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A REGION-WISE ANALYSIS OF SUPPLY RESPONSE OF COTTON CROPS IN PUNJAB

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ABSTRACT

The study estimates the supply response of cotton crops at regional level in Punjab. To analyse the supply response, three acreage response models were developed separately on the basis of Nerlovian lagged adjustment model. A fast increase in area under cotton American in South- western region took place mainly due to the forces of substantial increase in the price, yield and in turn value productivity per hectare of this crop as compared to its competing crops. Cotton American occupied very small percentage of gross cropped area of the central region and therefore does not occupy an important place in the cropping pattern of the region. Due to this fact the farmers in central region have not responded significantly to various price and yield factors.

I. INTRODUCTION

Cotton is a major commercial crop of Punjab in kharif season. Cotton crop not only feeds our much expanded textile industry but also meets a considerable percentage of the requirements of edible oil. There has been in recent years an increasing tendency in the area under cotton in Punjab. The cotton area in Punjab is nearly ten percent' of the total cropped area under this crop in India.

A lot of efforts are being done by the government towards boosting the cotton production in order to meet the increasing demand of the fast growing population. However, the effective implementation of agricultural development programmes depends on the farmers who finally make the decision regarding the allocation of land for particular crop. Do the farmers respond rationally to various price and non-price incentives and how do they make production decisions? The knowledge of all these factors require the understanding of supply response analysis, which in turn is very much helpful in the formulation of plans for agricultural development.

A few investigations² have been conducted to study farmers' response to prices in so far as the allocation of acreage to cotton crops i. e. cotton American and cotton Desi are concerned. But no study so far has been made to test the supply response of cotton crops at regional level in Punjab. In the present study an attempt has been made to test the supply response of cotton crops at regional level in Punjab. In the present study an attempt has been made (i) to analyse

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the trends and pattern of growth of area, production and yield of cotton crops in Punjab and its various sub-regions, (ii) to study how far price and non-price factors like yield, irrigation, rainfall and variability due to yield and prices, influenced the supply of cotton crops in the state and (iii) to estimate the short run elasticities of acreage under cotton crops with respect to various price and non-price factors.

For inter- regional analysis, the state has been divided into three regions. These regions differ among themselves with respect to agro-climatic as well as technoeconomic conditions. Of three regions, the sub-mountainous region consists of Gurdaspur, Hoshiarpur and Ropar districts. Central region consists of Amritsar, Kapurthala, Patiala, Jalandhar and Ludhiana districts. South-western region comprises the districts of Sangrur, Bhatinda, Ferozepur and Faridkot.

Data source

The entire study is based on secondary data obtained mainly from the sources published by the Government of Punjab. The data on area, yield production, farm harvest prices, gross irrigated area, rainfall etc. were obtained from various annual issues of 'Statistical Abstract of Punjab'. The study was based on 26 years time series data from 1966-67 to 1991-92 for the state as a whole and its three sub-regions, for two cotton crops i. e. cotton American and cotton Desi. The time period 1966-67 to 1991-92 is the post green revolution period, during which major changes in the area and production of cotton crops took place in various regions of the state.

Methodology of the study is placed in section II. Results are presented and interpreted in section III. Conclusions are drawn in the last Section indicating some policy implications too.

II. METHODOLOGY

Farmers face a number of constraints while making production decisions in response to changes in economic environment . It is very rare that they are able to make cent percent adjustments in responding to various economic stimuli. In the field of agriculture, which is subject to weather uncertainties or which is undergoing changes in production technology, such constraints become still more severe. Under these circumstances, the adjustment lag model suggested by Marc Nerlove³ is considered appropriate for measuring the acreage response behaviour of the farmers.

For the purpose of present study, adjustment lag model has been used, which in the simplest form is based on the relation:

$$A_t^* = a_0 + a_1 P_{t-1} + U_t \quad (1)$$

where A_t^* is long run equilibrium acreage for a crop. A_t^* is a function of its price during the preceding year (P_{t-1}).

Because of techno-economic and socio-institutional constraints faced by the farmers, the actually realized change in acreage in a year may be a fraction of desired change which means the process of the realization of desired change may be spread over a number of years.

