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Determination of Optimum Cropping Pattern in the Faisalabad Division (Pakistan)

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ABSTRACT

Linear Programming Model was applied to calculate the crop acreage, production and income of the Faisalabad division. The study was conducted on 2702 thousand acres of the irrigated areas from the three districts. Crop included in the model were wheat, Basmati rice, IRRI rice, cotton, sugar cane, maize and potato. The results showed that the cotton, maize and wheat gained acreage by about 5-10%, while main losers were Basmati rice, IRRI rice, sugarcane and potato. Overall optimal crop acreage increased by 1.88% while, optimal income was increased by around 2% as compared to the existing solutions.

Key Words: Linear Programming; Optimal Solution; Cropping pattern; Gross margin

INTRODUCTION

The province of the Punjab accounts for about 73.4% of Pakistan's Agriculture both in terms of cropped acreage and income originating from the crop sector, respectively. Over 95% of agriculture income comes from the irrigated areas of Pakistan, of which 73% is contributed by the irrigated areas of the Punjab (Anonymous, 1999-2000a; 1999-2000b).

In the past, agriculture was improved through input and credit supply and their subsidization, price fixation, procurement, crop zoning, rural infrastructure, etc. No doubt good results were achieved but only part of the real potential of agriculture has been realized. Many of development instruments, however, have been exhausted, withdrawn and/or have little relevance or potential in the times ahead.

The most decisive option would comprise selection of optimum cropping patterns as a pre-requisite to efficient utilization of available resources of land, water and capital. This has never been done in the past for Pakistan's agriculture. Farmer's profit cannot be maximized without optimum cropping patterns, which ensure efficient utilization of available resources.

The present study was carried out to i) assess the farmer's income level under optimal cropping pattern and their comparison with the existing income level, and ii) to develop optimal cropping pattern for the Faisalabad Division (Pakistan).

METHODOLOGY

The study was carried out in whole Faisalabad division. The study was conducted on 2702 thousands acres which roughly accounts for more than 75% of irrigated area of the Faisalabad division. The data used in the study are the aggregate farm resources availability in the Faisalabad division, relative profitability and input-output, coefficients of various crop activities. Linear Programming Model of the following form was used in the analysis.

Mathematical presentation of the model. The objective of the model was to maximize total net income (gross margin) Algebraically the model is summarized below:

Basic assumptions. a) All producers in a division are having only the choice to produce certain product mixes, b) All producers in a division have identical input – output coefficients, c) Total production of various commodities is limited by the resources availability in the division, d) An acre of production can be substituted for an acre of other type of production, e) The economic objective of the produces is to maximize profit, i.e. gross margin, f) The production period is agricultural calendar year, g) Crops covering upto 2% or above of the total cropped area would be included in the optimal solutions, h) Farm labor supply does not pose limitation on crop production, i) Maximum and minimum area in optimal solution has been assumed not more than 1.1 and not less than 0.9 times respectively of the existing area under crops.

The model. Linear programming model of the following form was used as an analytical tool to explore the possibilities of optimizing farm returns.

The objective function was to maximize profit, where

$$Y = \sum_{i=1}^{m} \sum_{J=1}^{n} C_{ij} X_{ij}$$

Subject to the following constraints

Kharif land availability.

$$\sum_{J=1}^{n} a_{ij} X_{ij} \leq SL_{i} \quad for\ all\ i$$

Rabi land availability.

$$\sum_{J=1}^{n} a_{ij} X_{ij} \leq WL_i \quad \text{for all } i$$

Water availability.

$$\sum_{J=1}^{n} W_{ijg} X_{ijg} \leq W_{ig} \quad \text{for all } i \text{ and } g$$

Capital availability.

$$\sum_{J=1}^{n} K_{ij} X_{ij} \leq K_i \quad \text{for all } i$$

Maximum acreage constraint.

$$\sum_{i=1}^{m} a_{iJ} X_j \leq Max_j \quad \text{for all } i \text{ and } J$$

Minimum acreage constraint.

$$\sum_{i=1}^{m} a_{iJ} X_j \geq Min_j \quad \text{for all } i \text{ and } J$$

Non-negativity constraints.

