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Yield Gaps, Constraints and Potential in Cotton Production in North Karnataka – An Econometric Analysis

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INTRODUCTION

Cotton is considered to be an industrial commodity of worldwide importance. Cotton accounts for nearly 44 per cent of the world's fibre and supplies 10 per cent of the world's edible oil. Even though India holds the largest cotton area in the world, due to lower productivity it ranks third in production after China and the United States of America. During the year 1998-99, the country produced 12.18 million bales (170 kg) of cotton from an area of 9.29 million hectares with an average productivity of 223 kg. Karnataka accounts for 6.55 per cent of cotton area (6.08 lakh ha) and 7.02 per cent of the cotton production (8.55 lakh bales) in the country during the year 1998-99 (Fertiliser Association of India, 2000).

The adoption of a new technology often results in a tendency of variability in the production. Effective transfer and implementation of new technology demands a thorough understanding of the constraints confronting the farmers in its adoption. Before releasing any variety to the farmers for adoption, it is amply tested under different agro-climatic conditions at research stations through trials and demonstrations. However, yield levels realised by the farmers tend to be considerably lower than those recorded at the research stations and demonstration plots, leaving a considerable untapped yield potential. Once the constraints are identified, attempts could then be made to bridge the yield gaps caused by these factors. The present study was undertaken with the specific objectives of estimating the magnitude of yield gaps, sources contributing to the yield gaps, the constraints responsible for yield gaps and to suggest appropriate measures to bridge the yield gaps in cotton production in Karnataka.

METHODOLOGY

The study is based on the primary data collected from 80 sample farmers spread over in eight villages of four talukas from two leading districts, viz., Dharwad and Bellary with respect to cotton area in Karnataka. The sample farmers were selected with the help of multi-stage random sampling technique with district, taluka and

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villages as different stages of selection. The sample farmers were post-classified into small (< 2 ha) and large (≥ 2 ha) categories based on their land holdings. The data on various aspects of cotton production on farmers' fields, demonstration plots and research station plots were collected with the help of pre-tested schedules during the year 1996-97.

The methodology developed by the International Rice Research Institute (IRRI) was used to study the yield gaps. According to IRRI methodology, the total yield gap (TYG) is the difference between the potential yield (Y_p - yield realised on the research station) and the actual yield (Y_a - yield realised on sample farmers' fields). The TYG comprised Gap I [difference between the potential yield and the potential farm yield (Y_d - yield realised on the demonstration plots)] and Gap II [difference between the potential farm yield (demonstration plot yield) and the actual yield]. In addition to this, various indices of yield gaps, viz., *index of yield gap* [IYG = $(Y_p - Y_a) \div Y_p$], *index of realised potential yield* [IRPY = $(Y_a \div Y_p)$] and *index of realised potential farm yield* [IRPFY = $(Y_a \div Y_d)$] were also studied.

It may not always possible for the farmers to raise the crop productivity on their farms to the level of research station. However, it would be realistic to aim at demonstration plot yield (potential farm yield) level. Hence in this study more emphasis is given to Yield Gap II (now onwards referred as simply Yield Gap).

The following form of per hectare Cobb-Douglas type of production function was used in the present study for further analysis.

$$Y = a\, H^{b1}\, B^{b2}\, S^{b3}\, N^{b4}\, C^{b5} e^{u} \qquad \text{.... (1)}$$

where Y, H, B, S, N and C are the cotton yield (kg), expenditure on human labour (man-days), bullock labour (pair-days), seed (kg), expenditure on plant nutrients (NPK and farmyard manure) and capital [comprising expenditure on plant protection chemicals, seed treatment material and other miscellaneous items (Rs.)]. The random disturbance term is denoted by 'u', 'a' is the intercept and 'b_i' is the slope coefficient of the i-th variable (i = 1 to 5).