On expressing this gradual adjustment process in the form of partial adjustment model, we obtain

$$A_t - A_{t-1} = \beta (A_t^* - A_{t-1}) \quad 0 < \beta < 1 \quad (2)$$

where $A_t - A_{t-1}$ = Actual change in acreage

$A_t^* - A_{t-1}$ = Desired change in acreage.

β = coefficient of adjustment = $(1 - \text{coefficient of lagged area under the crop } A_{t-1})$. If the coefficient of adjustment (β) is nearer to one, it indicates that farmers have no constraint in adjusting their acreage to the desired level in short period. But if it is nearer to zero, then it implies that the farmers will take long time to adjust.

Now by substituting the value of A_t in equation (2),

we get, $A_t - A_{t-1} = \beta [a_0 + a_1 P_{t-1} + U_t - A_{t-1}]$

or $A_t - A_{t-1} = a_0 \beta + a_1 \beta P_{t-1} + \beta U_t - \beta A_{t-1}$

$A_t = a_0 \beta + a_1 \beta P_{t-1} + (1-\beta) A_{t-1} + \beta U_t$

$A_t = b_0 + b_1 P_{t-1} + b_2 A_{t-1} + V_t \quad (3)$

where $b_0 = a_0 \beta$

$b_1 = a_1 \beta$

$b_2 = (1-\beta)$

$V_t = \beta U_t$

Equation 3 is the computational equation, the parameters of which are estimated by the ordinary least square (OLS) method. In this model $V_t = \beta U_t$, where $0 < \beta \leq 1$. Therefore, if U_t satisfies the assumptions of the classical linear regression model, so will βU_t . Therefore, OLS estimation of the partial adjustment model will yield consistent estimates. Besides accounting for the 'lags' that occurred in farmers' adjustment behaviour, the Model postulated above also helps in the estimation of both the short run and long run supply elasticities.

Inclusion of additional variables such as yield, irrigation, rainfall and risk rather than concentrating on only the price factors is considered important to our understanding of the puzzle of shrinking acreage under some crops despite a rise in their prices. For the purpose of present study all these price and non-price variables have been considered separately in three different specifications of the acreage response model.

Specification I

$$A_t = b_0 + b_1 P_{t-1} + b_2 Y_{t-1} + b_3 CV_p + b_4 CV_Y + b_5 A_{t-1} + V_t$$

Specification II

$$A_t = b_0 + b_1 RP_{t-1} + b_2 RY_{t-1} + b_3 CV_{Rp} + b_4 CV_{RY} + b_5 A_{t-1} + V_t$$

Specification III

$$A_t = b_0 + b_1 RPR_{t-1} + b_2 CV_{RPR} + b_3 I_t + b_4 SSR_t + b_5 A_{t-1} + V_t$$

where A_t is the actual area planted in thousand hectares under the crop concerned, which is used as dependent variable in each model.

P_{t-1} and Y_{t-1} are respectively the price and yield of the crop concerned in $t-1$ year.

CV_P and CV_Y are the coefficients of variation of preceding 3 years' absolute price and absolute yield respectively.

RP_{t-1} and RY_{t-1} are respectively the relative price and relative yield of the crop.

CV_{RP} and CV_{RY} are the coefficients of variation of preceding 3 years' relative price and relative yield respectively.

RPR_{t-1} is the relative gross profitability i. e. ratio of the gross profitability of crop concerned to the gross profitability of the competing crop (s)⁴.

CV_{RPR} is the coefficient of variation of preceding 3 years' relative profitability used as a measure of relative profitability risk.

I_t Gross irrigated area under all crops in thousand hectares.

SSR_t Rainfall of sowing season for the crop concerned in centimetres.

A_{t-1} one year lagged area under the crop concerned in thousand hectares.

V_t error term.

The absolute price of the crop concerned lagged by one year (P_{t-1}) is considered to influence the farmers' decision of allocating his land to a particular crop. But even the realized price of a particular crop alone may not be sufficient to study the impact of price on acreage change under that crop if there is a simultaneous change in the prices of other crops especially the competing crops. Therefore in addition to the absolute price of the crop concerned as such, its relative price with respect to the competing crops in lagged form is another important independent variable.

