. Pandey, R.P. Srivastava, U. Jha, K.S.C. Rao and P. Abdulla

Name of the technology : **Meenakshi**

Year (s) of development : 1992

Technology details

Meenakshiis a chewing tobacco variety developed by hybridization and pedigree method from PV-7 x HV67-9 at ICAR-CTRI-RS Vedasandur, Tamil Nadu. It has an yield potential of about 3750 kg/ha. It was recommended to sun-cured chewing tobacco tract of Dindigul and Madurai Districts of Tamil Nadu.

Plant habit is open with short internodes, dark green leaves with medium auricle and acute tip. Leaves long (75-80cm) and broad (45-50cm), thick bodied with heavy puckering. Panicle semi-open, flowers in 60 - 70 days and matures in 120-125days after transplanting. Cured leaves are dark brown in colour, heavy bodied, elastic with whitish incrustations, sweet aroma and medium strength.It has quality profile of Nicotine 4.3%, reducing sugars 1.5% and chlorides 2.2%.

Impact of the technology

It has high yield potential of 400 kg/ha than the previously grown varieties, so it occupied siginifcant area in chewing tobacco grown area in Tamil Nadu in the late years of 1900.

Publications/commercialization

- Kumaresan, M. and V. Krishnamurthy. 2003. Effect of N and P sources on the growth attributes, cured leafyield and economics of chewing tobacco cv. Meenakshi under Vedasandur conditions of Tamil Nadu. Tobacco Research 29(2):133-7.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

J.S.L.Moses, C.S.B. Prasanna Simha Rao, K. Balagopal, Md.Elias Ahmed, R.Lakshminarayana, K.N. Subramanya, S.Krishnamurthy, R.V.S.Rao, C.V.Raghavaiah, M. Mohan, M.P. Ramasamy, R. Narayanasamy, C. Muruganantham, A. Hanumantha Rao and B.V.V. Sathyanarayana Murthy

Name of the technology : Abirami

Year (s) of development : 2006

Technology details

Abirami is a chewing tobacco variety developed through mutation breeding from 164 at ICAR-CTRI RS, Vedasandur. Has a yield potential of 4000 kg/ha.Suitable for inland chewing tobacco tract of Tamil Nadu.

Plant habit of Abirami is open. Leaves are thick broad shiny green with good auricle development, acute tip. Leaves are long (65-70cm) and broad (40-50cm), heavily puckered. Panicle semi-open. Transplanting to flowering: 60 –70 days. It contains about 5.35% nicotine, 1.26% reducing sugars and 4.17% chlorides. Cured leaves have dark brown color, heavy bodied, elastic with whitish incrustations, sweet aroma and medium strength.

Impact of the technology

In view of the high yield potential coupled with good leaf quality, Abirami occupied nearly 44% of the area (3500 ha) in Tamil Nadu. The productivity of the Abhirami growing areas increased from 3700 to 4000 kg/ha.The increase in demand for the seed supply for this variety is a testimony for its popularity in chewing tobacco farming community. Every year about 200-250 kg of seed is being distributed for cultivation.

Publications/commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

R.Lakshminarayana, K.N.Subramanya, R.V.S.Rao, K.Palanichamy, C.V.Narasimha Rao, J.A.V.Prasad Rao, M.Kumaresan, M. Mohan, R. Athinarayanan, M.P. Ramasamy, R. Narayanasamy, S. Chellaiah, C. Muruganandam, R. Rajendran and A.C. Rajaseharan

HOOKAH AND CHEWING (RUSTICA) TOBACCO

Name of the technology : **Dharla**

Year (s) of development : 2003

Technology details

Dharla is a chewing tobacco variety developed through pedigree method of breeding from a cross,C-304 x DD-437. It has a yield potential of 2700 Kg/ha and tolerant to brown spot. Recommended for motihari tobacco growing areas of West Bengal.

Dharla plants have open and semi erect plant habit with thick bodied and medium green colour leaves. Plant grows to a height of 45 cm with short intermodal length under topped condition. Stalk is thick, ridged, hairy and green in colour,Yields 10-11 curable leaves/plant. It matures at 110-120 days. Contain 3.0 - 3.21% nicotine, 1.0 - 1.29% reducing sugars and 0.21 - 0.32% chlorides.

Impact of the technology

Dharla is a popular variety in the motihari tobacco growing areas of West Benga.It occupies 10% of the area and gives around 500 kg/ha higher yield than previous cultivated variety in farmers' fields.

Publications/Commercialization

- Deo Singh, K., S. Roy, R.L. Arya and S. Amarnath. 2005. Dharla - A promising motihari tobacco variety. ICAR News, Jan.-Mar. pp 17.
- Roy, S., K. Deo Singh, R.L. Arya and S. Amarnath. 2007. "Dharla" - A high yielding variety of Motihari tobacco. Indian Farming 57(2): 31-4, May.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

V.K. Dobhal, A.G.K. Murthy, D. Monga, R. Lakshminarayana, M. Someswara Rao, P.V. Venugopala Rao, S.K. Dhar, I.V. Subba Rao, P.K. Ghosh, S. Chanda, B.V.V. Satyanarayana Murthy and A.S. Mahapatra

MOTIHARI TOBACCO (WEST BENGAL)

Name of the technology : **Torsa**

Year (s) of development : 2008

Technology details

Torsa is a hookah tobacco variety developed through mass selection from farmer's fields. It has a yield potential of 2200 Kg/ha. Recommended for silty/sandy loam soil region in *Motihari* tobacco tract of CoochBehar district of West Bengal.

Plant height is 45 – 47 cm under topped condition. Leaves are oval shaped. Yields 8-9 leaves under topped condition. Comes to maturity at 85-95 days. Contain 5.73% nicotine, 0.34% reducing sugars and 1.34% Chlorides.

Impact of the technology

Occupies 40% of the motihari tobacco areas of Cooch Behar District. It gives around 300 kg/ha higher yield than previous cultivated variety in farmers' fields.

Publications/Commercialization

- Amarnath, S., V. Krishnamurthy, K. Deo Singh, S. Roy and R.L. Arya. 2011. Torsa - A high yielding early maturing *Motihari* tobacco (*N. rustica* L.) variety for Terai Region of West Bengal. Environment & Ecology 29(2):639-42.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

S. Amarnath, V. Krishnamurthy, K. Deo Singh, S. Roy, R.L. Arya, S.K. Dhar, S. Chanda. M. Burman and S.K. Dam

NATU TOBACCO

Name of the technology : Gajapati

Year (s) of development : 2002

Technology details

Gajapati is a*natu* tobacco variety developed from selection in Pyruvithanam and released byAINPT Centre, Berhampur, Odisha.It yields higher curable leaves of about 1800 kg/ha. Recommended for cultivation in Ganjam, Gajapati and Phulbani districts of Odisha

Plant is moderately open, 140 - 160 cm in height under un-topped and 70 - 95 cm in topped condition. Leaves are sessile, narrow and long with leaf length 35 - 45 cm and width 15 - 20 cm, dark green, non-drooping, medium to thick leaf lamina and medium to close nodes. Leaves are 20 - 24 per plant with 12 - 15 curable leaves. Leaf quality is superior with good taste and aroma. Leaf quality parameters: nicotine 6.69%, reducing sugars 1.90 - 3.62 %, chlorides 0.76 - 0.87%.

Impact of the technology

Gajapathi is the only improved pikka tobacco variety released for cultivation in Ganjam, Gajapati and Phulbani districts of Odisha. It occupies 20% of the pikka area of Odisha. It gives around 150 kg additional yield than the previous variety.

Publications/Commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

Y.N. Sarma, B. Bisoi, B.Baisakh, R.C. Mishra, K. Nagarajan, R. Lakshminarayana, S.N. Das, G. Raja Rao, H.K. Mohapatra and S. Panda

Name of the technology : Bhairavi

Year (s) of development : 2006

Technology details

Bhairaviis a *natu* tobacco varietydeveloped by pedigree method of breeding from cross, White Ash Frill x Viswanthat ICAR-CTRI-RS, Guntur, Andhra Pradesh. It has yield potential of about 2600 kg/ha. Recommended for traditional black soils in Guntur, Prakasam, Kurnool districts of Andhra Pradesh and Mahaboobnagar district of Telangana.

Bhairaviplants areopen in habit and produces about 24 curable leaves. Stem colour is green with medium internode length. Leaves are dark green, narrow, lanceolate, base is round with high auricle development, entire margin, acute tip and smooth surface. Leaf quality: Nicotine 3.2 - 5.1%, Reducing sugars 1.35 - 1.65%, Chlorides 0.3 - 0.8%.

Impact of the technology

Bhiravi occupied significant area in the traditional black soils in Guntur, Prakasam, Kurnool districts of Andhra Pradesh and Mahaboobnagar district of Telangana. It gives around 500 kg higher yield than *Natu* special.

Publications/Commercialization

- Indian Tobacco – Compendium of Varieties-2019.

Investigators/ Developers

T. Sitaramachari, K. Deo Singh, R. Lakshminarayana, G.S.B. Prasannasimha Rao, A.S. Krishna Murthy, M. Umamaheswara Rao, P.V. Venugopala Rao, P. Harishu Kumar, P.V. Rao, A.V.S.R. Swamy,J.A.V. Prasada Rao, G. Raghupathi Rao, A.V. SekharaBabu, S.S.K. Rao and B.V.V. Satyanarayana Murthy

CHEROOT TOBACCO

Name of the technology : **Lanka Special**

Year (s) of development : 1981

Technology details

Lanka Special is a cheroot tobacco variety developed by backcross method from DR 1 x Kuofan at ICAR-CTRI, Rajahmundry, Andhra Pradesh. It yields about 2780 kg/ha. It is resistant to powdery mildew. Recommended for river-side lankas of East Godavari district of Andhra Pradesh.

Lanka Special plants are short and bushy with green colour stem. Leaves are dark green, longer, petiolate, boat shaped and lanceolate with acute tip. It Produces 10 - 12 curable leaves per plant. Matures in 90 - 100 days after planting. The cured leaf has all desirable characters like good aroma, good burn in quality and high nicotine content. Leaf quality parameters: nicotine 2.5 - 4.5%, reducing sugars 0.99%, chlorides 0.5 - 1.0%.

Impact of the technology

Lanka special occupies 100% (4000 ha) river-side lankas of erstwhile East Godavari district of Andhra Pradesh. It gives, around Rs. 6000/- returns/ha than the variety grown before its release.

Publications/Commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/ Developers

T. Sitaramachari, K. Deo Singh, R. Lakshminarayana, G.S.B. Prasannasimha Rao, A.S. Krishna Murthy, M. Umamaheswara Rao, P.V. VenugopalaRao,P. Harishu Kumar, P.V. Rao, A.V.S.R. Swamy, J.A.V. Prasada Rao, G. RaghupathiRao, A.V. SekharaBabu, S.S.K. Rao and B.V.V. Satyanarayana Murthy

Name of the technology : Sangami

Year (s) of development : 2008

Technology details

Sangami is a high yielding cheroot tobacco variety developed through pedigree method from a cross, I.737 x DG.3 at ICAR-CTRI RS, Vedasandur. It yields about 3265 kg/ha. Recommended for the cheroot tracts of Erode & Salem districts of Tamil Nadu. Specially suited to narrow leaf country cheroot tobacco tract ofBhavani, Kurichi and Anthiyur areas of Erode District and Edapady area of SalemDistrict of Tamil Nadu.

Sangamiplants are open in habit with narrow lanceolate dark green leaves with pointed leaf tip, medium auricle and moderate puckering. Internodes medium long and stem girth moderate. Transplanting – flowering 45 – 50 days. Matures in about 95-100 days from the date of transplanting. Cured leaves have dark brown colour, light bodied, elastic with sweet aroma and medium strength. Physical and chemical quality characteristics are in acceptable range. It contains 2.51% nicotine, 0.85 - 1.10% reducing sugars and 1.2% chlorides.

Impact of the technology

In early 2010s, Sangami grown in 20% of the country cheroot area in Tamil Nadu. It gives around 500 kg/ha higher yield than the variety grown before Sangami.

Publications/commercialization

- Swamy, A.V.S.R., V. Krishnamurthy, K. Palanichamynd M. Mohan. 2010. Sangami: A high yileding countrycheroot tobacco variety for Tamil Nadu. Tobacco Research 36(1&2): 16-8.
- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

K. Palanichamy, A.V.S.R.Swamy, M. Kumaresan and M. Mohan

BURLEY TOBACCO

Name of the technology : **Banket A1**

Year (s) of development : 1994

Technology details

Banket A1 is a burley tobacco variety introduced from Zimbabwe and evaluated for its suitability at Jeddangi, Andhra Pradesh by ICAR-CTRI. It is free from lodging and resistant to TMV. It yields about 1800 kg/ha. It is recommended for light Soil agency areas in East Godavari, Visakhapatnam and Vizianagaram districts of Andhra Pradesh.

Banket A1 plant grows to a height of about 150 - 200 cm. Stem and midribs are creamy white in color with medium internode length. Leaves are broad ovate with wavy margin, acuminate tip and small auricle. It produces 30 - 35 curable leaves. Flowers in about 80 days after transplanting. It produces higher bright grades. Leaf nicotine (0.2 - 1.5%), reducing sugars (< 1%), and chlorides (< 0.5%) are in desirable ranges.

Impact of the technology

It replace the existing variety, Burley 21 in the light soil of agency area in East Godavari, Visakhapatnam and Vizianagaram districts of AP. Later, when burley cultivation spread to Vinukonda area in AP, it is the single dominant variety cultivated in the area. It gives around Rs. 600 kg/ha higher yield than its predecessor variety.

Publications/commercialization

- Indian Tobacco – Compendium of Varieties - 2019.

Investigators/Developers

M.S. Chari, R. Subba Rao, B.V. Ramakrishnayya, A.S. Krishna Murthy, T. Sitaramachari, K. Nagarajan and M. Umamaheswara Rao

Name of the technology : **Vijetha (YB 22)**

Year (s) of development : 2023

Technology details

Vijethais a burley tobacco variety developed from the cross 324C X Banket A1. It is a high yielding 2900 kg/ha and suitable for rainfed burley tracts of AP. It is resistant to TMV.

Vijetha produces ~36 long and broad leaves with around 33 good bodied curable leaves. The leaves are light yellowish green colored, strongly puckered and sessile. Cured leaf is tan colored with good aroma. The chemical quality parameters percentage of nicotine (3.12-3.34%) and reducing sugars (0.4-0.42 %) are within the acceptable range.

Impact of the technology

Vijetha gives around Rs. 22,000/- additional revenue than existing varieties. Occupied 5% (2,000 ac) of burley area (40,000 ac) during 2022-23.

Publications/commercialization

- Indian Tobacco – Compendium of Varieties-2019

Investigators/Developers

P. V. Venugopala Rao, T.G.K. Murthy, K. Sarala, A.V.S.R. Swamy, K. Prabhakara Rao, S. Kasturi Krishna, U. Sreedhar, D. Damodar Reddy, Y. Subbaiah, P. Venkateswarlu, C. Chandrasekhara Rao and M. Anuradha

PRODUCTION TECHNOLOGIES

S. No.	Technology	Developed by	Year
1.	Technologies for maximizing the farm returns through intercropping in chewing and hookah tobacco	B.T. Sajnani *et al.*	1961
2.	Technology for better seedling establishment	P. Harishu Kumar *et al.*	1990
3.	Optimum irrigation schedule for FCV tobacco in irrigated Alfisols	M. Sannibabu *et al.*	2000
4.	Revised nutrient recommendations for FCV tobacco of Karnataka	K. Giridhar *et al.*	2004
5.	Higher farm returns in chewing tobacco through intercropping with Annual moringa	M. Kumaresan *et al.*	2005
6.	Alterations in INM with different organic sources for productivity and soil health	S.V. Krishna Reddy *et al.*	2008
7.	Alternative cropping systems for FCV tobacco in Vertisols	S.Kasturi Krishna *et al.*	2010
8.	Tobacco based cropping systems and Integrated Farming System (IFS) model for FCV tobacco in Karnataka	M. Mahadeavaswamy *et al.*	2010
9.	Micro sprinkler irrigation in tobacco nursery for enhanced water and nutrient use efficiency	K. Krishna Rao *et al.*	2011
10.	Drip fertigation for water and nutrient use efficiency	C. Chandrasekhara Rao *et al.*	2011
11.	Integrated weed management in FCV tobacco	S. Kasturi Krishna *et al.*	2011
12.	Polytray tobacco seedlings technology for better field establishment	C. Chandrasekhara Rao *et al.*	2014
13.	Agro-technologies for high leaf yields for alternative uses of tobacco	S. Kasturi Krishna *et al.*	2015
14.	Integrated management of *Orobanche* in FCV tobacco	S. Kasturi Krishna *et al.*	2017
15.	Dense planting – A climate resilient planting technology for FCV tobacco	M. Anuradha *et al.*	2018
16.	Drought mitigation technologies for FCV tobacco in Karnataka	M. Mahadevaswamy *et al.*	2019
17.	Crop intensification technologies in tobacco	T. Kiran Kumar *et al.*	2019

Name of the technology : **Technologies for maximizing the farm returns through intercropping in chewing and hookah tobacco**

Year (s) of development : 1958-1961

Technology details

For increasing farm returns, inter crop studies with garlic, onion, coriander and no intercrop as control were studied. Planting of intercrops taken up 3 weeks after transplanting of tobacco. Onion bulbs and individual unit parts of garlic bulbs were planted in single rows in between the tobacco rows spaced 3 feet apart at a distance of about 6"-8" from bulb to bulb while coriander seeds were uniformly sown in a row in between tobacco rows spaced 3 feet apart and thinning done after germination.

The shallow rooted crops under study containing cylindrical and finely divided compound leaves do not give enough shade to cover the main tobacco crop so as to impair the yield and quality of tobacco. They also have very shallow root system and feed from upper 6" strata of the soil and do not compete for food material with the main crop of tobacco. On an average growing of garlic in between the tobacco rows produced slightly better cured leaf and first grade leaf yield followed by coriander, control and onion in order.

There was no adverse effect on yield and quality of tobacco was obtained by growing shallow rooted crops like onion, garlic and coriander.

Impact of the technology

Amongst the three inter crops, growing of onion in between the tobacco rows gave the maximum net profit. An extra net profit of Rs. 400, Rs. 112, and Rs. 146. per hectare was obtained on an average due to growing of onion, garlic and coriander respectively as inter crops in between the tobacco rows as compared to the control (no inter crop). Since growing of shallow rooted crops in between the tobacco rows did not affect the yield and quality of tobacco adversely and also it gives extra income to the cultivators, it is decidedly advantageous to follow this practice.

Publications/Commercialization

- Sajnani, B.T., K.C. Dhyani and A. N. Singh. 1962. Effect of Mixed Cropping with Shallow Rooted Crops on the Yield and Quality of Hookah & Chewing Tobacco. Indian Tobacco. 12: 131-40.

Investigators/ Developers

B.T. Sajnani, K.C. Dhyani and A.N.Singh

Name of the technology : **Technology for better seedling establishment**

Year (s) of development : 1988-1990

Technology details

Paddy straw is the conventional seed bed mulch in the tobacco nurseries. The seedlings emergence and development are relatively low under paddy straw mulch due to the rain drop erosion.

Use of coir mat pandals encourages seedling growth and reduced the precocity effectively. However, the third and fourth pulling and later, recorded less percentage increase. The cumulative totals, after every pulling, have also indicated the superiority of coir mat pandal over geo textiles pandal or paddy straw mulch. Coir mat pandals recorded 61.4% increase in transplantable seedlings in the first pulling over conventional paddy straw. Requirement of nitrogen varied with the amount of seasonal rainfall. High rainfall season required 80 kg N/ha while for a low rainfall season, a dose of 40 kg N/ha was as good as 80 kg N/ha.

Besides early germination, seedlings development due to surface mulches was reported by many workers. The use of low cost fabricated mats made of waste jute and rough coir as pandals has precocity of seedling development.

Impact of the technology

Use of coir mat pandals 62% increase in transplantable over geo textiles pandals or paddy straw mulch. The dual advantages of these mats are durability over a period of 3 to 4 years and control of rain drop erosion.

Publications/Commercialization

- Harishu Kumar, P., R. Sinha, RB. Narayana Rao and N. Prabhakara Rao. 1992. Effect of seed bed covers on nitrogen and water requirement of light soil tobacco nurseries. Tobacco Research. 18: 89-92.