To examine the structural break in the production relations on the farmers' fields and the demonstration plots, the above equation was estimated using the ordinary least squares (OLS) technique separately for the sample farmers' fields, demonstration plots, pooled data set and pooled data set with a dummy for intercept.

$$\ln Y_1 = \ln a_0 + a_1 \ln H_1 + a_2 \ln B_1 + a_3 \ln S_1 + a_4 \ln N_1 + a_5 \ln C_1 + U_1 \qquad \text{....(2)}$$

$$\ln Y_2 = \ln b_0 + b_1 \ln H_2 + b_2 \ln B_2 + b_3 \ln S_2 + b_4 \ln N_2 + b_5 \ln C_2 + U_2 \qquad \text{....(3)}$$

$$\ln Y_p = \ln d_0 + d_1 \ln H + d_2 \ln B + d_3 \ln S + d_4 \ln N + d_5 \ln C + U_p \qquad \text{....(4)}$$

$$\ln Y_d = \ln d_0 + d_1 \ln H + d_2 \ln B + d_3 \ln S + d_4 \ln N + d_5 \ln C + U_p + f_0 D_0 + U_p \qquad \text{....(5)}$$

where Y_1, Y_2, Y_p and Y_d are the cotton yield levels on the farmers' fields, demonstration plots, pooled data set and pooled data set with intercept dummy respectively. The inputs have the symbol as stated above along with associated coefficients. D_0 is the intercept dummy (D=1 for demonstration plots; 0 otherwise) and f_0 is its regression coefficient.

The structural break in the production surfaces between the demonstration plots and the farmers' fields due to shift in the intercept or/and due to change in the slope was tested using the Chow's (1960) test. Once the Chow's 'F' statistic was found significant, it could be inferred that the two functions differed significantly. Then using Bisaliah's (1977) Output Decomposition Model, different sources contributing to yield gap were estimated. Decomposition model was arrived at with the help of functional forms specified in equations (2) and (3).

$$\ln (Y_2/Y_1) = [\ln (b_0/a_0)]+[(b_1-a_1) \ln H_1+(b_2-a_2) \ln B_1+(b_3-a_3) \ln S_1+(b_4-a_4) \ln N_1 + (b_5-a_5) \ln C_1] + [b_1 \ln (H_2/H_1) + b_2 \ln (B_2/B_1) + b_3 \ln (S_2/S_1) + b_4 \ln (N_2/N_1) + b_5 \ln (C_2/C_1)] + [U_2 - U_1] \quad \text{.... (6)}$$

This equation involves decomposing the Yield Gap. The summation of the first and second bold bracketed terms on the right hand side of the decomposition model together represented the Yield Gap II, attributable to the difference in the cultural practices. The third term represented the yield gap, attributable to the differences in the input use (input gaps) between the demonstration plots and the farmers' fields. The last term takes care of the random disturbance which the model could not take into account.

The opinions survey of sample farmers about the various constraints influencing the magnitude of yield gap were collected. For identifying and quantifying the influence of these constraints on yield gap, the principal components analysis was carried out. A large number of constraints in the form of dummies were included in the analysis. Those constraints that appeared in the first and second principal components were included in the following regression model. The yield gap was defined as a linear function of a set of identified constraints. Value '1' was assigned to the variables denoting the presence of the constraint and zero otherwise.

$$Y = a + \sum_{i=1}^{8} b_1 X_1 + e^u \quad \text{.... (7)}$$

where Y indicates the size of yield gap (per cent); 'a' indicates the intercept denoting the percentage of yield gap attributable to environmental factors and other constraints (not included in the model); X_i indicates the constraint (i=1 to 8) and b_i indicates the proportion of yield gap that could be reduced by eliminating the constraint in question.

RESULTS AND DISCUSSION

Yield Gaps and Indices of Yield Gaps

With the advent of new technology in agriculture, significant improvement in the crop productivity was noticed. However, proper resource mix and appropriate cultural practices become a pre-requisite for the adoption and success of new farm technology, which are often beyond the reach of a majority of the farmers. It could be observed from Table 1 that there existed a wide gap in the cotton productivity between the research station, the potential farm (demonstration plots) and the sample farmers' fields.