Like prices, yield of the crop concerned is also considered as an important variable because it is representative of the technological changes related with the crop and hence represent latter with regard to its impact on the area. But an increase in the average yield of the crop concerned alone may not be significant if similar changes have taken place in case of competing crops too. In this situation, relative changes in the yield level vis-a-vis competing crops will be more useful. That is why yield of the crop concerned as well as relative yield of the crop were alternatively considered as independent variables for changes in the acreage of various cotton crops.

Similarly, the gross value productivity⁵ of the crop concerned deflated with average weighted gross value productivity of the competing crop (i. e. relative profitability (RPR_{t-1})) is an other important explanatory variable from the point of view of acreage response analysis. The changes in gross irrigated area have also an important influence on acreage allocation.

For the purpose of present study multiple linear regressions were developed and the reliability of the estimated regression equations and regression coefficients of variables included in the models was evaluated on the basis of the values of R^2 and t-values respectively. The presence of autocorrelation has been indicated by h-statistics.⁶

The short run elasticity of acreage with respect to independent variables has been calculated by multiplying the regression coefficient of each independent variable with the ratio of average of that independent variable and area under the crop over the period under study.

III. ANALYSIS OF THE FINDINGS

Growth pattern of Area, Production and Yield of Cotton American and Cotton Desi.

Table 1 shows that cotton American is the most important fibre crop of Punjab. It is an area specific crop confined mainly to the south-western region of the state due to the

Table 1. Area, Production and Yield of cotton American and Cotton Desi in Punjab and its Sub-Regions at three Points of time.

Variables	Regions				Regions			
	Sub-Mountainous	Central	South-Western	Punjab State	Sub-Mountainous	Central	South-Western	Punjab State
	Crop: Cotton American				Crop: Cotton Desi			
Area								
(000'Hectares)								
1966-71	1.58	41.68	174.42	217.68	7.58	40.66	144.46	192.80
1976-81	-	21.52	427.62	449.35	5.98	39.86	119.36	165.40
1987-92	-	10.52	623.38	633.90	1.08	7.46	59.20	68.00
Growth Rate	-	-8.44*	6.28*	5.20*	-7.78*	-7.29*	-5.41*	-5.76*
Production								
(000.Metric Tons)								
1966-71	0.28	12.40	67.92	80.60	1.14	10.84	47.11	59.09
1976-81	-	5.36	158.16	163.52	1.04	8.52	33.36	42.92
1987-92	-	4.10	341.10	345.20	0.23	1.67	18.48	20.38
Growth Rate	-	-8.41*	7.28*	6.41*	-5.84*	-8.70*	-5.98*	-6.30*
Yield								
(Kg./Hectare)								
1966-71	177	298	389	370	150	267	326	306
1976-81	-	249	370	364	174	214	279	259
1987-92	-	390	547	544	213	224	312	299
Growth Rate	-	0.03 ^{NS}	0.93 ^{NS}	0.90 ^{NS}	2.12*	-1.52**	-0.57 ^{NS}	-0.55 ^{NS}

Note : 1. -refers to nil.

2. * refers to singnificance at 1 percent leveland NS refers to non-significant.

3. Annual compund growth rates of area, production and yield of cotton crops have been calculated for the period 1966-67 to 1991-92.

Source: Statistical Abstract of Punjab, various issues.

availability of suitable soil and climatic conditions for the cultivation of this crop. Cotton American covered 4.14 percent (217.68 thousand hectares) of the total cropped area of the state in 1966-67, which increased substantially to 8.53 percent (633.9 thousand hectares) in the period 1987-92. Within various regions, the area under cotton American increased only in south-western region from 174.42 to 623.38 thousand hectares, while in central region it has shown decline from 41.68 to 10.52 thousand hectares in 1987-92 over 1966-71. The area under this crop in submountainous region is almost nil. The yield of cotton American has shown positive rates of growth in various regions and state as a whole.