Investigators/ Developers

P. Harishu Kumar, R. Sinha, R.B. Narayana Rao and N. Prabhakara Rao

Name of the technology : **Optimum irrigation schedule for FCV tobacco in irrigated Alfisols**

Year of development : 1985-2000

Technology details

The crop is generally planted during the second fortnight of October and receives only 100-300 mm rain during crop growth. It is observed that quantum of irrigation water used is directly proportional to the chloride content of the leaf. Hence excess and indiscriminate use of irrigation water results in, the production of poor quality leaf from IW/CPE field studies it can be concluded that for the variety K-326 (NLS-4) in NLS of A.P. a total of 367 ha-mm of irrigation water in 12-13 irrigations (average is 12.33) with 2-3 irrigations at IW/CPE ratio of 1.0 from 40-75 days (IW 50mm) and 10 irrigations at IW/CPE ratio of 0.8 till harvest (IW 25 mm) including 70 mm of 4 initial irrigations (10 mm at the time of planting, 10 mm at 5-6 DAP, 25 mm at 15 DAP and 25 mm at 30 DAP) would be needed for getting higher yield coupled with superior quality.

After harvesting, 5 irrigations can be given in alternate furrow method to save quantity of water to an extent of 50 ha mm and to get quality leaf.

Impact of the technology

Irrigation schedule was standardized for the exotic introduction *cv. Kanchan* with 12-13 irrigations and irrigation water requirement 462 mm with WUE of 5.49 kg cured leaf/mm of IW. This practice is followed in the alfisols grown FCV tobacco. This method of irrigation is simple and controls the indiscriminate use of underground water by the farmers. In Alternate furrow irrigation after harvesting 50 ha mm water can be saved and it is recommended to farmers.

Publications/Commercialization

- Sannibabu, M. 1985.Alternate skip/furrow irrigation method to check the undue usage of underground water resources with reference to irrigated FCV tobacco in Andhra Pradesh. Indian Tobacco Journal 17(2):6-9,

- Krishna Reddy, S.V., Kasturi Krishna S. and Reddy, P.R.S. 2008. Irrigation scheduling based on IW/CPE ratio approach for better yield and quality of FCV tobacco *(Nicotiana tabacum) cv. Kanchan* in irrigated Alfisols of Andhra Pradesh. Tobacco Research *34* (1&2): 35-42.

Investigators/ Developers

Sannibabu, M, S.V. Krishna Reddy, S. Kasturi Krishna and P.R.S Reddy

Name of the technology : **Revised nutrient recommendations for FCV tobacco of Karnataka**

Year(s) of development : 1999-2004

Technology details

The continuous application of phosphorus @ 80 kg/ha, despite the low requirement by the crop (about 14 kg/ha), resulted in the buildup of available 'P' in the soil. The trials in low, medium and high 'P' status soils for four years conclusively proved that 40 kg $P_2 0_{-5}$-/ha is optimum for better yield and quality of FCV tobacco in KLS. The returns per rupee invested on fertilizer 'P' ranged from Rs.16 to 24 at 40 kg phosphorus, as against Rs.7 to 9 at 80 kg due to the yield decline as well as increased fertilizer cost at higher dose.

Potassium is an important input for improving the crop productivity and leaf quality in tobacco farming. Balanced nutrition through proper N and K_2O application will play a vital role in sustaining the quality and yield of this commodity grown in KLS.

The total dry matter (TDM) production was positively influenced by increasing K_2O levels upto 120 kg/ha. Application of higher doses of K_2O (120 to 140 kg/ha) resulted in increased K content in both leaf and stalk. Application of K_2O at 80 kg/ha and above significantly influenced all the yield parameters. While the maximum response was noticed at 120 kg K_2O for cured leaf, the response of Top-Grade Equivalent (TGE) to K_2O levels maximum at 140 kg/ha in the cured leaf quality characteristics like nicotine, reducing sugars and chlorides were not significantly affected by levels of K_2O application.

Field with 40 kg P_2O_5/ha

Crop with 120 kg K_2O/ha

Impact of the technology

The returns per rupee invested on fertilizer 'P' ranged from Rs.16 to 24 at 40 kg phosphorus, as against Rs.7 to 9 at 80 kg due to the yield decline as well as increased fertilizer cost at higher dose.

Revised K dose @ 120 kg K_2O/ha is being implemented and included in the fertilizers schedule by tobacco board since 2011. It has greatly Impacted in better harvests and curability resulting in higher productivity and quality of KLS tobacco in around 50,000 ha in Karnataka.

Publications/commercialization

- ICAR-CTRI RS, Hunsur, Farm recommendation at glance (2003).
- Mahadevaswamy, M. and V. Krishnamurthy. 2006. Effect of levels and methods of potassium application on growth, yield and quality of FCV tobacco in Karnataka light soils. Tobacco Research 32(2):56-60.

Investigators /developers

K. Giridhar, M.M. Shenoi, P.R.S. Reddy, C.C.S. Rao and S. Ramesh M. Mahadevaswamy and V. Krishnamurthy

Name of the technology : **Higher farm returns in chewing tobacco through intercropping with Annual moringa**

Year (s) of development : 2001-2005

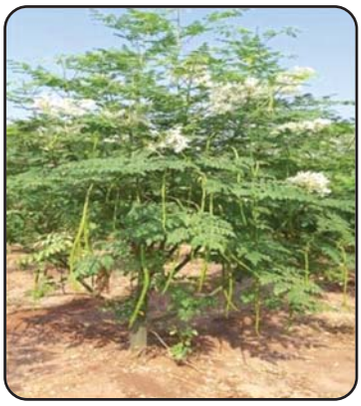
Technology details

Super phosphate 625 kg +2.5 t/ha of sieved FYM were mixed and were spot applied. The tobacco seedlings were planted at 75 cm spacing. The annual *moringa* PKM 1 seedlings grown in poly bags were planted at a spacing of 1.5m x 1.5 m. Chewing tobacco was fertilized by 75+ 50 NK kg /ha. The annual *moringa* was fertilized with 160+140+80 NPK kg/ha after the harvest of chewing tobacco. Tobacco was harvested at 120 days, by stalk cut method. Annual *moringa* was harvested from 5th month onwards. Annual *moringa* was given irrigation once in 7 days depending up on the soil moisture. Plant protection measures were done for both Annual *moringa* and chewing tobacco.

Tobacco equivalent yield was significantly higher with chewing tobacco + annual moringa during the first cycle (6.60 t/ha) and second cycle (5.82 t/ha) over sole tobacco. Net return was higher with chewing tobacco + annual moringa in the first cycle (Rs.76,500/ha) as well as in the second cycle (Rs.71,400/ha).

Higher tobacco equivalent yield and net returns could be achieved with chewing tobacco + annual moringa , an economically viable intercropping system for the chewing tobacco belt of Tamil Nadu.

Chewing tobacco + Moringa



Moringa

Impact of the technology

This technology is adopted by more than 50% of the farmers in the chewing tobacco areas. The system productivity and farm returns were higher with this technology.

Publications/Commercialization

- Kumaresan, M. and C. Chandrasekhara Rao. 2013. Production potential and economic feasibility of chewing tobacco (Nicotiana tabacum) - based intercropping system. Indian Journalof Agricultural Research 47(1): 66-72.

Investigators/ Developers

M. Kumaresan and C. Chandrasekara Rao

Name of the technology : **Alterations in INM with different organic sources for productivity and soil health**

Year (s) of development : 2000-2009

Technology details

Integrated nutrient management involving conjunctive use of organic manures and fertilizer N with P and K may improve the productivity, yield and quality of tobacco. Hither to Farm Yard Manure (FYM) used to be abundantly available to the farming community and were applying to the farming fields. Due to the dwindling cattle population, the availability of FYM has become scarce.

Organic manures such as farmyard manure, filter press cake, vermi-compost, castor cake, sunnhemp [*Crotalaria juncea* (L.) Rotar and Joy] *in situ* green manuring along with no organic manure treatment and three nitrogen doses were tested and it was found that conjunctive application of FYM (10t/ha) or sunnhemp *in situ* green manuring in combination with 120 kg N/ ha would be optimum for FCV tobacco cv. Kanchan for obtaining higher yield coupled with superior leaf quality characters and also higher net returns and B: C ratio in NLS of Andhra Pradesh. Sunnhemp *in situ* green manuring can be successfully used as alternative organic manure in NLS when the FYM is scarce.

Sunnhemp

Pillipesara

Green leaf manuring with *pillipesara* (*Vigna trilobata* (L) is a suitable alternative to FYM whenever its availability is scarce in Vertisols of Andhra Pradesh for FCV tobacco cultivation and its application reduced the TSNA harmful substances by 25% in FCV tobacco.

Impact of the technology

Sunnhemp *in situ* green manuring followed by tobacco with application of 120 kg N/ha in 25: 75 organic : inorganic proportion gave higher cured leaf yield, grade index and also lower TSNA levels (cancer causing substances) in leaf. It gave net returns of Rs 35000/ha with a B: C ratio of 1.50 and profitability of Rs 220.ha/day.

This technology is very much popularized among the farmers in NLS area and being adopted by >80% of farmers growing tobacco in 25000 ha. (>80% of the farmers are following this technology due to the paucity of FYM as a result of dwindling cattle population. This technology is included in the institute package of practices of NLS region

Publications

- Krishna Reddy, S.V., Kasturi Krishna S., Deo Singh, K., Harishu Kumar, P. and Krishnamurty, V. 2009. Integrated nutrient management in FCV tobacco (*Nicotiana tabacum*) in irrigated Alfisols. Indian Journal of Agronomy 54 (1):74-79.

- Krishna Reddy, S.V., Kasturi Krishna S., Deo Singh, K., Harishu Kumar, P. and Krishnamurty, V. 2008. Effect of conjuctive use of FYM and nitrogen on yield, quality and economics of FCV tobacco (*Nicotiana tabacum*). Indian Journal of Agronomy 53(4):318-322.

Investigators/ Developers

S.V. Krishna Reddy, S. Kasturi Krishna, K. Deo Singh, P. Harishu Kumar and V. Krishnamurthy

Name of the technology : **Alternative cropping systems for FCV tobacco in Vertisols**

Year (s) of development : 2002-2010

Technology details

India being a signatory to Framework Convention on Tobacco Control (FCTC) under World Health Organization (WHO), the tobacco production is to be reduced. After *kharif* maize with minimum tillage, *rabi* crops *viz.* chickpea, red gram and horse gram can be grown successfully to achieve higher system productivity, sustainable yield index and net returns and also to improve the soil fertility. Soybean–chickpea (net returns of 53,338/ha) as one of the economically viable alternative cropping systems to FCV tobacco (net returns of 52,000/ha) is developed and followed in the uplands of East Godavari and in rainfed vertisols of Guntur Districts in Andhra Pradesh where FCV tobacco cultivation was withdrawn.

Maize based cropping systems

Impact of the technology

Maize based cropping sequences are followed in Vertisols where tobacco cultivation is not feasible due to inferior quality. Most of the area is reduced in the traditional black soils and adopting maize based and other cropping sequences. ICAR-CTRI is conducting Seminars, demonstrations and trainings on alternative crops in collaboration with Tobacco Board to reduce the area under tobacco. Soybean–chickpea developed and followed in the uplands of East Godavari and in rainfed vertisols of Guntur Districts in Andhra Pradesh where FCV tobacco cultivation was withdrawn.

Publications

- ICAR-CTRI Newletter 28(4):1, 2006.
- Kasturi-Krishna, S., Krishna Reddy,S.V., Harishu Kumar, P, Krishnamurthy,V., Nageswara Rao, M. 2010. Agronomic and economic evaluation of alternative cropping systems for FCV tobacco (*Nicotiana tabacum*) on vertisols of Andhra Pradesh. Indian Journal of Agronomy 55(4):270-275.
- Kasturi Krishna, S., P. Harishu kumar, S.V. Krishna Reddy, R. Subba Rao and M. Nageswara Rao. 2004. Conservation tillage for Rabi crops in Sequential cropping systems under vertisols. Andhra Agricultural Journal 50: 399-400

Investigators/Developers

S. Kasturi Krishna, P. Harishu Kumar, S.V. Krishna Reddy, R. Subba Rao and V. Krishnamurthy

Name of the technology : **Tobacco based cropping systems and Integrated Farming System (IFS) model for FCV tobacco in Karnataka**

Year (s) of development : 2002-2010

Technology details

Nearly 30% of the rainfall is received during October-December months from north-east monsoon. Under these circumstances, the rainfall received during the monsoon can be effectively utilized for raising short duration rabi crops for increasing the cropping intensity for optimum utilization of natural resources. The economics of various rabi crops in rotation with kharif tobacco indicated that castor was found more remunerative with a net return of Rs.10,796/ha followed by finger millet (Rs.8,134/ha) while all the other crops resulted in lower net returns.

An integrated farming system model involving agri-horti, silvipasture, cropping systems and subsidiary enterprises is developed and evaluated in one acre operational area at Hunsur farm. Castor crop in agri-Horti system, fodder crops in silvipasture and cotton, pigeonpea + groundnut (2:8), finger millet, maize+cowpea (1:1) in kharif and field bean, horse gram etc. (rabi) in the cropping system blocks were raised. In addition, vegetable production (nutrition garden),

Integrated Farming System

Tobacco based cropping system

FYM and vermicompost production, animal husbandry etc. were taken up to earn additional farm income and to generate organic resources for the system. Live fence with Jatropha was further developed in the model. The fourth year economic evaluation of the model indicated a total revenue of Rs. 25,077/ - from the 1.0 acre model from all the systems during 2008-09 season. There was good growth and higher productivity of *kharif* crops like cotton, pigeonpea,

groundnut, finger millet etc. as the rainfall and weather were very much favourable for the crop production. Maximum returns (Rs. 20,747/-) were obtained from the subsidiary components/ enterprises as observed in the previous seasons indicating the importance of allied enterprises in agriculture, especially in the rainfed farming situations such as KLS.

Impact of the technology

For getting enhanced farm returns Kharif tobacco followed by rabi castor or ragi recommended in KLS conditions.

Tobacco based farming system comprising of various subsidiaris one economically viable and ecologically sustainable in the rainfed farming situations of Southern transitional zone of Karnataka. About 1000 farmers visited the model and got benefited.

Publications/commercialization

- Mahadevaswamy, M., K. Giridhar and P. Harishu Kumar. 2006. Comparative studies on tobacco based sequential cropping systems in Karnataka. Tobacco Research 32(2):73-5.

Investigators /developers

M. Mahadeavswamy, M.M. Shenoi, S. Ramakrishnan, C. Mahdeva, and T. Venkatesh

Name of the technology : **Micro sprinkler irrigation in tobacco nursery for enhanced water and nutrient use efficiency**

Year (s) of development : 2007-2011

Technology details

The lateral and micro sprinkler in between beds of 1 m width of each and 4 sprinklers are required for irrigating two beds of 1 m width and 10 m length. The optimum spacing between laterals is found to be 2.5 m and the spacing between micro sprinklers is 2.5 m under the operating pressure of 1.25 to 1.5 kg/cm^2. Root volume, weight and height of the seedlings and transplantable seedlings are higher in case of seed beds irrigated by micro-sprinklers when compared to rose cans. Seedlings growth under micro-sprinkler is rapid and are ready for transplanting in 45 days against 60 days in conventional water application. Fertigation in tobacco nursery through micro-sprinklers improved number of transplantable seedlings and saved the fertilizers to an extent of 20 % compared to conventional fertilizer application

Impact of the technology

Applying water to tobacco seed beds through micro-sprinklers reduced the labour cost by Rs.1, 45,000/ha. Micro sprinkler irrigation technique developed by ICAR-CTRI, saves 24% and 35% of irrigation water at nursery bed level and at total system level respectively in comparison to rose can watering system.It is widely followed by tobacco farmers in Andhra Pradesh and Karnataka.

Publications/commercialization

- Krishna Rao.B.,C. Chandrasekhara Rao, M. Anuradha and V.C. Pande.2014. Effect of microsprinkler system on input use efficiency, labourcost and economic viability in tobacco (*Nicotiana tabacum)* seedling production. Indian Journal of Agricultural Sciences 84(4): 439-43.

Investigators/Developers

B.V. Krishna Rao, C. Chandrasekhara Rao, V. Krishna Murthy and P. Harishu Kumar

Name of the technology : **Drip fertigation for water and nutrient use efficiency**

Year (s) of development : 2008-2011

Technology details

Drip irrigation with recommended dose of fertilization (RDF) increased green leaf yield by 16%, cured leaf yield by 18% and grade index by 15% per hectare when compared to furrow irrigation with RDF. Drip fertigation with 100% RDF proved its superiority over drip irrigation with RDF and furrow irrigation with RDF. Drip fertigation with recommended dose increased green leaf yield by 27%, cured leaf yield by 12% and grade index yield 11% when compared to drip irrigation with RDF.When compared to furrow irrigation with RDF, the green leaf yield increased by 47%, cured leaf yield by 32 % and grade index by 28% per hectare. Drip fertigation with 80% RDF recorded yields comparable to drip fertigation with 100% RDF and significantly higher than drip irrigation with RDF and furrow irrigation with RDF there by saves fertilizers to an extent of 20%. Water saving (> 50 %) could be achieved through drip irrigation as compared to conventional furrow irrigation at CTRI Research station Vedasandur.

Drip lines

Furrow irrigation

Drip fertigation in chewing tobacco

Drip irrigation and drip fertigation accrued additional profit of 25,285, benefit: cost ratio of 1.82, water use efficiency (WUE) of 11.74 kg of cured leaf/ ha-mm of water as compared to 5.77 kg of cured leaf/ha-mm in normal seedlings, furrow irrigation and soil application of fertilizers was realized at CTRI Research Station, Jeelugumilli, Andhra Pradesh. Only 57.2% of total quantity of furrow irrigation is required for drip irrigation and there is 203.5% increase in WUE with drip irrigation as compared to furrow irrigation.

Impact of the technology

The technology was disseminated to farmers in collaboration with Tobacco Board. The technology was adopted by >60% farmers in NLS region in view of its impact on crop growth, yield, leaf quality and mainly the labour saving. Only 57.2% of total quantity of furrow irrigation is required for drip irrigation and there is 203.5% increase in WUE with drip irrigation as compared to furrow irrigation.This technology is followed by 12,000 ha in alfisols of AP, and 5000 ha in chewing tobacco of TN.

Publications/commercialization

- ICAR-CTRI Annual Reports 2009, 2010 & 2011.
- Kumaresan, M., C. Chandrasekara Rao and D. Damodar Reddy. 2019. Influence of drip fertigation on growth, yield and leaf-quality characters of sun cured chewing tobacco (Nicotiana tabaccum). Indian Journal of Agronomy 64(3): 24-28.
- Krishna Reddy, S.V., C.C.S. Rao and S. Kasturi Krishna. 2022. Enhancement of productivity, water and nutrient use efficiency and economics through drip fertigation and tray seedlings in FCV tobacco (*Nicotiana tabacum*) under irrigated Alfisols of Andhra Pradesh. Indian Journal of Agronomy 67(3): 294-303.

Investigators/Developers

C. Chandrasekhara Rao, B. Krishna Rao, M. Kumaresan and S.V. Krishna Reddy

Name of the technology : **Integrated weed management in FCV tobacco**

Year (s) of development : 2009-2011

Technology details

Monocots weeds are dominant in FCV tobacco growing irrigated Alfisols and most of the weeds in between tobacco rows are controlled by intercultural operations up to ridge formation (45-50 days). But the weeds around the plants with in the row and after 45-50 days after planting are to be controlled by manual weeding only. Under these conditions inclusion of chemicals is the best option for weed control due to labour scarcity.. Wherever herbicide application was included in weed management statistically lower weed dry matter production was recorded at 30, 60, 90 days and at harvest. Weed management practices involving Quizalofop-ethyl recorded cured leaf yields on par with that of weed free check. Post emergence spraying of Quizalofop-ethyl at 15+75, days after planting effectively controlled the grassy weeds and also gave higher yields.Net returns accrued in the above treatment was Rs 87,334 with B:C ratio of 0.33 when compared to control plot with net returns of Rs 9,768 and B:C ratio of 0.04. The above recommended practice of leaf samples were sent to ICAR-DWSR ,Jabalpur and residues were below detection limits.

Two post emergence sprays of Quizalofop-ethyl @ 60 g a.i./ha at 15 and 75 DAP can be used in integrated weed management along with three intercultures to control monocot weeds *viz*,*Dactyloctenium aegyptium*, *Digitaria sanguinalis* ,*Cynodon dactylon*, *Panicum sp*, which constitute 90 % of weeds in the irrigated Alfisols in case of labour scarcity for hand weeding .

Quizalofop ethyl application at 15 and 90 days after planting tobacco

Impact of the technology

Two post emergence sprays of Quizalofop-ethyl @ 60 g a.i./ha at 15 and 75 DAP can be used in integrated weed management along with intercultures to control monocot weeds which are dominant in the irrigated alfisols even during cyclonic conditions. It is followed by the farmers as laborers are scarce nowadays and also during continuous rains when hand weeding and inter cultivation is not possible.

