RESEARCH ARTICLE

YIELD GAP ANALYSIS IN COTTON PRODUCTION IN MAHARASHTRA: IMPLICATIONS FOR FARMERS' INCOME

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Abstract: Suggestive measures for bridging yield gap are an important means of enhancing farmers' income. This paper aims at analyzing the relationship between cotton farmers output and their socio-economic characteristics, estimation of yield gap and to identify the factors responsible for yield gap in the study area. The study adopted multistage sampling technique in selecting 120 cotton farmers in four villages from Kalmeshuwa and Saona blocks in Nagpur district, Maharashtra. Both primary and secondary data were used for the study. Primary data was collected with the aid of structured questionnaires administered to the cotton farmers and secondary data on potential yield in the research station, potential yield in the demonstration plot and recommended input usage was obtained from the Central Institute for Cotton Research, Nagpur (CICR). Frequencies, percentage and cross tabulation, yield gap index and multiple regression model were used for analyzing the data obtained. Results from cross tabulation indicated that gender, farm size and educational status of the respondents might not necessarily guarantee larger cotton output in the study area. Findings from yield gap analysis showed that yield gap I, yield gap II and total yield gap in the study area were 375kg/ha, 815.11kg/ha and 1190.11kg/ha respectively, implying that there is still scope for increasing actual farmers' yield and hence more farm income. Results from the multiple regression model revealed that educational status, farm size, seed rate gap and location of the farmers were the major factors responsible for yield gap in the study area. The study therefore suggested a need to sensitize farmers by relevant Government agencies on the unfavorable effects of excess input usage with a view to minimize yield gap in the study area.

Keywords: Yield gap, Potential yield, Demonstration plot

INTRODUCTION

Cotton (Gossypium spp.) 'king of fibre' belonging to the genus Gossypium under Malvaceae family which closely linked to the human civilization itself is a large, rich and economically important cash crop comprising about 40 species of which four are commercially cultivated for cotton lint and seed (Dhandhalya, 2009). All the four cultivated species are being grown in India viz., Gossypiumhirsutum, Gossypiumbarbadense, Gossypiumarborium and Gossypiumherbacium. Gossypiumhirsutum which covers about 50 per cent of the area followed by that of Gossypiumarborium with 29 per cent and Gossypiumherbacium with 21 per cent. Area under Gossypiumbarbadense is negligible and covers only a few thousand hectares (Santhy et al., 2008).

The main cotton producing countries are USA, China, India, Pakistan, Uzbekistan, Australia, Greece, Brazil and Turkey. In total world cotton production, 70% comes from four countries; China, India, the United States and Pakistan. In the year 2012-13, cotton production increased compared to the previous years. For many developing and underdeveloped countries, the export of cotton is the main source of foreign currency earnings. The figures in Table 1 depict the main producers of cotton and share in global production from 2007-08 to 2015-16.

Table 1. Global Cotton production (Million metric tons)

Country	Years						
	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2015-16
India	5.23 (19.94)	4.92 (20.89)	5.01 (22.49)	5.53 (21.94)	5.99 (22.22)	6.21 (22.46)	5.75 (27.00)
China	8.06 (30.74)	7.99 (33.92)	6.97 (31.29)	6.64 (26.34)	7.29 (27.06)	7.62 (27.58)	4.90 (23.00)
USA	4.18 (15.95)	2.79 (11.83)	2.66 (11.93)	3.94 (15.63)	3.55 (13.17)	3.77 (13.63)	2.77 (13.00)
Pakistan	1.87 (7.14)	1.89 (8.04)	2.09 (9.39)	1.92 (7.60)	2.18 (8.08)	2.02 (7.33)	1.50 (7.00)
Brazil	1.61 (6.15)	1.20 (5.08)	1.20 (5.38)	1.96 (7.77)	1.96 (7.27)	1.31 (4.73)	1.28 (6.00)
African franc zone	0.50 (1.91)	0.48 (2.03)	0.46 (2.05)	0.46 (1.81)	0.33 (1.21)	0.85 (3.07)	1.07 (5.00)
Uzbekistan	1.18 (4.49)	1.00 (4.25)	0.85 (3.81)	0.89	0.91 (3.39)	0.98 (3.55)	0.85

