Agrotechnology
ISSN: 2168-9881

Sarala et al., Agrotechnol 2013, 2:3
DOI: 10.4172/2168-9881.1000113

Review Article Open Access

Tobacco Research in India: Trends and Developments

Sarala K*, Murthy TGK, Prabhakara Rao K and Ravisankar H

Division of Crop Improvement, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh, India

Abstract

Tobacco is a leading commercial crop valued for its leaf containing several important phyto-chemicals including nicotine. Conventionally, tobacco is used in the manufacture of cigarettes, bidis, scented chewing mixtures, cigars, cheroots, zarda, hookah, hookah tobacco paste, snuff, gutka, quiwam etc. Tobacco research in India, aimed at improving tobacco plant for higher leaf biomass with desirable leaf quality suitable for its conventional uses of smoking, chewing and snuffing. As a result of sustained research efforts, the productivity potential of tobacco increased to 3.0 t/ha in FCV and 4.0 t/ha in non-FCV with commensurate leaf quality so as to meet trade preferences. In view of the perceived health hazards associated with the traditional form of tobacco consumption, research efforts are intensified towards exploiting tobacco for its non-conventional and economically viable alternative uses.

The research work done in this direction brought out tremendous scope for exploiting the crop for extraction of many valuable phytochemicals. Tobacco is an excellent source of phytochemicals viz. nicotine, solanesol, seed oil, edible proteins (green leaf) and organic acids (malic and citric) having pharmaceutical, agricultural and industrial uses. Realizing the potential of tobacco for its alternative uses, research priorities are fine tuned towards increasing the seed/seed oil content and concentration of various phytochemicals in the tobacco plant, development of efficient methods for the extraction of phyto-chemicals, studying the suitability of seed oil for human consumption etc. Tobacco plants can also be used for molecular farming of important biomolecules viz., antibiotics, vaccines, cancer treating, other medicines, blood substitutes, biodegradable plastics, industrial enzymes and solvents through genetic engineering.

Developing economically viable and eco-friendly agro-technologies for enhancing productivity & quality, reducing harmful substances and developing value-added products from tobacco are the key issues, requiring innovative scientific interventions. In view of the apprehensions about tobacco use, there is a need to exploit the tobacco crop for alternative uses through policy initiatives, re-orientation of research efforts and forging effective collaboration with the industry.

Keywords: Tobacco; Research; Alternative uses; R&D approaches

Introduction

Tobacco (*Nicotiana tabacum* L.) is a leading commercial crop valued for its leaf containing several important phyto-chemicals including nicotine. Botanically, tobacco belongs to the genus *Nicotiana*, which is one of the five major genera of the family *Solanaceae, Nicotiana tabacum* and *Nicotiana rustica* being the two commercially cultivated species. Conventionally, tobacco is used in the manufacture of cigarettes, bidis, scented chewing mixtures, cigars, cheroots, zarda, hookah, hookah tobacco paste, snuff, gutka and quiwam. Some of the unique features of tobacco plant are: grows even on soils unsuitable for other crops; withstands vagaries of the weather; less prone to attack by insect-pests; excellent model for biological research and a valuable source of many phyto-chemicals with agricultural and industrial applications beneficial to the mankind.

In India, tobacco is an important commercial crop fetching more than Rs. 4,400 crores of foreign exchange and generates over Rs 14,000 crores excise revenue to the exchequer, besides giving direct or indirect livelihood to nearly 34 million people. India occupies 2nd place in tobacco production (750 M kg) after China (2350 M kg) and 2nd in Exports (260 M kg) after Brazil (730 M kg). Indian tobacco has an edge over the leading tobacco producing countries in terms of availability of different styles produced with relatively low production costs. Some of the positive and significant features of Indian tobacco are the lower levels of heavy metals, Tobacco Specific Nitrosamines (TSNAs) and pesticide residues compared to other tobacco producing countries. Thus, the situation presents a significant opportunity for the Indian tobacco industry to expand and consolidate its position in the world market.