Publications

S. Kasturi Krishna, S.V.Krishna reddy, K.Nageswara Rao and T.Kiran Kumar. 2019. Integrated weed management in FCV tobacco (*Nicotiana tabacum* L.) grown under irrigated alfisols .Tobacco Research 45(1): 33-38.

Investigators/Developers

S. Kasturi Krishna, S.V.Krishna reddy and K.Nageswara Rao

Name of the technology : **Polytray tobacco seedlings technology for better field establishment**

Year (s) of development : 2010-2014

Technology details

Conventional nursery raising on raised seedbeds is costly and requires the high amount of natural resources. Application of water and weeding are labour intensive and there will be Shortage of labour due to its seasonality. 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 composted coirpith 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. Seedlings of 20-25 days are planted in the poly trays 72/98 cells filled with coir pith by making a suitable hole using a nail or small stick. Seedlings are raised 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 100% establishment, improves the yield by 10-25%. Uniform crop growth due to less gap fillings (<1%), no transplantation shock, No Weed problem, Water and fertilizer use efficiency will be more. It is a Farmer friendly technology that can be performed in back yards unlike conventional nursery. Crop duration will be reduced by 10 days. Tray seedlings reduced the Root Knot Index than conventional nursery in Karnataka.



Impact of the technology

Front line demonstrations and training programmes were conducted to farmers and stake holders at different locations. In collaboration with Tobacco Board, sensitization programmes were conducted through Field Friends programme. More than 80% farmers in Northern Light soils of Andhra Pradesh and 90% farmers in Karnataka light soils adopted the technology.

Publications/commercialization

- Mahadevaswamy, M., M.M. Shenoi, S.S. Sreenivas and S. Ramakrishnan. 2007. Studies on production of tray nursery seedlings of FCV tobacco under KLS situation. Tobacco Research 33(1&2): 17-20.

Investigators/Developers

C. Chandrasekhara Rao, M. Mahadevaswamy, V. Krishna Murthy, K. Siva Raju

Name of the technology : **Agro-technologies for high leaf yields for alternative uses of tobacco**

Year (s) of development : 2010-15

Technology details

Tobacco is a rich source of phytochemicals having pharmaceutical, agricultural and industrial importance like nicotine an alkaloid, solanesol a trisesquiterpene alcohol and organic acids (malicand citric) etc. With the objective of maximizing leaf biomass production for optimum recovery of nicotine, solanesol and proteins in tobacco, a field experiment was conducted.

HDBRG (Harvel De Bouxo Rio Grande) with 60 x40cm spacing and 150:75:75 NPK kg/ha recorded higher biomass leaf yields of 392.05 q/ha followed by 60 x40cm spacing and 100:50:50 NPK kg/ha with an yield of 370.64 q/ha with same spacing. Line RT 46-1 followed by TI-163 X A-145 recorded higher nicotine yields with 80 x40 cm spacing and 150:75:75 NPK kg/ha. HDBRG followed by TI-163 X A-145 with a spacing of 70 x40cm and 150:75:75NPK kg/ha gave higher solanesol yield. HDBRG with 70 x 40cm spacing and 150:75:75 NPK kg/ha recorded higher protein yield which was on par with TI-163 X A-145 at same spacing and fertilizer level

HDBRG

TI-163 X A-145

Impact of the technology

HDBRG identified for higher (48kg/ha) solanesol and protein (976 kg/ha) recovery while RT 46-1(74.6 kg/ha) followed by TI-163 X A-145(74.2kg/ha) for nicotine. HDBRG is the variety grown for solanesol purpose in Guntur area in 2000 ha.

Publications/commercialization

- S. Kasturi Krishna, T.G.K .Murthy, K.Siva Raju and S.V.Krishna Reddy. 2020.Tobacco leaf biomass enhancement for alternative uses by management practices in different lines. Tobacco Research. 46(2):53-57

Investigators/Developers

S. Kasturi Krishna, T.G.K .Murthy, K. Siva Raju and S.V. Krishna Reddy

Name of the technology : **Integrated management of *Orobanche* in FCV tobacco**

Year (s) of development : 2011-2017

Technology details

A review of literature on control measures of broom rape indicates that there is no single consistent, effective and economical method for complete eradication of broomrape infestation in tobacco. Therefore, the only effective way to combat weedy root parasite like *Orobanche* is through an integrated approach, combining a variety of measures in a concerted manner.

In Vertisols lower infestation of 1.7 % at 75 days and 14.3% at 100 days was recorded in two year rotation of sorghum preceding tobacco. In two year rotation of sesamum preceding tobacco 2.7 % and 18 % infestation at 75 and 100 days after planting respectively was recorded. Hand pulling for three years continuously also reduced the infestation in solo tobacco. In highly infested fields of Orobanche in tobacco integration of trap crops of sorghum or sesamum rotation for two years with hand weeding is recommended for Orobanche management in Vertisols.

In different field trials in alfisols only 2 %*orobanche* infestation was observed in tobacco grown succeeding kharif grown sesamum with neem cake application to tobacco at 30 days after planting @10g per plant followed by hand weeding.

Sesamum trap crop

Sorghum - Tobacco

Control plot

Impact of the technology

There is saving of labour 70 mandays per hectare with this technology as two times weeding can be avoided with integration of 1. Summer ploughing, 2. Growing sesamum in kharif ,3.application of 10g neemcake perplant and 4. One hand weeding to reduce the infestation of Orobanche in FCV tobacco in alfisols. In Vertisols trap crop rotation (sorghum/sesamum) with hand weeding is recommended for management of Orobanche.

Publications/commercialization

- ICAR-CTRI Annual Reports 2016-17 & 2017-18.
- S. Kasturi Krishna, S.V. Krishna Reddy, T. Kiran Kumar and V.S.G.R. Naidu 2022. Effect of trap crop rotation cycles on broomrape infestation in FCV tobacco. Tobacco Research 48(1): 23-29.

Investigators/Developers

S. Kasturi Krishna, S.V. Krishna reddy, and V.S.G.R. Naidu

Name of the technology : **Dense planting – A climate resilient planting technology for FCV tobacco**

Year (s) of development : Development: 2016-18
Evaluation and Validation through OFTS and FLDS-2018-21

Technology details

FCV tobacco productivity is low in SLS Andhra Pradesh region as the soils are poor in fertility and moisture retention. In this region the crop is normally planted with the onset of North East monsoon. In recent years, due to changed climatic scenario, the monsoon is getting delayed due to which the crop is not getting enough time to exhibit its full potential and in turn resulting in further reduction in yield.

During late plantings, enhancing plant population by reducing plant to plant spacing from 65 cm to 32.5 cm could minimize the yield loss of 410 kg/ha without affecting the leaf quality. This strategy is tested on farmer's fields (On-farm testing) and found that increasing the plant population (dense planting) minimized the cured leaf yield loss to an extent of 11-26% under low productivity areas of SLS domain and or situation when planting is delayed due to late onset of monsoon and realized additional net returns of Rs 10,300-27,800/- per ha over normal method of planting.

Dense planting

Dense planting demonstration

Impact of the technology

It is a climate resilient technology advocated as contingent measure in FCV tobacco cultivation under rainfed areas of southern Andhra Pradesh under delayed monsoon situation.Increasing the plant population (dense planting) minimized the cured leaf yield loss to an extent of 11-26% under low productivity areas of SLS regionof Andhra Pradesh when planting is delayed due to late onset of monsoon and realized additional net returns of Rs 10,300-27,800/- per ha over normal method of planting.

Publications/commercialization

- ICAR-CTRI Annual Report 2018-19 (p.44).

Investigators/Developers

M. Anuradha, D. Damodar Reddy, K.C. Chenchaiah, L.K. Prasad and J. Poorna Bindu

Name of the technology : **Drought mitigation technologies for FCV tobacco in Karnataka**

Year (s) of development : 2012-2019

Technology details

FCV tobacco is an important commercial crop grown under rainfed farming on red sandy to sandy loam soils in Southern Transitional Zone of Karnataka. Calcium is a mineral element with a much higher demand by tobacco plant like K and it helps in increasing cell wall strength, cell thickness and also helps in better root development to overcome drought conditions. Tobacco cured leaf productivity could be enhanced to an extent of 11.9 -12.8% by increasing the plant density to 22,222 plants/ha adopting inter row spacing of 100 cm and intra row spacing of 55 cm (100 x55 cm) instead of 18,181 plants/ha (with the normal spacing of 100 x 55 cm). Calcium nitrate fertilizer applications (containing 15.5% N and 19.0% calcium) as starter nutrient dose at planting time enhanced the seedling establishment and growth resulting in mean increase of 6.5 – 11.0% in productivity across the season/locations in the dry and semi dry zones of KLS.

Foliar application of N and K nutrients with Potassium Nitrate fertilizer (fully water-soluble foliar grade containing 13.5% N and 45% K_2O) @ 1.0% during crop growth phase at 45 and 55 days after transplanting increased the leaf productivity by 9.3% to 11.2%. Foliar sprays of nutrients can result in increasing the photosynthetic efficiency of the crop.

Calcium nitrate application

Potassium nitrate application

Dense planting

Impact of the technology

High density planting with 22,222 pl/ha, Calcium nitrate fertilizer applications as starter dose and foliar application of N and K nutrients with Potassium Nitrate fertilizer are drought mitigations measures recommended for improved productivity by early maturity to the farming community in drought situations.

Publications/commercialization

- Mahadevaswamy, M., C. Chandrashekara Rao, D. Damodar Reddy, S.Ramakrishnan and P. Sreenivas. 2021. Agronomic measures for enhancing seedling growth & field establishment, crop growth, leaf productivity and quality of FCV tobacco grown in KLS. Tobacco Research 47(1): 35-38.
- Mahadevaswamy, M. 2017. Foliar nutrition of Nitrogen and potassium for optimizing the productivity and enhancing the bright grade leaf productivity of FCV tobacco in KLS in Southern transitional Zone of Karnataka. Tobacco Research 43(1): 27-31.

Investigators /developers

M. Mahadevaswamy and S. Ramakrishnan

Name of the technology : **Crop intensification technologies in tobacco**

Year (s) of development : 2017-2019

Technology details

There is greater scope for intensification of tobacco with maize or sorghum during *kharif* season followed by tobacco in *rabi* instead of the fallow-tobacco. Among the different cropping systems maize –tobacco system is recorded higher system productivity, profitability in tobacco growing Vertisols of Andhra Pradesh.

A one hectare based integrated farming system (IFS) study was undertaken to evaluate different cropping systems, livestock and fish cultivation as components of IFS for enhancing system productivity, profitability and resource recycling. One hectare integrated farming system generated a net returns of Rs. 1,65,443/ha/year besides providing employment opportunities to the farm family as well as meeting food, feed and fodder requirement from same land holding.

Under rainfed Alfisols pre rabi korra is suitable technology for enhanced farm returns. Growing fox tail millet (korra) as pre-rabi crop, an additional net income of Rs 10,000 to 25,000/- can be obtained per hectare.

Maize-tobacco system | Tobacco based integrated farming system | Pre rabi Korra

Impact of the technology

Maize-tobacco system enhanced the productivity (37.3%) and profitability (41.5%) in comparison to fallow-tobacco in tobacco growing black soil Region of Andhra Pradesh. Tobacco based Integrated farming system enhanced the farm income (net returns of Rs. 1,65, 443/ha/year) year besides providing employment opportunities to the farm family as well as meeting food, feed and fodder requirement from same land holding.

An additional net income of Rs 10,000 to 25,000/- can be obtained per hectare depending on the rainfall in kharif season by growing fox tail millet (korra) as pre-rabi crop, in southern region of Andhra Pradesh.

Publications/commercialization

- Kumar, T.K, D. Damodar Reddy, C. Chandrasekhararao and S. Kasturi Krishna. 2020. Resource use efficiency and system productivity as influenced by crop intensification in FCV tobacco growing Vertisols of Andhra Pradesh. Tobacco Research. 46(2): 66-68.
- Kumar, T K, D. Damodar Reddy, C. Chandrasekhararao, S. Kasturi Krishna. And Y. Subbaiah. 2021. Diversified Integrated farming system for enhancing system productivity and profitability in tobacco growing Vertisols of Andhra Pradesh Tobacco Research. 47(2): 94-96.
- ICAR-CTRI Annual Reports 2018-19 & 2019-20.

Investigators/Developers

T. Kiran Kumar, M. Anuradha, D. Damodar Reddy, C. Chandrasekhara Rao, S. Kasturi Krishna and M. Sheshu Madhav

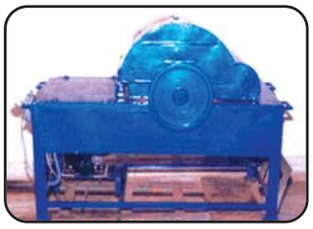
Drudgery Reduction and Labour Saving Technologies

S. No.	Technology	Developed by	Year
1.	Palmyrah Fibre Separator : A drudgery reducing machine	I. Srinivas *et al.*	1999
2.	Drudgery Reducing dry-land Spiked Weeder	K. Suman Kalyani *et al.*	2000
3.	Banana Fibre Extractor: Farmer's friendly invention	R. Sudhakar *et al.*	2005
4.	Pedal operated Paddy and Millet Winnowing machine	K. Suman Kalyani *et al.*	2009
5.	Tobacco Bale Pressing and Packing Machine	N.D. Suresh *et al.*	2010
6.	Coconut Husk Remover : A drudgery reducing and labour saving device	R. Sudhakar *et al.*	2012
7.	Technology for solar drying of amla and mango	K. Suman Kalyani *et al.*	2015
8.	Hand held battery operated Topping Tool in tobacco	ICAR-CTRI	2021

Name of the technology : **Palmyrah Fibre Separator : A drudgery reducing machine**

Year (s) of development : 1996-99

Technology details



The palmyrah fibre separation was a tedious and cumbersome process. Traditionally, a family comprising of 4 to 5 members can produce 5 to 6 kg of fibre/day by manual process. This involves high drudgery and low fibre output. High drudgery causes ill-health to rural and tribal poor. The bodies of the children get deformed at chest and shoulders. The middle-aged men suffer from chest pains, arthritis, and respiratory disorders. To address these problems, it was felt that development of an efficient drudgery reducing device is essential. In this backdrop, KVK of ICAR-CTRI has designed and developed a drudgery reducing device for palmyrah fibre separation christened as palmyrah fibre separator (PFS) for the extraction of fibre from petiole and leaf butts of palmyrah on commercial basis.

Palmyrah Fibre Separator Machine was a low-cost portable device works with 1 HP single phase electric motor, machine size 4"x3"x3", weighing about 185 kg,out put:50 – 60 kg Dry Fibre/ 8 hours, Production cost:Rs. 25-30/kg, Product value:Rs.50-80/kg, Net income: Rs. 495/ day, Cost of the machine is Rs.75,000/-

The palmyrah fibre separator machine uses the impact force with the drum and shear force cum combing action with the nails mounted on it to separate the fibre from the fronds. Initially each frond is held firmly by the operator under the guiding rod and fed inch by inch into the drum chamber. As the drum rotates in downward direction towards the frond, the nail mounted wooden strips separate the fibre from the frond within short time.

Impact of the technology

Reduces the drudgery by eliminating the beating and combing actions involved in manual process.

- Increase in fibre production. A family can extract 50-60 kg of fibre/ day as against 5 – 6 kg fibre by manual process. Thus, earning net income of Rs.500/day/head.
- The waste which comes as bi-product during the mechanical separation can be used as organic manure.

Publications/Commercialization

- The fabrication rights were assigned to M/s. Vijaya Lakshmi Engineering works, Rajahmundry through MOU between ICAR-CTRI and the firm.
- Total Machines Supplied through KVK - 87; through DRDA - 150; others - 26
- Publications: Entrepreneurship in PalmyrahFibre

Investigators

I. Srinivas, R. Sudhakar and K. Nagarajan

Name of the technology : **Drudgery Reducing dry-land spiked Weeder**

Year (s) of development : 2000

Technology Details

Weeding activity is strenuous, time consuming process in dry land agriculture. Women have to remain in bending and squatting postures for 6-7 hours per day putting all the pressure on knees and back, thus leading to drudgery in farm women. Dry land spiked weeder is a simple low cost implement designed to suit the ergonomic posture of the farm women. Dry-land weeder has a long conduit pipe beam with handle at the top and the rotary weeding hoe at the bottom. The rotary weeding hoe consists of spiked reel discs and v-blade. The weight is around 3 kg and made of iron. The spiked reel discs facilitate easy movement to the weeder. The sharp v-blade is attached both to the frame and beam through rivets. An arrangement is provided at the beam to change the cutting depth of v blade as desired.The hand tool was designed at KVK during the year 2003 and modified with spikes during 2008.

When the weeder is pushed forward, the spiked reel rotates in the soil and the v-blade penetrates to a depth of 6-8 cm in the soil which in turn cuts the roots of the weeds. The spiked reel mulches the weeds in the soil with the forward and backward movement of the weeder. The mulched weeds act as organic manure for the soil. Eight women together can weed a hectare of land. The weeding efficiency was found to be 89% with low plant damage when compared to power weeders. The field capacity is 0.08 ha/day/individual.

Impact of the technology

It is simple, user friendly, portable, cost effective (Rs. 800/-) and highly suitable for weeding in row crops with a minimum space of 15cm in rainfed dry land soils. It reduces the labour from 15 to 8 members/hectare/day. The mulched weeds act as organic manure for the soil. It reduces drudgery by distributing the work load on both the shoulders. Best suitable for vegetables, pulses and commercial crops (turmeric, tobacco and chillies).

Publications/commercialization

- Eenadu, November, 1999 and Swarna Sedyam September 2005 & June 2009.

Investigators/Developers

K. SumanKalyani and V.V. LaxmiKumari

Name of the technology : **Banana Fibre Extractor: Farmer's friendly invention**

Year (s) of development : 2000-05

Technology details

Currently 1000 million tons of banana pseudo stems are dumped as waste at farm level in India. The effective utilization of pseudostems is a challenge in banana cultivation. Extraction of fibre and preparation of organic manure from banana pseudostems are found to be highly useful and economical to the farmers.

ICAR-CTRI–KVK, Kalavacharla developed a need based user-friendly machine christened as Banana Fibre Extractor for the extraction of fibre from unutilized portions of banana such as pseudostems, peduncles and petioles on commercial basis. The machine works with the principle of beating and scraping of the fibre simultaneously.

The Banana fibre extractor uses the impact force with the roller drum and scrapping action with the blunt blades mounted on it to separate the fibre from banana stem sheaths. Initially, each sheath is held firmly by the operator through the guiding rods and fed inch by inch in to the roller drum. By scrapping action of the blades, the pith component of the sheath will be removed and fibre will be extracted while driving back the sheath within short time. Banana Fibre Extractor is a low-cost portable machine works with 1 HP single phase electric motor, size of the machine 4"x3"x2.5" weighing about 176 kg, output:15kg DF/ 8 hours, Production cost:Rs. 150 -170/kg, Product value:Rs. 200 - 250/kg, Net income: Rs. 500-700/day, the cost of the machine is Rs.75,000 – 1,00,000/-.

Impact of the technology

Reduces the drudgery by eliminating the scraping and combing actions involved in manual process.Increase in fibre production. Four persons can extract 15 kg of fibre/ day as against 2 kg fibre by manual process. Thus earning net income of Rs.500-700/day. It is a user friendly machine and cost-effective. It requires less maintenance cost, safe and easy to operate, gives superior quality fibre with required strength, length, softness and colour.

Publications/ Commercialization

- A total no of 360 machines were supplied in 18 states of India.
- Two Banana Fibre Extractor machines (Export Quality) were supplied to The University of West Indies, St.Augustine, Trinidad, West Indies under UNDP Programme in the year 2009.

Investigators/Developers

R. Sudhakar, V. Venkata Subramanian, K. Deo Singh and I. Srinivas

Name of the technology : **Pedal operated Paddy and Millet Winnowing machine**

Year (s) of development : 2009

Technology details

Winnowing, the process of separating quality grains from chaff, is a crucial post harvest process in the cultivation of paddy. The manual winnowing activity is time consuming and depends on the wind velocity. The tribal farmers have to depend on the tractor mounted winnowers when there is no wind and these implements are not readily available in these hilly areas.Pedal operated winnowing fan is designed and developed to reduce the drudgery among farming community. This implement is easy to use and works with the help of foot pedals by utilizing pedal power. The frame of the equipment is made of iron. The fan is connected to the small/ driven sprocket via shaft. A handle is attached to the grill of the implement to get a firm grip while pedaling. The power to the winnower is conveyed by a roller chain passing over a sprocket wheel with the teeth of the sprocket wheel meshing with the holes in the links of the chain. The power from the large sprocket wheel is transmitted to small sprocket wheel via the roller chain which in turn rotates the fan of the winnower. The fan is attached to the small sprocket wheel via shaft with 80 rpm. The small machine was developed during 2009, when working in Tribal Empowerment Project sponsored by DBT.

