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Case Study

YIELD GAINS IN INDIAN FLUE-CURED VIRGINIA TOBACCO: A CASE STUDY

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Abstract- Tobacco is an important export oriented commercial crop being cultivated over the years in India. A study was conducted to assess the rate of improvement with respect to area, production and productivity in major tobacco types i.e. FCV (Flue Cured Virginia) and non-FCV along with the total tobacco grown in India. The results indicated that total tobacco cultivated area in India remained more or less constant with increase in production and productivity. There is an increase in the FCV tobacco area and reduction in non-FCV area over the years without any substantial improvement in total tobacco area. FCV tobacco recorded higher rate of increase in production compared to non-FCV and vice versa in productivity. Further, except in NBS/CBS zone, improvement was witnessed in the area and production among the different FCV tobacco zones whereas productivity Improvement is there in all the areas. Productivity improvement in all the FCV areas clearly indicates the positive impact of technological interventions of research like improved varieties and cultural practices on increase of per hectare yields. With the advent of these, leaf yield potential in the FCV cultivars reached to 3000 kg/ha. Estimates of projected yield in FCV, non FCV and total tobaccos were made based on the existing rates of improvement by the year 2025. Nevertheless, the study indicated a wide scope to improve the productivity and realize leaf yield potential in SLS and KLS areas

Keywords- FCV tobacco, Crop, Research impact, Yield, Rate of improvement

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Introduction

In India, tobacco is an important commercial crop fetching more than Rs. 6,059 crores of foreign exchange and generates over Rs 19,890 crores excise revenue to the exchequer, besides giving direct or indirect livelihood to nearly 36 million people. Due to the prevalence of varied agro-climatic conditions such as fertile soils, rainfall and ample sunshine, ten different tobacco types *viz*., Flue-cured Virginia (FCV), Burley, Oriental, Cigar, Hookah, Chewing, *Bidi*, *Natu*, HDBRG and *Lanka* are cultivated in India. Among the ten types, FCV tobacco is the major one with high export potential and grown mainly in the states of Andhra Pradesh and Karnataka. FCV tobacco is being cultivated in six agro-climatic zones namely Northern black soils (NBS), Central black soils (CBS), Southern black soils (SBS), Northern light soils (NLS) and Southern light soils (SLS) in Andhra Pradesh and Karnataka light soils (KLS) in Karnataka. All the other types of tobaccos collectively constitutes non-FCV.

In India, various public and private organizations are involved in conducting research on FCV tobacco [1]. In public sector, ICAR-Central Tobacco Research Institute (CTRI), Rajahmundry and its Regional Stations at Guntur, Kandukur, Jeelugumilli and Hunsur are catering to the requirements of FCV tobacco farmers in different agro-climatic zones by developing improved varieties and crop production technologies. The All India Network Project on Tobacco (AINPT) with its headquarters at ICAR-CTRI, Rajahmundry coordinates research on FCV tobaccos with its AINPT centres located at Rajahmundry, Guntur, Kandukur, Jeelugumilli, Hunsur and Shimoga. Among the private firms, M/s ITC Pvt. Ltd. with its comprehensive R&D facilities carries out research on different aspects of tobacco crop cultivation. Research effort of these agencies for the past 70 years resulted in release of around 94 tobacco varieties for commercial cultivation. Further, suitable agro-technologies and plant protection measures were recommended for optimizing the yields of these varieties under on-farm situation. As a result, there is a steady improvement in FCV tobacco leaf yields over the years in both the states.

In the present study, an effort was made to quantify the yield gain due to technological innovations in non- FCV, FCV tobacco and total tobacco grown in India. This information is essential for formulating future tobacco research and developmental strategies for tobacco crop grown in various areas

Materials and Methods

Data collection: Data on tobacco production statistics and yields of tobacco cultivars are collected from different sources *viz.,* ICAR-Central Tobacco Research Institute, Rajahmundry; Tobacco Board, Guntur; Directorate of Economics and Statistics [2], New Delhi etc. The data on total tobacco and FCV tobacco is available from 1950 onwards, whereas zones wise FCV tobacco data is available from 1985 onwards. The data also collected from the DACNET and FAO web sources [3, 4].

