RESEARCH ARTICLE

Is There any Shift in Cropping Pattern in Maharashtra after the Introduction of Bt Cotton?

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Abstract

Many early studies found that Bt cotton was well suited for irrigated condition. Since 96% of the cotton cultivation in Maharashtra is under rainfed condition, massive adoption of Bt cotton in Maharashtra raised a lot of questions whether cotton cultivation in the state is viable. The study was carried out to find out if there was any change in the cropping pattern after the introduction of Bt cotton in the state. It was found that there was a marginal shift in cotton cultivation from Vidarbha region to Marathwada and Khandesh regions where these regions have better irrigation facility. The trade-off of oilseeds and pulses with cotton cultivation was well established in Maharashtra in the last decade and a sizable area under cotton in Vidarbha region, converted to these crops. It was also found that there was an enhancement in cotton production in Maharashtra, due to introduction of advanced production and protection technologies, increase in gross irrigated area, and sufficient use of yield enhancing inputs for the cotton cultivation.

Keywords: Cotton Production, CAGR, Bt Cotton, Cotton Productivity, Cropping Pattern, Maharashtra
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Introduction

Ever since the introduction of Bt cotton in India, there were numerous studies on Bt cotton focused on increase in productivity, reduction in insecticide application, good return to farm level etc. There were numerous arguments and studies on genuine contribution of Bt cotton in the overall cotton production in the country. Cotton is grown in ten states, out of which nine states grow both Bt as well as Non-Bt cotton and Odisha is the state which grows only Non-Bt cotton. Maharashtra, Gujarat and Andhra Pradesh occupy 75% of the total cotton area in India and 72% of overall cotton production in the country. These three states cultivate cotton in different agro-climatic conditions. Maharashtra state is the second largest producer and also has the largest area under cotton cultivation in the country, but per hectare productivity is far below all the other cotton growing states. In Maharashtra, cotton is the major crop cultivated in large extent besides soya bean, maize, rice, wheat, pulses and other oilseeds. Primarily, crops are cultivated during *Kharif* season and about 60% of the total gross area is cultivated during *kharif* season in the state.

In general, Bt cotton hybrids are suitable for irrigated condition and it has been proved from production and productivity levels of Gujarat, Punjab and Haryana. In Maharashtra, cotton is cultivated primarily under rainfed condition and about 96% of the cotton was cultivated under rainfed condition that led to low productivity.Many early studies also found that Bt cotton was well suited for irrigated condition. Kaphengat *et al.,* (2010) studied that not all Bt cotton hybrids are equally suitable for all climatic conditions, which can lead to Bt yields below the yields of conventional varieties grown by farmers. The comparative returns from Bt cotton is expected to be less in rainfed cotton cultivation, where the adoption of various yield-increasing inputs and practices is generally less due to uncertainty in crop output (Narayanamoorthy, 2006).Ashok Gulati, Surbhi Jain (2011) have also mentioned that growing Bt cotton in Maharashtra under rainfed conditions is fraught with high risk and cotton farmers in Maharashtra have not gained much from this new technology.Fact finding team on Vidarbha also mentioned that most Bt cotton seed packets carry the information that "Best grown in irrigated conditions" in small letters as reported by Farmers. However, there are other versions also for suitability of Bt cotton for different agro-climatic conditions. Kranthi (2012) mentioned that Bt-cotton technology is highly suited for all conditions including rainfed and irrigated. However, the unsuitability and the low productivity of cotton in rainfed regions including Vidarbha is only related to hybrids, especially the long duration hybrids that suffer moisture stress at boll formation stage, due to poor water retention of shallow soils.

Productivity level has increased in the last decade in cotton from

100 kg/ha in 2000-01 to 322 kg/ha in 2010-11 (Table 2). Maharashtra attributed this to introduction of Bt cotton to some extent, but there are other factors also that essentially contributed to the enhancement in productivity not only in cotton, but in other crops also. Fertiliser consumption in Maharashtra also increased two-folds from 73 kg/ha in 2000-01 to 163 kg/ha in 2010-11. The gross irrigated area also increased up to 30% during the same period which led to 14% increase in cropping intensity in the state (Table 4).To substantiate further, the other non-GM crops like cereals, pulses and oilseeds recorded 60-70% productivity enhancement from 2000-01 to 2010-11 in the state (Table 2). The increase in cotton production level after the introduction of Bt cotton cannot be solely attributed to the technology, ignoring area, irrigation, improved hybrid effects, and advances in pesticide technology advances (Ramasundaram *et al.*, 2011 and Ramasundaram and Vennila, 2013).This paper analyses the cotton scenario in Maharashtra and also the impact of Bt cotton adoption and shift in cropping pattern in major crops and particularly cotton.