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				(3.54)			(4.00)
Turkey	0.68 (2.58)	0.41 (1.76)	0.39 (1.76)	0.46 (1.81)	0.67 (2.50)	0.59 (2.13)	0.85 (4.00)
Australia	0.13 (0.50)	0.33 (1.39)	0.39 (1.76)	0.91 (3.63)	1.09 (4.04)	1.00 (3.62)	0.64 (3.00)
Rest of the world	2.79(10.63)	2.55(10.81)	2.26(10.17)	2.50(9.93)	2.98(11.07)	3.29(11.90)	1.70(8.00)
World total	**26.21**	**23.56**	**22.27**	**25.21**	**26.95**	**27.63**	**21.3**

Source: United States Department of Agriculture. *Figures in parenthesis indicate the percentage of world production

India is the largest producer of cotton in the world accounting for about 27% of the world cottonproduction. It has the distinction of having the largest area under cotton cultivation in the world ranging between 10.9 million hectares to 12.8 million hectares and constituting about 38% to 41% of the world area under cotton cultivation.

Cotton is largely grown in states like Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Andhra Pradesh, Haryana and Tamil Nadu. The area under cotton cultivation has also shown significant increase over the years. This increase in area is because of the fact that more and more farmers are switching over to cotton from other crops like sugarcane, pulses. It is significant to note that the contribution of cotton to the total production in the country in 2014-15 season is estimated at about 40 percent.

The productivity (504 kg to 566 kg per hectare) is however still low against the world average of about 701 Kgs to 766 kg per hectare (Consultant and Pradesh, 2017). This may be due to inappropriate decision on how best to allocate resources thus leading to yield gap between potential farm yield and actual farm yield per hectare realized which in turn affects productivity and profitability of farmers. In order to realize increased production and efficiency, farmers in developing countries need to efficiently utilize the limited resources accessed for improved food security and farm income generation. This present paper will help in framing appropriate measures to raise productivity and profitability of farmers by minimizing total yield gap in the study area. This present study therefore seek to analyse the relationship between farmers' output and their socioeconomic characteristics, estimate the yield gap in cotton production as well as to determine the factors responsible for yield gap in the study area.

METHODOLOGY

Data Collection and Sampling Technique

Primary data was collected from 120 cotton producers using structured questionnaire administered by the researcher and well trained enumerators. Data collection was carried out in the month of January 2018. Multistage sampling technique was adopted in selecting the respondents. In the first stage, Maharashtra was purposively selected because it is at number one in terms of cotton production.In the second stage, Nagpur district was purposively selected from the thirty six districts of Maharashtra because it has the highest cotton production. The third stage involves the random selection of two blocks out of the thirteen blocks in Nagpur district (Kalmeshuwa and Saona). In the fourth stage, two villages were randomly selected from each block making a total of four villages. In the final stage, 30 cotton farmers were randomly selected from each village making a total of 120 respondents.

Data Analysis

Descriptive statistics involving frequency, percentage and cross tabulation was used to achieve the first objective. The yield obtained by the farmers was converted to per hectare and divided in to three categories; (1053-1666kg/ha, 1667- 2280kg/ha and 2281-2894kg/ha) which was cross tabulated against farmers' socio-economic characteristics such as gender, farm size and educational status. Yield gap in cotton production was estimated using the methodology developed by International Rice Research Institute (IRRI) as used by Singh (2015).

TYG = YG I + YG II

Where, TYG = Total yield gap

YG I = Yield gap I

YG II = Yield gap II

YG I = Yp – Yd

Yp = Potential Yield (Per hectare crop yield realized on the research station)

Yd = Potential farm yield of the demonstration plot.

YG II = Yd – Ya

Yd = Potential farm yield of the demonstration plot (Per hectare yield realized on the demonstration plot)

Ya = Actual farm yield realized by the farmers (per hectare yield realized by farmers on their field)

Yield gap I and II will were converted to percentages and then summed. This gave the total yield gap in percentage for the study area.