Impact of Research on yields: Impact of research on Flue-cured Virginia tobacco crop yields in India was studied by collecting the data on area, production and productivity of Indian tobacco, Indian FCV tobacco, Indian non-FCV tobacco

and FCV tobacco grown in various zones during 1985-2013 and inferences were drawn accordingly. Regression of yield data against years was used to calculate the rate of yield improvement/ yield gain and comparisons/conclusions were made. Improvement in productivity over years and its rate were the criteria followed for studying the effect of research on yield. The trends in area and production in total tobacco and FCV tobacco were also studied from 1950-2013 by plotting the five years average values during the period (during the crop holiday year, average of four years was taken) against the years and individual year values for productivity.

Yield potential Improvement in FCV cultivars: Yield potential Improvement in the FCV cultivars was studied from mid-1980s onwards by considering the cured leaf yield potential of high yielding popular varieties in various tobacco growing areas *viz.*, black soils/SLS and NLS areas of Andhra Pradesh and KLS of Karnataka. However, Varieties released for special purposes and less popular ones are not considered.

Realized yield potential at farm level: In view of its exportability, the yield potential realized at farm level were estimated. The average farm yields of last five years (2008-13) of different FCV tobacco growing zones were calculated. These average farm yields and the potential yields of popular varieties grown in that area were used in estimating the percent yield potential realized at farm level.

Forecasting of tobacco productivity improvement: Leaf yield productivities of Indian tobacco and FCV tobacco grown in different areas were predicted for the year 2020 and 2025 using regression equations used for calculating the rate of yield improvements as mentioned earlier

Results and Discussion

Yield improvement in any crop can be attained by cultivating high yielding varieties with suitable package of practices that optimize the expression of yield potential. Around 94 varieties/ hybrids were released for commercial cultivation in India along with suitable production packages for maximizing the yields. Simultaneously, integrated pest management strategies recommended for major pests and diseases of tobacco, both for nursery and main field, for stabilizing yields. In general, the varietal impact can be visualized at field level in three to four years after release based on their field spread. Considering these aspects, the contribution of tobacco research in increasing the total, FCV and non-FCV tobacco yields at different zones over the years during 1985-2013 was discussed below.

Impact of Research on Flue-Cured Virginia Tobacco Crop Yields in India

The rate of improvement in area, production and productivity during 1985-2013 was calculated for Indian tobacco along with the non-FCV and FCV tobacco grown in various zones [Tables-1-2] and suitably compared for drawing inferences. As it denotes there is an increase in the FCV tobacco area and reduction in non-FCV area over the years without any substantial improvement in total tobacco area. It is evident from the data that the rate of increase in total tobacco area is 1303 ha/yr (non-linear) and FCV tobacco area is 4991 ha/yr [Table-1]; [Fig-1 & 2]. However, Non-FCV tobacco showed reduction in tobacco area to the tune of 3689 ha/yr. The rate of increase in Indian total tobacco production is slightly higher (8774 t/yr) compared to FCV tobacco (8198 t/yr) [Table-1]; [Fig-1 & 2] and non-FCV recorded lowest production gain (439 t/yr). This clearly indicates the increase in total tobacco production is mainly due to gain in FCV tobacco production. On the other side, In productivity, non-FCV recorded higher improvement (27 kg/ha/yr) than total India tobacco (16 kg/ha/yr) and FCV (17 kg/ha/yr) [Table-1]; [Fig-1 & 2]. This higher rate of productivity supported the corresponding increase in production irrespective of depleting in non-FCV tobacco area. Interestingly, the rate of improvement in FCV area of Karnataka (3649 ha/yr) is nearly double than that of Andhra Pradesh (1889 ha/yr) [Table-2]. While in Andhra Pradesh, SLS area recorded higher rate (1849 ha/yr) followed by NLS (683 ha/yr) and SBS (572 ha/yr) areas [Table-2]. There was a dramatic decline in NBS/CBS tobacco area (1215 ha/yr) during the period under study. This might be due to the varied international market demand for KLS tobacco in view of its high filling value coupled with easy blending nature, NLS tobacco for its semi-flavourful to flavourful nature and domestic demand for SLS.