TABLE 1. COTTON YIELD REALISED AND THE ESTIMATED YIELD GAPS UNDER DIFFERENT FIELD SITUATIONS

(kg per hectare)

Sr. No. (1)	Particulars (2)	Study district: Dharwad (3)	Bellary (4)	Overall (5)
1.	Potential yield	2,695.00	2,703.00	2,699.00
2.	Potential farm yield	1,812.50 [17]	1,796.35 [13]	1,805.50 [30]
3.	Actual yield			
	(a) Small farms	1,145.43 [23]	1,161.75 [20]	1,153.02 [43]
	(b) Large farms	1,182.94 [17]	1,206.30 [20]	1,195.57 [37]
	(c) Overall farms	1,161.37 [40]	1,184.03 [40]	1,172.70 [80]
4.	Yield Gap I	882.50	906.65	893.50
5.	Yield Gap II			
	(a) Small farms	667.07	634.60	652.48
	(b) Large farms	629.56	590.05	609.93
	(c) Overall farms	651.13	612.32	632.80
6.	Total yield gap			
	(a) Small farms	1,549.57	1,541.25	1,545.98
	(b) Large farms	1,512.06	1,496.70	1,503.43
	(c) Overall farms	1,533.63	1,518.97	1,526.30

Note: Figures in square brackets indicate sample size under respective field situations.

The magnitude of total yield gap worked out to be 1,526.30 kg/ha, which comprised relatively higher size of Yield Gap I (893.50 kg/ha) than Yield Gap II (632.80 kg/ha) in the overall study area. Higher Yield Gap I implied that greater amount of potential yield was left untapped on the demonstration plots. This was attributable to the significant environmental differences and partly to the non-transferable component of technology like cultural practices. Hence, the technology develc ed at research station could not be fully replicated on the demonstration plots. Farm size-groupwise analysis of the total yield gap over the districts showed the highest (1,549.57 kg/ha) magnitude recorded on the small farms of Dharwad district, while the lowest (1,496.70 kg/ha) magnitude was noticed on the large farms of Bellary district. A similar tendency was noticed with respect to the magnitude of Yield Gap II.

The estimated index of yield gap worked out to be 56.55 per cent (Table 2). So, there existed a tremendous scope to improve the cotton production in the study area. The index of potential yield worked out to be 43.45 per cent in the overall category of sample farms. It may not always be possible for the farmers to adopt certain aspects of new technology developed in research stations due to differences in the environmental factors and other constraints operating at the farm level. The sample farmers realised 65 per cent (index of realised potential farm yield) of the farm potential in the study area (Table 2). Thus, if all the recommended packages and production technology used on the demonstration plots are adopted, the sample farmers could obtain 35 per cent more cotton output. Farm size-group analysis showed that large cultivators obtained relatively better yield levels than their small counterparts. Cotton crop being more capital intensive, it demands more of costly inputs, hence due to better economic conditions, large farmers have taken up timely spraying and application of plant nutrients and realised higher yield levels. The results of the study are in conformity with Basavaraja (1988) for cotton production.

TABLE 2. ESTIMATED INDICES OF YIELD GAPS IN COTTON UNDER DIFFERENT FIELD SITUATIONS

(per cent)

Sr. No. (1)	Particulars (2)	Dharwad district (3)	Bellary district (4)	Overall (5)
1.	Index of yield gap			
	(a) Small farms	57.50	57.02	57.28
	(b) Large farms	56.11	55.37	55.70
	(c) Overall farms	56.91	56.20	56.55
2.	Index of realised potential yield			
	(a) Small farms	42.50	42.98	42.72
	(b) Large farms	43.89	44.63	44.30
	(c) Overall farms	43.09	43.80	43.45
3.	Index of realised potential farm yield			
	(a) Small farms	63.19	64.67	63.86
	(b) Large farms	65.27	67.15	66.22
	(c) Overall farms	64.08	65.91	64.95

Structural Break in Production Relations

The results on Chow's test to know the homogeneity between the parameters of the production functions are presented in Table 3. It was found that the dummy coefficient for intercept as well as the calculated Chow's F-statistic for overall functions and slope parameters were significant. This implied that production functions that defined the cotton production on the farmers' fields and the demonstration plots differed significantly. These differences were due to changes in the slope as well as intercept parameters. This result offered the required justification for the decomposing yield gap into its constituent sources.