Cotton Desi was an important fibre crop in quinquennium 1966-71 and occupied an area of 192.8 thousand hectares, which came down to 68 thousand hectares in 1987-92 in Punjab state as a whole. The area under cotton Desi declined at a rate of 7.78, 7.29 and 5.41 percent per annum between 1966-67 and 1991-92 in sub-mountainous, central and south-western region respectively. Yield of this crop has also shown significant negative growth rate in central region and insignificant negative growth rate in south-western region and Punjab state as a whole.

Supply Response Analysis of Cotton crops

The estimated acreage response regression equations explaining various factors influencing area under cotton American and cotton Desi during 1966-67 to 1991-92 (based on three different specifications) are presented in Table 2, 3 and 4. The short run elasticities of acreage with respect to independent variables and coefficients of adjustment are presented in Table 5. Main results of the supply response analysis are discussed below. a) Price Response

One year lagged absolute price (P_{t-1}) and relative price (RP_{t-1}) of cotton American with respect to Bajra and cotton Desi (competing crops) have shown significant positive influence on area under this crop in south-western region and Punjab state as a whole, while in central region, the impact of these variables has been positive but insignificant as shown in the regression coefficients presented in Table 2 and 3. The elasticities of acreage with respect to relative price variable were 0.314 for Punjab state and 0.279 for south-western region, being significant at 5 percent and 10 percent level respectively (Table 5). The relative price elasticities obtained in the present study were lower than the elasticities obtained by Raj Krishna⁷ (0.72) for Punjab and Sangwan⁸ (0.79) for Haryana.

In case of cotton Desi, absolute price lagged by one year (P_{t-1}) has exercised significant negative impact on area under this crop in various regions and state as a whole. The elasticity of acreage with respect to price was highest for Punjab state as a whole (-0.701) and lowest for central region (-0.223), being significant at 1 percent and 20 percent level respectively (Table 2 and 5). This type of significant negative impact of price on area under cotton Desi was observed due to the fact that despite a significant increase in the price of this crop from

Table 2. Estimates of Area Response Functions of Cotton American and Cotton Desi in Punjab and its sub-Regions, 1966-67 to 1991-92 (Based on specification I).

Variables	Regions				Regions			
	Sub-Mountainous	Central	South-Western	Punjab State	Sub-Mountainous	Central	South-Western	Punjab State
	Crop: Cotton American				Crop: Cotton Desi			
Constant	-	-13.751	-97.569	-108.003	4.826	12.066	-5.757	145.296
P_{t-1}	-	0.006	0.082 [@]	0.158 [@]	-0.008*	-0.022 [@]	-0.118**	-0.316*
		(0.456)	(1.704)	(1.455)	(-2.997)	(-1.646)	(-2.780)	(-2.929)
Y_{t-1}	-	0.013**	0.093**	0.113*	0.001	0.009	0.083*	0.093**
		(2.209)	(3.349)	(3.140)	(0.398)	(0.853)	(3.441)	(2.248)
CV_p	-	-0.007**	1.731 [@]	1.490 [@]	0.030	0.220	1.706*	2.854**
		(-2.387)	(1.718)	(1.504)	(0.927)	(1.065)	(2.871)	(2.218)
CV_Y	-	0.102	0.205	0.978	0.008	-0.247***	0.466	-0.015
		(0.589)	(0.237)	(1.118)	(0.391)	(-1.780)	(1.123)	(-1.021)
A_{t-1}	-	0.963*	0.841*	0.787*	0.441*	0.627*	0.478*	0.460*
		(5.253)	(7.234)	(6.890)	(2.362)	(3.986)	(2.861)	(4.385)
R^2	-	0.839	0.954	0.953	0.915	0.903	0.907	0.880
F-Value	-	19.932	79.811	76.688	40.942	35.555	37.307	27.972
h-statistics	-	1.662	1.653	0.712	0.279	0.644	0.673	1.318
Inferences	-	SC	SC	NSC	NSC	NSC	NSC	NSC

Note: Figures in brackets are t-values. *, **, *** and @ indicate significance at 1 percent, 5 percent, 10 percent and 20 percent respectively.

SC=Serial Correlation, NSC= No serial correlation.