Structural organization of tobacco research in India

Research on tobacco improvement in India was initiated by the Howards at Pusa as early as 1906, and later continued at the Indian Agricultural Research Institute (IARI). Subsequently, breeding work was started in several states of India. Tobacco processing and export companies were active in introducing and trying different foreign types from time to time. However, no comprehensive and coordinated programme of improvement was started until after the formation of the Indian Central Tobacco Committee in 1945. Subsequently with the establishment of Central Tobacco Research Institute, at Rajahmundry during 1947 and AICRP (Tobacco) in 1970, research efforts on various types of tobacco grown in India were intensified [1]. Seven tobacco research stations/centers' were established under CTRI at Guntur (for FCV, Natu and HDBRG), Kandukur (for FCV), Jeelugumilli (for FCV and Irrigated Natu) and Jeddangi (for White Burley) in Andhra Pradesh, Vedasandur (for Chewing, Cheroot, Cigar Filler and Cigar Wrapper) in Tamil Nadu, Hunsur (for FCV) in Karnataka and Dinhata

***Corresponding author:** Sarala K, Division of Crop Improvement, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh, India, Tel: 0883-2449871, E-mail: ksarala@rediffmail.com

Received June 20, 2013; **Accepted** September 26, 2013; **Published** October 03, 2013

Citation: Sarala K, Murthy TGK, Prabhakara Rao K, Ravisankar H (2013) Tobacco Research in India: Trends and Developments. Agrotechnol 2: 113. doi:10.4172/2168-9881.1000113

(for Chewing, Hookah, Cigar filler and Cigar wrapper) in West Bengal for conducting research on different types of tobaccos. In addition, All India Network Research Project on Tobacco (AINRPT) with its head quarters at Rajahmundry is coordinating research on different types of tobaccos. AINRPT is having four main centres (Rajahmundry, Shimoga Anand and Pusa), seven sub-centres (Guntur, Hunsur, Dinhata, Araul, Berhampur, Nipani, and Nandyal) and four valuntary (Kandukur, Jeelugumilli, Vedasandur and Ladol). CTRI and AINRPT Stations/Centres are catering to the requirements of the tobacco farmers in different agro-climatic zones by developing improved varieties and crop production technologies. Research at CTRI, its Research Stations and AINRPT Centres is being pursued with the vision, "Enhancing productivity and quality of Indian tobacco to make it more remunerative, globally competitive and promoting alternative uses to sustain the crop in the country. Identification, demonstration and popularization of alternative crops/cropping systems to tobacco in different zones in the country to release more area for cultivation of food crops, pulses and oil seeds".

Research perspectives in tobacco

Tobacco research, in India, earlier used to be in the direction of improving tobacco plant for higher leaf biomass with desirable leaf quality suitable for its conventional uses of smoking, chewing and snuffing. Conventional tobacco research aimed at the development of improved varieties suitable for conventional tobacco uses, improving the input use efficiency, development of plant protection measures, improved post harvest management practices etc. Sustained research and developmental effort of tobacco scientists have resulted in evolving high yielding varieties and appropriate agro-technologies, which made a significant impact on tobacco production, marketing and export earnings. As a result of sustained research efforts, the productivity potential of tobacco increased to 3.0 t/ha in FCV and 4.0 t/ha in non-FCV with commensurate leaf quality so as to meet trade preferences. As a result of adoption of high yielding varieties and proven production and protection technologies, there has been quantum jump in average productivity levels in FCV tobacco and non-FCV tobacco types in different tobacco growing areas. The average productivity of tobacco in India, steadily increased to around 1,600 kg/ha for FCV and 2,000 kg/ha for non-FCV Tobacco.

Prioritization and thrust areas in Tobacco research

In addition to improving the yield of tobacco by the development of high yielding and pest resistant varieties, efforts initiated to develop hybrid tobacco, low tar and Tobacco Specific Nitrosamines, Mechanization of tobacco cultivation and to develop energy saving technologies.