TABLE 3. STRUCTURAL BREAK IN PRODUCTION RELATIONS IN COTTON PRODUCTION

(per hectare)

Sr. No.	Explanatory variable	Pooled data set of demonstration plots with farmers field			Pooled data set of demonstration plots and farmers field with intercept dummy		
		Small farms	Large farms	Overall	Small farms	Large farms	Overall
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Human labour	0.3565**	0.3346**	0.3012**	0.4252**	0.3726*	0.3128**
		[0.1576]	[0.1215]	[0.1123]	[0.1703]	[0.1821]	[0.1232]
2.	Bullock labour	0.1023	0.3625**	0.1625	0.1832	0.3132*	0.1826
		[0.0945]	[0.1325]	[0.0952]	[0.1288]	[0.1025]	[0.1123]
3.	Seeds	0.2456*	0.1620*	0.3242*	0.2126*	0.1252	0.3127*
		[0.1175]	[0.0853]	[0.1602]	[0.0925]	[0.0813]	[0.1521]
4.	Plant nutrients	-0.1524	0.0625	-0.1002	-0.1321	0.1128	-0.0362
		[0.1024]	[0.0521]	[0.9125]	[0.1064]	[0.0832]	[0.0212]
5.	Capital	0.3942**	0.2137*	0.3625**	0.3875**	0.2232*	0.3725*
		[0.1029]	[0.0985]	[0.1046]	[0.1246]	[0.0925]	[0.1826]
6.	Intercept	1.7526#	2.2123#	2.0201#	1.4125#	2.2732#	2.1873#
		[0.7520]	[0.8844]	[0.1855]	[0.4678]	[0.0897]	[1.0021]
7.	Intercept dummy	-	-	-	0.2853*	0.1836*	0.2132**
					[0.1628]	[0.0997]	[0.0852]
8.	$\bar{R}^2$	0.7210**	0.8245**	0.7696**	0.7523**	0.8835**	0.8791**
9.	F-value	10.99**	16.44**	29.65**	36.64**	82.62**	134.04**
10.	Number of observations	73	67	110	73	67	110
11.	Degrees of freedom	61	55	98	60	54	97
12.	Residual sum of squares	7.6425	7.2645	8.2639	7.1521	6.8913	7.2315
13.	Chow's 'F'-test for testing						
	(i) Overall structural break				48.84**	40.13**	83.31**
	(ii) Difference in slope				57.91**	48.50**	89.77**

Note: Figures in square brackets are standard errors of the respective coefficients.
** and * Significant at 1and 5 per cent level respectively.
# Intercepts in natural logarithms.

Production Function Estimates

Decomposition analysis needs values on production function estimates and geometric mean levels of inputs and output. The production function estimates are presented in Table 4. It is apparent from the table that more than 87 per cent of the variation in cotton production on demonstration plots was explained by the variables included in the model as indicated by the values of the adjusted coefficient of multiple determination. Human labour (0.5842), bullock labour (0.2156) and seeds (0.4725) turned out to be the most important variables governing the production as these regression coefficients were significant at one per cent probability level. Capital input did not exert any significant influence on cotton production, while the plant nutrients (-0.2452) was excessively used.