Methodology and Data

District level area, production and productivity data of different crops from the year 2000-01 to 2010-11 were collected from State Department of Agriculture, Government of Maharashtra. The above years are chosen because the main thrust of this study was to find the impact of Bt cotton vis-a-vis other crops in Maharashtra. Cost of cultivation for different crops and state wise irrigation pattern data was collected from Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. In this paper, we used simple growth rate (SGR), compound annual growth rate (CAGR), and simple correlation. CAGR would be the ideal tool to analyse, if there is any pattern change in area, production and productivity in cotton and other crops. Correlation coefficient was used in this analysis to find out the kind of association that exists for production with area and productivity. Methodology for finding SGR, CAGR and correlation coefficient are given below:

$$\text{Simple growth rate} = \left[\frac{(X_b - X_a)}{X_a}\right] \times 100; \text{ where,}$$

a = past value; b = present value

$$\text{Compound annual growth rate} = \left[\left(\frac{X_b}{X_a}\right)^{1/n} - 1\right] \times 100; \text{ where,}$$

= past value; = present value; = no. of years

$$\text{Coefficient of Correlation } (r) = \sum \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

where, x and y are variables and n is no. of years

Results and Discussion

Cotton Cultivation in Maharashtra

Maharashtra is the largest cotton growing state in the country where majority of the farming community solely depend on this crop ever since from the beginning of their business in farming. It covers about 35% of total cotton area and contributes to 22% of the production as per 2012-13 data in India. In the year 2012-13, Maharashtra produced approximately 75 lakh bales of 170 kg. About 96% of the cotton crop is cultivated under rainfed condition and mostly grown in black cotton soil. Generally cotton crop is grown in the *Kharif* season and sowing is done with onset of Monsoon. *G hirsutum* and *G arboreum* are the two cotton species grown in the state besides *intra-hirsutum* hybrids which are also grown in large scale. Most of the cotton varieties and hybrids grown in the state are in medium and medium long fibre classes.

Bt Cotton was introduced in Maharashtra in the year 2002-03. Initially the adoption was very slow with just one percent, and increased to 91% within a span of five years and it's estimated at 96% in 2011 to total cotton area in the state (Kranthi, 2012). Bt cotton uses more of yield increasing inputs like fertiliser, human labour and other operational cost. It was found that there was 31.65% and 36.83% excess cost of cultivation in Bt cotton over Non-Bt cotton respectively for irrigated and rainfed cotton cultivation in a survey conducted by Gandhi and Namboodiri (2009). Bt cotton was not much beneficial for farmers of Maharashtra in terms of yield but reduction in number of sprays for controlling bollworm infestation was observed in many of the previous studies. A survey by ISCI in 2013 found that cultivation of Bt Cotton was seen as a status symbol among farming community. Also farmers from Maharashtra opined that Bt cotton cultivation enabled them to raise a second crop such as pulses, oilseeds and vegetables. Raising a subsequent crop was one of the key factors for cotton farmers to adopt Bt cotton in Maharashtra. The same survey found that just 24% of the Maharashtra farmers consider Bt cotton yield as major benefit from adoption of Bt cotton and conversely, 79% and 100% farmers considered yield as major benefit in Andhra Pradesh and Punjab, respectively (Mayee and Bhagirath, 2013). In Andhra Pradesh to a great extent Bt cotton was cultivated under irrigated or assured rainfall condition and in Punjab 100% Bt cotton cultivation was under irrigated condition.