Table-1 *Trends in tobacco area, production and yield in India (1985-2013)*

S. No.	Growing region	Regression Equation		
		Area (000' ha)	Production (000' tonnes)	Yield (kg/ha)
1	Indian Tobacco	y = 1.3027x + 380.4 R² = 0.0381	y = 8.7739x + 448.49 R² = 0.3281	y = 16.21x + 1198.4 R² = 0.6501
2	India FCV Tobacco	y = 4.9914x + 87.856 R² = 0.618	y = 8.1984x + 62.389 R² = 0.7437	y = 17.178x + 845.84 R² = 0.6866
3	India Non-FCV Tobacco	y = -3.6888x + 292.54 R² = 0.3572	y = 0.4393x + 388.74 R² = 0.0015	y = 26.77x + 1281.6 R² = 0.5582

Table-2 *Trends in FCV tobacco area, production and yield in major FCV tobacco growing states of India (1985-2013)*

S. No.	Growing region	Regression Equation		
		Area (000' ha)	Production (000' tonnes)	Yield (kg/ha)
1	Karnataka Tobacco	y = 3.6488x – 0.316 R² = 0.9149	y = 4.2046x - 5.3487 R² = 0.8975	y = 11.246x + 845.76 R² = 0.3187
2	A P Tobacco	y = 1.8893x + 82.394 R² = 0.4587	y = 4.5747x + 63.879 R² = 0.7724	y = 22.338x + 841.59 R² = 0.7461
3	NLS Tobacco	y = 0.6831x + 9.3686 R² = 0.8428	y = 1.8859x + 4.5814 R² = 0.9292	y = 41.875x + 971.64 R² = 0.7169
4	SLS Tobacco	y = 1.8493x + 19.538 R² = 0.798	y = 2.0919x + 8.4513 R² = 0.8376	y = 12.087x + 634.85 R² = 0.4327
5	SBS Tobacco	y = 0.5722x + 20.545 R² = 0.4943	y = 1.8294x + 14.225 R² = 0.8704	y = 39.834x + 798.43 R² = 0.7733
6	NBS/CBS Tobacco	y = -1.2154x + 32.942 R² = 0.7281	y = -1.2326x + 36.622 R² = 0.6541	y = 22.895x + 1022.1 R² = 0.3366

In spite of lower improvement in area, Andhra Pradesh has witnessed higher rate of increase (4575 t/yr) in FCV tobacco production than Karnataka (4205 t/yr) due to high productivity. The rate of FCV production improvement in Andhra Pradesh and Karnataka is combinely (4575+4205=8780 t/yr) higher than all India FCV production indicating reduction in rest of the FCV areas. In Andhra Pradesh, SLS recorded higher rate (2092 t/yr) of increase in production followed by NLS (1886 t/yr) and SBS (1829 t/yr) areas. Substantial decline in the rate of tobacco production (1233 t/yr) was found in NBS/CBS region.

The rate of increase in FCV productivity is double in Andhra Pradesh (22 kg/ha/yr) compared to Karnataka (11 kg/ha/yr). In Andhra Pradesh, NLS area recorded

higher rate (42 kg/ha/yr) followed by SBS (40 kg/ha/yr), NBS/CBS (23 kg/ha/yr) and SLS (12 kg/ha/yr). Sarala *et. al.* [5] also estimated rate of gain in cured yield during 1953-98 in traditional black soils as 26 kg/ha of which 12 kg/ha is due to genetic improvement and rest due to production technology. These Improvements in productivity of various zones over years signify the positive impact of technological interventions like improved varieties and cultural practices on increase of per hectare yields. Further, differential impact in different areas observed may be due to the variability in agro-climatic conditions.