Impact of the technology

The winnower is a simple and user friendly implement and cost effective (Rs 800/-) and portable device, works on the principle of conversion of human power to mechanical power. One tonne of paddy can be winnowed with the help of two persons within 6 hours with the help of this machine. Where as, 8 persons are required to do the winnowing manually. It is highly suitable for winnowing the paddy, millets and other food grains. It is an eco-friendly technology, suitable for rural, high attitude tribal and power outage zones in India

Publications/ Commercialization

- Swarna Sedyam, Annadatha, June 2009.

Investigators/Developers

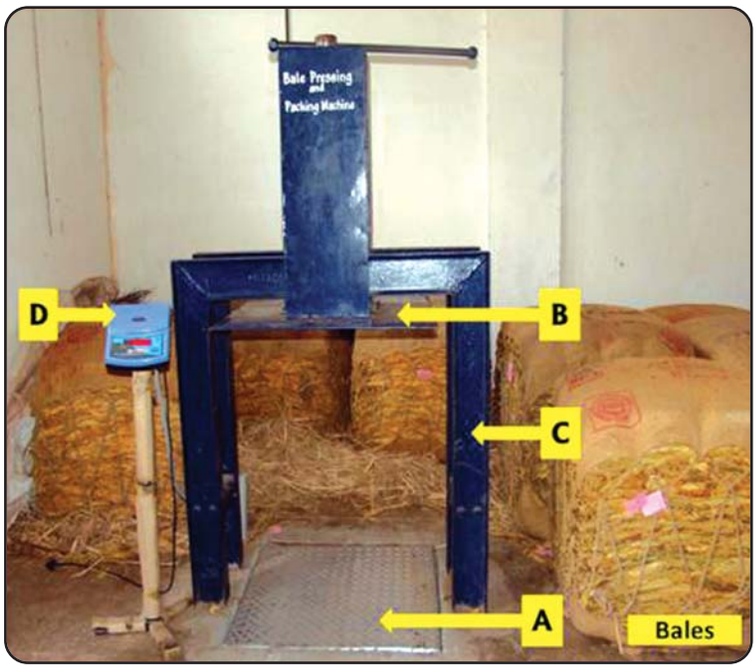
K. Suman Kalyani, V. Krishna Murthy and C. Chandrasekhara Rao

Name of the technology : **Tobacco Bale Pressing and Packing Machine**

Year (s) of development : 2010

Technology details

Usually baling is done manually which is time consuming and laborious process. ICAR-CTRI developed a bale pressing and packing machine during 2010.The machine consists of an Steel plate (A) of size (30x30") fixed on cement platform. An adjustable manually operated iron plate (B) of size 29 x 29" with the help of a screw handle is fixed to the Iron frame(C) of 43" size fixed over the steel plate (A) on the ground. A weighing scale (D) is attached to the machine to monitor the weight of the bale. The wooden box is placed on the steel plate (A) and the cured leaf is packed periodically in a systematic manner with the help of the adjustable iron plate (B) fixed to the Iron frame. After packing the required cured leaf (110-150 kg), the wooden boards of the bale boxes are removed and the bale is packed with gunny bag and ropes.



Impact of the technology

Baling of graded cured leaf through bale pressing machine reduces the labour, drudgery and improves the efficiency. By this machine 25% labour charges can be saved apart from improving uniformity in baling.Farmer will get an additional income of 1500-2000/ha.

Publications/Commercialization

- ICAR-CTRI Annual Reports 2008-10.

Investigators/ Developers

N.D. Suresh, C. Chandrasekhara Rao and S. Kasturi Krishna

Name of the technology : **Coconut Husk Remover: A drudgery reducing and labour saving device**

Year (s) of development : 2010-12

Technology details

Coconut husk removal is a time consuming, tedious manual labor-oriented job. Due to the increase in the labour fares in the market currently the workers are demanding higher for removal of coconut husk. "Coconut Husk Remover" is an innovative new product developed by CTRI-KVK to address the problems of coconut farmers and distributors. The machine reduces the cost of coconut peeling by 70% while increasing the speed of the operation by 100% and eliminating drudgery. Coconut Husk Remover is powered by a 1 HP single phase electric motor. The machine employs custom designed roller set on which the coconut is mounted. A spring-loaded fixture is provided on top of the roller to hold the coconut in place on the rollers. The operator places the coconut on the rollers and switches the machine on. One roller rotates the coconut while the other provides the cutting action to remove the husk. The spring-loaded fixture is operated to hold the coconut in place on the rollers and prevent it from slipping.The cost per peeling one coconut comes down from Rs 0.45 to Rs 0.13, 70% reduction. In an 8 hour shift the machine can be used to peel at least 1600 coconuts compared to 800 coconuts per day manually. Cost of the machine is Rs 75,000/-.

Currently workers use a crowbar fixed in ground to peel the coconut. A total no of 800-1000 coconuts can be peeled by a person in a day. This operation requires significant physical strength and takes heavy toll on the body.



Impact of the technology

In manual peeling process, 800 coconuts can be peeled by traditional methods in a span of 8 hours by a single skilled worker for an amount of Rs. 500/-. With the help of coconut husk remover one can peel around 2,000 coconuts in a span of 8 hours and can earn with a net income of Rs. 1,000/-. Even women can take up this activity as a homestead activity.

Publications/Commercialization

- This machine was developed in coordination with RAKI INDUSTRIES, Kakinada, and Bharatiya Kisan Sangha, Ambajipeta and supplied 10 machines to BharatiyaKisan Sangha, Ambajipeta.

Investigators/Developers

R. Sudhakar, C. Chandrasekhar Rao and V. Krishna Murthy

Name of the technology : **Technology for solar drying of amla and mango**

Year (s) of development : 2015

Technology details

Since ancient times, natural sun light and heat have been utilized by Indians to preserve food products by open drying. Prolonged drying period and contact with ultraviolet light (UV) could degrade some valuable phyto-chemicals and vitamins *viz.*, chlorophyll, essential oil, β-carotene and ascorbic acid in open drying.

Solar drying of Amla and Mango by modified blanching method: Blanching is scalding vegetables in boiling water or steam for a short time. It is typically followed by quick, thorough cooling in very cold or ice water. Blanching stops enzyme actions which otherwise cause loss of flavor, color and texture. In addition, blanching removes some surface dirt and microorganisms, brightens color and helps slow vitamin losses. About 5 kgs of fresh raw amla fruits are selected and washed thoroughly. Each of the amla fruits are pinched with the help of pin or needle and soaked in the solution of calcium hydroxide (1.5%) for two hours. Then the fruits are cut into 5-6 slices and blanched for 2 to 3 minutes in hot water (90^{0}C). The blanched pieces are spread in the solar trays for drying. After complete drying, the pieces can be ground to make a powder form.

Impact of the technology

Use of proper solar dryer with pre-treatment of raw materials is highly useful to overcome the problem of contamination during processing and storage through hygienic processing protects the nutritional value. This can be taken up as a homestead unit by rural women and also micro enterprise for unemployed rural youth.

Publications/ Commercialization

- Annadatha, February 2011, April 2014.
- This technology was developed during 2014 during the DBT sponsored Project. It takes 12 hours (day hours) to dry the fruits to an extent of 10% moisture with good hygiene and sanitation, where as open drying invites flies, dust and unwanted material which is not healthy.

Investigators/Developers

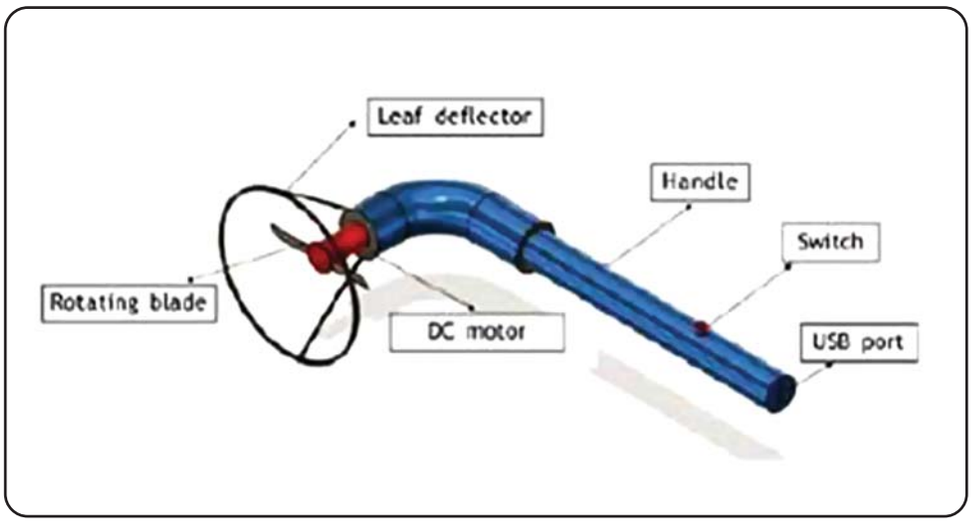
K. Suman Kalyani and V.V. LaxmiKumari

Name of the technology : **Hand held battery operated Topping Tool in tobacco**

Year (s) of development : 2021

Technology details

Topping is a unique cultural operation in tobacco, arrests the apical dominance, aid in increasing the size & weight of leaves and thereby overall yield (20-25%) per hectare. Farmers generally do topping manually, which is tedious and time consuming. To replace the manual topping, ICAR-CTRI has developed hand held battery operated topping machine consisting of rotating blades with leaf deflector, DC motor, battery and PVC handle. The machine will run up to 8 hours with 3 hours of charging. For ease of convenience, an USB port was provided for charging and can be used with a regular USB cable.



Impact of the technology

Topping at right time and effective control of suckers will help the plants to utilize the nutrients and water efficiently in turn lead to accumulation of more photosynthates in leaves. Effective Topping and sucker control is proved to increase leaf yield by 25% along with better quality. The machine is evaluated in burley tobacco and found to be effective in terms of ease of topping, saving labour and time.

Publications/Commercialization

- ICAR-CTRI Annual Report 2021.

Investigators/ Developers

ICAR-CTRI, Rajahmundry.

Crop Protection Technologies

S. No.	Technology	Developed by	Year
1.	Technology for damping-off disease management	D.I. Mathrani *et al.*	1959
2.	Technology for management of anthracnose in nurseries	V. Venkateswarlu *et al.*	1979
3.	Low cost technology for pest management in nursery	G.V.G. Krishnamurty *et al.*	1979
4.	Technologies for management of black shank	M.M. Shenoi *et al.*	2000
5.	Integrated management techniques for tobacco caterpillar	S. Sitaramaiah *et al.*	2001
6.	Technology for management of brown spot disease	M.M. Shenoi *et al.*	2001
7.	Bio-rational management technologies for root knot nematodes	S. Ramakrishnan	2011
8.	Integrated disease managemet technology for Fusarium wilt and root knot complex	S. Ramakrishnan *et al.*	2012
9.	Weather based disease prediction model for brown spot of *Motihari* tobacco	Satyajit Roy *et al.*	2014
10.	Technology for management of ground beetle	U. Sreedhar *et al.*	2015
11.	Integrated management technologies for sucking pests	K.C. Chenchaiah *et al.*	2020
12.	Integrated management technologies for bud worm	P. Venkateswarlu *et al.*	2020

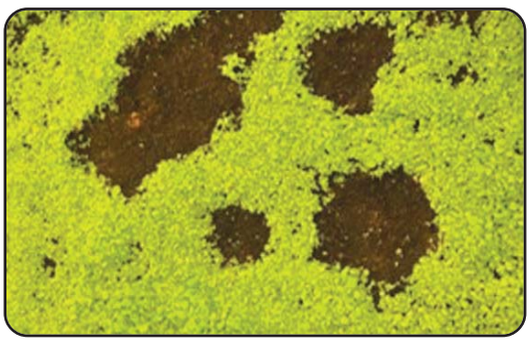
Name of the technology : **Technology for damping-off disease management**

Year (s) of development : 1958-1959

Technology details

Damping off is a soil borne disease caused by *Pythium aphanidermatum* in the tobacco nursery and leads to severe loss of healthy seedlings. Sudden collapse of seedlings in patches is the characteristic symptom of the disease. The rot appears in individual seedlings, patches or even entire seed beds. After drying seedlings become thin, appear papery and ultimately get mixed up in soil. The disease can be managed by taking sufficient precautionary measures. One prophylactic application, 2-3 days before sowing at the rate of 25 gallons for one cent of nursery bed is beneficial in reducing the intensity of pathogen in the soil. The first application of Bordeaux mixture should be done three weeks after sowing or earlier if there are signs of the disease. The second and third applications of bordeaux mixture should be done at weekly intervals if there are no heavy rains. When there is continuous rain and cloudy weather, the spray intervals should be reduced to five days or even less.






Impact of the technology

Damping off is a serious problem in nurseries. Control measures are suggested by ICAR-CTRI regularly. Cent percent nursery growers are following the Institute recommendations.

Publications/Commercialization

- Mathrani, D.I. 1959. 'Damping off' - How to control it? Indian Tobacco 9: 185-8.

Investigators/ Developers

D.I. Mathrani

Name of the technology : **Technology for management of anthracnose in nurseries**

Year (s) of development : 1979-1982

Technology details

Among the leaf spots, anthracnose is a major disease caused by *Colletotrichum* sp. Cloudy weather coupled with high humidity is congenial for the multiplication of the causal agent and symptoms appear as water soaked lesions on seedlings resulting in complete loss of young seedlings. Spraying Carbendazim @ 0.1% concentration effectively checks the anthracnose incidence in the nursery beds.

Impact of the technology

Carbendazim @ 0.1% concentration was the most effective and promising fungicide for the control of anthracnose and other leaf spot diseases and to produce good quality seedlings. Anthracnose management technology reduces production costs through reduction in pesticide usage. This technology has huge impact in the tobacco nurseries where around 60 % of the tobacco farmers of Northern Black Soils (NBS) were benefitted.

Publications/Commercialization

- Abdul Wajid, S.M., N.A. Elias and G. Bhaktavatsalam. 1981. Control of anthracnose leaf spot in tobacco nurseries by new chemicals. Tobacco Research 7: 81-84.

Investigators/ Developers

V. Venkateswarlu, N.C. Gopalachari and K. Nagarajan

Name of the technology : **Low cost technology for pest management in nursery**

Year (s) of development : 1978-1979

Technology details

Rabbing the seedbeds with paddy husk was proven to be an efficient method for the simultaneous control of fungal, nematode and weed problems in tobacco nurseries. Paddy husk was spread @ 6 kg on 1x10 m nursery beds to form a 6 cm thick layer. Two cowdung cakes were inserted inside the husk layer in such a way, so as to form an inverted 'V" shaped arch in the husk layer into which a small piece of burning cowdung cake, was placed. The burning points were arranged at 1 meter spacing on the bed. After complete burning and soil sterilization and after the beds cooled down, which took about 30 hours, the ash was mixed *in situ*. Later tobacco seed was sown and the nursery was raised as per the package of practices. Observations were taken at 20 days after sowing for weed population, at 2-5 weeks for damping-off disease, at 35 days for seedling growth and at 50 days for root-knot nematode disease and seedling population count of nursery. There was no incidence of soil borne diseases and nematodes in the rabbed seed beds.

In another experiment conducted with treatment combinations that is with and without rabbing, with and without ash and nitrogen application. Rabbing has reduced the weed growth, while ash application, apart from reducing the weed growth, has also improved the growth and yield of seedlings.

Impact of the technology

Considering 50% saving in the pest management expenditure, Rs.35,000 could be saved per hectare. At present, paddy husk rabbing costs Rs.25,000 per hectare, with a net saving of Rs.10,000 per hectare. Paddy husk rabbing works out to be a cheaper method, compared to the total cost of treatments towards damping-off control, weed control, nematode control.

Publications/Commercialization

- Krishnamurthy, G.V.G., K. Nagarajan and Ramji Lal. 1979. Multiple advantages of rabbing with paddy husk on tobacco seed beds. Tobacco News. 2(7-8):17-20.
- ICAR-CTRI Annual Report 1983-85.

Investigators/ Developers

G.V.G Krishnamurty, K. Nagarajan, Ramji Lal and M. Bangarayya

Name of the technology : **Technologies for management of black shank**

Year (s) of development : 2000-2018

Technology details

Blight and Black shank are soil borne diseases caused by soil inoculum of *Phytophthora parasitica* f.sp.nicotianae in nursery and field respectively. Management strategies in FCV tobacco nurseries are foliar sprays of Propiconazole 25% EC @ 0.05% and Bordeaux mixture up to 35 DAS. They controlled leaf infection phase (leaf blight) up to 97% and stem infection phase (black shank) up to 91.0% besides effectively controlling frog-eye spot disease (82%) as well. Curzate M-8 is efficient enough at 0.3% concentration for the control of blight, damping off and was on par with Ridomil MZ for the control of black shank; indicating that both the products can be used in rotation for FCV tobacco nursery to avoid any possible development of resistance in the pathogen. Chlorothalonil + Metalaxyl M effected 84.1 to 91.9 % reduction in damping off and black shank, and was on par with Ridomil MZ 72 WP with an ICBR of 1:8.4.



Impact of the technology

Blight and Black shank were effectively managed by adopting the CTRI technology. Almost 80 % of the farmers in KLS adopted the technology.

Publications/commercialization

- ICAR-CTRI Annual Report 2011-12 (p.50).
- Diseases of FCV tobacco and their Management in Karnataka Light Soil Region. Eds: M.M. Shenoi and K. Nagarajan.
- Ramakrishnan,S., S.S.Sreenivas and M.M.Shenoi. 2018. Efficacy of Folio gold 440 SC against damping off and blight & black shank diseases in FCV tobacco nurseries of KLS. Tobacco Research 44(1):30-33.

Investigators /developers

M.M. Shenoi, S.S. Sreenivas and S. Ramakrishnan

Name of the technology : **Integrated management techniques for tobacco caterpillar**

Year (s) of development : 2001-2023

Technology details

Tobacco caterpillar, *Spodoptera litura* Fabricius (Noctuidae: Lepidoptera) defoliate the leaves and cause huge losses to the tobacco nurseries and planted crop. Complete reliance on inorganic pesticides leads to accumulation of pesticide residues which could become a great concern for tobacco which has export value. As an integrated management approach, microbial biocontrol agents Nuclear Polyhedrosis Virus (NPV) and *Bacillus thuringiensis* (Bt) @1kg/ ha, pheromone traps, castor trap crop, insecticide baits and novel insecticide pyridalyl were employed to reduce the avoidable losses and contribute to farm returns.

Spodoptera litura Sl NPV when used on 3-4 weeks nursery @ 250 larval equivalents (LE)/ ha mixed with 250 g starch during the evening hours, effectively manages the larval population. Alternately 1 % neem seed kernel extract or *Bacillus thuringiensis* could be used @ 1 kg/ 1125 l water to manage the larvae effectively. Castor, an ovipositional trap crop for the caterpillar could be sown two weeks before sowing tobacco around the nursery. *Spodoptera litura* pheromone traps installed 3 weeks after planting @ 4-5/ acre monitors the Spodoptera population and when the population crosses ETL of 5 % infestation or 5 moths per trap per night, baits or insecticides could be utilized. Insecticide baits were prepared with 100 g of emamectin benzoate or 200 ml of novaluron mixed in 5 litres of water, along with 2.5 kg jaggery and 10 kg rice bran. The bait mixture when applied in the terminal bud of the tobacco plants offers maximum protection to the tobacco leaves from late instar larvae, which are sturdy and escape other modes of treatments. Application of pyridalyl with novel mode of action @ 10 ml/10 litres showed least seedling and foliar damage and saved 20 % yield from pest damage.

This integrated *Spodoptera litura* management approach efficiently managed tobacco caterpillar and subsequent increase in healthy transplantable seedlings by 54.3%. The technology helps in minimizing the pesticide residues in the cured leaf.


Healthy *Spodoptera*


NPV infected larva


Adult


Caterpillar damage


Pheromone trap


Insecticide bait application

Impact of the technology

The technology has a huge impact on the FCV farmers in Northern light Soils (NLS) area of Andhra Pradesh covering the districts of East Godavari, West Godavari and Khammam. About 15,000 tobacco farmers were benefitted by adopting this technology. Due to the integration of various components, the number of pesticide sprays was reduced to 5. Nearly 20 % yield loss is avoided and about Rs.3000 per hectare towards pest management was saved by implementing this technology.