Introduction of Bt cotton in 2002-03 changed the cotton cultivation scenario in Maharashtra in different aspects.Analysis of data reveals that though districts like Nasik, Dhule, Ahmednagar and Nandurbar, have not appeared in top ten districts based on cotton production in 2010-11, but its CAGR in production was more than 20% between 2000-01 and 2010-11 and also saw increase in cotton production levels ranging from 7 to 18 folds in these districts. The contribution of cotton production from these districts increased from 4.5% in 2000-01 to 10.36% to total cotton production in the state. Again, the cotton production contribution to overall cotton production from districts like Aurangabad, Jalna and Nanded has increased from 12.88% to 28.34% during the same period and production and productivity growth rate was high in these districts (Table 1). On the other hand, the traditional cotton growing districts

like Akola, Amaravati and Wardha, the cotton production contribution to overall cotton production in the state reduced from 25.77% in 2000-01 to 11.61%in 2010-11. The slump in cotton production in Akola, Amaravati and Wardha mainly was attributed to shift in considerable area under cotton to oilseed and pulses. Report on the fact finding team in Vidarbha also found that there was increase in cotton adoption in Vidarbha regions in early 2000s but the present trend shows a reduction in area under cotton and a marked increase of area under Soybean.

Other crops in Maharashtra

Soybean is the other major crop next to cotton cultivation in Maharashtra. Soybean cultivation has picked up in Maharashtra during last decade and the area under soybean increased from just 11.42 lakh ha in 2000-01 to 27.29 lakh ha in 2010-11with CAGR of 9.11% and production increased from 12.66 to 43.16 lakh tonnes with CAGR of 13.05% (Table 2). Total cereal production increased from 85 to 119 lakh tonnes though the area under cereals reduced by 12% from 2000-01 to 2010-11, particularly the production of cereals was good in Nasik, Dhule, Jalgaon, Ahmednagar and Aurangabad districts due to better productivity.However, the area under cereals in Nasik, Ahmednagar and Aurangabad witnessed a decreasing trend (Table 1).

Table 1 : CAGR of area and production of major crops

	Cotton Area		Cotton Production		Cotton CAGR		Cereal CAGR		Pulses CAGR		Oils seed CAGR	
	2000-01	2010-11	2000-01	2010-11	Area	Production	Area	Production	Area	Production	Area	Production
Nasik	57	505	57	1006	24.4	33.3	-0.7	10.5	0.1	5.5	4.4	12.0
Dhule	659	1331	329	3359	7.3	26.2	2.7	19.3	2.6	14.4	0.4	21.4
Nandurbar	296	560	174	1166	6.6	21.0	0.7	13.3	-2.6	5.3	11.1	23.2
Jalgaon	4115	5097	2811	10971	2.2	14.6	1.7	10.8	0.7	9.6	-1.3	10.2
Ahmednagar	157	1017	256	2211	20.5	24.1	-1.0	5.7	2.5	7.6	0.0	7.3
Solapur	65	18	112	52	-12.0	-7.4	-1.3	2.3	0.4	2.1	-8.8	-7.2
Satara	56	16	106	13	-11.8	-18.9	-0.8	1.6	1.0	4.6	1.2	2.8
Sangli	36	35	65	41	-0.3	-4.5	-1.2	2.4	-0.8	3.2	-2.2	-2.3
Aurangabad	1324	3329	552	8792	9.7	31.9	-2.2	9.2	1.7	13.2	-10.1	2.2
Jalna	1382	3033	936	7766	8.2	23.6	-3.5	1.5	-1.3	5.7	2.6	14.9
Beed	829	2768	689	4222	12.8	19.9	-3.9	-1.8	1.4	6.8	-0.6	9.1
Latur	222	34	197	80	-17.1	-8.6	-2.3	-0.9	1.2	13.3	6.5	21.7
Osmanabad	26	182	11	387	21.5	42.8	-0.6	-2.1	1.9	4.2	1.9	9.9
Nanded	2700	3021	834	4622	1.1	18.7	-3.2	-2.9	1.8	7.4	14.8	27.9
Parbhani	2024	2324	905	4048	1.4	16.2	-0.8	-1.9	0.5	7.3	8.3	15.4
Hingoli	1043	819	525	1333	-2.4	9.8	-2.8	-2.7	2.0	7.4	11.7	20.3
Buldhana	2198	2515	892	4361	1.4	17.2	0.2	3.4	0.5	9.0	9.4	20.9
Akola	2278	1678	1555	2689	-3.0	5.6	0.2	-0.3	2.8	10.7	11.9	20.5
Washim	1057	620	535	1287	-5.2	9.2	-2.5	-0.3	1.3	6.6	7.9	12.4
Amravati	3091	2043	1497	3362	-4.1	8.4	-4.4	-3.7	1.1	4.1	3.2	12.8
Yavatmal	4477	4798	2382	7759	0.7	12.5	-3.6	-3.4	-0.8	-1.1	8.4	11.3
Wardha	1404	1906	1594	2630	3.1	5.1	-5.8	-1.9	4.4	4.6	-0.1	-0.7
Nagpur	711	808	631	1260	1.3	7.2	2.8	5.4	6.5	11.3	0.3	4.8
Chandrapur	554	933	364	1263	5.4	13.2	-3.4	1.4	5.6	10.7	1.7	0.7
State Total	30769	39419	18026	74727	2.5	15.3	-1.3	3.4	1.2	6.6	3.4	9.1