Development of Hybrid tobaccos

As the productivity levels of Indian cultivars are more or less plateau and land requirement for other important crops is increasing, there is a need for breaking the yield barriers so as to release the land for cultivation of other important crops. Development of hybrids in different tobacco types can address this problem especially for breaking yield barriers and combining the higher productivity with high leaf quality. Research efforts resulted in the development and release of two Bidi hybrids, GTH-1 and MR GTH-1 (Mosaic resistance) and a chewing hybrid, Kamatchi. In addition, two FCV tobacco hybrids (CH-1 and CH-3) were identified for released.

Reduction of harmful substances

Smoke tar (nicotine free total particulate matter), carbon monoxide and tobacco specific nitrosamines (TSNA) are the chemical substances responsible for tobacco related health problems. In view of this, reducing these substances in the cultivated varieties is essential for the production of safer tobacco. Reduction of TSNA (<1 ppm) in burley tobacco and smoke tar (<12 mg/cigarette) in FCV tobacco are important breeding objectives. Research at CTRI and its research stations resulted in the development of low tar advanced FCV breeding lines viz., JS-117, JS-78 and JS-62 and low TSNA burley line, 324C. Low tar line, JS-117 and low tar hybrid, NLSH-1 are in the pre-release evaluation stage.

Increasing input use efficiency

For saving the inputs and labor, tray seedlings technology, sprinkler irrigation, drip irrigation, tractor mounted ridger cum blade, bale pressing unit, stubble remover etc were developed. Use of agri-wastes for briquettes and various barn modification techniques were developed for saving energy during flue-curing of FCV tobacco.

Production of higher levels of phytochemicals

The work done so far has brought out the tremendous scope for exploiting the crop for extraction of many valuable phytochemicals of pharmaceutical and industrial importance [2-6]. Tobacco crop can be cultivated for the production of the following valuable phytochemicals (Table 1).

Realizing the potential of tobacco for its alternative uses, research priorities at CTRI are fine tuned towards increasing the seed/seed oil content and concentration of various phytochemicals in the tobacco plant, development of efficient methods for the extraction of phytochemicals, studying the suitability of seed oil for human consumption etc.

Nicotine: Nicotine ($C_{10}H_{14}N_2$) is the principal alkaloid synthesised in roots and accumulated in the leaf. Nicotine is known for its insecticidal property in the form of 40% Nicotine sulphate. Further, tobacco decoction is used for controlling several pests in cereals and vegetables in many countries. In recent years, pure nicotine has gained

Phytochemical	Product (s)	Use (s)
Nicotine	40% Nicotine sulphate	Botanical pesticide
	Pure nicotine	Drugs/Tobacco cessation products
Solanesol	Coenzyme Q9 Coenzyme Q10	Cardiac drug
	Vitamin K	Anti-haemorrhagic vitamin
	Vitamin E	Anti-sterility vitamin
Organic acids	Crude organic acid fraction	Solubilisation of Rock phosphate
	Malic acid	Foods & Beverages
	Citric acid	Foods & Beverages
Proteins (Green leaf)	Crude protein	Feed supplement
Seed oil	Crude oil	Paint and soap industry
	Refined oil	Edible oil

Table 1: Valuable phytochemicals produced in tobacco, their products and uses.

Tobacco type	Type of curing	Nicotine (%)
Burley	Air-curing	0.5-1.0
FCV	Flue-curing	2-3
Lanka/Natu	Sun-curing	3-4
Hookah/chewing	Air curing	4-6
Bidi	Sun-curing	6-10

Table 2: Nicotine content of different tobacco types.

importance for its use in Tobacco Cessation Products (TCP) like, chewing gum, nicotine patches, nicorette tablets and in the preparation of drugs and pharmaceuticals. Recent scientific evidence suggests that nicotine and nicotine like compounds may slow down or ameliorate the symptoms of certain diseases like Tourette's syndrome, Alzheimer's disease, Parkinson's disease, Ulcerative Colitis and Attention Deficit Disorder (ADD). Nicotine is also a raw material for making nicotinic acid, nicotinamide and nikethamide [3].