$$X_{iJ} \geq O$$

Where Y = Gross margin i.e. gross income - variable cost; C_{ij} = Gross margin from J-th activity in the i-th districts: i = 1, Faisalababd district, i = 2, T.T Singh district, i = 3, Jhang district; J = 1, Wheat, J = 2, Basmati Rice, J = 3, IRRI Rice, J = 4,Cotton, J = 5, Sugarcane, J= 6, Maize, J = 7, Potato X_{ij} = Level of J-th activity in the i-th district; a_{ij} = Amount of land needed per unit of J-th activity in the i-th district; SL_i = Amount of land available during the kharif season in the i-th district; WL_i = Amount of land available during the Rabi season in the i-th district; w_{ijg} = Quantity of water required per unit of j-th activities in the i-th district during the g-th month: g = 1, January; g = 2, February, g = 3, March, g = 4, April, g = 5, May, g = 6, June, g= 7, July, g = 8, August, g = 9, September, g = 10, October, g = 11, November, g = 12, December

X_{ijg} = Level of J-th activity in the i-th district during the g-th month; W_{ig} = Total amount of water available in the i-th district during the g-th month; k_{ij} = Amount of capital required for the J-th activity in the i-th district; K_i = Total amount of capital available in the i-th district; X_J = Level of j-th activity; Max_J = Maximum level of j-th activity; Min_i = Minimum level of j-th activity

RESULTS AND DISCUSSION

Optimal solutions. Optimal cropping pattern resulting from the application of LP model in comparison to the existing cropping patterns for Faisalabad division are presented in Table I.

In the Faisalabad division, cotton, maize and wheat gained acreage by 9.96, 9.85 and 5.18%, respectively. The crop, which lost acreage Basmati by a margin of 10.10%, IRRI, sugarcane and potato by 10% each. Overall optimal cropped acreage increased by 1.88% as compared to the existing solution.

The results show that production of wheat, cotton and maize increased by 5.18, 9.96 and 9.85%, respectively as compared to the existing levels. While, the production as Basmati rice, IRRI rice, sugar cane and potato decreased by about 10% each as compared to the existing levels.

Optimal income (gross margin) was up by 0.171 billion in the Faisalabad division. Optimal income increased from existing level of Rs. 8.973 to Rs. 9.114 billion showing an improvement of almost 2% (Table II). The optimal income level as compared to the existing one is presented in Table III.

The results, therefore, plead that the LP model suggestions are worth trying. The results of this study are in line with the results of the studies conducted by Saini (1975), Radhakrishnan and Sivandhram (1975), Bajwa, (1978), Jolayemi and Olaomi (1995) and Carvalho *et al*. (2000). They found that the optimal solution increased income.

Table I. Comparison of Cropping Pattern under Optimal Solutions with Existing Condition

Crops	Existing (000 acres)	Optimal Solutions (000 acres)	% of Existing
Wheat	1600	1653	105.18
Basmati Rice	208	187	89.90
IRRI Rice	20	18	90.0
Cotton	321	353	109.96
Sugar Cane	462	416	90.0
Maize	71	78	109.85
Potato	20	18	90.0
Total	2702	2753	101.88

Table II. Comparison of Crop Production under Optimal Solutions with Existing Condition

Crops	Existing (000 maund)	Optimal Solutions (000 maund)	% of Existing
Wheat	46576	48992.1	105.18
Basmati Rice	3731.52	3354.78	89.90
IRRI Rice	760	684	90.0
Cotton	4551.78	5005.54	109.96
Sugar Cane	200849.9	180851.8	90.0
Maize	2840	3120	109.85
Potato	3258.2	2932.38	90.0

Table III. Comparison of Income Level under Optimal Solutions with Existing Condition

Existing Income Rs. Billion	Optimal solutions Rs. Billion	% of Existing
8.973	9.144	101.9

CONCLUSIONS AND SUGGESTIONS

As a result of optimal cropping pattern, farm income increased by 2%. The results showed that farmers in the Faisalabad division were more or less at the optimal level because cropped area increased by about 2%. However, the optimal solution pattern suggested significantly change in the cropping pattern. It suggests 5.18% increase in wheat acreage, while about 10% increase in each of cotton and maize. On the other hand it suggested reduction in the acreage of Basmati rice, IRRI rice, sugarcane and potato of about 10% each.

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