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Yield improvement in black soil virginia tobacco (*Nicotiana tabbacum* L.)

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Abstract

The rate of improvement in leaf yields of TBS tobacco (*Nicotiana tabbacum* L.) varieties grown in India since 1947 and basis of yield improvements was studied. The estimated rate of gain in yield from 1953-98 is 178, 26, 20 and 24 kg/ha in green, cured and bright leaf and grade index, respectively. The rate of genetic gain from Chatham (1950) to VT1158 (1993) is 67, 12, 5 and 9 kg/ha in green, cured and bright leaf yields and grade index, respectively. The rate of gain due to production technology is 111, 14, 15 and 15 kg/ha in green, cured and bright leaf and grade index, respectively. Higher yields could be achieved mainly through development of light to medium cast varieties with late flowering and improvement in various morphological characters. Improvement in leaf number, leaf area and specific leaf weight and fine-tuning of leaf cast nature and flowering are essential for future yield gains.

Key words: Tobacco, yield improvement, genetic gain

Introduction

The tobacco (*Nicotiana tabbacum* L.) grown in traditional black soils (TBS) of Andra Pradesh, India has its place in the international market as cheap neutral filler. Scientific system of tobacco cultivation was introduced in these areas with the establishment of Central Tobacco Research Institute (CTRI) at Rajahmundry in 1947. Over the last 50 years, with its concerted research efforts, the Institute has made significant contributions to the economic upliftment of the TBS tobacco farmers by releasing 14 different high yielding varieties and recommending suitable package of practices. The production potential of TBS varieties has been increased from 1000-1100 kg/ha with low grade out turn (20-25%) to 2000 kg/ha with high bright grade out turn (70%). After completion of 50 years of research efforts for the development of TBS tobacco, there is a need to quantify the yield gain due to technological innovations, and to study the impact and basis of yield gains. This information is highly essential for formulating future tobacco breeding strategies for TBS region. Periodic reviews on yield gains and basis of such yield gains are available in many crops *viz.*, barley [1], wheat [2], maize [3], rice [4] and tobacco [5] etc. Based on such reviews breeding strategies of different crops were drastically modified. In cereal crops like rice and wheat, when rate of gain attained plateau levels, the breeding methodologies were reoriented towards production of hybrids instead of pure lines. Keeping these things in view the present study was under taken during 1998-99 season.

Materials and methods

Fifteen different FCV tobacco varieties *viz.*, Harrison special. Chatham, Virginia gold, Delcrest, Hicks, Kanakaprabha, Dhanadayi, CTRI special., Jayasri, CTRI special (MR), Godavari special., Jayasri (MR) or JMR, Hema, Gauthami and VT 1158, which were released, cultivated and are under cultivation in TBS tobacco, since 1947, were included in the study (Table 1).

A replicated trial was conducted with all the released varieties during 1998-99 and 1999-2000 seasons at CTRI farm, Katheru. In both the seasons, observations were recorded on green leaf, cured leaf and bright leaf and grade index. During 1999-2000, observations were recorded on various morphological, physiological and bio-chemical characters. Leaf pigments were estimated by Weybrew method [6]. Leaf Nicotine and reducing sugars in cured leaf were estimated by auto-analyser [7]. Starch content of the cured leaf was also estimated [8]. Regression of various characters, of all the varieties except Harrison special and Godavari special, against cultivar age was used to understand the impact of varietal improvement and basis of yield gains. Cultivar age was calculated starting from the release of Chatham However, exclusion of Harrison special and Godavari special (not included as their varietal identity was doubtful) does not pose any problem in drawing valid conclusions.

Yields of different varieties recorded under different plant breeding experiments/AICRP trials from 1953-98 were collected from the records and regressed against

Table 1. Tobacco varieties recommended and released by CTRI for traditional black soils (1947-97)

Decade	Varieties released	Year of release	Breeding Methodology
I decade (1947-57)	Harrison special	1940	Introduction
	Chatham	1950	Introduction
	Virginia gold	1956	Introduction
II decade (1958-67)	Delcrest	1960	Introduction
	Hicks	1960	Introduction
III decade (1968-77)	Kanakaprabha	1971	Pedigree
	Dhanadayi	1971	Introduction
	CTRI special	1976	Pure line selection
IV decade (1978-87)	Jayasri	1979	Mutation breeding
	CTRI Special (MR)*	1980	Back cross breeding
	Godavari special*	1981	Back cross breeding
	Jayasri (MR)*	1986	Back cross breeding
	Hema	1987	Pedigree
Vdecade (1988-97)	Gauthami	1992	Pedigree
	VT1158*	1993	Pedigree

*TMV resistant variety.

years to compute the rate of yield gains. For calculating the rate of genetic gain, average yields of seven varieties (Chatham, Virginia Gold, Delcrest, Dhanadayi, Jayasri, Hema and VT1158) collected from the above RBD experiment (1998-2000) were regressed against cultivar age. Contribution due to production technology was estimated by subtracting the actual genetic gain from the total yield gain.