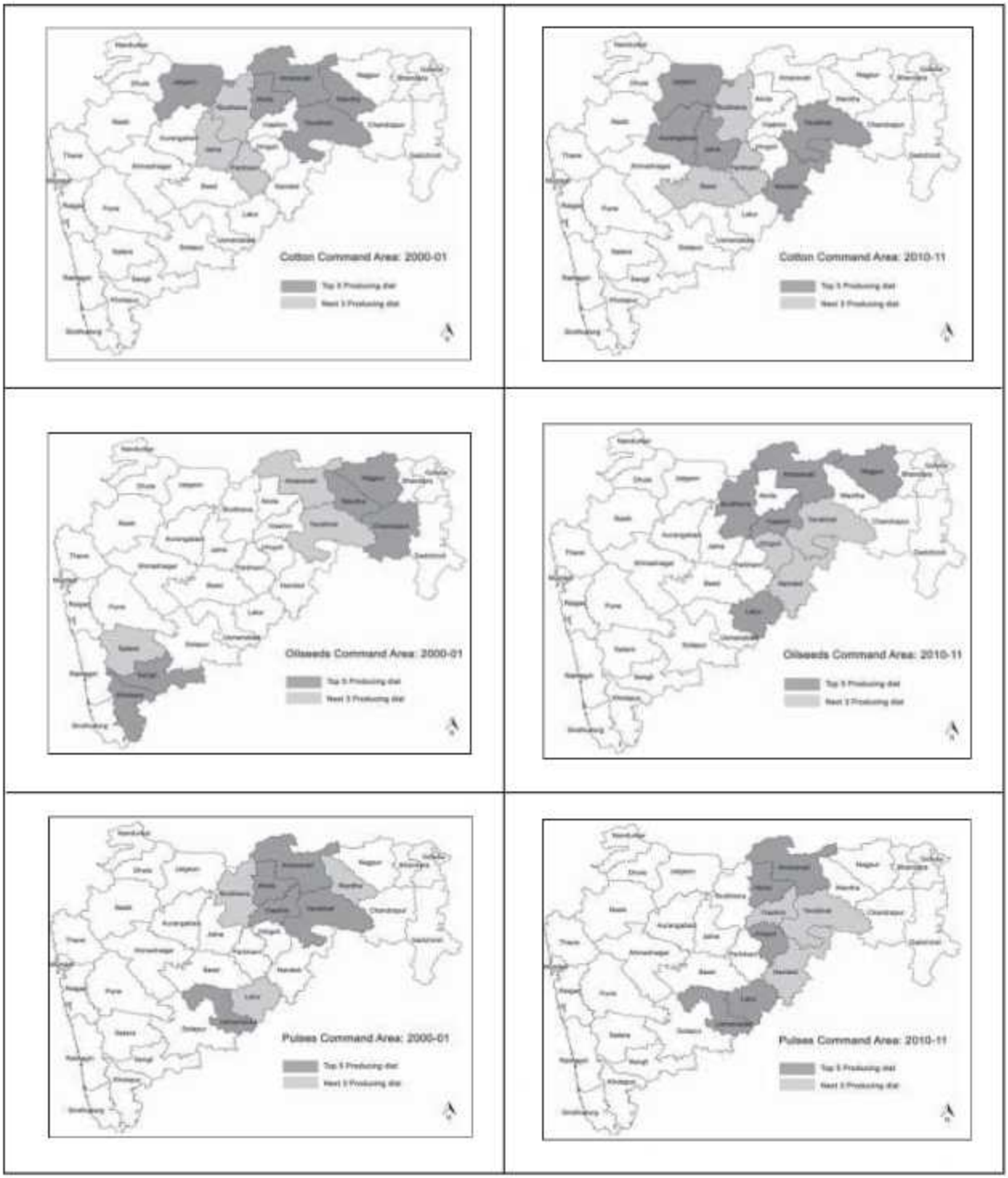
Area in 00 Ha; Production in 00 bales of 170 Kg.
Estimated by M. Sabesh, 2014 based on data from Department of Agriculture, Govt of Maharashtra