This technology reduces production costs to tobacco farmers through reduced levels of pesticide use and mitigation of pesticide residues, supposed to be a major impediment to exports. Apart from benefit to the farmers, the natural enemies *viz.*, coccinellids, spiders and reduvid bugs, were also protected from elimination by creating congenial ecosystem for their conservation.

Publications/Commercialization

- Sitaramaiah, S., U. Sreedhar, G. Ramaprasad and S.V.V. Satyanarayana. 2001. Management of tobacco leaf eating caterpillar, *Spodoptera litura* F with insecticide baits in NLS tobacco. Tobacco Research 27(1):7- 11.
- ICAR-CTRI Annual Report 2012.
- ICAR-CTRI Annual Report 2020 (p.56).

Investigators/ Developers

S.Sitaramaiah, M.S. Chari, U. Sreedhar, G. Ramaprasad, S.V.V. Satyanarayana, P. Venkateswarlu, S.S. Sreenivas, G. RaghupathiRao, B. Sailaja Jayasekharan, V. Venkateswarlu and K. Rajasekhara Rao

Name of the technology : **Technology for management of brown spot disease**

Year (s) of development : 1998-2001

Technology details

Brown spot is a fungal disease of major concern causing significant economic losses in few pockets of tobacco area. Brown spot first appears on older leaves and then transcends to young leaves. Water soaked circular spots gradually enlarge to form brown spots, surrounded by yellow halo with addition of concentric rings. In severe cases these spots will appears on stalks/stems, petioles etc. Brown spot management strategies include avoiding high doses of nitrogenous fertilizers, application of potassic fertilizers in two splits and uniformly spraying propiconazole @ 10 ml / 10 litres.

Impact of the technology

Management of brown spot reduces production costs of tobacco farmers through reduced levels of pesticide use. The technology helped the farmers in prevention of brown spot disease incidence and thereby improving the bright grade productivity in KLS. Around 60 % of the KLS tobacco farmers were benefitted using this technology.

Publications/commercialization

- Flue-Cured tobacco production package for Karnataka, CTRI RS, Hunsur.
- ICAR-CTRI Annual Reports 2000 & 2001.

Investigators /developers

M.M. Shenoi, S.S. Sreenivas and S. Ramakrishanan

Name of the technology : **Bio-rational management technologies for root knot nematodes**

Year (s) of development : 2011-2020

Technology details

Root knot nematode, *Meloidogyne incognita* is a major limiting factor in both nursery and main field causing yield losses to FVC tobacco grown in Karnataka both in terms of quality and quantity. Application of *Paecilomyces lilacinus* ($2x10^6$spores/g) or *Pochonia chlamydosporia* ($2x10^8$ spores) enriched vermicompost / FYM in solarized soil is effective against nematodes in tobacco nursery. Integration of *Paecilomyces lilacinus* (20 g) with poultry manure @ 1 kg/m^2 or with neem cake @ 1 kg/m^2 caused 55.4% increase in healthy transplants count and significantly reduced RKI to 1.56 compared to 3.70 in check. Use of tray media or coir pith fortified with *Trichoderma viride* + *Paecilomyces lilacinus*, both @ 50 g each per 1.2 kg media incubated under polythene sheet is beneficial in preventing the disease in tray seedlings. Planting radish and sunn hemp as preceding *rabi* crops contributed to 42.8% and 38.6% reduction in root knot nematode population respectively and also reduced the root knot index (RKI) in subsequent *kharif* FCV tobacco to 1.8 and 2.0 respectively as compared to RKI of 3.3 in *kharif* tobacco grown after fallow.

Impact of the technology

Bio-rational nematode management technologies being eco-friendly and cost effective are being widely adopted to the tune of 70 % across the FCV tobacco regions of KLS. It helps the entire KLS growers in the production of root knot free and healthy seedlings for timely planting.

Publications/commercialization

- ICAR-CTRI Annual Report 2011-12 & 2022.
- Ramakrishnan, S. and Nagesh, M. 2011. Evaluation of beneficial fungi in combination with organics against root knot nematode in FCV tobacco nurseries. Journal of Biological Control. 25: 164-167.

Investigators /developers

S. Ramakrishnan

Name of the technology : **Integrated disease managemet technology for Fusarium wilt and root knot complex**

Year (s) of development : 2011-12

Technology details

Fusarium wilt disease complex caused by *Fusarium oxysporum* f. sp. *nicotianae* in association with root-knot nematodes, *Meloidogyne incognita* is a major threat to the successful production of FCV tobacco crop in light textured soils of Karnataka. Bio-management involves application of *Pseudomonas fluorescens* in talc formulation (2 x 10^8 cfu/g) @ 1g/plant in combination with *Aspergillus niger* (AN 27 strain) enriched FYM @ 1g/plant at the time of planting to manage the disease complex. Neem cake formulation of *T. viride* was found to be more promising than talc formulation and effected 60.9% control. This is the first report on the neem cake formulation of *T. viride* successfully controlling tobacco wilt pathogen. There is a significant reduction of root-knot nematode incidence in terms of RKI to 1.93 and soil population of 72.5 as compared to 3.71 and 140 in untreated check. The disease management practices resulted in better cured leaf yield (1311 kg/ha) and bright grade out turn (926 kg/ha) compared to untreated check. Carbendazim and propiconazole were also found to be very effective in controlling the wilt to an extent of 61.47 and 60.29% respectively.

Impact of the technology

The recommended technology against Fusarium wilt- root knot nematode disease complex was widely adopted by the farming community in KLS. There are accrued benefits of ecological sustainability and management of root knot disease complex along with higher farm returns.

Propiconazole was found to be the most promising fungicide and *T. viride* in neem cake formulation, the most reliable bioagent. The management strategy gave an Incremental Cost Benefit Ratio (ICBR) of 1: 7.35 and 1: 7.38 in chemical and bioagent respectively.

Publications/ commercialization

- Ramakrishnan, S. and Sreenivas, S.S. 2012. Bio-management of Fusarium wilt disease complex with *Pseudomonas fluorescens* and *Aspergillus niger*. Journal of Biological Control. 26: 368-372.
- Sumana, K., S. Ramakrishnan, S.S. Sreenivas and N. S. Devaki. 2012. Field evaluation of promising fungicides and bioagents against Fusarium wilt and root knot complex disease in FCV tobacco crop. Journal of Agricultural Technology 8(3):983-991.

Investigators/ Developers

S. Ramakrishnan and S.S. Sreenivas

Name of the technology : **Weather based disease prediction model for brown spot of *Motihari* tobacco**

Year (s) of development : 2009-14

Technology details

Weather based disease prediction model for brown spot was developed in *Motihari* tobacco with three dates of planting *i.e.* early, normal and late. Micro and Macro weather variables were recorded from weather station at CTRI RS, Dinhata and brown spot incidence was recorded under periodical light intensity, relative humidity, canopy temperature and infra red temperature, respectively. Diameter of the leaf spots was measured daily after first appearance of the spots. Brown spot weather prediction model in *Motihari* tobacco (*N. rustica*) indicated the presence of small (up to 4 mm) and big (> 4 mm) type of spots. The rate of progression and coverage of spots on tobacoo leaves was much faster in larger spots compared to smaller spots.

Impact of the technology

Disease forecasting/ prediction model developed based on weather parameters can help in devising early prophylactic measures to combat the disease for the benefit of tobacco farmers.

Publications/Commercialization

- ICAR-CTRI Annual Report 2010.

Investigators/ Developers

Satyajit Roy and J.K. Roy Barman

Name of the technology : **Technology for management of ground beetle**

Year (s) of development : 2015-2020

Technology details

Ground beetles *Mesomorphus villiger* (Tenebrionidae: Coleoptera) infest freshly transplanted tobacco crop and cut the tender stems, resulting in the death of the seedlings and thereby creates the necessity for gap filling in the field. The incidence is severe after prolonged dry spell soon after planting. During severe infestation, 50-60 % of the seedlings get destroyed. For the management of the pest, chlorantraniliprole was used which belongs to the anthranilic diamide group of insecticides with selectivity for insect ryanodine receptors and low mammalian toxicity. Spray drench of tray seedlings before transplanting or transplant water treatment on the day of planting with chlorantraniliprole 18.5 SC @ 0.005 % or imidacloprid 200 SL @ 0.005 % is recommended for protection of the tobacco seedlings from ground beetles. The highest cured leaf yield (2675 kg/ha) was recorded in the tray seedlings treated with spray drench of chlorantraniliprole 18.5 SC @ 0.005 % a day before planting over untreated check (1955 kg/ha). Expenditure on the necessity for gap filling and the associated costs are avoided with this technology.

Impact of the technology

This technology was adopted by the farmers in managing the ground beetles in FCV tobacco grown in Northern light Soils (NLS) of Andhra Pradesh. About 20,000 tobacco farmers of West Godavari in A.P. and Khammam district in Telangana adopted the recommendation and got benefitted. Cost of re-transplanting in almost 50 % of the field is completely saved by adopting this technology.

Publications/commercialization

- ICAR-CTRI Annual Report 2018 (p.55).
- Sreedhar, U. 2020. Novel methods for the management of ground beetle, *Mesomorphus villiger* in Virginia Tobacco. Journal of Applied Zoological Researches. 31(2): 200-205.

Investigators/Developers

U. Sreedhar, G. Raghupathi Rao, B. Sailaja Jayasekharan and V. Venkateswarlu

Name of the technology : Integrated management technologies for sucking pests

Year (s) of development : 2017-2023

Technology details

Two sucking insect pests, aphid and whitefly are the major insect pests in FCV tobacco. The whitefly, *Bemisia tabaci* Gennadius, is a vector of leaf curl virus (LCV) disease and tobacco aphid, *Myzus nicotianae* Blackman, vectors Cucumber mosaic Virus (CMV) disease on FCV tobacco.

In Southern light Soils (SLS) and Black soils, IPM module with two rows of sorghum barrier crop sown 2 weeks before planting of tobacco, application of 2 % NSKS @ 10 and 35 DAP, foliar spray with pymetrozine 50 WG @ 0.02% at 20 DAP and flonicamid 50 WG @ 0.02% or afidopyropen 50 DC @ 20 ml/ 10 litres at 45 DAP efficiently managed both the sucking pests. Afidopyropen 50 DC, a pyropene class of insecticide modulates the chordotonal organ TRPV channels. It is efficient not only in terms of its bioefficacy but also in increasing cured leaf yield. It is also relatively safe to natural enemies and hence it can be a promising alternative to the existing insecticides for the management of tobacco aphids.

In Karnataka Light Soils (KLS), pearl millet barrier crop with one spray of *Lecanicillium lecanii* @ 0.3% at 45 DAP is an effective integrated pest management approach for the control of *M. nicotianae* in FCV tobacco field crop over farmers practice.

Validation of management modules for sucking pests in FCV tobacco

Impact of the technology

The technology is being adopted by about 80 % farmers in Andhra Pradesh and 75% farmers in Karnataka. The technology contributes to higher yields to the farmers with a cured leaf yield of 2380 kg/ha. Besides the monetary returns, the natural enemy population is also conserved.

Publications/commercialization

- ICAR-CTRI Annual Report 2019 (p.51-53).

Investigators/Developers

K.C. Chenchaiah, U. Sreedhar, G. RaghupathiRao, V. Venkateswarlu, S. Ramakrishanan, S.K. Dam, Vallepu Venkateswarlu, B. Sailaja Jayasekharan and K. Rajasekhara Rao

Name of the technology : **Integrated management technologies for bud worm**

Year (s) of development : 2018-2023

Technology details

Tobacco budworm, *Helicoverpa armigera* (Hubner) is one of the major insect pests of FCV tobacco causing damage above economic threshold level (> 10 % infestation) in southern black soil (SBS) region of Andhra Pradesh. For the effective management of tobacco budworm, *Helicoverpa armigera* an Integrated pest management (IPM) approach consisting of 2 rows of marigold as trap crop around tobacco, setting up of bird perches @ 20/ha, hand picking of larvae for every 5 days from 25 days after planting (DAP), spraying of NSKE 2% at 25 DAP, spraying *Helicoverpa armigera* Ha NPV @ 250 LE/ha at 40 DAP and one spray of chlorantraniliprole 18.5 SC @ 0.005% at 55 DAP is recommended.

Impact of the technology

This technology impacted the FCV grown in an area of 30,000 ha in Southern Black Soils (SBS) of Andhra Pradesh and 70% tobacco farmers of SBS were benefitted. Integrated pest management reduces production costs of tobacco farmers through reduced levels of pesticide use. This technology shows 6.07% increase of cured leaf yields with benefit cost ratio of 2.42 over untreated control.

Publications/commercialization

- ICAR-CTRI Annual Report 2018 (p.55).

Investigators/Developers

P. Venkateswarlu, U. Sreedhar, V. Venkateswarlu, B. Sailaja Jayasekharan and K. Rajasekhara Rao

Technologies for Leaf Quality and Soil Fertility Assessment

S. No.	Technology	Developed by	Year
1.	Technology for enhancing germination at supra-optimal temperatures	N.L. Pal *et al.*	1968
2.	An inexpensive method for long term tobacco seed storage	K. Nageswara Rao *et al.*	1984
3.	Technology for recovery of tobacco leaf protein	A. Gopalam *et al.*	1986
4.	Technology for effective sucker control for enhanced productivity and quality	M. Bangarayya *et al.*	1988
5.	Integrated barn technology for enhancing wood fuel use efficiency	M.M. Shenoi *et al.*	1999
6.	Nutrient deficiency cards: A ready reckoner to detect the deficiency and toxicity symptoms of nutrients	M. Anuradha *et al.*	2004
7.	A mathematical model for predicting growth and dry matter	C. Chandrasekhara Rao *et al.*	2009
8.	Chlorophyll content index - A tool for non-destructive evaluation of lamina nitrogen content	M. Anuradha *et al.*	2011
9.	Simple and inexpensive water extraction method for assaying potassium in plant tissue	D. Damodar Reddy *et al.*	2013
10.	Climate resilience technologies for waterlogging	M. Anuradha *et al.*	2014
11.	Technology for refinement of tobacco seed oil	K. Siva Raju *et al.*	2017
12.	Tobacco stalk biochar as a soil amendment	J. Poorna Bindu *et al.*	2017
13.	Technology for nicotine recovery and purification from tobacco waste	C.V.N. Rao *et al.*	2019
14.	Novel technologies for leaf quality assessment	L.K. Prasad *et al.*	2020
15.	Oil palm empty fruit bunches: A suitable alternate fuel for curing of FCV tobacco	J. Poorna Bindu *et al.*	2020
16.	Novel STCR based fertilizer recommendation system for precision farming	L. K. Prasad *et al.*	2021
17.	A novel method for simultaneous screening and quantitative estimation of multiple pesticide residues	Anindita Paul *et al.*	2022
18.	New leaf chemical quality index (LCQI) for assessment and seasonal monitoring of FCV tobacco quality	L. K. Prasad *et al.*	2023
19.	Technology for exploring solar thermal energies for FCV tobacco curing	C. Chandrasekhara Rao *et al.*	2023

Name of the technology : **Technology for enhancing germination at supra-optimal temperatures**

Year (s) of development : 1968

Technology details

Gibberellic acid (GA) as an aqueous solution was used for soaking the seed to improve the seed germination high temperatures during nursery raising. The stock solution of suitable strength *viz.* 10,000 ppm was prepared in absolute alcohol and diluted with water to the working concentrations.

FCV tobacco seed (variety: Virginia Gold), was soaked in the GA acid solution at laboratory temperature (29°C to 38°C). In each case 2 ml. of solution was added to 1 g of seed in specimen tubes and stoppered. The solution was sufficient to cover the seed fully. They were then sown on moist filter papers kept over a layer of sterilized moist sand dishes. To cut down evaporation, the dishes were covered with glass plates. Testing was done in incubators maintained at constant temperature. The germination was studied at 35°C after soaking the seed with 0 (water soaking), 10, 25, 100, 500, 1,000 ppm. GA for the periods of 6, 24 and 48 hours.

Gibberellic acid even at low concentration of 10 ppm could bring about improvement in germination compared to water soaking (control). With the increasing soaking period, the germination also improved at lower concentrations *viz.* 100 ppm and below. G.A of 100 ppmwas found optimum with 48-hours soaking period. To obtain a uniform and better germination, soaking tobacco seed for 48 hours in 500 ppm of Gibberellic acid is recommended.

Mean percentage germination at 35°C.

Concentration of	Soaking periods			Mean
	6 hr.	24 hr.	48 hr.	
1. Water (control)	Nil	6.3	2.7	3.0
2. 10 p.p.m.	12.7	16.7	19.7	16.3
3. 25 p.p.m.	4.7	33.0	50.0	29.2
4. 100 p.p.m.	23.3	81.0	95.7	66.7
5. 500 p.p.m.	80.0	98.0	99.7	92.6
6. 1,000 p.p.m.	97.3	97.0	97.0	97.1
Mean	36.3	55.3	60.8	

Impact of the technology

The above study clearly demonstrates that gibberellic acid can bring about good germination in tobacco seed even at high temperature like 35°C and as such could be utilized as a substitute: for low temperature treatment.This may find practical application in tobacco nurseries wherein scanty germination, attributed to the prevalence of high temperatures during sowing time, is often reported.

Publications

- Pal, NL and M. Bangarayya. 1968. Influence of gibberellic acid on germination of tobacco seed at supra-optimal temperatures. Scientific Culture 34: 126-7.

Investigators/ Developers

N.L. Pal and M. Bangarayya

Name of the technology : **An inexpensive method for long term tobacco seed storage**

Year (s) of development : 1983-84

Technology details

Flue cured tobacco seed (CTRI Special and White gold) of crop season was stored at ambient temperature in 500 g capacity container since 1975–76 with and without desiccant, anhydrous calcium chloride. Seed stored with 5–6% and lower than 3% initial seed moisture with desiccant (dry storage) maintained viability and the moisture content was below 4.5% for a period of 24 years (1975-2000) whereas seed stored without desiccant (control) contained seed moisture of 6–7% and lost viability in 24 months. The technology was tested by storing the tobacco seed (CTRI Special. (MR)) of 1982–83 crop season was stored in bulk in 50 kg drums with desiccant (250 and 500g) at ambient temperature and the seed remained viable for 17 years (1983-2000). Seed stored without desiccant lost viability in 24 months and its seed moisture was 6–7%. Stored seed was tested in nursery for seedling production, and it was at par with fresh seed. Hence, storage of tobacco seed at ambient temperature using desiccant is reliable and inexpensive method as compared to traditional method of cold storage for long term tobacco seed storage.

Impact of the technology

Tobacco seed can be stored for a long period which helps in effective storage of excess seed produced and wasless expensive.

Publications/commercialization

- Bangarayya, M., D. Prabhakarababu and Ch. Madhavarao. 1984. Effect of storage methods on the viability of tobacco seed at ambient temperature. Tobacco Research 10:13-17.
- K. Nageswararao, D. Prabhakara babu and M. Bangarayya. 2003. Tobacco seed storage. An inexpensive method for long term seed storage. Indian Journal of Agricultural Sciences 37: 9-16.

Investigators/Developers

K. Nageswara Rao, D. Prabhakara babu and M. Bangarayya

Name of the technology : **Technology for recovery of tobacco leaf protein**

Year (s) of development : 1982-86

Technology details

Tobacco green leaf contains ~ 2.25 % crude protein on dry weight of leaf which contain both soluble and insoluble proteins. The soluble proteins are further divided into two major categories *viz.* Fraction 1 Protein (F1P) and Fraction 2 Protein (F2P) based on molecular size. The F1P is a single protein, which accumulates in the chloroplast and exhibits ribulose 1, 5 – bisphosphate carboxylase/ oxygenase activity. Quantitatively, F1P makes up about 50 per cent of total soluble proteins in the plant, surpassing any other plant product in terms of usable protein.

The unique feature of tobacco F1P is that it readily crystallizes and can be isolated very easily when compared to all other leaf proteins. The concentration of protein varies in different types of tobacco and some types have up to 20 per cent more protein than the standard lines of Flue- cured tobacco.

Impact of the technology

The tobacco leaf protein can be the alternate source of edible protein which might be as a dietary component in human as well as cattle feed.