CTRI has developed an Ion Exchange process for extraction of pure nicotine. Nicotine content among different tobacco types found to vary from 0.5-10% (Table 2). Molecular mapping studies for identifying molecular markers and traits linked to nicotine is in progress. This will helps to develop and identify high nicotine lines for increasing the nicotine production.

Solanesol: Solanesol ($C_{45}H_{74}O$), a tri-terpene alcohol, is an ubiquitous compound present in plant kingdom, is a major component of tobacco and ranges from traces to 4.7%. Solanesol has gained importance because of its value as a source of isoprene units for the synthesis of metabolically active quinones, vitamin K analogs, vitamin E, coenzyme Q9 (CoQ9) and coenzyme Q10 (CoQ10) [7]. Research findings have also indicated that pure solanesol can be directly used as a clinical drug, the main clinical uses being: anti-heart failure, treatment of liver injury, as well as an adjuvant in cancer therapy. Recent reports have focused on the importance of solanesol in the development of novel hybrid natural products as anti-diabetic agents and wound-healing agents [8].

Research work done at CTRI helped to identify high solanesol yielding tobacco lines. Chewing tobacco variety, Abirami and HDBRG tobacco were found to higher solanesol content (2.0-3.5%). CTRI got a patent for the process of extraction of Solanesol of 95% purity. A number of solanesol derivatives viz., O- alkylated xanthone, carbazoles and coumarins have been synthesized and screened for their *in vitro* anti-diabetic activity as glucose-6- phosphatase, glycogen phosphorylase and alpha glucosidase inhibitors and compounds showing significant inhibition were identified. The work on molecular mapping of solanesol trait is in progress and this studies help to identify molecular markers/traits linked to solanesol. This information helps to develop and identify high solanesol yielding lines.

Organic acids: Tobacco leaf contains malic acid (4.0-4.5%) and citric acid (0.5-2.0%). These acids can be extracted from leaf and can be used for solubilisation of Rock phosphate and as foods and beverages.

Fraction-1 protein: It is the most abundant protein in tobacco and constitutes about 50% of soluble protein and 25% of total protein. This can be used for manufacturing emulsifiers and high dietary supplement.

Seed oil: Tobacco plant is a prolific producer and the tiny tobacco seed contains 35 per cent oil. The refined tobacco seed oil has already been in use as edible oil in countries like Bulgaria, Turkey, Tunisia and Greece. In India, however, the tobacco seed oil is not being used for edible purpose but finds extensive use in paints, varnishes, lubricants and soap industries.

High seed-yielding varieties (A-145, a chewing tobacco variety) and hybrids (A-145xGT7, TI-163xHDBRG and A-119xAbirami) with a potential yield of more than 2,000 kg seed/ha have been identified at CTRI for seed oil purpose (Table 3). Tobacco seed oil content found to vary from 20 to 40% in tobacco germplasm accessions of various tobacco types. Also, agronomic packages have been developed for maximizing the seed and oil yields.

Cultivar/Hybrid	Seed yield potential (kg/ha)
A-145 (cv.)	1,100
A-145×GT7 (Hybrid)	2,000
A119×Abirami (Hybrid)	2,213
TI-163×HDBRG (Hybrid)	2,514

Table 3: High seed yielding cultivars/hybrids developed at CTRI.

Parameter	Tobacco Seed oil	Sunflower oil	Groundnut oil
Refractive index	1.47	1.47	1.47
Relative viscosity (kg/m^2)	1.27	1.00	1.20
Specific gravity (g/cc)	1.18	1.02	1.03
Iodine number (mg/g)	132	128	97
Saponification value (mg/g)	190	189	168
Acid value (mg KOH/g)	3.52	3.46	3.24
Peroxide value (meq/kg)	5.04	3.98	2.98
Free oleic acid (%)	2.3		
Colour (Lovibond Tintometer	6		
Fatty acid profile			
Palmitic (C16:0)	15.2		13.0
Stearic (C18:0)	4.8		3.0
Oleic (C18:1)	13.2		55.0
Linoleic (C18:2)	66.7		25.0
Linolenic (C18:3)	-		1.0
Arachidonic (C20:3)	-		1.0
PUFA level	66.7		26.0

Table 4: Quality characteristics of tobacco seed oil vis-a-vis common edible oils.