Cereal production in many of the districts in 2010-11 except Dhule, Nagpur and Jalgaon districts, the CAGR for area in last decade was negative but the production and productivity was positive (Table 1). Oilseeds production also increased from 21 to 50 lakh tonnes with an increase of just 10 lakh ha during the last decade. While the area of pulses has not increased significantly, its production has doubled during the last decade from 16 to 31 lakh tonnes due to better productivity (Table 2).

Transition in cropping pattern

Considerable transition in cropping pattern in terms of location and production trend has taken place across districts in Maharashtra during the last decade. Introduction of Bt cotton has brought a new cropping pattern and a large scale shift in cotton cultivation has taken place in Vidarbha, Eastern Marathwada, and Khandesh regions. The analysis of the data shows a marginal shift in cotton cultivation from Vidarbha region to Marathwada and Khandesh regions (Figure 1). Presumably, under National Food Security Mission (NFSM) programme in 2007-08, significant area was covered for cultivation of pulses in Akola, Amravati, Nagpur and Wardha districts (NFSM website). Once a strong hold for cotton cultivation, districts like Akola, Amravati, Nanded and Wardha have lost a sizable area under cotton to other crops and witnessed a decrease in production

Figure 1 : Transition in cropping pattern in Maharashtra 2000-01 and 2010-11



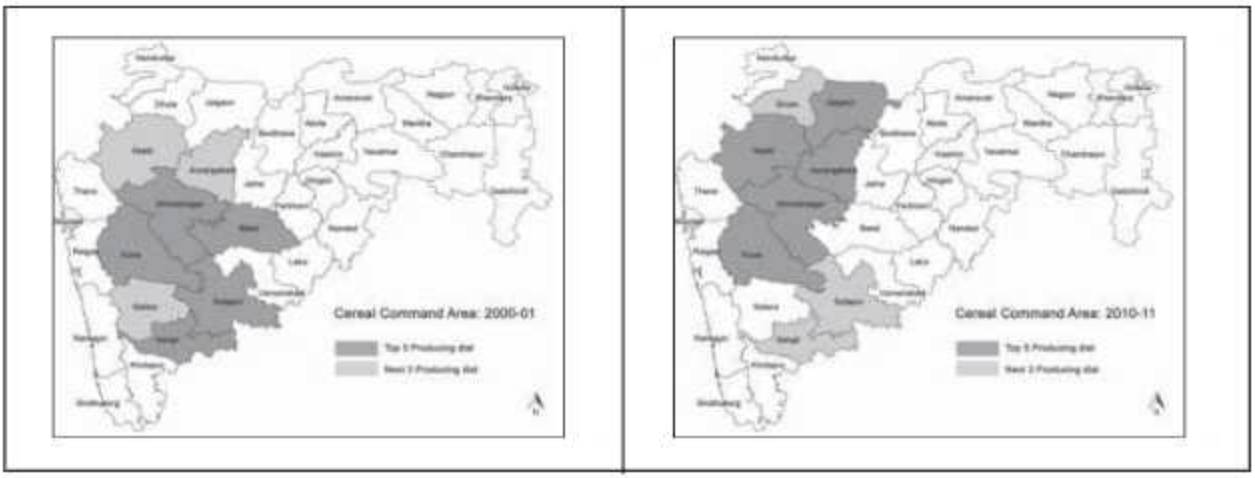


Figure prepared by M.Sabesh and M. Ramesh, 2014 based on data from Department of Agriculture, Govt of Maharashtra.