Rs. 125.45 in 1965-70 to Rs. 658.89 per quintal in 1986-91, the area under this crop has declined tremendously in various regions during the period under study (Table 1). Thus we see that fast increase in the price of cotton Desi at a rate of 8.33 percent per annum during 1965-92 was accompanied by significant fall in area under this crop in all regions of the state.

Lagged relative price of cotton Desi (RP_{t-1}) has shown significant negative impact on cotton Desi acreage in state as a whole, while in case of various regions (except central region), the impact of this variable has been negative, though insignificant (Table 3). The insignificant impact of relative price variable shows that farmers in various regions did not take into consideration the relative price of cotton Desi while allocating area under this crop. This was due to the fact that although the price of cotton Desi has increased in the state but simultaneously the price of the major competing crop i. e. cotton American has also increased

Table 3. Eastimates of area Response Functions of Cotton American and Cotton Desi in Punjab and its Sub-regions, 1966-67 to 1991-92 (Based on specification II).

Variables	Regions			Punjab State	Regions			Punjab State
	Sub-Mountainous	Central	South-Western		Sub-Mountainous	Central	South-Western	
	Crop: Cotton American				Crop: Cotton Desi			
Constant	-	-10.190	-342.792	-432.690	1.371	0.388	-29.355	106.23
RP _{t-1}	-	3.111	64.720***	79.599**	-0.682	1.158	-29.491	-84.521@
		(0.973)	(1.788)	(2.189)	(-0.523)	(1.167)	(-0.606)	(-1.361)
RY _{t-1}	-	5.896	182.268*	244.745*	0.439	16.145@	137.497***	66.944@
		(0.911)	(3.537)	(4.879)	(0.616)	(1.628)	(2.034)	(1.580)
CV _{RP}	-	0.051	3.545**	2.190@	-0.003	-0.097@	-0.559@	-1.692@
		(0.444)	(2.407)	(1.480)	(-1.074)	(-1.417)	(-1.574)	(-1.630)
CV _{RY}	-	-0.004	-0.620	-1.521@	-0.008	-0.514**	-0.473	-0.252@
		(-0.926)	(-0.589)	(-1.403)	(-0.542)	(-2.679)	(-1.278)	(-1.511)
A _{t-1}	-	0.812*	0.928*	0.959*	0.933*	0.805*	0.613*	0.854*
		(7.032)	(15.823)	(15.500)	(7.707)	(7.976)	(4.199)	(6.923)
R ²	-	0.784	0.959	0.958	0.879	0.908	0.869	0.864
F-Value	-	14.523	88.750	87.277	29.161	28.119	25.224	25.508
h-statistics	-	0.529	0.097	0.607	0.574	0.027	0.516	0.223
Inferences	-	NSC	NSC	NSC	NSC	NSC	NSC	NSC

Note: Figures in brackets are t-values. *, **, *** and @ indicate significance at 1 percent, 5 percent, 10 percent and 20 percent level respectively.

NSC= No serial correlation.

at a rate of 6.90 percent per annum during 1965-91. That is why insignificant increase in the relative price of cotton Desi crop could not influence significantly the area under it in most of the regions.

b) Yield Response

One year lagged absolute yield of cotton American (Y_{t-1}) has significant positive regression coefficients for Punjab state and its two sub-regions. But the coefficients of one year lagged relative yield of cotton American with respect to bajra and cotton Desi (competing crops) turned out to be significantly positive in south-western region and Punjab state as a whole with short run relative yield elasticities of 0.598 and 0.767 respectively, significant at 1

Table 4. Estimates of Area Response Functions of Cotton American and Cotton Desi in Punjab and its sub-regions, 1966-67 to 1991-92 (Based on specification III).

