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RESEARCH NOTES

MAXIMIZATION OF RETURNS THROUGH FARM PLANNING UNDER FERTILIZER CONSTRAINT IN ALIPUR BLOCK OF THE UNION TERRITORY OF DELHI

Agricultural development leading to self-sufficiency in food is one of the basic objectives of economic planning in India. Until very recently, a major part of the foreign exchange which could have been used for industrial development programmes was used up in the imports of foodgrains to feed the growing population of the country. Introduction of Mexican varieties of wheat after the mid-sixties helped the country to lessen the drain of foreign exchange needed in the imports of foodgrains. But this was only a short relief. Food shortage with consequent food imports was observed again in 1972-73. The recent petrol crisis has further complicated the problem of food production due to the fall in the supply of fertilizers and power needed for agricultural production. The Green Revolution which boosted production of wheat in the late sixties was the outcome of dwarf varieties of wheat which could stand higher doses of fertilizer and thus yielded higher production. A cut-back in the supply of fertilizer had an adverse impact on foodgrain production. Until the production and supply of fertilizer come up to the required levels for agricultural production, most economic use of this scarce input has to be made for maintaining agricultural production. An attempt has, therefore, been made in this paper to examine the role of optimal farm planning in increasing or maintaining agricultural production of farm returns under fertilizer constraints. Optimal farm plans with multiple cropping were prepared with fertilizer supplies equal to half the amount of the supplies of 1971-72 and also with the full supply of fertilizer to suggest the needed changes in the cropping pattern for maximizing agricultural production under conditions of fertilizer scarcity.

Since multiple cropping with crop rotations having legume crops is one way of increasing agricultural production, Alipur block of the Union Territory of Delhi was selected for the present study as this block is being used as one of the areas selected for the Pilot Project on Multiple Cropping in the country by the Department of Agriculture, Ministry of Food and Agriculture, Government of India, so that data on multiple cropping could be available at the farmer's level.

METHODOLOGY

The data for this study were obtained by survey method from the farmers of the villages selected randomly from the Alipur block. The two villages selected in the sample were Holumbi Kalan and Ghoga. The farms were stratified into three categories, namely, small farms (up to 7.50 acres), medium farms (7.51 to 15 acres) and large farms (above 15 acres). A sample of 25 per cent of the total population of farms was selected randomly from each of the three categories of farms. Thus, in all, 38 farms, *viz.*, 14 small, 15 medium and 9 large farms were included in the sample.

The data on prices, inputs and outputs of crop rotations including multiple cropping, crop area constraint, fertilizer supplied, minimum feed and fodder requirements from the farmers were collected by interviewing them with the help of pre-tested questionnaire.

Linear programming was used as the analytical tool for working out optimum farm plans at three levels of fertilizer supplied, two levels of each availability and two levels of multiple cropping. The total of the crop returns was used as the objective function for maximization subject to the constraints of land, labour, working capital, fertilizer, specific area of crops and feed and fodder. Average resource supply levels were worked out from synthetic farm situation for each of the three categories of farms.

The measures which have been examined in this study for maximization of farm returns under the constraints of fertilizer are (1) optimal reorganization of crops and use of multiple cropping (growing three crops a year) and (2) use of credit facilities for production. As stated earlier, the data on multiple cropping were obtained from the farms of the area studied. Its feasibility was, therefore, examined subject to resource constraints such as labour, capital availability, etc. To examine the contribution of each of the above measures, optimal farms plans were prepared with two levels of multiple cropping at restricted and unrestricted levels of capital availability. For examining the effect of fertilizer constraint on production, optimal plans were prepared with three levels of fertilizer, *viz.*, full supply levels of nitrogen as used by the farmer in the year 1971-72, half of this supply level, and unrestricted supply of fertilizer.

FINDINGS

The farm production and returns of the various optimal plans for the small, medium and large farms at different levels of fertilizer, capital and multiple cropping are shown in Table I and the impact of fertilizer supply constraint in Table II. The suggested cropping patterns under these plans for maximizing the farm returns are shown in Tables III, IV and V. The results of the study are described under the following sub-heads: (*i*) Effects of fertilizer constraint on farm returns; (*ii*) Effects of resource optimization and multiple cropping on farm returns; and (*iii*) Effects of credit facilities on farm production and returns.

Effects of Fertilizer Constraint on Farm Returns

Comparison of figures in columns (4) and (5) in Table I indicates the effect of fertilizer constraint on farm returns without multiple cropping, and comparison of figures in columns (6) and (7) indicates the effect of fertilizer constraint with multiple cropping (three crops a year). It may be seen from Table II that the hardest hit from the point of view of production and income, due to fertilizer constraint, were large farms followed by small farms, with and without multiple cropping. On medium farms the decrease in farm returns was very small (5.7 per cent decrease without multiple cropping and 0.1 per cent decrease with multiple cropping). On small farms the

TABLE I—FARM RETURNS UNDER EXISTING AND OPTIMAL PLANS AT TWO LEVELS OF FERTILZER SUPPLY ON DELHI FARMS (1971-72)

(*Rs.*)

Situation	Farm size (acres)	Existing plan	Optimal plan					
			Without multiple cropping		With multiple cropping			
			With restricted capital		With restricted capital		With unrestricted capital	
			At existing fertilizer supply	At half of existing fertilizer supply	At existing fertilizer supply	At half of existing fertilizer supply	At existing fertilizer supply	At half of existing fertilizer supply
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Small farms (bullock operated)								
Net returns	4.00	4,525.17 (100.00)	4,958.05 (109.56)	4,379.43 (96.78)	7,623.51 (168.46)	6,875.27 (151.93)	7,623.51 (168.46)	6,875.27 (151.93)
Fertilizer used N kg.		50	50	25	50	25	50	25
Medium farms (bullock operated)								
Net returns	12.00	17,875.75 (100.00)	21,392.95 (119.68)	20,182.55 (112.90)	25,008.82 (139.90)	24,985.32 (139.77)	27,464.46 (153.64)	25,001.02 (139.86)
Fertilizer used N kg.		125	125	62.50	125	62.50	125	62.50
Large farms (tractor operated)								
Net returns	23.00	34,415.83 (100.00)	34,461.50 (100.13)	29,992.60 (87.15)	44,337.88 (128.83)	40,987.46 (119.09)	49,199.36 (142.95)	42,300.04 (122.91)
Fertilizer used kg.		610	610	305	610	305	610	305

Note:—Figures in parentheses indicate the percentages to the existing plan.