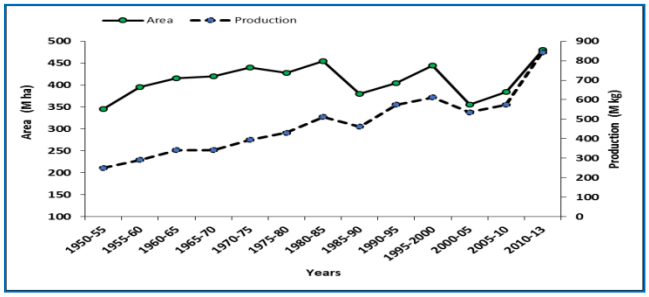

Fig-1 Trends in Area and Production of Tobacco in India (1950 to 2013)

Note: All the values used are five years average except for 2000-05, which covers crop holiday year

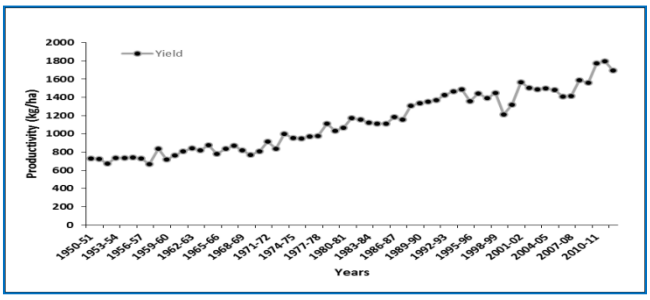

Fig-2 Productivity Improvement in Indian Tobacco(1950 to 2013)

To be more specific, the soil related constraints and erratic rain fall patterns in SLS and weather related factors in KLS may be attributed for lower productivity levels. Similarly, Evenson and Gollin [6] studied the productivity impacts of international crop genetic improvement research in developing countries. They concluded that in association with national research programs, international agricultural research centers have contributed to the development of "modern varieties" for many crops over the period (1960-2000). Though these varieties are instrumental for the large increases in crop production, productivity gains, however, have been uneven across crops and regions.

The above results clearly indicate that there is higher rate of increase in area and lower increase in production and productivity in Karnataka compared to AP. Though, the area increment is less than half in AP compared to Karnataka, double the gain in productivity resulted in the higher rate of production. However, In AP, SLS recorded higher rate of increase in area and production and lower rate in productivity compared to other zones. Among all the FCV areas, NLS found to be highly productive and KLS is low. Based on these, it is imperative that concerted research efforts to improve productivity in SLS and KLS areas are needed to achieve higher FCV production.

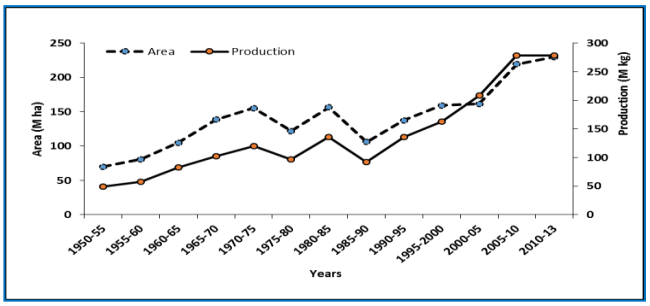

Fig-3 Trends in Area and Production of FCV Tobacco in India (1950 to 2013)

Note: All the values used are five years average except for 2000-05, which covers crop holiday year