Compounds	Uses
Fraction-II Protein	Industrial enzyme production
Bacterial Lysozyme	Preservative, Anti-bacterial agent
Phyto-sterols	Production of steroids
Protease inhibitors	Anti-carcinogens
Coenzyme Q10	Treatment of heart disease
Carotenoids and Anti-oxidant pigments	Production of colourants & dyes
Diterpenoids	Flavours & Fragrances
Sucrose esters	Insecticides

Table 5: Various bio-molecules produced in tobacco plant and their uses.

Tobacco oil found to be rich in linoleic acid and have high PUFA value and 1.5% W-3-fatty acid (an essential fatty acid). Chemical quality of the oil is comparable to safflower oil and is superior to groundnut oil (Table 4). The peroxide value increased from 8.24 to 84.24 me peroxide/kg within 90 days from the date of extraction whereas it varied from 6.24 to 50.12 me peroxide/kg within 90 days in sunflower oil. The highest recovery of tobacco seed oil (44%) was achieved by crushing the seed with prototype expeller followed by solvent extraction. Efforts are on for the characterization, pre-clinical toxicological and efficacy evaluation of tobacco seed oil for human consumption.

Other phytochemicals: In addition to above compounds, tobacco is a source of number of other compounds having various medicinal and industrial uses as given in the Table 5 below.

Bio-engineered products

Researchers and bioengineering entrepreneurs have begun to use tobacco plants as hosts for bioengineering processes that could be used to produce new antibiotics, vaccines, cancer treatments, other medicines, blood substitutes and biodegradable plastics and industrial enzymes and solvents. Similarly, other researchers are exploring the possibility of using genetically engineered tobacco plants that could

S. No.	Challenge	R & D approaches
1.	Sustained anti-tobacco campaign in view of the associated health hazards	Lowering TSNA and tar contents in tobacco leaf through genetic and agronomical manipulations.
2.	The non-price, price and tax measures envisaged by FCTC to reduce the supply and demand for tobacco in the world	Identifying and popularizing suitable alternative cropping systems to tobacco crop with emphasis on non-FCV tobaccos for different tobacco growing regions.
3.	Increase in cost of production due to escalation in input costs and labour wages	▪ Improving the leaf yield potential of tobacco to 4.0 t/ha in FCV and 4.5 t/ha in case of non-FCV tobacco. ▪ Incorporating resistance to TMV, Damping-off, Black shank, Brown spot, Hollow stalk, Fusarium wilt. ▪ Development of agro-technologies for increase in N, K & water use efficiency.
4.	Lack of energy and labour saving devices in tobacco cultivation	Mechanization of tobacco production including seedling production, planting, stitching, unloading, field operations, barn technology, seed processing and delivery, for manpower saving
5.	Emerging multinutrient deficiencies scenario in different tobacco procution zones	Development of eco-smart soil fertility management strategies using customized and farm specific fertilizers and fertilisation
6.	Low input use efficiency and depletion of soil organic matter due to continuous cultivation	Improving in-put use efficiency (water & nutrient) and supplementing organic matter to soil through other organic sources
7.	Issue of deforestation due to fire-wood used in tobacco curing and shortage of coal for curing tobacco	Scaling up of use of alternative fuel materials in place of firewood & coal, further improvement of curing technology and use of solar energy for improving the fuel efficiency.
8.	Vagaries of weather/climate change	Development of climate resilient interventions for management of biotic and abiotic stresses
9.	Low proportion of flavourful tobacco available for export	▪ Developing high yielding tobacco varieties with superior quality and flavour. ▪ Identification of new areas for the cultivation of flavourful tobaccos

Table 6: R&D approaches for addressing the various challenges faced in tobacco cultivation.

clean up contaminated areas around weapons factories and munitions dumps just by being grown in the contaminated dirt. Tobacco plants are ideal for these biotechnology procedures because tobacco is leafy, readily accepts the procedures, grows quickly, relatively easy to harvest and yields millions of new seeds per plant [9].