Table 2 : Compound growth rate (%) of area, production and productivity of major crops in Maharashtra

	Cotton	Cereal	Pulses	Soya bean	Oil Seed
Area					
2000-01	30769	98243	35572	11415	25586
2010-11	39419	86020	40228	27291	35617
SGR %	28.00	-12.44	13.09	139.08	39.21
CAGR %	2.51	-1.32	1.24	9.11	3.36
Production					
2000-01	18026	84965	16369	12662	20988
2010-11	74727	119221	30958	43158	50226
SGR %	315.00	40.32	89.13	240.85	139.31
CAGR %	15.28	3.45	6.58	13.05	9.12
Productivity					
2000-01	100	865	460	1109	820
2010-11	322	1386	770	1581	1410
SGR %	222.00	60.00	67.00	43.00	72
CAGR %	12.40	4.83	5.28	3.61	5.57

Area in 00 Ha; Production in 00 Tonnes; Productivity Kg/ha;
Production of Cotton (00 bales of 170 Kg);
Estimated by M. Sabesh, 2014 based on data from Department of Agriculture, Govt of Maharashtra.

levels. On the other side, escalation in area under cotton and production levels have taken place in districts like Beed and Aurangabad. Besides, a remarkable adoption of cotton has taken place in non-traditional districts like Nasik, Dhule, Nandurbar and Ahmednagar.

The transition of oil seed cultivation from Khandesh region to Southern Marathwada and Western Vidarbha regions was observed in Maharashtra. Large scale adoption of oilseeds has taken place in Nanded, Akola, Yavatmal, Wasim, Hingoli and Latur districts; and reduction in area under oilseed was observed in Pune, Solapur, Sangli and Aurangabad districts. In case of soybean cultivation, more area was brought under cultivation and remarkable production was also experienced in Western Vidarbha and Eastern Marathwada. Latur, Buldhana, Wasim, Akola, and Amravati districts have adopted soybean cultivation in large scale and production level was also alarming in these districts during the last decade. Sawant *et al.*, (1999) had studied that non-conventional crops such as soybean and sunflower which are not only short duration crops but more sturdy and profitable too have picked up in many low to medium rainfall districts of Maharashtra particularly Vidarbha region.

Pulses cultivation continued to concentrate in Western Vidarbha and Southern Marathwada region during last decade. Significant transition in cereal cultivation from Pune division to Nasik division has also taken place and reduction in area under cereals in many of the leading cereal producing districts was observed. The trade-off of oilseeds particularly soya bean and pulses with cotton cultivation was well established in Maharashtra in the last decade and a sizable area under cotton in Vidarbha region especially, Akola and Amravati districts, was transformed to these crops.

Table 3 : Correlation between area and productivity to production (from 2000-01 to 2010-11)

	Rice	Wheat	Total Cereals	Pulses	Sugarcane	Cotton	Soybean	Oilseeds
Correlation Coefficient								
Area to Production	0.56	0.97	-0.16	0.84	0.98	0.77	0.60	0.56
Yield to Production	0.99	0.96	0.94	0.95	0.72	0.97	0.54	0.82
Compound Annual Growth Rate (CAGR)								
Area	0.04	5.79	-1.32	1.24	4.94	2.51	9.11	3.36
Production	3.37	9.04	3.45	6.58	5.63	15.28	13.05	9.12
Yield	3.32	3.07	4.83	5.29	0.65	12.40	3.61	5.57

Estimated by M. Sabesh, 2014 based on data from Department of Agriculture, Government of Maharashtra

Table 4: Agro profile of cotton in Maharashtra

Year	Area (00 ha)*	Production (00 bales)*	Productivity (Kg/ha)*	Bt Adoption (%)#	Fertiliser consumption (kg/ha)&	Pesticide consumption (in MT) (Tech Grade)@	Rainfall (in mm)	Gross irrigated area (00 ha)$	Cropping Intensity (%)$
2000-01	30769	18026	100	–	73.08	3239	1038	N.A.	N.A.
2001-02	31047	26896	147	–	80.43	3135	1040	3727	121.9
2002-03	27999	25961	158	1	88.40	3724	984	3806	121.6
2003-04	27624	30801	190	7	64.30	3385	1096	4088	127.3
2004-05	28395	29385	176	22	94.21	3030	1109	3990	127.9
2005-06	28750	31601	187	57	97.47	3198	1478	4043	129.1
2006-07	31069	46175	253	82	100.20	3193	1473	4236	129.2
2007-08	31954	70149	373	91	109.68	3050	1312	4363	129.7
2008-09	31460	47523	257	91	132.98	2400	1181	4328	128.9
2009-10	33915	51113	256	96	153.40	4639	1118	4352	129.9
2010-11	39419	74727	322	96	163.40	8317	1529	4850	138.3

Note: Pesticide and fertiliser consumption for all crops in Maharashtra
Sources: * = Department of Agriculture, Government of Maharashtra; # = Kranthi, 2012
& = Fertiliser Association of India, GOI; $ = Ministry of Statistics and Programme Implementation, GOI;
@ = Ministry of Agriculture, GOI.