TABLE 4. PER HECTARE COBB-DOUGLAS PRODUCTION FUNCTION ESTIMATES IN COTTON PRODUCTION

Sr. No. (1)	Explanatory variable (2)	Demonstration plots (3)	Small farms (4)	Large farms (5)	Overall (6)
1.	Human labour	0.5842**	0.7422**	0.5627**	0.3829**
		[0.2156]	[0.2123]	[0.1925]	[0.1832]
2.	Bullock labour	0.5522**	0.2947	0.5493*	0.2328
		[0.2372]	[0.1882]	[0.2658]	[0.1697]
3.	Seeds	0.4725**	0.3584**	-0.1042	0.5942**
		[0.1273]	[0.1232]	[0.0927]	[0.1326]
4.	Plant nutrients	-0.2452*	-0.4032*	0.0852	-0.1495
		[0.1209]	[0.1913]	[0.0721]	[0.0823]
5.	Capital	0.2152	0.4219*	0.2079*	0.3348*
		[0.1496]	[0.2053]	[0.1042]	[0.1395]
6.	Intercept	4.9853#	3.2362#	1.6969#	3.5297#
7.	$\bar{R}^2$	0.8498**	0.9063**	0.8846**	0.9196**
8.	Number of observations	30	43	37	80
9.	Residual sum of squares	0.7456	0.8216	0.8615	0.8542
10.	F-value	32.24**	79.58**	54.38**	184.74**

Note: Figures in square brackets are standard errors of the respective coefficients.
** and * Significant at 1 and 5 per cent level respectively.
# Intercepts in natural logarithms.

In the case of sample farms also, the Cobb-Douglas type of production function turned out to be a good fit, since $\bar{R}^2$ and F values were significant at one per cent probability level. About 90 per cent of the variation in cotton production on the farmers' fields was explained by the variables included in the model. The production elasticities of all the inputs on all the farmers' fields were invariably lower than unity implying diminishing marginal productivity with respect to each of these inputs. Human labour and capital coefficients were significant at one per cent on all the farms. Seed coefficient exerted a significant influence on cotton production on all sample farms barring large farms, wherein the coefficient was negative (0.1042) but non-significant. The geometric mean values of inputs presented in Table 5 showed that human labour and bullock labour were used in higher quantity on demonstration plots, whereas the use of all other inputs was more on the farmers' fields.

TABLE 5. GEOMETRIC MEAN VALUES OF INPUTS AND OUTPUT UNDER DIFFERENT FIELD SITUATIONS IN COTTON PRODUCTION

(per hectare)

Sr. No. (1)	Variables (2)	Farm category			
		Demonstration (3)	Small (4)	Large (5)	Overall (6)
1.	Human labour (man-days)	138.38	114.38	112.85	113.67
2.	Bullock labour (pair-days)	15.58	12.98	14.51	13.67
3.	Seeds (kg)	2.50	2.61	2.68	2.64
4.	Plant nutrients (Rs.)	3,501.25	3,681.09	3,781.15	3,727.37
5.	Capital (Rs.)	6,039.38	6,684.33	7,421.15	7,025.11
6.	Output (kg)	1,782.35	1,150.79	1,183.25	1,165.80

Decomposition Analysis of Yield Gaps

Comparatively more difference was noticed across the farms (42.55 kg) than across the districts (38.81 kg) with respect to the magnitude of Yield Gap II, hence the decomposition analysis was carried for different farm size-groups only. The results on decomposition analysis of yield gaps presented in Table 6 revealed that about 42.45 per cent of the potential farm yield of cotton left untapped by the sample farmers. The magnitude of yield gap on the small and large farms worked out to be 42.97 per cent and 40.97 per cent respectively. Therefore, there is a scope to raise the cotton production at least by 40 per cent.