Publications/commercialization

- ICAR-CTRI Annual Report 1982-86

Investigators/Developers

A. Gopalam and R.N. Adsule

Name of the technology : **Technology for effective sucker control for enhanced productivity and quality**

Year (s) of development : 1985-1988

Technology details

Topping and sucker control is one of the cultural practices followed to improve leaf yield and can also be used to manipulate the quality of tobacco leaf produced. After topping suckers grow vigorously there by influences the yield, quality, and chemical composition of cured leaf. Hence effective control of suckers is important to obtain the benefit of topping. Manual sucker control, i.e. hand removal of suckers, is seldom practicable until the suckers are at least 5 cm long, by which time they have already offset some of the beneficial effects of topping. In addition, it is tedious, time consuming and requires more labour. Therefore, different chemicals were evaluated and found fatty alcohol 1-Decanol ($C_{10}H_{22}O$), action is an effective sucker control agent. It kills small suckers by burning when comes into contact. It must be applied to run down the stalk to leaf axil. It does not leave any residues. From the experiments, it was found that the suckericide formulation with a C_8-C_{10}fatty alcohol based active ingredient and an emulsifier will control the suckers effectively. This suckericide formulation was extensively tested in field trails in FCV, burley and chewing tobaccos for control of suckers. Application of suckericide at a concentration of 4% effectively controls the suckers in FCV tobacco.

Topping and sucker control practice

Impact of the technology

Topping and sucker control is an important cultural practice in FCV tobacco, and it improves the yield (20-25%) and quality substantially. It is followed by all farmers in the NLS region.

Publications/commercialization

- ICAR-CTRI Annual Reports 1986-1988.

Investigators/Developers

M. Bangarayya, K. Nageswara Rao and D. Prabhakara Babu

Name of the technology : **Integrated barn technology for enhancing wood fuel use efficiency**

Year (s) of development : 1999

Technology details

Integrated barn technology comprising of low-profile barn, ventury furnace, barn ceiling insulation with paddy straw and modified flue pipe system was developed to enhance the fuel wood efficiency. The fuel use was around 2.4 kg of wood as against 5 kg wood to produce 1 kg of cured leaf in control barn of 16'x16'x16' size, without any energy saving modifications. High efficacy of integrated barn is due to the combined effects of efficient burning of wood in ventury furnace, minimization of heat loss due to the ceiling insulation, improved heat circulation through low profile barn and prolonged retention of heat with better thermal transfer through modified flue pipe system. The integrated barn with its high energy saving potential (51%) over the conventional barns, can drastically minimize the fuel requirement for flue curing tobacco.

Impact of the technology

Technology led to saving of energy up to 51% over the conventional barn and minimized the fuel requirement for flue curing tobacco to farmers of Karnataka and AP leading to reduction in cost of cultivation and increased net profit. The extent of adoption was up to 70 % especially in Karnataka.

Publications/commercialization

- Shenoi, M. M. *et. al.*, 2006. 50 golden years of tobacco research, CTRI, RS, Hunsur (Profile).

Investigators /developers

M.M. Shenoi, K.N. Subrahmanya, M.M. Swamy and S. Ramakrishnan

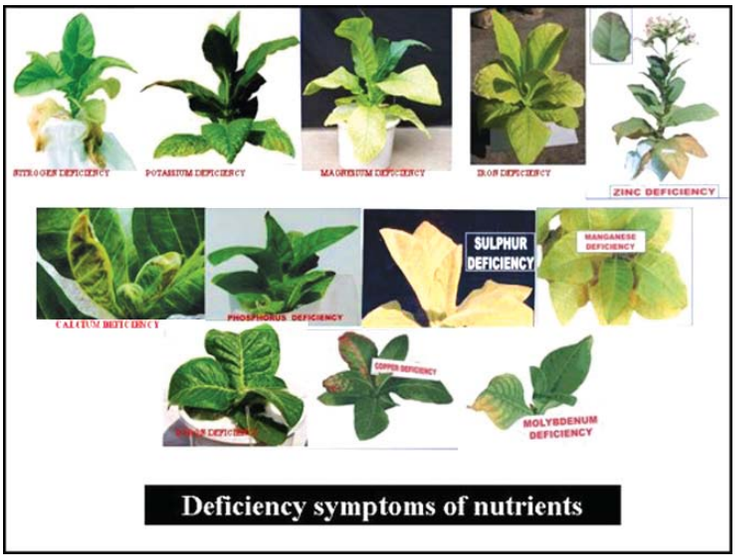
Name of the technology : **Nutrient deficiency cards: A ready reckoner to detect the deficiency and toxicity symptoms of nutrients**

Year (s) of development : 2002-2004

Technology details

Tobacco is a nutrient demanding crop and responds well to the quantity and the nutrient source. The yield and quality of tobacco depends on the availability of plant nutrients in the rhizosphere and their uptake by the plant besides the other factors. As the tobacco plant responds well to different plant nutrients, their limited or excess availability in the soil results in visual response of plant in the form of symptoms typical of each nutrient.

Thus, the identification of deficiency and toxicity symptoms of different plant nutrients at field level becomes imperative to take corrective measures for obtaining maximum productivity, desirable quality with balanced leaf chemistry, The deficiency and toxicity symptoms of essential plant nutrients, N, P, K, Ca, Mg, S, Fe, Zn, B, Cu, Mn, Mo and Cl were developed under controlled conditions in flue-cured tobacco and a ready reckoner along with remedial measures was developed for helping tobacco farmers and extension workers.



Impact of the technology

It helps the farmers and extension workers to identify the nutritional disorders at field level and address the problem by giving correction measures instantaneously and help in avoiding the yield loss thereby in income.

Publications/Commercialization

- M. Anuradha, K. Nageswara Rao, K.Deo Singh and V. Krishnamurthy. 2005. Tobacco Plant Nutrition-Mineral Nutrients: Deficiency and Toxicity Symptoms and Corrective Measures published by ICAR-CTRI, pp.36.

Investigators/Developers

M. Anuradha, K. Nageswara Rao, K. Deo Singh and V. Krishnamurthy

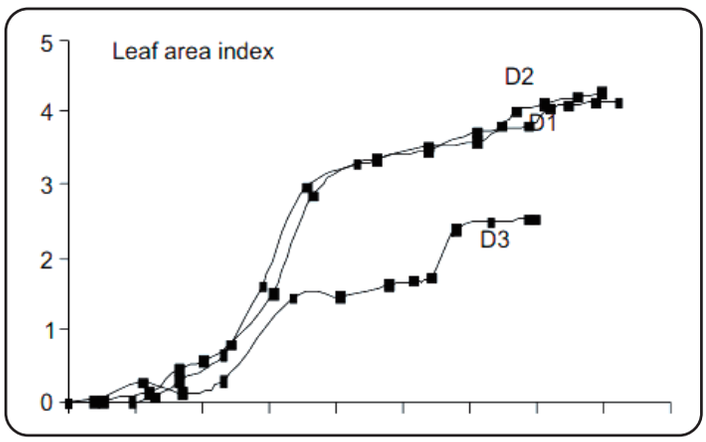
Name of the technology : **A mathematical model for predicting growth and dry matter**

Year (s) of development : 2009

Technology details

Field experimentation with 'Kanchan' flue-cured tobacco (*Nicotiana tabacum* L.) under irrigated condition correlating dry matter accumulation, leaf weight, growth parameters, weather parameters and developed suitable mathematical models to predict the dry matter and leaf weight. Late planting showed reduction in cured leaf yields, leaf area, dry matter accumulation but specific leaf weight increased compared to early and normal planting.

Maximum crop growth rate and net assimilation rate were recorded between 40 and 80 days after planting. Among various growth parameters, leaf area index and specific leaf weight had highest positive correlation with total dry matter production and leaf weight. Leaf area index can alone predict the total dry matter (R^2=0.96) and leaf weight (R^2 =0.93) of flue cured virginia tobacco with high degree of accuracy. By including the specific leaf weight and weather parameters, *viz* temperatures, rainfall and sunshine hours the accuracy was further improved. Predicted values of total dry matter and leaf weight with the selected multiple regression equations, correlated significantly with actual values.



Effect of different dates of planting on leaf area index of flue-cured tobacco.

Impact of the technology

These prediction equations would help in formulating the production and marketing regulation strategy of FCV tobacco in northern light soils of Andhra Pradesh.

Publications/commercialization

- C Chandrasekhararao, M Anuradha, K Siva Raju, S Kasturi Krishna, H Ravisankar and V Krishnamurthy. 2009. Prediction of growth and dry matter production of Flue-cured Virginia Tobacco (*Nicotiana tabacum*) using mathematical models in irrigated Alfisols of Andhra Pradesh.Indian Journal of Agricultural Sciences 79 (12): 991–95.

Investigators/Developers

C. Chandrasekhararao, M. Anuradha, K. Siva Raju, S. Kasturi Krishna, H. Ravisankar and V. Krishnamurthy

Name of the technology : **Chlorophyll content index - A tool for non-destructive evaluation of lamina nitrogen content**

Year (s) of development : 2008-2011

Technology details

Tobacco is very sensitive to nitrogen. Evaluation of nitrogen status in tobacco leaves a time consuming and laborious process where leaf samples are to be digested and the nitrogen will be estimated in the digested extract using auto-analyser. Such procedures have limited use as a diagnostic tool for optimizing N supply. The chlorophyll meter provides a simple, quick, non-destructive method of estimating leaf chlorophyll content. As the leaf chlorophyll content is closely related with leaf N concentration, the measurement of chlorophyll provides an indirect assessment of nitrogen assessment. Hence developed the chlorophyll content index using chlorophyll meter by conducting the field experiments with six levels of nitrogen (0, 40, 80, 120, 160, 200 kg N/ha) in flue-cured tobacco variety Kanchan. The leaves were processed and analyzed for lamina nitrogen content. Increased nitrogen fertilisation increased chlorophyll content index and nitrogen content in the leaf at all the stages.

The positive correlation (r = 0.843) between chlorophyll content index and lamina nitrogen content is highly significant which denotes that chlorophyll content index is a valuable tool for non-destructive estimation of lamina nitrogen content in flue-cured tobacco during active crop growth period.

From zero to 200 kg N /ha with 40 kg increment

Impact of the technology

Chlorophyll content index can be used as an index for evaluating lamina nitrogen content which is an indicator for nitrogen nutrition. Based on the nitrogen status of the leaf which indicates the N requirement the management practices of nitrogen can modified to get quality leaf as well as help in saving of N fertilizers.

Publications/commercialization

- ICAR-CTRI Annual Reports 2009-2012.

Investigators/Developers

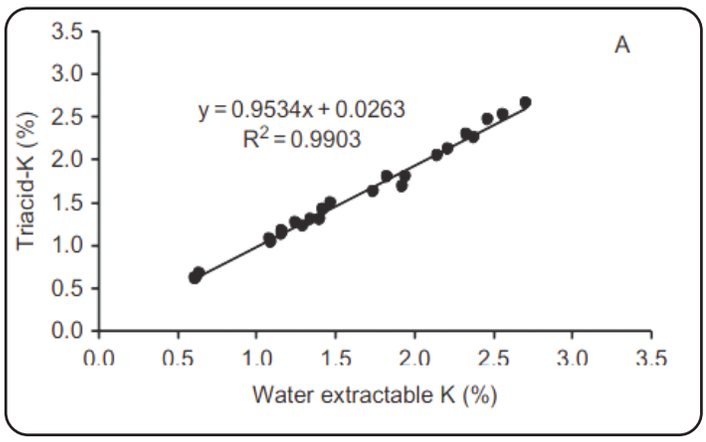
M. Anuradha, K. Nageswararao, C. Chandrasekhararao and V. Krishnamurthy

Name of the technology : **Simple and inexpensive water extraction method for assaying potassium in plant tissue**

Year (s) of development : 2013

Technology details

Potassium (K) in plant tissue is not bound to organic compounds and occurs in soluble forms, thus indicating the ease of its extractability. The conventional methods of plant-sample preparation for K determination are often tedious, time-consuming, and/or require chemicals, making the analysis expensive. A water extraction method for assaying K concentration in tobacco leaf tissue was developed and evaluated in comparison to the established methods, namely, triacid digestion, 1 N ammonium acetate (NH_4OAc) extraction, and 0.5 N hydrochloric acid (HCl) extractions. The proposed method entails extracting K from 0.5 g finely ground plant tissue (<0.5-mm sieve) with distilled water at a 1:100 ratio (sample weight to water volume, w/v) by shaking for 20 mins and filtering before K measurement by flame photometry. Tobacco leaf samples having a wide range in K concentrations showed very close agreement between the values of K determined by the proposed water extraction method and the established methods. The mean K concentration obtained with water extraction method was within 3 to 6% of those measured by established methods. The correlations between the K values obtained by the established methods and the water extraction method were highly significant (P = 0.01), and the relationships are best described by linear regression equations with high values of R^2 (>0.99).



Relationship of triacid K, and water extractable K in tobacco leaf tissues.

Impact of the technology

Being simple, rapid, and inexpensive, the water extraction method could be used as an alternative to the most commonly employed standard, tri-acid digestion, for routine analysis of K in tobacco plant tissue. It reduces the use of toxic acid method and cost of the analysis.

Publications/commercialization

- D. Damodar Reddy and V. Krishnamurthy. 2013. Simple and Inexpensive Water Extraction Method for Assaying Potassium Concentration in Tobacco Plant Tissue. Communications in Soil Science and Plant Analysis 44:962-970.

Investigators/Developers

D. Damodar Reddy and V. Krishnamurthy

Name of the technology : **Climate resilience technologies for waterlogging**

Year (s) of development : 2011-2014

Technology details

In recent years tobacco crops are facing a series of cyclonic rains leading to water logging and prolonged droughts coupled with high temperatures due to change in climate. These changes result in a reduction of productivity and tobacco quality. Even though tobacco can withstand water deficit to some extent, it is very sensitive to excess water. There is need to develop a suitable technology to minimize the negative effect of water logging on productivity and quality of flu-cured tobacco. In this context, field experiments were conducted using different nutrients/ growth hormones/ polyamines (Soil application of KNO_3, Foliar application of KNO_3, Hoagland solution, Salicylic acid, Putriscine, kinetin) to alleviate the negative effects of waterlogging. The condition of waterlogging was imposed under field condition. Soil application of KNO_3 (5 g on either side of the plant by making holes) in combination with kinetin spray @ 50 ppm twice at 10 days interval minimized the negative affect of excess water stress on yield and quality in flue-cured tobacco.

Water logging effect

Recovery of water logged crop

Impact of the technology

Soil application of KNO_3 in combination with kinetin spray @ 50 ppm twice at 10 days interval is cheaper and accessible technology which reduces the negative impact of water stress on yield and quality help farmers to get better returns.

Publications/commercialization

- IRC and ICAR-CTRI Annual Reports 2012-2015.

Investigators/Developers

M. Anuradha, D. Damodar Reddy, K. Sivaraju and T.G.K.Murthy

Name of the technology : **Technology for refinement of tobacco seed oil**

Year (s) of development : 2015-2017

Technology details

Tobacco seed has ~30% oil, composition include linoleic (72.5 to 79.1%), linolenic acid (1.3 to 3.0%), palmitic (2.5 to 3.6%), stearic (5.5 to 8.1%) and oleic acids (9.2 to 13.6%), predominantly. It has a higher ratio of polyunsaturated to saturated fatty acids. (8.27) than sunflower (5.33) and groundnut (1.42) oil and comes under class 1 of nutrition classes of edible oils. However, a critical look at the physico-chemical properties of the tobacco oil clearly indicated that the quality of the oil must be improved by refining before its safety evaluation studies. Refining technology was developed for degumming, neutralization, bleaching and deodorization for the removal of phosphatides, free fatty acids, coloring pigments and odoriferous matter respectively in collaboration with IICT, Hyderabad. Tobacco seed oil refined with the final color of 12.0 (8Y,0.8R), low content of free fatty acids (0.06%) and obscene of phosphorus. Characterization of the oil showed that the major tocopherols present in tobacco seed oil are α- tochopherol and tricontanol. Overall, fatty acid composition in tobacco seed oil is like sunflower and safflower oil. The lead, mercury, arsenic and nickel were absent, and the aflatoxin content was below 1.6 ppb. The seed oil is reported as "devoid of nicotine". While TSNA is less than 1 ppb. Tobacco seed oil was refined, and the quality of refined oil is better than sunflower oil and equal to safflower oil. Feeding tobacco seed oil and other edible oils through diet did not induce any abnormalities under experimental conditions.

Impact of the technology

The results of safety evaluation studies using experimental animals indicate that it will be safe for consumption as edible oil. In the light of the global oil shortage, tobacco seed oil can be a viable alternative for addressing import dependence on edible oils.

Publications/commercialization

- Siva Raju K., D. Damodar Reddy and C.V. Narasimha Rao. 2015. Comparative study on characteristics ofseed oil and nutritional composition of seed cake in different tobacco types cultivated in India.Tobacco Research 41(1): 6-14.

Investigators/Developers

Lead: K. Shiv Raju, D. Damodar Reddy, ICAR-CTRI
Associate: P. P.Chakrabarti, CSIR-IICT, Hyderabad, B. Dinesh Kumar, ICMR-NIN, Hyderabad

Name of the technology : **Tobacco stalk biochar as a soil amendment**

Year (s) of development : 2014-2017

Technology details

In light textured soils with poor nutrient retention capacity, fertilizer nutrients are often subjected to leaching losses resulting in low fertilizer use efficiency. Tobacco crops generate about 1000 kg/ha stalks every year. Such a huge and renewable biomass which is traditionally discarded as solid waste or burned off in heaps. Tobacco stalk biomass can be sustainably utilized by producing Tobacco Stalk biochar(TSB).TSB was prepared by complete charring of tobacco stalk biomass at a temperature of 500 ^{0}C and holding time of 90 minutes with the yield recovery of 40%. The TSB is rich in total organic carbon, and carbonate and carbonate-carboxyl functional groups indicated the ability for nutrient retention where the per cent inhibition of leaching of ammonium and potassium applied by TSB were 28.10 and 25.28 respectively. Application of TSB (1 t ha^{-1}) coupled with 100% RDF not only improves tobacco productivity but also causes a significant enhancement in crop nutrient uptake and use efficiency of applied nutrients over 100% Recommended Dose of Fertilizers (RDF). Hence, application of TSB (1 t ha^{-1}) along with 100% RDF can be recommended to FCV improve yield and nutrient uptake of tobacco and acts as an effective soil amendment for minimizing nutrient leaching losses, enhancing soil fertility and crop productivity.

Tobacco stalk biomass

Tobacco stalk biochar

Impact of the technology

FCV Tobacco soils are poor in organic carbon content. Biochar application to soils, especially to light textured soils will help in carbon sequestration, improvement in physical, chemical and biological properties of soils and helps in improving soil fertility. Most of the NLS soils are acidic in nature with a pH below 6.0 TSB as a liming agent helps in improving the availability of nutrients thereby improvement in leaf yield and quality.

Publications/commercialization

- Poorna Bindu J, Damodar Reddy D, Santhy P, C. Chandrasekhara Rao C., and Ghosh RK. 2023. Effect of Chemical Fertilizer and Tobacco Stalks-derived Biochar on FCV Tobacco Yield, Nutrient Use Efficiency and Carbon Management Index in a Light Textured Alfisol. International Journal of Plant and Soil Science 35(2), 88-107.

Investigators/Developers

J. Poorna Bindu and D. Damodar Reddy

Name of the technology : **Technology for nicotine recovery and purification from tobacco waste**

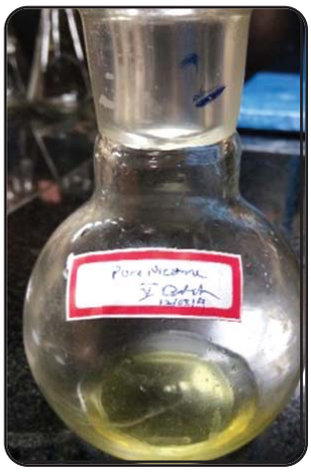
Year (s) of development : 2016-2022

Technology details

Nicotine is a tobacco constituent with high commercial value. It is a hygroscopic, colorless, yellow-brown, oily liquid, which is readily soluble in alcohol, ether or light petroleum. It is miscible with water in its neutral amine base form between 60 °C and 210 °C. It is a dibasic nitrogenous base, having $Kb^1=1\times10$, $Kb^2=1\times10^{11}$. It is generally synthesized in roots of the plant and transported to leaf. Nicotine content of tobacco by virtue of its stimulatory effect on the smoker is an important constituent.

Scope of high purity Nicotine: *Medical and Pharmaceutical uses:* The primary therapeutic use of nicotine is treating nicotine dependence through gums, dermal patches, lozenges, inhalers, or nasal sprays. Nicotine can treat Parkinson's disease, a cognitive enhancer, improves short-term memory, help people with ADHD (attention deficit hyperactivity disorder), normalizes schizophrenic brain activity and provide an Alzheimer's breakthrough.