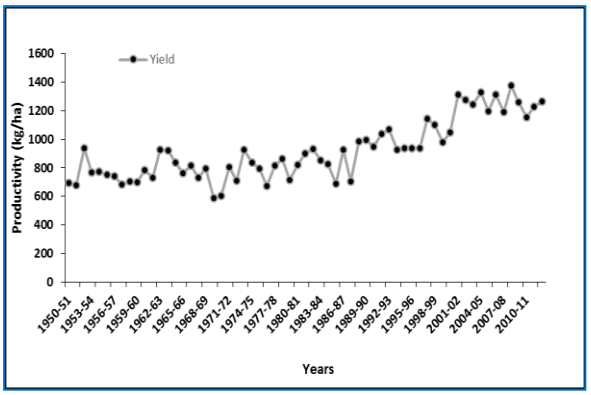

Fig-4 Productivity Improvement in Indian FCV Tobacco (1950 to 2013)

Yield Potential Improvement in FCV Cultivars

An estimate of yield potential Improvement in the FCV cultivars was carried out, from early-1980s onwards, based on the important varieties released in Andhra Pradesh and Karnataka [Table-3]. In black soils/SLS, yield potential improved from 1525 kg/ha (in Godavari Spl. variety released in 1982) to 2900 kg/ha (in Siri released in 2006). However, Siri found to give a maximum yield of around 2000 kg/ha under SLS. Yield potential in NLS gradually improved from Mc Nair-12 variety (1880 kg/ha) to CM-12(KA) (2000 kg/ha), Kanchan (2400 kg/ha) and CH-1 (2900 kg/ha). In KLS, yield potential improved from 1450 kg/ha in Swarna variety released in 1984 to 3000 kg/ha in FCH-222 released in 2012.

Table-3 *High Yielding Tobacco Varieties/Hybrids Released in India*

Variety/Hybrid	Year of release	Cured leaf yield (kg/ha)
Black soils of Andhra Pradesh and Southern Light Soils		
Godavari Spl.	1982	1525
Hema	1987	1800
Gauthami	1992	2000
VT-1158	1993	2000
Kanthi	2006	2000
Hemadri	2006	2300
Siri	2006	2900
Northern light Soils		
Mc Nair-12	1986	1880
CM-12(KA)	1993	2000
Kanchan	1998	2400
CH-1 (hybrid)	2015	2900
Karnataka Light Soils		
Swarna	1984	1450
Kanchan	1998	2000
Bhavya	1988	2000
Trupthi	1998	1800
Rathna	2001	2000
Sahyadri	2009	2000
FCH-222	2012	3000

Further, the trend line analysis of potential yield improvement in FCV tobacco varieties released in India [Fig-5] indicated that there is 48 kg/ha estimated annual improvement in yield from 1982 to 2012. In a similar study, Bowman *et al.* [7] observed an annual estimated yield increase of 49.5 Kg/ha for flue-cured tobacco from 1954 to 1981 in USA.

Realized yield potential at farm level

Yield potential of popular FCV tobacco varieties grown in various areas and average farm yields of last five years (2008-13) were used to estimate realized yield potential at farm level [Table-4]. It was evident from the analysis, highest yield potential realized in NLS area (83%) and lowest in SLS (49%). Whereas, around half the potential was realized in NBS/CBS (51%), SBS (58%) and KLS (54%) areas. The realization of highest potential in NLS is mainly due to

availability of irrigation and controlled cultural practices. Poor realization in SLS may be due to erratic rainfall, lack of irrigation facilities and low fertility. For realizing higher genetic potential of the varieties grown in these areas, there is a need to develop location specific climate resilient agro-technologies.