TABLE 6. DIFFERENT SOURCES CONTRIBUTING TO YIELD GAPS IN COTTON PRODUCTION

(per cent)

Sr. No. (1)	Source of difference (2)	Sample farm category: Small farms (3)	Large farms (4)	Overall (5)
1.	Total difference in output (Yield Gap II)	42.97	40.97	42.45
2.	Sources of contribution			
	1. Difference in cultural practices	24.59	30.96	27.79
	2. Input use gaps			
	(a) Human labour	11.13	11.91	11.49
	(b) Bullock labour	10.25	3.93	7.47
	(c) Seeds	-2.04	-3.29	-2.58
	(d) Plant nutrients	1.23	1.89	1.54
	(e) Capital	-2.18	-4.43	-3.25
	Due to all inputs	18.39	10.01	14.66
3.	Total estimated Yield Gap II from all sources	42.97	40.97	42.45

Among the different sources contributing to the yield gap, the differences in technique of production or difference in cultural practices between the farmers' fields and the demonstration plots turned out to be the major (about 28 per cent) contributor to the yield gap on the overall category of farmers' fields, while the input use differences contributed about 15 per cent. Thus there is more scope to raise the cotton productivity by improving the techniques of production rather than by raising the input use levels.

The term 'technique of production' referred to better and timely crop management practices like land preparation, sowing, maintaining optimum plant density and spacing, timely application of recommended dose of plant nutrients and plant protection chemicals. The better technique of production adopted on the demonstration plots resulted in the shift of scale and slope parameters. This implied that by adopting recommended crop cultivation practices and without incurring extra expenditure on under-supplied inputs, yield levels could be increased by 28 per cent.

As noted earlier, the demonstration plots were supervised by technically well trained extension workers, which adopted all the recommended practices. So the production technology used on the demonstration plots was superior to that was used on the farmers' fields. Thus deviation from the recommended package of practices on farmers' fields adversely affected the yield performance of cotton. Hence, efforts on the part of the extension agencies to persuade the farmers to accept, adopt and reap the full benefits of the recommended technology is an urgent need in the present condition.

On overall category of farms, of the total of about 15 per cent contribution from the sub-optimal use of inputs to the yield gap, lower use of human labour and bullock labour on farmers' fields compared to the demonstration plots explained the major portion (11.5 per cent and 7.5 per cent respectively). Thus by using more number of man-days and bullock labour on farmers' fields, yield gap could be reduced by about 19 per cent, as there also existed positive gaps in the use of both these inputs on the farmers' fields vis-à-vis demonstration plots (Table 5). The contribution from the sub-optimal use of plant nutrients was meagre (1.54 per cent). Even though the regression coefficient of this input was negative on demonstration plots, the positive contribution can be attributed to the higher input use level on all the categories of farmers' fields than on the demonstration plots. Seed and capital inputs have contributed negatively to the yield gap. This was attributable to comparatively higher input use level on the farmers' fields. Thus reduction in the use of these inputs will reduce the yield gap by 5.83 per cent.

The analysis of contribution of various inputs to the yield gap revealed that across the two categories of the sample farms, among the different inputs, the contribution of human labour (11.91 per cent) was comparatively more on large farms, while the contribution of bullock labour was more (10.25 per cent) on small farms than any other inputs. However, the possibility of exploiting the untapped potential farm yield in cotton by using more of seed and capital inputs was rather impossible as both the inputs were excessively used.

Constraints Responsible for Yield Gaps

The study depicted a large amount of untapped yield potential (Table 1). Various constraints operating at the farm level may be partly responsible for this yield gap. Hence, the opinion of sample farmers on the difficulties in realising potential farm yield was collected and it is presented in Table 7. Non-availability of labour during weeding and picking seasons was a major problem as expressed by three-fourths of the respondents. More than 70 per cent of the sample farmers opined that the incidence of pests and diseases like bollworm, whitefly and leaf reddening prevented them from achieving greater farm potential in cotton. Therefore, there is a need to train the farmers on various aspects of integrated pest and disease management practices. The proportion of sample farmers expressing their difficulty in obtaining the operating funds was high (71.25 per cent). Cotton, being a capital intensive crop, requires huge funds to take up timely plant protection measures and therefore the opinion of the farmers was justifiable. More than 40 per cent of the sample farmers expressed their dissatisfaction towards the germination quality and cost of seed, quality and cost of fertilisers and plant protection chemicals. Costly seed material prompted the sample farmers to use the recommended rate of seed. Many of them were confused in using the plant protection chemicals as there existed numerous and newer plant protection chemicals for the same pest or disease. Hence, there is a need for validation of plant protection technology.