Variables	Regions				Regions			
	Sub-Mountainous Crop: Cotton American	Central	South-Western	Punjab State	Sub-Mountainous	Central	South-Western	Punjab State
Constant	-	51.340	-394.366	-225.940	5.482	17.677	15.923	16.173
RPR _{t-1}	-	2.059 (1.010)	60.532* (2.894)	55.801*** (1.753)	-0.062 (-0.107)	-1.606 (1.202)	2.679@ (1.437)	29.071@ (1.524)
CV _{RPR}	-	-0.071@ (-1.649)	-4.715* (-2.960)	-3.098@ (-1.672)	-0.016@ (-1.485)	-0.089@ (-1.358)	-0.024 (-1.024)	-0.175@ (-1.414)
I _t	-	-0.017** (-2.562)	0.241* (4.525)	0.070** (2.563)	-0.013*** (-1.970)	-0.015*** (-1.816)	-0.028@ (-1.455)	-0.026*** (-1.796)
SSR _t	-	-0.025 (-0.537)	0.738 (0.808)	0.272 (0.669)	0.004 (0.145)	0.022 (0.277)	-0.094 (-0.269)	0.091 (0.797)
A _{t-1}	-	0.342@ (1.649)	0.280@ (1.647)	0.539** (2.616)	0.601* (3.452)	0.842* (6.007)	0.616** (2.698)	0.641* (4.055)
R ²	-	0.849	0.972	0.945	0.899	0.873	0.844	0.869
F-Value	-	21.821	134.812	65.857	38.940	16.614	20.554	33.384
h-Statistics	-	1.230	1.328	ND	0.321	0.707	ND	1.293
Inferences	-	NSC	NSC		NSC	NSC		NSC

Note : Figures in brackets are t-values. *, **, *** and @ indicate significance at 1 percent, 5 percent, 10 percent and 20 percent level respectively.

NSC = No Serial correlation ND = Not Defined.

percent level each. The impact of relative yield variable on area under cotton American in Central region was insignificantly positive (Table 2, 3 and 5).

The absolute yield factor (Y_{t-1}) in case of cotton Desi has emerged most positive and significant in south-western region and Punjab state as a whole, with short-run supply yield elasticity of 0.657 and 0.518, both being significant at 1 percent and 5 percent level respectively. In case of other two regions, the impact of this variable has remained very weak (Table 2 and 5).

The relative yield of cotton Desi with respect to its competing crops has exercised a strong positive impact on area under cotton Desi in south-western region, followed by central region and Panjab state as a whole with short run relative yield elasticities of 0.905, 0.361 and 0.346 respectively significant at 10, 20, and 20 percent level, while in case of sub-

mountainous region the impact of relative yield variable is insignificantly positive (Table 3 and 5)

Table 5. Coefficients of Adjustment and Short-Run Elasticities of Cotton American and Cotton Desi Acreage with Respect to Price and Non-Price Variables in Punjab and its Sub-Regions, 1966-67 to 1991-92.

Variables	Regions				Regions			
	Sub-Mountainous	Central	South-Western	Punjab State	Sub-Mountainous	Central	South-Western	Punjab State
	Crop: Cotton American				Crop: Cotton Desi			
Absolute price (P_{t-1})	-	0.103	0.081@	0.148@	-0.495*	-0.223@	-0.351**	-0.701*
Relative Price (RP_{t-1})	-	0.234	0.279***	0.314**	-0.148	0.041	-0.217	-0.560@
Absolute Yield (Y_{t-1})	-	0.508**	0.286**	0.318*	0.102	0.191	0.657*	0.518**
Relative Yield (RY_{t-1})	-	0.307	0.598*	0.767*	0.078	0.361@	0.905***	0.346@
Relative Profitability (RPR_{t-1})	-	0.186	0.334*	0.287***	-0.013	-0.039	0.184@	0.248@
Irrigation (I_t)	-	-1.759**	1.598*	0.903**	-1.356***	-1.065***	-0.653@	-0.953***
Rainfall (SSR_t)	-	-0.049	0.038	0.061	0.026	0.029	-0.017	0.057
Coefficients of Adjustment								
Specification I	-	0.037	0.159	0.213	0.559	0.373	0.522	0.540
Specification II	-	0.188	0.072	0.041	0.067	0.195	0.387	0.146
Specification III	-	0.658	0.720	0.461	0.399	0.158	0.384	0.359

Note: *, **, *** and @ show significance at 1, 5, 10 and 20 percent level respectively.