Input gap = Recommended input dose – Actual inputs used by the farmers

Multiple regression model was used to ascertain the determinants of yield gap in the study area. The model is specified as follows;

$Y= \beta_0 +\beta_1 D_1 +\beta_2 X_2 +\beta_3 X_3 +\beta_4 X_4 + \beta_5 X_5 + \beta_6 D_6 + U$

Where,

Y = Total yield gap in kg/ha

D_1 = Dummy for Educational Status (1 if farmer is educated and 0 otherwise)

X_2 = Fertilizer rategap in kg/ha X_3 = Amount expended on labour (Indian rupees)

X_3 = Labour expenses in rupees/ha

X_4 = Farm size in ha

X_5= Seed gap in kg/ha

D_6 = Dummy for location (1 = Kalmeshuwa and 0= Saona)

U = Error term

RESULTS AND DISCUSSION

Farmers Output in Relation to Socioeconomic Characteristics

The output of the cotton farmers' varied between 1053kg/ha to 2894kg/ha as indicated in Table 1. Results obtained from cross tabulation between gender and productivity indicates that only 2.5% of the respondents are female and all of them had low productivity (between 1053-1666kg/ha). On the other hand, majority of the respondents are male out of which 41.7%, 40.0% and 15.8% obtained low, average and above average yield respectively. Since, the highestpercentage of farmers in both gender (2.5% in female and 41.7% in male) had low productivity. This implies that gender of the respondents does not necessarily guaranty larger output among the respondents.

Table 1. Cotton farmers output andgender

Output range	**Gender of the respondents**		**TOTAL**
	Female	Male	
Low	3(2.5)	50(41.7)	53(44.2)
Average	0(0.0)	48(40.0)	48(40.0)
Above Average	0(0.0)	19(15.8)	19(15.8)
Total %	**2.5**	**97.5**	**100**

Source: Field Survey, 2018.*1053-1666kg/ha (Low), 1667- 2280kg/ha (Average) and 2281-2894kg/ha (Above average)

The cotton farmers output relative to their farm size is depicted in Table 2. The results indicates that majority of the respondents (51.7%) are marginal farmers (having less than 1ha) out of which 28.3%, 17.5% and 5.8% of them obtained low, average and above average yield respectively. Findings from the study further indicates that 45.0% of the cotton farmers operate on a small scale basis (between 1-2ha) out of which 15.8%, 19.2% and 10.0% obtained low, average and above average yield respectively. Further findings from the study indicates that only 3.3% of the respondents are medium scale farmers and all obtained average yield (1667-2280kg/ha). Going by this result more than half of the small and medium farmers had obtained average productivity. This implies that large farm size does not necessarily translate to higher productivity. This corroborates the findings of Salihu *et al*., (2018).

Table 2. Cotton farmers' output and farm size

Output range	**Farm size**			**Total**
	Marginal	Small	Medium	
Low	34(28.3)	19(15.8)	0(0.0)	53(44.2)
Average	21(17.5)	23(19.2)	4(3.3)	48(40.0)
Above Average	7(5.8)	12(10.0)	0(0.0)	19(15.8)
Total %	**51.7**	**45.0**	**3.3**	**100**

Source: Field Survey, 2018. *1053-1666kg/ha (Low), 1667- 2280kg/ha (Average) and 2281-2894kg/ha (Above average)

The results of cotton farmers output in relation to educational level in Table 3 showed that 41.7%, 35.8%, 0.8% and 8.3% attained 5^{th} class, 10^{th} class, 12^{th} class and tertiary education respectively while

13.3% of the farmers had no formal education. This revealed low literacy rate among the sampled farmers. Further findings from this study showed that out of the 41.7% farmers that attained 5th class, 16.7% had low yield and another 16.7% obtained average yield. Also the second largest category of farmers (35.8%) are educated up to 10th class out of which 14.2% and 16.7% obtained low and average yield respectively while only 5.0% obtained above average yield. This clearly depict that educational level of the farmers might not be a necessary factor that guarantees high yield in the study area.

Table 3. Cotton farmers output and Educational Level

Output range (kg/ha)		**Educational level**					**Total**
		No formal education	Up to 5th Class	10th Class	12th Class	Tertiary education	
Low		12(10.0)	20(16.7)	17(14.2)	0(0.0)	4(3.3)	53(44.2)
Average		4(3.3)	20(16.7)	20(16.7)	0(0.0)	4(3.3)	48(40.0)
Above Average		0(0.0)	10(8.3)	6(5.0)	1(0.8)	2(1.7)	19(15.8)
Total %		**13.3**	**41.7**	**35.8**	**0.8**	**8.3**	**100**

Source: Field Survey, 2018. *1053-1666kg/ha (Low), 1667- 2280kg/ha (Average) and 2281-2894kg/ha (Above average)

Yield Gap Estimate of the Respondents

The results in Table 4revealed that yield gap II in cotton production was 815.11kg/ha (31.43%) which was almost thrice yield gap I (12.72%). The total yield gap in the study area was estimated to be 1190.11kg/ha (44.15%). This implies that there is still scope within the farmers' control for improving cotton yield and realizing more farm income. This corroborates the findings of Zelda and Sekar (2015) who reported a high yield gap in seed cotton production in Tamil Nadu State, India.