TABLE 7. OPINIONS OF SAMPLE FARMERS ON PROBLEMS CONFRONTED IN REALISING POTENTIAL FARM YIELD IN COTTON

Sr. No.	Problems	Small farms		Large farms		Overall	
		Number	Per cent	Number	Per cent	Number	Per cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Soil problem	15	34.88	14	37.83	29	36.25
2.	Difficulty in obtaining genuine seeds	19	44.19	15	40.54	34	42.50
3.	Substandard and costly fertilisers and plant protection chemicals	21	40.83	16	43.24	37	46.25
4.	Unfavourable climatic conditions and insufficient moisture	18	41.86	18	48.65	36	45.00
5.	Labour problem during peak crop season	31	72.09	29	78.39	60	75.00
6.	Problem of pest and disease incidence	34	79.06	25	67.58	59	73.75
7.	Lack of credit facilities	31	72.09	26	70.27	57	71.25
8.	Lack of technical know-how	30	46.51	13	35.14	33	41.25

More than 40 per cent of the sample farmers were not aware of recommended spacing and seed rate, dose and schedule of application of chemical fertilisers and plant protection chemicals. This implied that either the right kind of technology was not available to them or, if available, was not adopted by them. This suggests that the extension services should create awareness among the farmers about new options and development of efficient crop management skills. Growing of cotton on the unsuitable soils as a factor hindering productivity was reported by one-third of the sample farmers.

Contribution of Different Constraints to Yield Gap

To quantify the impact of various constraints on yield gap, regression analysis was carried out and the results are presented in Table 8. The coefficients of multiple determination for all the set of functions were not only high but also significant. This implied that the binary variables included as constraints in the model provided a satisfactory explanation for the major proportion of variation in the yield gap. The constant term in the regression model of the constraints influencing yield gap represents the environmental and other factors not included in the model, which accounted for about 32 per cent of the observed yield gap on the overall category of sample farms.

TABLE 8. REGRESSION ESTIMATES OF CONSTRAINTS INFLUENCING YIELD GAP IN COTTON PRODUCTION ON FARMERS' FIELDS

Sr. No. (1)	Explanatory variable (2)	Small farms (3)	Large farms (4)	Overall (5)
1.	Soil dummy	6.1805	0.6438	5.6678
		[4.1537]	[3.0623]	[3.0814]
2.	Moisture dummy	7.7823*	1.1925	3.7744
		[3.7668]	[3.7300]	[3.0186]
3.	Seeds dummy	5.4617	4.9336*	0.0251
		[3.0805]	[2.4557]	[2.2933]
4.	Fertiliser dummy	11.5854*	4.7506	5.1508*
		[5.2841]	[3.6450]	[2.1050]
5.	Plant protection chemicals dummy	0.5012	4.7505	3.6020
		[7.4793]	[3.6450]	[4.9337]
6.	Pest and diseases dummy	11.7216**	0.1813	5.5882**
		[4.3301]	[5.0863]	[1.8815]
7.	Labour dummy	8.9621	6.5923**	7.4246**
		[5.2582]	[2.2107]	[2.8691]
8.	Funds availability dummy	4.3746	1.5361	2.4463
		[5.5027]	[5.4771]	[4.4121]
9.	Intercept	21.0197#	35.1502#	32.0131#
		[9.6158]	[4.7428]	[9.2050]
10.	$\bar{R}^2$	0.7210**	0.7696**	0.7515**
11.	Number of observations	43	37	80
12.	F-value	9.1481**	14.6633**	12.1361**

Note: Figures in square brackets are standard errors of the respective coefficients.
** and * Significant at 1and 5 per cent level respectively.
# Intercepts in natural logarithms.