c) Relative Profitability

Relative profitability of cotton American lagged by one year (RPR_{t-1}) has shown significant positive impact on area under cotton American in south-western region and Punjab state as a whole with elasticities of 0.334 and 0.287 respectively significant at 1 percent and 10 percent level (Table 5). The relative profitability of cotton Desi has shown insignificant negative impact on area under cotton Desi in sub-mountainous and central region of the state. This shows that relative profitability of cotton Desi does not influence the allocation of areas of cotton Desi growers in these two regions. This could be due to the fact that cotton Desi

covered very small proportion of gross cropped area i.e. 0.15 and 0.30 percent of gross cropped area in sub-mountainous and central region and that is why it did not compete with other crops. The elasticity of acreage with respect to relative profitability was positive and significant at 20 percent level each in south-western region (0.184) and Punjab state as a whole (0.248) (Table 4 and 5). The positive impact shows that decline in relative profitability of cotton Desi with respect to cotton American (competing crop) in south-western region and state as a whole was accompanied by fall in area under this crop.

d) Irrigation

The increase in gross irrigated area has favourably influenced the area under cotton American in south-western region and Punjab state as a whole. The positive short run elasticity of acreage with respect to irrigation was 1.598 for south-western and 0.903 for Punjab state, being significant at 1 and 5 percent level respectively. The impact of irrigated area on area under this in Central region was significantly negative with a very high acreage irrigation elasticity of -1.759, significant at 5 percent level (see Table 5). This shows that with an increase in area under irrigation, the farmers in central region have shifted area from cotton to other more productive crop of rice, because land on which cotton is grown is also suitable for growing rice and the increasing irrigation facilities can meet the requirements of much needed water for the cultivation of rice.

The response of cotton Desi acreage to irrigation has been negative and significant in various regions and state as a whole. The short run elasticities of acreage with respect to irrigation varied between -1.356 for sub-mountainous region (significant at 10 percent level) and -0.653 for south-western region (significant at 20 percent level) (Table 4 and 5). This negative effect shows that with the increase in area under irrigation, the farmers in various regions have shifted area from low yield cotton Desi crop to other high yielding crops.

e) Rainfall

Other variable of water availability i.e. sowing season rainfall (SSR_t) has not emerged as an important factor influencing area under both cotton crops in various regions and state as a whole (Table 4 and 5).

f) Risk factors

Among various risk factors considered in the analysis, risk arising due to variations in absolute price has shown significant positive impact on area under cotton American and cotton Desi in south-western region and Punjab state as a whole. The absolute price risk variable has shown significant negative impact on area under cotton American in central region. The absolute yield risk variable (CV_y) has shown significant negative impact on area under cotton Desi in case of central region only, while in other regions and state as a whole, the impact of this variable has been insignificantly positive in case of both crops (see Table 2).

The significant positive impact of various price risk factors on area under both crops in most of the regions and insignificant positive impact of absolute yield risk factors on area

under cotton American in various regions was observed mainly due to continuous trends in price and yield levels of both crops included in the study.

In fact the total variability, considered by us consists of expected and unexpected variability and it is the latter which actually accounts for risk. If some crops have continuous expected trends in yield or price, the expected variability may predominate the total variability and hence the signs opposite to expected one may occur for risk variables. For example, variability in the prices of cotton crops may increase, but if this increase is always caused by upward trend in prices, the resulting effect of this variability will not be negative as the variability was expected.

The impact of relative price risk variable ($_{CVRP}$) has been significantly positive in case of cotton American in south-western region and state as a whole, while in case of cotton Desi crop, the impact of relative price risk variable was significantly negative in most of the regions and state as a whole (Table 3).

The impact of relative yield and relative profitability risk variables on area under-cotton crops has been significantly negative in almost all regions of the state (Table 3 and 4).

The coefficients of lagged acreage (A_{t-1}) under both cotton crops have emerged significant and positive in various regions and state as a whole. The values of coefficients of adjustment obtained from various regression equations presented in Table 5 ranged between 0.037 and 0.658 in central region, 0.072 and 0.720 in south-western region and 0.041 and 0.461 in Punjab state as a whole in case of cotton American crop. The values of coefficients of adjustment were comparatively low in case of cotton Desi crop ranging/between 0.067 to 0.559, 0.158 to 0.373, 0.384 to 0.522 and 0.146 to 0.540 respectively in three regions, and state as a whole, these values show that there was less scope for adjusting the acreage under cotton Desi crop in Punjab and its various sub-regions, mainly due to less profitability and more risks in case of yield and profitability of this crop as compared to its competing crops.