As a Pesticide in agriculture: Nicotine has been used as an insecticide since at least the 1690s, in the form of tobacco extracts and widely used as an insecticide. Keeping in view the importance and utilization of tobacco waste for this purpose, a nicotine extraction method was developed with 84 % recovery and 75 % purity to improve the commercial value of the extracted nicotine and its efficacy. It is an easy, efficient, less time-consuming nicotine extraction process.



Impact of the technology

This method can be upscaled as a commercially viable option for extraction of nicotine from bidi waste.

Publications/commercialization

- Commercial companies required the pure nicotine for manufacturing botanical pesticides, Nicotine Cessation products and pharmaceutical companies for making drugs.

Investigators/Developers

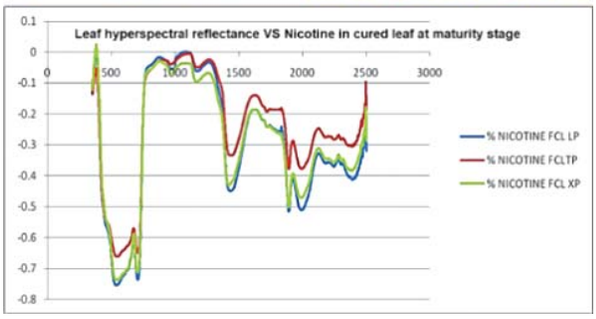
C.V.N Rao, L.K. Prasad, Anindita Paul, C. Chandrasekhara Rao, D. Damodar Reddy, M. Sheshu Madhav and N. Johnson

Name of the technology : **Novel technologies for leaf quality assessment**

Year (s) of development : 2020 - 2021

Technology details

a) *Non – Methanol based extraction for the estimation of nicotine, reducing sugars and chlorides in FCV tobacco:* A simple, inexpensive, and less hazardous extractant for simultaneous extraction of nicotine, reducing sugars, and chlorides in tobacco cured leaf was developed using 10 % acetic acid to replace methanol based extractant which is hazardous and expensive. Passing & Bablok's regression and CUSUM test for linearity showed no significant deviation from linearity & found high correlation between the proposed and the reference extractants (0.97-0.99). Youden plot indicated a high degree of comparability between the proposed and the reference extractants. Estimated cost of assaying nicotine, reducing sugars, and chlorides in 100 cured leaf samples of tobacco by the reference extractant was higher (INR 445/ 6.09 USD) compared to the cost of analyzing with the proposed extractant (10% acetic acid) was INR 250/ /3.42 USD. The proposed extractant (10 % acetic acid + 4 cc activated charcoal suspension) is simple and less expensive.



b) A non-destructive way of assessing and estimating FCV tobacco leaf quality using hyper spectral remote sensing technique: FCV tobacco leaf is a commercial agricultural product mainly classified and marketed on its quality. The hyper-spectral remote techniques make it possible to monitor leaf quality non-destructively. Keeping in view the advantages of new technologies available, a non - destructive method of assessing FCV tobacco leaf quality in-situ was developed using identified sensitive bands and multiple linear regression models developed for leaf potassium, nicotine, reducing sugars, total nitrogen, and total chlorophyll.

Impact of the technology

The novel method of estimating the chemical quality with 10% acetic acid replace the existing traditional methods with toxic substances and is cheaper. Non-destructive estimation of leaf quality technology will be very useful in assessing crop quality during the season before the harvest, reducing the wastage of nutrients and other resources.

Publications/commercialization

- L.K. Prasad, C. Chandrasekhara Rao, D. Damodar Reddy, K. Padmaja and N. Johnson. 2022. A New Extractant for Concurrent Estimation of Nicotine, Reducing Sugars and Chlorides in Tobacco Cured Leaf. Communications in Soil Science and Plant Analysis 53(13): 1685-91.

Investigators/Developers

L. K. Prasad, M. Prabhakar, M. Anuradha, C. Chandrasekhara Rao, D. Damodar Reddy, K. Padmaja and N. Johnson

Name of the technology : **Oil palm empty fruit bunches: A suitable alternate fuel for curing of FCV tobacco**

Year (s) of development : 2017-2020

Technology details

Oil palm is mainly cultivated in Andhra Pradesh (85%) and Kerala (10%) states in India and is an intensive producer of biomass. Oil palm biomass comprises empty fruit bunch, fronds and trunks etc. and is often considered a waste. Global crude palm oil production is ~72.27 million metric tonnes. Production of one kg of palm oil is associated with approximately 4 kg dry biomass. One third of the oil palm biomass is represented by empty fruit bunch (EFB). In recent times, there has been growing interest in using oil palm biomass as the source of renewable energy. FCV tobacco is cultivated in an area of 28,000 ha in the northern light soils (NLS) region of Andhra Pradesh, where oil palm also occupies substantial area. Tobacco curing is done in specialized structures called barns, requiring large quantities of wood fuel (4-5 kg /kg cured leaf). EFB biomass as a fuel alternate to wood in curing FCV tobacco was studied against wood fuel. The quantity of EFB biomass consumed per 1 kg cured leaf is 4.0 kg in comparison to 5.6 kg wood fuel.The fuel equivalence value of EFB is 1.4 which indicates EFB as fuel for curing tobacco is 40% more efficient than standard wood fuel. EFB biomass can replace about 16% of wood fuel in NLS region. The oil palm empty fruit bunch biomass waste can be effectively utilized as a potential alternate fuel for curing FCV tobacco.

Oil plam empty fruit bunches

Impact of thetechnology

We can save the wood fuel for curing FCV tobacco. Utilization of Empty fruit bunch alone as a fuel for curing in entire NLS region will save 15.6 % of wood fuel. In the existing technology we need to cut the trees for fuel wood, whereas in the oil palm empty fruit bunch technology we can avoid deforestation and the biomass which is otherwise a waste can be effectively utilized for curing of FCV tobacco especially in northern light soils area of FCV tobacco.

Publications/commercialization

- J. Poorna Bindu, D. Damodar Reddy, C. Chandrasekhara Rao, M. Sheshu Madhav, K.Viswanath Reddy ,K. Manorama, L. K. Prasad , S. Kasturi Krishna, K. Ramachandrudu, R. K. Mathur and T. Kiran Kumar .2022. Oil Palm Biomass Waste as Rooting Media for Tobacco Tray Seedlings and as a Fuel for Curing of FCV Tobacco. Tobacco Research 48(1): 18-21.

Investigators/Developers

J. Poorna Bindu, D. Damodar Reddy, C. Chandrasekhara Rao, L.K. Prasad, S. Kasturi Krishna, T. Kiran Kumar, K. Viswanath Reddy, M. Sheshu Madhav, K. Manorama, K. Ramachandrudu, R.K. Mathur and D.V.L. Satyavathi

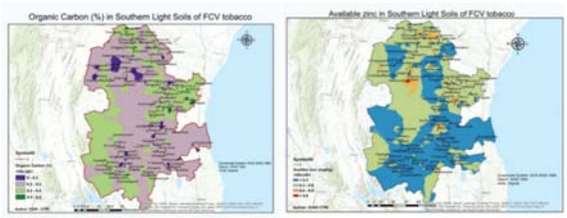
Name of the technology : **Novel STCR based fertilizer recommendation system for precision farming**

Year (s) of development : 2020 – 2021

Technology details

Soil Fertility Spatial Maps of FCV Tobacco regions: Nutrient status of FCV tobacco soils is depleting due to continuous removal of nutrients without replenishment. Efficient use and management of nitrogen and potassium is crucial in FCV tobacco as they play a key role in improving the yield and quality. Hence, it is imperative to assess soil fertility on a spatial scale and spatial thematic map as a tool is the better way to observe the variation in identifying hot spots and specific zones of interest. Spatial thematic maps of soil fertility of FCV tobacco regions were developed as decision making tool for developing strategies for optimum fertilizer use and enhancing FCV tobacco productivity.

Soil Test Crop Response based online fertilizer recommendation system for FCV tobacco: Soil testing as a tool for judicious fertilizer use is a recognized practice all over the world. The concept of STCR and targeted yield approach was used, and prescription equations were developed for FCV tobacco to give precise quantitative fertilizer dose for different soil test values for a yield target. The nutrient prescriptions were linked with online software which gives fertilizer recommendation for soil test data with a targeted yield.



Spatial distribution of Organic Carbon and Available Zinc in Southern Light Soils Region of FCV tobacco

The STCR based fertilizer recommendation software for FCV tobacco

Impact of the technology

This is a useful GIS based digital decision tool along with the online STCR based fertilizer recommendation system for a targeted yield. It would help in balanced nutrient application to enhance productivity of FCV tobacco of a specific agro-climatic region and report can be generated from anywhere.

Publications/commercialization

- Digital thematic maps., Technical brochure ICAR/CTRI/SPTB_1: Soil Test Crop Response Based Online Fertilizer Recommendation for yield targets in FCV Tobacco and Copyright for the software: SW-14310/2021.

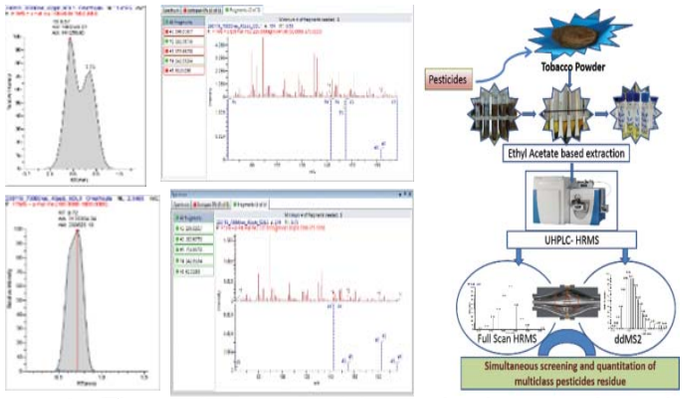
Investigators/Developers

L.K. Prasad, C. Chandrasekhara Rao, D. Damodar Reddy, H. Ravishankar, J. Poorna Bindu and M. Sheshu Madhav

Name of the technology : **A novel method for simultaneous screening and quantitative estimation of multiple pesticide residues**

Year (s) of development : 2018-2023

Technology details



A rapid and sensitive method for multi-pesticide residue determination using LC high resolution MS/MS (ORBITRAP) technique in combination with triple quadrupole mass spectrometry (MS/MS) in tobacco matrix was developed to comply with the reducing trend in Guidance Residue Level (GRLs) in tobacco.The developed method is fast, selective, and sensitive (LOQs <40 ng/g) for large-scale multiresidue analysis of pesticides in tobacco matrix. The performance of the method was evaluated on ORBITRAP-LC-MS/MS against traditional LC-MS/MS. As a unique and single unified approach of sample preparation was analysed simultaneously using gas chromatography tandem mass spectrometry (GC-MS/MS) and LC-MS/MS. Method performance for 69 GC and 238 LC amenable pesticides are complied with SANTE/11813/2017 guidelines,with significant savings in time and cost. Furthermore, the vDIA-based non-target approach established the strength of retrospective data mining for identification of any suspected analytes. It is ideal for regulatory analysis of analytes ranging from non-polar organochlorine pesticides to polar pesticides.

As tobacco is an exportable commodity, in compliances of the trade barriers, the chlorantraniliprole 18.5 SC pesticide residue estimation was developed by GC-MS/SIM analytical method and based on this novel technology, Pre Harvest Interval (PHI) was established in connection to produces pesticide residue below GRL in tobacco leaf

Impact of the technology

The SDLs of the method ensured screening of different types of tobacco matrices for a wide range of pesticides at concentrations lower than the GRL of the pesticides. In compliance with the trade barrier, multiple pesticide residue level below GRL, can increase the exports of Indian tobacco. The detection technology will provide precise estimation of various pesticide *viz.*, chlorantraniliprole, organocholrine, pendimethalin etc. residues which will guide farmer to employ timely application with proper dosage.The PHI based technology can be recommended to tobacco growers of particular location to envisage safe use of chlorantraniliprole in insect pest management.

Publications/commercialization

- Paul A, Khan Z, Bhattacharyya A, Majumder S and Banerjee K. 2021. Multiclass pesticide residue analysis in tobacco (*Nicotiana tabacum*) using high performance liquid chromatography-high resolution (Orbitrap) mass spectrometry: A simultaneous screening and quantitative method. *Journal of Chromatography A*, 1648: 462208.

Investigators/Developers

Lead: Anindita Paul, Scientist, ICAR-CTRI
Associate: Kaushik Banerjee, Director, ICAR-NRCG, Pune, Sujan Majumder, Scientist, ICAR-IIVR, Varanasi

Name of the technology : **New leaf chemical quality index (LCQI) for assessment and seasonal monitoring of FCV tobacco quality**

Year (s) of development : 2022 - 2023

Technology details

FCV tobacco is grown in an area of 1.39 lakh hectares in India and is a commercial product that is marketed in the national and international market under stringent quality norms which influence the Indian exports. Determination of chemical quality characters *viz.*, nicotine, reducing sugars and chloride incured leaf grown in different regions and seasons as a key activity for assessing and comparing the leaf quality. However, comparing each quality parameter across regions and seasons over a period is complex and is a difficult task. Hence, a single index for assessment of critical quality parameters was developed as a tool to visualize the spatial and temporal dimensions of leaf quality.

The index was developed by assigning weights to quality parameters based on their contribution towards quality assessment and the weighted values of each parameter are added to get a single value and square root of the same for obtaining the index i.e. CLQI=SQRT(((RS/Nic*0.8)+(Cl *0.2)). The range of index values is categorized into five classes. The single index-based leaf quality assessment tool assists in seasonal monitoring of the leaf quality which is essential for marketing and to obtain better price. It is the first of its kind quality-based index for monitoring the FCV tobacco leaf quality. It is a simple single index and colour coded method helps as a tool for implementing strategies for producing better quality leaf.

CLASS	INDEX RANGE	COLOUR CODE				
		1.0	1.1	1.2	1.3	1.4
Poor	1.0 -1.4					
		1.5	1.6	1.7	1.8	1.9
Medium	1.5 -1.9					
		2.0	2.1	2.2	2.3	2.4
Good	2.0 - 2.4					
		2.5	2.6	2.7	2.8	2.9
High	2.5 - 2.9					
		3.0	3.1	3.2	3.3	3.4
Very High	3.0-3.4					

Standard Chart of Quality based on CLQI in FCV tobacco

Impact of the technology

It is first of its kind quality-based index developed in FCV tobacco for monitoring the leaf quality spatially and temporally in different FCV tobacco growing regions. It is a simple and colour gradient coded method and it helps as a tool for implementing strategies for producing better quality leaf.

Publications/commercialization

- Leaf Quality Assessment of FCV Tobacco. Technical Bulletin No.: ICAR-CTRI/CC&SS/01/2023.

Investigators/Developers

L.K. Prasad, C. Chandrasekhara Rao, M. Seshu Madhav, Anindita Paul, K. Padmaja, N. Johnson and K. Veeranna

Name of the technology : **Technology for exploring solar thermal energies for FCV tobacco curing**

Year (s) of development : 2016-2023

Technology details

Tobacco, one of the high-value commercial crops, is grown in India in an area of 0.45 M ha to produce ~800 M kg of cured leaf. Among the different tobacco types grown in the country, Flue-Cured Virginia (FCV) tobacco meant for making cigarettes accounts for about 30% of total tobacco production in the country. Post-harvest curing of green leaves is an important operation carried out in specialized structures called barns. Firewood is used as fuel for flue-curing, and assuming 80% of FCV tobacco is cured with wood fuel @ 5 kg wood per kg of cured leaf, the annual wood consumption is estimated at 1x 10^6 metric tons per year, resulting in deforestation and is an environmental concern.

It is therefore imperative to utilize solar thermal energy to reduce the dependency on wood fuel. Innovative techniques, i.e., (i) Poly Carbonate Roof Chamber (PCRC) (ii) Solar Hot Water (SHW) circulation system (iii) Solar hot air (SHA) circulation systems were developed and tried for harnessing the solar energy for FCV tobacco curing individually and in integration.

Flue-curing of FCV tobacco green leaves was carried out in comparison with conventional barn at CTRI Black soil research farm Katheru during 2019-2023. Energy-saving interventions such as thermocol ceilings of walls, cement flooring on barn floors, and adjustable metal frames to hold the cured leaf were developed to reduce energy losses. Solar energy interventions helped in raising the leaf temperature inside the barn between 6-12^0 F during the curing process by reduced the wood requirement for curing. Green energy interventions, *viz.*, Poly Carbonate Roof Chamber (PCRC), (ii) Solar Hot Water (SHW) Circulation System, and (iii) Solar Hot Air (SHA) Circulation System, reduced wood consumption up to ~ 33%, thereby reducing the wood fuel requirement for curing the FCV tobacco.



Poly Carbonate Roof Chamber. Solar Hot Water Circulation System.Solar Hot air Circulation System.

Impact of the technology

The wood fuel requirement for curing the FCV tobacco green leaf is reduced to an extent of 33% with the integration of the three solar thermal energy techniques developed. The technology is eco-friendly, utilizes the solar energy to reduce the dependency on natural wood and also the cost of cultivation.

Publications/commercialization

- C. Chandrasekhara Rao, D. Damodar Reddy, L.K. Prasad, J. PoornaBindu, S. Kasturikrishna and M. Anuradha. 2019. Poly carbonate roof chamber: A fuel saving intervention in FCV tobacco curing through harnessing solar energy. ICAR-CTRI, Rajahmundry.

Investigators/Developers

C. Chandrasekhara Rao, D. Damodar Reddy, L.K. Prasad, J. Poorna Bindu, S. Kasturi Krishna and M. Anuradha

Technologies for Information Dissemination & Policy Directions

Sl. No.	Technology	Developed by	Year
1.	Mobile App on good agricultural practices of FCV tobacco	H. Ravisankar *et al.*	2022
2.	Mobile App on Non-FCV tobacco	C.Chandrasekhara Rao *et al.*	2023
3.	Innovative Decision Support System for sustainable tobacco seed delivery	H. Ravisankar *et al.*	2023
4.	Extension advisories for crop diversification	Y. Subbaiah *et al.*	2016
5.	Policy modelling for optimum crop size ixation to ensure supply–demand balance and shield price volatility syndrome in commercial crops	K. Viswanatha Reddy *et al.*	2022
6.	Methodology for policy impact assessment: WHO-FCTC (Framework Convention on Tobacco Control) on the Indian tobacco sector	K. Viswanatha Reddy *et al.*	2023
7.	Strategic policy framework to augment agricultural export competitiveness of commercial crops from India	K. Viswanatha Reddy *et al.*	2022
8.	Econometric modeling framework for identification of determinants of tobacco exports from India	K. Viswanatha Reddy *et al.*	2023
9.	Impact of tobacco crop holiday on the socio economics of farm labour in the FCV tobacco growing areas of A.P.	Y. Subbaiah *et al.*	2003

Name of the technology : **Mobile App on good agricultural practices for FCV tobacco**

Year (s) of development : 2020 - 2022

Technology details

Android Based Static Mobile App was developed on Good Agricultural Practices of FCV tobacco for global accessing of the information through smart phones in English and Telugu language and it was installed in google play store with URL as https://play.google.com/store/apps/details?id=com.icar.ctri&hl=en. The software was developed in XML and HTML languages and it was executed in Android studio 4.1.3 operating system. This app contains the entire information on package of practices on nursery, field crop and post-harvest management. The app consists of four main modules *viz.*, 'TOBACCO', 'SHARE' 'CONTACT' and 'ABOUT'. The first module 'Tobacco' provides technical information supported by photographs about 'Good Agricultural Practices of FCV Tobacco' through 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, Insect pest and disease management'. In 'Feld crop' module, information on 'Planting, Cultural operations, Irrigation and Fertilization' based on soil type *viz.*, Northern Light Soils (NLS), Southern Light Soils (SLS), Southern Black soils (SBS) and Karnataka Light Soils (KLS) can be accessed. In addition to this, information on 'Insect pest management, Disease management, Nutrient Management, Weed Management, Topping and sucker control, Harvesting and Orobanche Management Measures' can also be retrieved from 'Feld crop' module. 'Nutrient Management' module, as a decision support system, allows the user to view the visual deficiency symptoms along with corrective measures. 'Weed Management' module covers the information on description of weeds with photographs and control measures. 'Post-Harvest Management' module provides the information on "Green leaf management, Curing, Bulking, Grading and Baling' of FCV tobacco. The second module 'SHARE' contain hyperlink to access CTRI website. 'CONTACT' module make available the contact details for sending the suggestions, if any, by the user. The module 'ABOUT' contains the general information about CTRI.