On small farms, the adequacy of the soil moisture was a crucial factor in tapping the farm potential (7.78 per cent) as its coefficient was statistically significant, while growing of cotton on problematic soils was responsible for 6.18 per cent of the yield gap. Non-application of chemical fertilisers at the recommended level and incidence of pest and diseases were responsible for 11.58 per cent and 11.72 per cent of the yield gap. Therefore, 23.30 per cent of the observed yield gap could be bridged by using the recommended quantity of fertilisers and adopting efficient plant protection measures against pest and diseases. On the other hand, non-availability of recommended variety and genuine seeds restricted the large category farmers to exploit about 5 per cent less of the farm potential. Non-availability of labour during the peak crop seasons was responsible for 6.59 per cent of the observed yield gap and coefficient of this variable was significant at one per cent probability level.

In the overall study area, the incidence of pest and diseases suppressed the exploitation of farm potential by 5.58 per cent, while non-availability of labour and growing of cotton on unsuitable soils resulted in 7.42 per cent and 5.66 per cent of the observed yield gap respectively. The coefficient of these three dummy variables were highly significant at one per cent probability level. Application of chemical fertilisers at the recommended level would reduce yield gap by 5.15 per cent and the regression coefficient of this variable was significant at 5 per cent probability level.

POLICY IMPLICATIONS

In the present study, the magnitude of yield gaps, factors contributing to yield gaps and constraints responsible for the presence of yield gaps were examined. These fall within the purview of policy formulation and depending upon the nature of location these could be altered. The important policy implications that could be drawn from the findings of the study are as follows.

1. *Suitability of farm technology:* The magnitude of Yield Gap I was more than 43 per cent which implied that the technology developed at the research station could not be duplicated on demonstration plots to exploit the full potential of cotton. This gap was attributable to environmental differences and non-transferable component of technology. So an intensive research effort is needed to modify the existing technology to reduce the non-transferable component of technology to exploit the yield potential of cotton.

2. *Cultural practices:* The faulty cultural practices being followed on farmers' fields led to yield gap to the extent of 27 per cent. The farmers usually do not adopt a technology as a package but take up individual practices suitably trimmed to fit into their budget, management and operational skills which lead to the variation in the adoption of cultural practices and consequently to the yield gaps. Therefore, cultural practices like sowing time, recommended dose and balanced use of plant nutrients, plant protection measures, weeding and intercultural operations have been very crucial for exploiting untapped farm potential, which entail little cost.

3. *Reallocation of expenditure among different inputs:* The decomposition analysis showed that differences in the use of various inputs had substantially contributed to yield gap. Further, use of plant nutrients on farmers' fields was deviated from the recommended dose. Therefore, reduction in the use of plant nutrients and additional use of human labour and bullock labour could profitably be applied to obtain substantial productivity gains. Among the several land saving and land augmenting technologies, use of recommended dose of plant nutrients, timely plant protection measures, adoption of suitable crop varieties and other yield increasing inputs are of crucial importance. The structural disabilities confronting farmers in their input supply can be overcome by developing suitable institutional arrangements for timely supply of the required quantity of essential inputs through single window approach.

4. *Demonstrations and extension network:* Lack of technical knowledge on the part of the farmers about recommended variety of seeds, plant nutrients, seed rate, spacing, etc., prevented them from exploiting the greater farm potential. Even though the research and extension linkages are fairly strong, the qualitative improvement by involvement of crop scientists and extension personnel is very much needed. The problems and corresponding solutions should obviously be very location- and time-

specific. Therefore, emphasis should be placed on location- and time specificity while directing effects of research and extension policy. It is needless to stress on farmers' assessment of constraints; possible technology and policy options will be a pre-requisite to bring out any desirable change. Therefore, the perceptions and views of the farmers need to be considered at each stage by researchers, policy makers and extension workers.

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