IV. CONCLUSIONS AND POLICY IMPLICATIONS

The overall analysis shows that area under cotton American has increased tremendously in south-western region of Punjab, while in other two regions, the area under it has shown significant decline during the period under study. Such a fast increase in area under cotton American in south-western region took place mainly due to the forces of substantial increase in price, yield and in turn value productivity per hectare of this crop as compared to its competing crops. The farmers in central region have not responded significantly to various price and yield factors. It might be due to the fact that cotton American occupies very minor i.e. 0.4 percent of gross cropped area of central region and therefore does not occupy an important place in the cropping pattern of the region. Keeping in view the relative gross profitability of this crop, there is a good scope for expanding area under it in central and sub-mountainous region of the state; yet this crop can replace the rice crop very negligibly because

cotton and rice lands are very much different in nature, especially with regard to the drainage requirements.

Due to low level of value productivity and relative yield of cotton Desi, the area under this crop declined substantially in various regions of Punjab. The farmers in sub-mountainous and central regions have responded significantly negative to absolute price and irrigation, while the response of the farmers towards other factors was relatively weak and insignificant. Both these regions occupied very small percentage of total area under cotton Desi in the state. South-western region which occupied almost 87 percent of the total area under cotton Desi in state responded significantly positive to yield and relative profitability factors and significantly negative to price and irrigation factors. Almost similar pattern was also observed for Punjab state as a whole.

The significant negative impact of relative yield and relative profitability risk factors on area under both cotton crops in various regions of Punjab showed that variations in these factors did unfavourably affect cotton cultivators and the farmers in the state were risk averse.

Despite the availability of fairly high yielding varieties of cotton Desi, the farmers in the state have not paid proper attention towards the plant protection measures. As a result of it, yield level of cotton Desi remained very low and crop failures are also very common, especially in sub-mountainous and central region of the state. If the farmers take proper care at the production level and the possibilities of export markets are fully explored, this crop has some scope to replace rice crop at the margin in various regions of the state. Thus, the most important requirement on the production side is the exquisite application of spraying schedules. In order to motivate the farmers to put more area under cotton crops, the government should make efforts to reduce instability in their yield and profitability, and this in turn can be done by discovering better varieties of disease-resistance cotton crops. Suitable, assured and remunerative support prices and procurement of the produce brought in the market is very much necessary to stabilise acreage under both of cotton crops and sustain their production at a high level in future.

NOTES

1. Statistical Abstract of Punjab, 1993.
2. a) Raj Krishna, 1963, pp. 477-487.
b) J.L. Kaul and D.S. Sidhu, 1971, pp. 427-439.
3. Nerlove, M. 1956, pp. 495-508.
4. The competing crop (s) for each crop concerned have been selected keeping in view of their percentage share in the total cropped area of the regions. The competing crops are cotton Desi and Bajra for cotton American in various regions and state as a whole. Groundnut and mash for cotton Desi in sub-mountainous region; groundnut and cotton American for cotton Desi in central region and Punjab state as a whole; and cotton American for cotton Desi in south-western region.
5. Gross value productivity has been obtained by multiplying yield per hectare by the price of the crop.

6. The presence of autocorrelation in the present study has been indicated by h-statistics.

$$h = (1 - \frac{1}{2}d) \sqrt{\frac{n}{1 - n \cdot v(b)}}$$

where

n= number of observations

d= usual durbin-watson 'd' Statistics

v (b)= is to variance of the coefficient of lagged acreage (A_{t-1}) in simple least square regression.

The h-statistics is tested as standard normal deviate; Thus if $h < \pm 1.645$, one would accept the hypothesis that there is no (first order) serial correlation in data at 5 percent level of significance. But this test is not applicable or the value of h-statistics is not defined if $n \cdot v(b)$ exceeds one.

7. Raj Krishna, (1963), pp. 477-487.
8. S.S. Sangwan (1985), pp. 173 to 184.

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