Influence of Area and Productivity on Production

Production of any agricultural produce is influenced by either area or productivity. If correlation coefficient between area and production is positive and high, it would result in production induced by appropriate area enhancement over the years and if correlation coefficient between productivity and production is positive and high, then it is production induced by productivity enhancement. It may be mentioned that production induced by productivity is attributed to adequate use of inputs, less destructive pest and diseases activities, achievements of the production and protection technologies and finally conducive weather condition. On the contrary, production induced by area may be attributed to non-availability of other crops, forced cultivation of subsistence crops, less cost of cultivation, less crop production and protection management, unpredictable weather condition, etc.

There were mixed influences of area and productivity on production levels of different crops in Maharashtra. The correlation analysis (Table 3) shows that increase in production level in cotton was mainly due to productivity enhancement and the association between production and productivity was high (97%) and the association between area and production was low (77%).To supplement the above findings, growth rate for cotton productivity was 12.40% whereas cotton area growth rate was just 2.51% between 2000-01 and 2010-11. The same pattern was observed in pulses, oil seeds and cereals with

Table 5 : CAGR of cost components of different crops from 2002-03 to 2010-11

	Cotton		Soybean		Sugarcane		CAGR		
	2002-03	2010-11	2002-03	2010-11	2002-03	2010-11	Cotton	Soybean	Sugarcane
Cost of Cultivation (Rs./ha)	20860	52583	13588	26554	70743	128997	12.25	8.74	7.80
Cost of Cultivation (Rs./Qt)	2392	3614	1034	1846	71	125	5.29	7.51	7.33
Yield (qt/ha)	8.62	14.4	12.99	14.07	946	987	6.62	1.00	0.53
Seed Cost (Rs./ha)	1090	2754	1422	2556	3359	7530	12.28	7.61	10.62
Insecticide Cost (Rs./ha)	667	1449	111	643	2.42	172	10.18	24.55	70.40
Fertiliser/ Manure Cost (Rs./ha)	1863	5014	1241	2135	10196	12357	13.17	7.02	2.43
Human Labour (Rs./ha)	4564	18740	2695	6862	19904	35243	19.31	12.39	7.40
Value of Main Product (Rs./ha)	17523	62685	14012	27643	62193	177939	17.27	8.86	14.04
Irrigation Charge (Rs./ha)	566	704	54	18	7062	11095	2.76	-12.83	5.81
Machine Labour (Rs./ha)	759	1523	1237	3232	6388	11271	9.10	12.76	7.36
Animal Labour (Rs./ha)	4959	6338	2541	3808	2684	3858	3.11	5.19	4.64
Minimum Support Price (Rs./Qt)	1675+20 1875+20	2500; 3000	885+10	2350	69.50	139.12			

Estimated by M. Sahesh, 2014 based on data from Department of Agriculture and Cooperation, GOI

increased association of production and productivity. Increase in sugarcane production in Maharashtra because of area enhancement reflected good association of area with production (98%). The results divulge that production enhancement in cotton and other crops by and large in the state was due to productivity enhancement, triggered by introduction of advanced production and protection technologies and also willingness of the farmers to use yield enhancing inputs for the crop cultivation due to availability of good market price for the produce.