Constraints and R&D Approaches in Tobacco Crop

In the recent years, the crop is facing various challenges viz., sustained anti-tobacco campaign in view of the associated health hazards, Increase in cost of production due to escalation in input costs and labour wages, lack of energy and labour saving devices in tobacco cultivation, issue of deforestation due to fire-wood used in tobacco curing and shortage of coal for curing tobacco, vagaries of weather, lack of organized marketing system for non-FCV tobacco similar to the system in vogue for FCV tobacco etc. The Framework Convention on Tobacco Control (FCTC) has added a new dimension to the complex nature of the crop. The treaty envisages non-price, price and tax measures to reduce the supply and demand for tobacco in the world. India being a signatory to the FCTC treaty, it is imperative that by 2020 AD, the area under tobacco cultivation ought to be reduced substantially. These issues are posing a serious challenge to tobacco production, commerce and industry.

In this background, the R&D approaches for addressing the above challenges are given in the Table 6 below.

Since the economic life-line of millions of people world-over depends on tobacco, the crop needs to be sustained by taking advantage of its potential for alternative uses. To convert this threat into an opportunity and to sustain the crop, research efforts need to be intensified towards channelizing tobacco into non-conventional and economically viable alternative uses. As tobacco generates considerable volumes of biomass per unit area and can acts as a biological factory for production various valuable phytochemicals, breeding tobacco cultivars with increased levels of these bio-molecules constitute an important research objective.

Conclusion

Developing economically viable and eco-friendly agro-technologies for enhancing productivity & quality, reducing harmful substances and developing value-added products from tobacco are the key issues, requiring innovative scientific interventions. Tobacco plants can be used for molecular farming of important biomolecules viz., antibiotics, vaccines, cancer treating, other medicines, blood substitutes, biodegradable plastics, industrial enzymes and solvents through genetic engineering. Genetically engineered tobacco plants are also being explored for cleaning up soils contaminated around weapons factories and munitions dumps.

In view of the apprehensions about tobacco use, there is a need to exploit the tobacco crop for alternative uses through policy initiatives, re-orientation of research efforts and forging effective collaboration with the industry.

References

1. Narayanan AI, Murthy TGK, Sarala K, Rao RVS, Venugopala Rao PV (2003) Division of crop improvement. Central Tobacco Research Institute, Rajahmundry, India.
2. Chakraborty MK, Patel BK, Tewari MN, Patel JA, Patel HD (1982) Alternative use of tobacco Raw material for agro-based industry. Indian Tobacco Journal 14: 9-16.
3. Chida AS, Vani PVSN, Singh AK (2005) Tobacco phytochemicals: Alternative Uses of Tobacco (Eds), Deo Singh K and Jain KC (Eds.) Central Tobacco Research Institute (ICAR), Rajahmundry, India 1-15.
4. Narasimha Rao CV, Prabhu SR (2005) Solanesol: Alternative Uses of Tobacco (Eds) Deo Singh K and Jain KC), Central Tobacco Research Institute, Rajahmundry, India. 16-25.
5. Narasimha Rao CV, Krishnamurthy V (2007) Tobacco plant: A source of pharmaceutical and industrial products. Invention Intelligence 3-12.
6. Patel JA, Patel BK, Chakraborty MK (1998) Production potential and quality aspects of tobacco seed oil. Tobacco Research 24: 44-49.
7. Colowick SP, Kaplan NO (1975) Ubiquinone group. In Methods in Enzymology Vol 18C, (Eds), Academic Press, New York, USA 137-232.
8. Srivatsava S, Kanwal Raj P, Khare AP, Bhaduri R, Chander et al. (2009) Novel hybrid natural products derived from solanesol as wound healing agents. Indian Journal of Chemistry 48: 1-12.
9. Rao SV, Narasimha Rao CV, Deo Singh K (2005) Bioengineered products from tobacco: Alternative Uses of Tobacco. Deo Singh K and Jain KC (Eds). Central Tobacco Research Institute, Rajahmundry, India 116-134.