Impact of the technology

The Mobile App was installed in 1000+ devices. Quick and instant mobile accessing will assist the tobacco farmers in semantic management of crop for achieving higher yields with desired quality. It also helps in transferring the latest technology instantaneously by which the Institute visibility is improved. it is first of its kind to develop a mobile app on good agricultural practices with complete details and photographs for easy understanding and accessing through Google Play Store which is useful for the tobacco community

Publications/commercialization

- H Ravisankar, D. Damodar Reddy, K..Sarala, C.C.S. Rao, M. Anuradha, U. Sreedhar, S. Kasturi Krishna, B. Hema and B. SailajaJayasekharan. 2022. CTRI-FCV Tobacco: An Android based mobile app on good agricultural practices for FCV Tobacco. Tobacco Research 48(2):55-61.
- Copyright obtained (SW-14004/202) from Government of India.

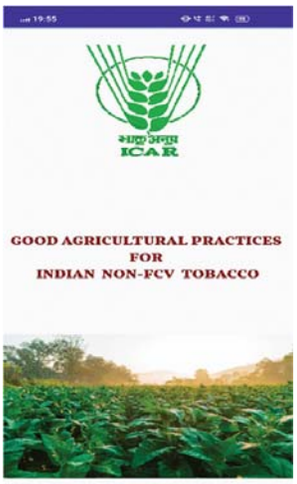
Investigators/Developers

H. Ravisankar, D. Damodar Reddy, K. Sarala, C. Chandrasekhara Rao, S. Kasturi Krishna, U. Sreedhar and B. Hema

Name of the technology : **Mobile App on Non-FCV tobacco**

Year (s) of development : 2022 - 2023

Technology details



Technology transfer brings modern and advanced agricultural practices that can lead to increased crop yields, better resource utilization, and overall improved productivity. The most important and neglected area of the present extension system is its limited ability to integrate different kinds of technologies. As a result, farmers adopt such technologies in isolation. Therefore, an arrangement has to be evolved by the extension system for selection and integration of technologies. Information and Communication Technology (ICT) tools facilitates communication and collaboration among individuals and organizations. There are several ways in which ICT contributes to agriculture and one among them is the Mobile Apps which provides easy accessing of information and services to farmers. Mobile Apps helps farmers to access real-time information about weather conditions, market prices, crop diseases and agricultural best practices. This information empowers them to make informed decisions about planting, harvesting and selling their produce. With this background, ICAR-CTRI initiated the development of an android based mobile application of Good Agricultural Practices (GAP) of Non-FCV tobacco. This app ensures quick and seamless access to vital information and empowers the farmers to adopt scientifically-backed methods and enhance their ability to achieve the desired yields.

This app was developed in Android studio environment using Java and XML languages. The content management of this software consists of complete information about eleven Non-FCV tobacco types. Various frames of this app consists of information about the areas where these tobacco are cultivated in India, research infrastructure, varieties released, good agricultural practices encompassing the soil & climate, nursery management, field crop management and post-harvest management practices. This App acts as a decision tool by providing comprehensive solutions to the farmers for taking decisions in right time to optimize the resources, hastening the production cycle which helps in achieving the higher productivity thereby the farm income. This app was hosted in Google Play Store with URL https://play.google.com/store/apps/details7id=com.nonfcv.mapplication.

Impact of the technology

Non FCV Mobile App was installed in 100+ devices. It is an icon based system which provides complete information on all types of Non-FCV tobacco and their good agricultural practices. It is first of its kind to develop a mobile app on Non-FCV tobacco which acts as a decision tool for the farmers, researchers and stake holders.

Publication / Commercialization

- Copyright obtained (SW-17633/2023) from Government of India.

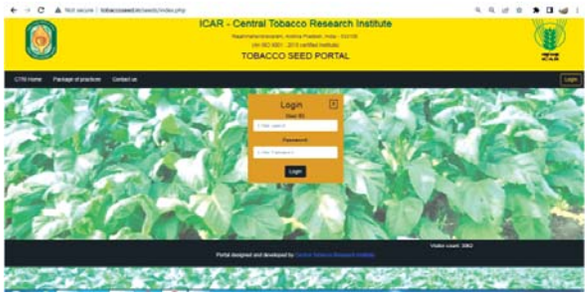
Investigators / Developers

C. Chandrasekhara Rao, H. Ravisankar, M. Sheshu Madhav, B. Krishna Kumari and T. Anuhya Jayapradha

Name of the technology : **Innovative Decision Support System for sustainable tobacco seed delivery**

Year (s) of development : 2021 - 2023

Technology details



ICAR- CTRI is playing a pivotal role in quality seed supply to tobacco farmers as the product integrity is vital for exports. ICAR-CTRI is supplying seed of released varieties to all the FCV tobacco growers manually through verification of grower's registration numbers and receipts are issued accordingly. It is a laborious, time consuming and requires more human resources. In order to overcome these difficulties, an efficient online digital seed distribution system 'Tobacco Seed Portal' was developed. It is a web based portal developed using PhP and MySql, for hassle free transparent and seamless seed supply of all tobacco types across the different regions. It was hosted in Internet with URL 'tobaccoseed.in'. The portal was initially implemented in seed supply to FCV tobacco farmers of Andhra Pradesh. The passport data comprising the basic details with Tobacco Board Grower (TBGR) Number of registered FCV tobacco growers of all auction platforms from four distinctive tobacco production zones (SLS, SBS, NLS and TBS). The software will be executed through authentication only i.e., using LOGIN and PASSWORD. To access the details of a specific farmer for seed sales, Tobacco Board Grower Register (TBGR) number is used as a primary key. This also enables to take a decision on quantum of seed and variety to be supplied. Further, the database of this software was also designed to generate the reports *viz.*, Auction Platform wise (APF) / Region wise / Variety wise / Location / Grower type / Payment mode/date. Specific provision was also made to monitor the seed sales in real-time environment with URL tobaccoseed.in/seeds/realtimedata.php. It also has the user interface to view the cultivation/production practices of the popular released varieties. The specified software surpassed the bottlenecks in the manual process of seed distribution and enabled to retrieve the data in real time. The generated reports will also help in monitoring, development and evaluation of crop strategies. This innovative seed portable will go a long way in hassle free transparent and seamless seed supply and can be emulated in seed supply in other crops.

Impact of the technology

Using this software, seed of six FCV and one Non-FCV tobacco varieties was distributed to around 24,000 FCV farmers and 120 Non-FCV tobacco farmers in 2022 and earned revenue of Rs. 75 lakhs. During 2023 season, a total quantity of 15798 kg seed was supplied to 23,648 FCV tobacco registered growers and also to 1430 commercial nursery growers and earned highest revenue of Rs. 179.0 lakhs which is a record since the inception of Revolving Fund scheme. The software facilitated the digital payment very easily resulting in seamless hassle free seed supply to farmers.

Publications/commercialization

- Copyright obtained (SW-16098/2023) from Government of India.

Investigators/Developers

H. Ravisankar, M. Sheshu Madhav, K. Prabhakara Rao, M. Anuradha, C. Chandrasekhara Rao and D. Damodar Reddy

Name of the technology : **Extension advisories for crop diversification**

Year (s) of development : 2016

Technology details

1. The FCV tobacco is under regulation by the Tobacco Board, GoI and is mainly meant for the export purpose. Hence, crop diversification initiative need to be taken up first in the non-FCV tobacco growing areas to ensure stable and high returns.
2. Focused approach of crop diversification is needed in FCV areas, where FCV tobacco is grown found to be unproductive.
3. To make diversification strategy to be successful, the crops that are having substantial acreage under their cultivation in a given area need to be considered as most likely suitable crops for replacing tobacco in that specific situation.
4. A concrete road map for viable crop/ cropping system options need to be prepared with a focus on crop insurance and by offering special incentives for the tobacco farmers opting for diversification.
5. Greater need to look at the possibilities of strengthening the institutional, marketing and other support systems for other crops as well and by creating opportunities for value addition in alternative crops, so as to motivate the tobacco growers to take up crop diversification
6. The strategy for promoting crop diversification in tobacco areas should consider the issues of profitability, institutional support, processing & marketing, infrastructure and employment potential as components of diversification. Formulation of clusters/ adoption of villages/ involving farmers organizations/ identification of viable options/ organizing awareness campaigns/ trainings/ cluster level demonstrations / use of mass media and you tube/ enhanced interaction between research and extension/policy support are identified as intervention points.



Impact of the technology

Crop diversification initiatives have been taken up. Farmers shifted towards adoption of viable options available as an alternative to tobacco in a given situation and as such the area under tobacco is decreased in states like Karnataka and Odisha.

Publications/commercialization

- Book on Crop Diversification in Tobacco Growing Areas. pp 62.

Investigators/Developers

Y. Subbaiah, D. Damodar Reddy and L.K .Prasad

Name of the technology : **Policy modelling for optimum crop size fixation to ensure supply–demand balance and shield price volatility syndrome in commercial crops**

Year (s) of development : 2020-22

Technology details

Globally, agricultural price volatility is a universal problem, indispensable for understanding its implications on the economy and devising strategies for its management. The frequent demand-supply imbalance and prices of agricultural commodities like chilli, tomato, and onion showed a high degree of volatility, which created a crisis-like situation in India in the recent past. In this context, a comparative analysis was carried out on the **policy-led crop size fixation in FCV tobacco versus crops without crop size fixation such as chilli and onion** with respect to variables such as production, prices, and exports during the last decade. The policy framework and the process of crop size fixation have been in practice in FCV tobacco for the past few decades in India. The comparative analysis found that the production variability was high in onion and chilli whereas it is low in FCV tobacco. On price front, stability index for FCV tobacco price was high (0.90), while it was low for prices of onion (0.41) and chilli (0.59) and stability index for the export of FCV tobacco was high (0.81), while it was low for onion (0.31) and chilli (0.52). This implies that policy framework and crop size regulation in FCV tobacco imparted production stability,reduced price volatility, and stabilized exports over the years. Nevertheless, such a policy framework with regulated production was not in place for commercial crops such as chilli, tomato and onion, which resulted in wide fluctuation in production, high price volatility, and export instability. Thus, there is an immense need for such commercial crops to have a similar kind of policy framework and its practical implementation to ensure supply-demand balance, shield price volatility syndrome, enhance farmers' income and protect consumers from violent price fluctuations. This is a unique regulatory mechanism successfully operating in India, which can be emulated in other commercial crops or any country for evolving vibrant production systems and ensuring price and export stability.

Impact of the technology

This policy modelling will aid in crafting policies for other commercial crops/sectors and provide regulation for production, marketing, and trade to ensure demand-supply balance and shield price volatility syndrome in agriculture commodities that experience market glut, and price fluctuation volatility, which adversely affect both the producers and consumers adversely in the economy.

Publications/commercialization

- K. Viswanatha Reddy and D. Damodar Reddy. 2022. Crop Size Fixation Shields Price Volatility Syndrome: Analysis of Some Commercial Crops in India. Indian Journal of Economics and Development. 18(1): 148-155.

Investigators/Developers

K. Viswanatha Reddy, M. Sheshu Madhav and D. Damodar Reddy

Name of the technology : **Methodology for policy impact assessment: WHO-FCTC (Framework Convention on Tobacco Control) on the Indian tobacco sector**

Year (s) of development : 2019-23

Technology details

Policy impact evaluation can have multiple objectives such as demonstrating the impact of the policy by measuring changes before and after the introduction of the policy and determining whether changes in outcomes can be attributed to the policy. The WHO-Framework Convention on Tobacco Control (WHO FCTC) was enforced in 2005 and India ratified the convention to implement demand and supply-side measures to control tobacco production and consumption. In this context, the policy analysis was undertaken to assess the impact of WHO-FCTC on the performance of the Indian tobacco sector in the context of changing global and national policy regimes. From the methodology, the impact assessment revealed that tobacco production and exports witnessed a low growth rate in export volume and export value with a low instability index and declining global competitiveness of tobacco exports in the post-FCTC regime. The policy impact study implies India being a signatory to WHO-FCTC, pragmatic implementation of tobacco control policies regulating tobacco production through crop size fixation by Tobacco Board, and growing public health awareness in India and across the globe. This impact study aids in crafting the policies towards identification of economically viable tobacco alternative crops to avert possible adverse environmental and socio-economic impacts in India. The comprehensive policy impact assessment during pre-and post-WHO-FCTC regimes would aid in policy advocacy and formulating strategies and roadmap for tobacco research in the Indian tobacco sector in response to policy changes, with a greater focus on increasing tobacco for exports, crop diversification, and exploring alternative livelihood security options.

Impact of the technology

The policy impact assessment would provide critical policy inputs for the Indian tobacco sector, which is emerging uncertainty over the years in the context of a changing policy environment on tobacco production and consumption.

Publications/commercialization

- K. Viswanatha Reddy, D. Damodar Reddy, M. Sheshu Madhav, P. Prakash, B. Hema, and A. Srinivas. 2023. Impact of WHO-FCTC on the performance of Indian tobacco sector, Current Science 124 (7): 840-844.

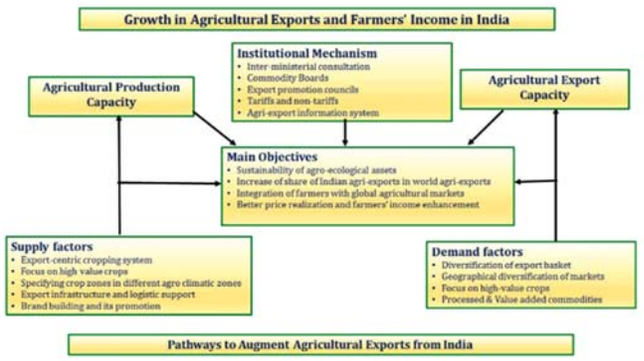
Investigators/Developers

K. Viswanatha Reddy, M. Sheshu Madhav, D. Damodar Reddy, L.K. Prasad, B. Hema and A. Srinivas

Name of the technology : **Strategic policy framework to augment agricultural export competitiveness of commercial crops from India**

Year (s) of development : 2019-23

Technology details



Strategies to promote agricultural export are gaining importance in developing economies like India to increase foreign exchange revenue and inclusive economic development. In recent years, government policies focused more on the agricultural sector, especially on the doubling of agri-exports, and the doubling of farmers' income to transform the Indian agricultural sector and to improve the welfare of the farming community. Moreover, there is an immense untapped potential in commercial agriculture, which needs to be fully harnessed with the changing facets of commercial agriculture. In this context, the study has assessed the export competitiveness of commercial crops in the post-WTO regime (2001-2019) and accordingly devised a strategic framework to augment the agricultural export competitiveness of commercial crops. As is evident from the export competitive indices, a high degree of export competitiveness was witnessed in tobacco, cotton, and spices, which exhibited strong competitiveness reflecting tremendous export potential, whereas it has declined in sugarcane, coffee, and tea which implies erosion in their competitiveness over the years. From this study, it is inferred that there is an immense need to redefine export strategies to augment agricultural exports and foreign exchange revenue by considering agricultural production capacity, agricultural export capacity, and supply and demand factors. Thus, the agricultural export strategy needs to concentrate on augmenting competitiveness by focusing on high-value crops, witnessing erosion in competitiveness while sustaining the crops with high competitiveness. The strategic framework (visual depiction) illustrated to augment export competitiveness aids in policy advocacy for the design of the agricultural export strategy and bring high export revenue to the economy.

Impact of the technology

The developed strategic framework will provide policy input for the design of export strategy to boost agri-exports, augment the export competitiveness of commercial crops in the country, encourage an export-centric farming system, and create a niche in the global agricultural markets.

Publications/commercialization

- K. Viswanatha Reddy, D. Damodar Reddy and R. Sendhil. 2022. An Assessment of Agricultural Export Competitiveness of Commercial Crops: Pathways to Augment Indian Agricultural Exports. Indian Journal of Economics and Development, 18(2):436-444.

Investigators/Developers

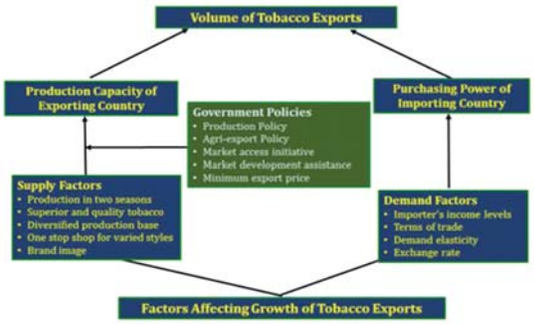
K. Viswanatha Reddy, M. Sheshu Madhav, D. Damodar Reddy and R. Sendhil

Name of the technology : **Econometric modeling framework for identification of determinants of tobacco exports from India**

Year (s) of development : 2021-23

Technology details

Factors affecting the growth of tobacco exports



Econometric modeling is employed as a tool to find out the driving factors of Indian tobacco exports using the temporal data on important economic variables over the past four decades (1980-2020). Currently, India is the second largest exporter of tobacco (accounts for ~ 9% of global exports) after Brazil in the world. As per the latest statistics, Indian tobacco exports accounted for ~219 million kg, which amounts to a share of 34% in domestic production (~758 million kg). This indicates that there was a lower degree of export orientation in tobacco, the crop being mainly destined to export market, over the years. In this background, the econometric analysis was carried out to identify the drivers of Indian tobacco exports in the global tobacco market. The econometric model estimated the relationship between the tobacco export volume with domestic production, export price, and global demand for Indian tobacco, and investigated the geographical shift in export destinations of tobacco in the context of changing global and national policy regimes on the sector. The econometric modeling framework confirms that there exists a statistically significant relationship between Indian tobacco export demand, domestic production, export price, and world demand for Indian tobacco. The geographical shift was evident in major export destinations during the post-WHO-FCTC (Framework Convention on Tobacco Control) regime. The model findings direct that India should take advantage of the export price, and global demand for tobacco, as India ratified WHO-FCTC; there is no scope for horizontal expansion of the area under tobacco. This modeling framework aids as a tool to direct and explore the possible options with a greater emphasis on **export-centric farming system in tobacco production** by augmenting crop compliance and quality to meet the standards of international markets. Thus, India needs to promote an export-led production strategy in tobacco to capitalize on the international markets, explore new strategic markets to consolidate tobacco exports at the global level, and augment foreign exchange revenue to the Indian economy.

Impact of the technology

This econometric modeling framework will provide policy inputs in crafting production policies for the export-centric farming system and formulating agricultural export policies/strategies to focus on crop compliance, product integrity, exploring strategic and quality-conscious export markets, and crop diversification strategies to avert possible adverse impacts of tobacco production on public health and the environment.

Publications/commercialization

- Research article titled "Empirical Analysis of Tobacco Exports in the Milieu of Changing Global and National Policy Regimes: Repercussions on the Indian Tobacco Sector"accepted in Frontiers in Environmental Economics, December 2023.

Investigators/Developers

K. Viswanatha Reddy, M. Sheshu Madhav, T. Kingsly Immanuelraj and R.Sendhil

Name of the technology : **Impact of tobacco crop holiday on the socio economics of farm labour in the FCV tobacco growing areas of A.P.**

Year (s) of development : 2001-2003

Technology details

The Tobacco Board under the Ministry of Commerce, GoI, declared a crop holiday for FCV tobacco cultivation in Andhra Pradesh for the year 2000-01. As the FCV tobacco cultivation is highly labour intensive, studied the impact of tobacco crop holiday on socio economics of labour engaged in tobacco cultivation. The ratio of women to men engaged in FCV tobacco cultivation is 4:1, and 10:1 in FCV tobacco nursery management. In general agriculture, the ratio of women to men is 10:9.

There was a substantial reduction (ranging from 45 to 110) in the number of working man-days during the year of the crop holiday. The suspension of most of the tobacco related trade activities further contributed to the loss in working man-days. It was found that the family income dropped substantially (20-41 %) during the year of crop holiday. The economic loss to the labour associated with FCV tobacco due to crop holiday is estimated to be Rs. 71.52 crores. As a result, the expenditure on health care, children's education and clothing was reduced in the labour families in all the FCV tobacco zones

Further, migration was increased to urban areas in the SLS and SBS zones of the Andhra Pradesh. The study clearly indicated that the tobacco crop holiday had an adverse impact on the socio-economic conditions of the labour and their families through reduction in working man-days, reduction in on-farm employment, reduction in family income, increase in debts, migration of families to urban areas and increase in malnutrition in the FCV tobacco growing areas of A.P.

Impact of the technology

In view of the hardships faced by the labour during the year of crop holiday, recommended not to resort to such measures in future and as such not adopted later in FCV tobacco.

Publications/commercialization

- Y. Subbaiah, P. Harishu Kumar and K.Deo Singh. 2003. Socio-economic impact of FCV tobacco in Andhra Pradesh- a Study by CTRI. Booklet, pp. 48.

Investigators/Developers

Y. Subbaiah, P. Harishu Kumar and K.Deo Singh

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