Agro input pattern

There was a significant rise in the area brought under irrigation in central zone states i.e., Gujarat, Madhya Pradesh, and Maharashtra which was reflected in the contribution of cotton production from these states to overall cotton production of the country. Gross irrigated area in Maharashtra has shown an increase in 2001-02 to 2010-11 from 37.27 lakh ha to 48.50 lakh ha. Due to the increase in gross irrigated area in Maharashtra, the cropping intensity also increased from 121% to 138% with growth rate of 13.45% from 2001-02 to 2010-11 (Table 4). The increase in cropping intensity is likely to be an indication of availability of technological advancement which promoted double cropping and more area brought under irrigation. This not only facilitated cotton but also the rotation of crops. Expansion in irrigation need not necessarily lead to higher cropping intensity. However, technological advances in the form of either short duration varieties of the existing or newly emerging non-conventional crops and crop sequences or cropping systems superior to the existing ones, if made available to the farmers, generally promote rise in cropping intensity (Sawant *et al.*, 1999).

Maharashtra is the third largest consumer of fertilisers in the country for the past 10-15 years. The overall as well as per hectare fertiliser (NPK) consumption in Maharashtra has increased, the total fertiliser consumption in the state was just 16.89 lakh MT in 2001-02 and it was 30.22 lakh MT in 2011-12 (Ministry of Agriculture, GOI); and it was 80 kg/ha in 2001-02 increased to 163 kg/ha in 2010-11. Pesticide consumption for all crops on an average was 3000 metric tonnes in Maharashtra from 2000-01 to 2008-09 but it was increased from 2009-10 and 2012-13. The escalation in pesticide consumption in later years of 2000 may not be attributed to intensive cultivation of cotton; there are other crops like vegetables, fruits, pulses and oilseeds cultivated intensively. Till date, we don't have adequate and authentic data on pesticide consumption for different crops not only in Maharashtra and also for India. A separate study on crop wise pesticide consumption in Maharashtra would reveal the actual situation.

[1] Average Market price for Maharashtra during 2002 was Rs. 2166/- and 2010 was Rs. 5225/- based on APMC data and for soybean it was Rs. 1349/- and Rs. 2184/-.

Cost of Cultivation

We have selected three crops to compare the cost of cultivation in this analysis. Based on the cost of cultivation data from DAC, though the cost of cultivation per ha for cotton in Maharashtra increased from Rs. 20,860 per ha in 2002-03 to Rs. 52,583 per ha in 2010-11 with CAGR of 12.25% which is higher than the cost of cultivation of soybean (8.74%) and sugarcane (7.80%), but the cost of cultivation for production per quintal for cotton is lower than soybean and sugarcane. It is just 5.29% for cotton whereas it is 7.51% for soybean and 7.33% for sugarcane (Table 5). Cost of cultivation to produce per quintal reduced in cotton due to higher per ha productivity and the Productivity CAGR estimated at 6.62% during the period and 1.00% and 0.53% for soybean and sugarcane, respectively. Though the rate of increase for cost of producing cotton per quintal reduced significantly from 2002-03 to 2010-11, the production cost was higher than the Minimum Support Price (MSP) announced by Government and market price[1] in 2002-03 and it was higher than MSP and lower than market price in 2010-11, whereas it was remunerative for soybean, and the market rates were higher than MSP as well as cost of producing soybean per quintal in both the periods.

In cotton there was a significant increase in labour cost, growing at rate of 19.31 % during the period. Another significant finding in this analysis was that increase in insecticide cost for cotton was just 10% whereas it was 24.55% and 70.40% for soybean and sugarcane, respectively, which shows that quantity of insecticide as well as amount spent for insecticide in cotton was reduced compared to other crops in Maharashtra.

Conclusion

No agricultural technology is inferior, since it undergoes rigorous evaluation for specific agro-ecological condition before it reaches target groups, but it is made unfit due to wrong adoption practices. Not all the agricultural technologies would be suitable and successful for all the environmental and social scenarios. Sustainability in agricultural production will not be achieved just by mere acceptance and adoption of technology by the farmers but the performance of the technology under ideal condition. The study revealed that there is a shift in cotton cultivation in Maharashtra and also found that there was much production and productivity in Bt cotton hybrids in non-traditional cotton areas in Marathwada and Khandesh regions and percentage of irrigation in these areas are higher than the traditional cotton growing areas (Vidarbha). This implies that Bt cotton hybrids are well suited for irrigated condition. There is a need for identification of agro-ecological zones suitable for Bt cotton cultivation to promote cotton cultivation in Maharashtra to sustain cotton production as well as increase in cotton productivity in the years to come.

Declaration: The views expressed by the authors in this study are personal and do not necessarily reflect the official policy or position of the organizations they represent.

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