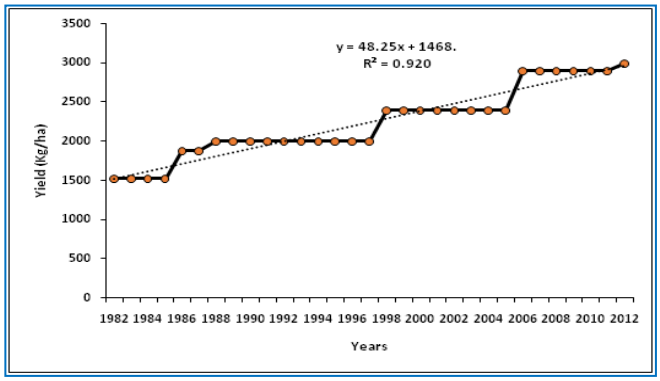

Fig-5 Yield Potential Improvement in FCV tobacco Varieties released in India

Similar observations were made by David *et al*. [8] in most of the major irrigated wheat, rice, and maize systems, yields appear to be at or near 80% of yield potential, with no evidence for yields having exceeded this threshold to date. A fundamental constraint in these systems appears to be uncertainty in growing season weather; thus, tools to address this uncertainty would likely reduce gaps. Otherwise, short-term prospects for yield gains in irrigated agriculture appear grim without increased yield potential. Average yields in rainfed systems are commonly 50% or less of yield potential, suggesting ample room for improvement, though estimation of yield gaps for rainfed regions is subject to more errors than for irrigated regions.

Forecasting of Tobacco Productivity Improvement

Leaf yield productivities of Indian tobacco and FCV tobacco grown in different areas were predicted for the year 2020 and 2025 using regression equations [Table-5]. With the current rate of improvement, the productivity of Indian tobaccos projected at 1742 kg/ha in 2020 and 1822 kg/ha in 2025, whereas FCV tobacco it is 1424 and 1509 kg/ha, and non-FCV 2200 and 2335 kg/ha, respectively. The predicted yield will be highest in Andhra Pradesh compared to Karnataka. In Andhra Pradesh, predicted productivity will be highest in NLS followed by SBS and SLS areas in the years 2020 and 2025.

Table-4 *Yield potential realized in various FCV tobacco growing zone*

S. No.	State	Tobacco growing zone	Popular varieties	Yield Potential of popular varieties* (kg/ha)	Average farm yields (2008-2013) (kg/ha)	Yield potential realized (%)
1.	Andhra Pradesh	NBS / CBS	Siri	2900	1468	51
		SLS	Siri	2000	975	49
		SBS	Siri	2900	1670	58
		NLS	Kanchan	2400	1984	83
2.	Karnataka	KLS	Kanchan	2000	1083	54

* Maximum yield potential realized by most popular variety in respective zones is considered

Table-5 *Predicted tobacco productivity Improvement by 2020 &2025*

S. No.	Growing region	Predicted leaf yield (kg/ha)	
		Year 2020	Year 2025
1	Indian Tobacco	1742	1822
2	India FCV Tobacco	1424	1509
3	India Non-FCV Tobacco	2200	2335
4	A P FCV Tobacco	1590	1700
5	Karnataka FCV Tobacco	1220	1275
6	NLS FCV Tobacco	2400	2610
7	SLS FCV Tobacco	1043	1103
8	SBS FCV Tobacco	2158	2358

Conclusion

The analysis of the data signifies that there is considerable expansion in FCV tobacco area and reduction in non-FCV area over the years without any substantial improvement in total tobacco area. Even though there is a reduction in non FCV are slight increase in production was observed due to higher productivity. With respect to FCV tobacco, there is an increase in area, production and productivity in the states of Andhra Pradesh and Karnataka during 1985-2013. However, the rate of FCV area improvement is lower, and production and productivity are higher in Andhra Pradesh compared to Karnataka. In Andhra Pradesh, highest rate of improvement in area and production observed in SLS followed by NLS and SBS areas with drastic decline in NBS/CBS. In Andhra Pradesh, NLS area recorded higher rate of improvement in productivity followed by SBS, NBS/CBS and SLS. Improvements in productivity of various zones over years signify the positive impact of technological interventions like improved varieties and cultural practices on increase of per hectare yields. It was evident from the analysis, highest yield potential realized in NLS area and lowest in SLS.

With the current rate of improvement, projections were made for the productivity of Indian tobaccos in the year 2020 and 2025. The study also indicated that concerted research efforts are required to improve productivity in SLS and KLS areas to achieve higher FCV production. For realizing higher genetic potential of the varieties grown in various areas, there is a need to develop location specific climate resilient agro-technologies.

Conflict of Interest: None declared

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