Table 4. Average yield gap estimate in the study area

Description	**Values**
A. Experimental potential yield (kg/ha)	2950
B. Potential farm yield (kg/ha)	2575
C. Yield gap I in kg/ha (A-B)	375
D. Yield gap I expressed in percentage	12.72
E. Average farm yield (kg/ha)	1759.90
F. Yield gap II in kg/ha (B-E)	815.11
G. Yield gap II expressed in percentage	31.43
H. Total yield gap in kg/ha (C+F)	1190.11
I. Total yield gap expressed in percentage (D+G)	44.15
G. Relative yield in percentage*	68.35

*Percentage of average farm yield to farm potential yield.
Source: Author's computation based on Mondal (2011).

Factors influencing yield gap in the study area

The results of regression analysis in Table 5 shows that four out of the six variables included in the model were statistically significant. Educational status (D1) of the farmers and seed gap rate (X5) were statistically significant at 5%, farm size (X4) was significant at 1% and location of the respondents was significant at 10%. The negative coefficient for education implies that yield gap for literate farmers in the study area were 404.017kg less than that of uneducated farmers. Baksh et al., (2005) also reported a similar result among cotton farmers in Sargodha, Pakistan. The coefficient for farm size of the respondents and seed rate is also negative implying that a unit increase in each of these variables would decrease yield gap by 646.33kg and 288.596kg respectively. Results from the model further revealed that the coefficient for location of the respondents is positive and statistically significant. This implies that yield gap in Kalmeshuwa block was 252.755kg higher than that of Saona. Fertilizer gap and expenses on labour were not significant and hence do not have any impact on yield gap in the study area. This result disagrees with the findings of Zelda and Sekar 2015 who reported that nitrogen and potash gap have significant influence on yield gap of marginal cotton farmers in Tamil Nadu State, India. The regression analysis also

revealed R^2 value of 0.62 implying that 62% variation in yield gap is as a result of the variables included in the model. F- Value was found to be positive and statistically significant thereby indicating a good fit and appropriateness of the functional form used for the analysis.

Table 5. Determinants of yield gap in the study area.

Variables	Parameters	Coefficient	t-ratio
Constant	β_0	200.834***	6.696
Educational status (D_1)	β_1	-404.017**	-2.010
Fertilizer gap (X_2)	β_2	-0.012NS	-0.089
Expenses on labour (X_3)	β_3	0.001NS	0.453
Farm size (X_4)	β_4	-646.337***	-2.839
Seed rate gap (X_5)	β_5	-288.596**	-2.503
Location (D_6)	β_6	252.755*	1.770
$R^2 = 0.62$ F = 3.362***			

Source: Field survey, 2018
***Significant at 1%
** Significant at 5%
* Significant at 10%
NS Not Significant

CONCLUSION AND RECOMMENDATIONS

The study revealed that total yield gap in the study area was 1190.11kg/ha with a relative yield of 68.35% indicating that actual farm yield was 31.65% lower than potential farm yield at the demonstration plot which implies that there is still scope for increasing yield of the farmers and hence earning more farm income. The study concludes that educational status of the respondents, farm size, seed gap rate and location of the farmers were the major factors influencing yield gap in cotton production in the study area. The yield gap differs significantly in the two blocks considered for this study In view of these, the following suggestions are made;

I. Efforts should be made to discourage land fragmentation because findings from this study indicated that a unit increase in the usage of land will reduce yield gap significantly in the study area and hence more farm income.
II. Since most of the farmers are not using the recommended dose of inputs such as seed, fertilizer etc., there is need to sensitize farmers by the relevant Government agencies on the detrimental effects of excess input usage with a view to minimize input gap in the study area.

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