Results and discussion

Genetic improvement of FCV tobacco of traditional black soils, since 1947: For almost three decades variety Harrison Special, an introduction from America was under cultivation along with mongrel types like "karedu" and 'putcha' in certain parts. After its establishment in 1947, CTRI has released a total number of 14 varieties. Major breeding methods adopted for the development of these varieties are introduction, pure line selection, hybridization followed by pedigree or back cross method of selection, mutation etc.. All the cultivars are homozygous, homogeneous and true breeding lines. Varieties released in the first three decades are mainly high yielders and later two decades are high yielding and disease (mainly mosaic) resistant varieties. This suggests that efforts need to be intensified to breed for varieties resistant to major pests and diseases.

Rate of yield gain: The rate of gain in yield from 1953-98 is to the tune of 178, 26, 20 and 24 kg/ha in green, cured and bright leaf and grade index, respectively (Fig. 1). Fig. 1 clearly show linear improvement in yields indicating further yield improvement is possible with the present breeding strategies. Proportion of genetic and production technologies to yield improvement of TBS tobacco are shown in Table 2. The rate of genetic gain from the release of Chatham (1950) to VT1158 (1993) is reported to be 67, 12, 5 and 9 kg/ha in green, cured and bright leaf yields and grade index, respectively. The contribution

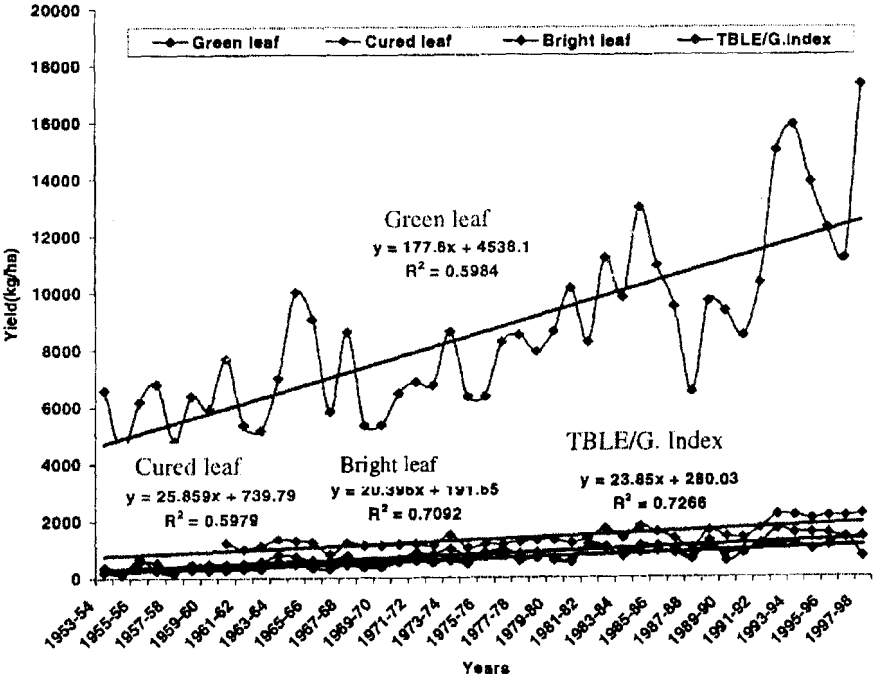

Fig. 1. Yield improvement due to total technology (1953-1998)

Table 2. Contribution of different technologies to yield improvement (kg/ha/year)

S.No.	Leaf yield	Genetic	Production
1.	Green	67(37.64)*	111(62.36)
2.	Cured	12(46.15)	14(53.85)
3.	Bright	5(25)	15(75)
4.	Grade index	9(37.5)	15(62.5)

*Figures in the parenthesis are percent contribution

of production technology was estimated to be 111 (178-67), 14 (26-12), 15 (20-5) and 15 (24-9) g/ha in green, cured and bright leaf and grade index, respectively. Bowman *et al.* [5] assessed the relative contributions of flue-cured tobacco breeding and production technology to yield and quality improvement in USA from 1954 to 1981. An annual estimated yield increase of 49.5 kg/ha was observed of which 68% was attributed to improved production technology and 32% to genetic improvement. Quality as defined by physical appearance and measured in dollar value per hundred kilograms showed significant improvement with an average annual increase of 264 per hundred kilograms.

Impact of yield improvement and basis of yield gain: Regression of various characters of high yielding varieties (varieties released only for disease resistance were not included) against cultivar age was used to estimate the effect of genetic improvement on various characters (Table 3). Specific leaf weight of middle leaves showed highest R^2 value and inter nodal length the lowest values. Continuous improvements were observed for plant height, total leaves, harvestable leaves, days to flowering, leaf area, leaf growth rate, specific leaf weight and carotene from Chatham to VT 1158. Reduction in rate of improvement was observed for inter nodal length and chlorophyll pigments.

Table 3. Impact of genetic improvement on plant characters

S. No.	Character	Rate of genetic gain	R^2 value
1.	Plant height (cm)	0.3734	0.1227
2.	Internodal length (cm)	–0.0057	0.0373
3.	Total leaf number (TL)	0.0851	0.1666
4.	No. of harvestable leaves (HL)	0.1158	0.2844
5.	HL/TL	0.0017	0.2517
6.	Leaf area (60 DAP)	0.0051	0.3479
7.	Leaf growth rate	4.5643	0.4330
8.	Specific leaf weight (Middle leaves)	0.0941	0.5322
9.	Specific leaf weight (Top leaves)	0.0193	0.0874
10.	Total chlorophyll	–28.5580	0.2095
11.	Chlorophyll A	–18.5260	0.2095
12.	Chlorophyll B	–7.6000	0.1956
13.	Carotenoids	3.9919	0.0991
14.	Carotene	–2.4767	0.1188
15.	Xanthophyll	4.2762	0.1414
16.	Days to flowering	0.2297	0.3566

Table 4. Differences between old and new tobacco varieties

S.No.	Old varieties*	New varieties**
1.	Mostly exotic introductions and dark cast lines	All were bred by the Institute only and mostly light cast
2.	Less number of total as well as harvestable leaves	More total and harvestable leaves
3.	Less harvestable to total leaf ratio	More Less harvestable to total leaf ratio
4.	Higher Inter nodal length	Mostly less inter nodal length
5.	Mostly early flowering	Mostly late flowering
6.	Less leaf area,specific leaf weight and leaf growth rate	More leaf area and higher leaf growth rate and specific leaf weight
7.	Higher chlorophyll content	Lower chlorophyll content
8.	Slow leaf maturity and harvesting period start lately	Medium leaf maturity and harvesting period start early
9.	Less leaves/priming	More leaves/priming
10.	Higher priming interval leading to extended leaf harvesting period	Even Priming interval and harvesting completes early

*Varieties released in first half i.e. 1947-1972; **Varieties released in second half i.e. 1973-1998

Nicotine content was more or less same in all the varieties (2.12-2.84%). Varieties showed differences for starch and reducing sugars. Reducing sugars were in acceptible limit in all the varieties (Data on cured leaf quality not presented).

Differences in various parameters related to high yielding varieties released in first half (1947-1972) and second half (1973-1998) of 50 years after the establishment of CTRI were studied to know the impact and basis of yield improvement (Table 4). The high yielding varieties released in the first half are Chatham, Virginia gold, Delcrest, Hicks, Kanakaprabha, and Dhanadayi and second half are CTRI spl., Jayasri, Hema, Gauthami and VT1158. These differences indicate that higher yields under black soil conditions could be achieved mainly through development of light to medium cast (leaves light to medium green colour) and late flowering varieties along with improvements in various morphological characters. Light cast lines showed early and faster leaf maturity compared to green cast lines. As a result primings started early and interval between primings reduced and all the primings completed before the temperatures raised in the end of the season. This has effectively enabled these lines to avoid severe water stress that a black soil variety has to encounter during the later phases of life, as they are grown under conserved soil moisture conditions. The green cast lines required longer time for leaf maturity. In view of this

priming intervals increased and many top leaves could not be harvested at the end of the season as leaf dried without maturing due to higher temperatures. This has resulted in reduction of total number of harvestable leaves and lower leaf yields. Light cast leaves gave higher bright grades compared to dark cast types under black soil condition. In general, late flowering allows the plant to divert most of its energies towards vegetative phase. Hence, late flowering in high yielding lines might be allowing them to divert more energies and time for leaf development, giving higher leaf yields. Improvements in various morphological characters *viz.*, total leaves, leaf area and specific leaf weight might have directly contributed to higher leaf yields.

Future improvement: As observed above, the yield improvements was mainly brought about by developing early maturing light cast lines with more number of harvestable leaves, higher leaf area and specific weight. This suggests that future yield gains can be obtained by improving any of these traits. Further improvement in light cast nature is not advised as the reduction in chlorophyll content of the leaves will affect photosynthesis and accumulation of biological material. Flowering also cannot be further delayed, as the plant has to complete its life cycle before the temperatures rise at the end of the season (after March). Plants with very late flowering will affect seed filling and also quality of the late harvested leaf due to lack of soil moisture at the end of the season. In view of this, breeding efforts has to be diverted towards the development of a variety with optimum chlorophyll content and days to flowering. Further, yield components *viz.*, leaf number, leaf length and width, leaf area and specific leaf weight along with leaf orientation, plant shape etc. need to be improved to get higher yields.

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