TABLE II—IMPACT OF FERTILIZER SUPPLY CONSTRAINT ON DIFFERENT CATEGORIES OF FARMS

(*Rs.*)

Category	Decline in net returns due to fertilizer supply constraint		
	Without multiple cropping		
	Restricted capital		
	Total	Per acre	Percentage decline
(1)	(2)	(3)	(4)
Small	579	145	11.7
Medium	1,210	101	5.7
Large	4,469	194	13.0

Category	Decline in net returns due to fertilizer supply constraint					
	With multiple cropping					
	Restricted capital			Unrestricted capital		
	Total	Per acre	Percentage decline	Total	Per acre	Percentage decline
(1)	(5)	(6)	(7)	(8)	(9)	(10)
Small	748	187	9.8	748	187	9.8
Medium	24	2	0.1	2,463	205	9.0
Large	3,350	146	7.6	6,899	300	14.0

decrease in returns due to reduction in fertilizer supply was Rs. 579 (11.7 per cent) without multiple cropping and Rs. 748 (9.8 per cent) with multiple cropping. On large farms, the decrease in net returns was greater in absolute and in percentage terms as compared to that on small and medium farms. On these farms the returns decreased by Rs. 4,469 (13 per cent) without multiple cropping and by Rs. 3,350 (7.6 per cent) with multiple cropping. The table clearly showed that a fifty per cent cut in the fertilizer supply reduced the net returns more on large farms as compared to those on small farms. This was because labour intensive cropping pattern was followed on small farms to compensate the loss in net returns due to fertilizer supply constraints. The per acre decline in net returns was more on large farms as compared to those on small and medium farms if multiple cropping were not adopted. But when multiple cropping was adopted the per acre decline in net returns was more on small farms as

TABLE III—CROPPING PATTERN: SMALL FARMS (BULLOCK OPERATED)

(*acres*)

Crops	Existing plan	Optimal plan	
	At existing fertilizer supply	With multiple cropping and unrestricted capital	
		At existing fertilizer supply	At half of existing fertilizer supply
(1)	(2)	(3)	(4)
Bajra *desi*	2.00 (22.22)	1.03 (8.93)	1.50 (13.23)
Bajra HB-4	—	0.33 (2.86)	—
Jowar	2.00 (22.22)	1.70 (14.75)	2.00 (17.63)
Maize *desi*	—	0.30 (2.60)	—
Paddy Sabarmati	—	0.14 (1.21)	—
Kharif vegetables	—	0.50 (4.34)	0.50 (4.41)
Tall wheat	3.00 (33.33)	1.70 (14.75)	2.09 (18.43)
Dwarf wheat	—	1.80 (15.60)	1.41 (12.43)
Rabi vegetables	1.00 (11.11)	0.50 (4.34)	0.50 (4.41)
Zaid vegetables	0.50 (5.56)	1.00 (8.67)	1.00 (8.82)
Jowar *chari* (*zaid*)	0.50 (5.56)	2.53 (21.95)	2.34 (20.64)
Total cropped area	9.00 (100.00)	11.53 (100.00)	11.34 (100.00)
Net cultivated area	4.00	4.00	4.00
Cropping intensity (per cent)	225.00	288.25	283.50

Note:—Figures in parentheses are the percentages to the total cropped area.

TABLE IV—CROPPING PATTERN: MEDIUM FARMS (BULLOCK OPERATED)

(*acres*)

Crops	Existing plan	Optimal plan	
	At existing fertilizer supply	With multiple cropping and unrestricted capital	
		At existing fertilizer supply	At half of existing fertilizer supply
(1)	(2)	(3)	(4)
Bajra HB-4	5.00 (19.23)	0.40 (1.34)	0.13 (0.47)
Jowar	6.00 (23.08)	6.78 (22.78)	7.37 (26.84)
Maize *desi*	—	0.80 (2.69)	1.50 (5.46)
Paddy Sabarmati	—	1.02 (3.43)	—
Kharif vegetables	1.00 (3.85)	2.00 (6.72)	2.00 (7.28)
Tall wheat	5.00 (19.23)	1.30 (4.37)	2.26 (8.23)
Dwarf wheat	—	7.70 (25.87)	2.20 (8.01)
Gram	—	—	4.42 (16.11)
Metra	—	—	0.12 (0.44)
Rabi vegetables	7.00 (26.91)	2.00 (6.72)	2.00 (7.28)
Sugarcane	—	1.00 (3.36)	1.00 (3.64)
Zaid vegetables	1.00 (3.85)	1.50 (5.04)	1.50 (5.46)
Jowar *chari* (*zaid*)	1.00 (3.85)	5.28 (17.68)	2.96 (10.78)
Total cropped area	26.00 (100.00)	29.76 (100.00)	27.46 (100.00)
Net cultivated area	12.00	12.00	12.00
Cropping intensity (per cent)	216.67	248.00	228.83

Note:—Figures in parentheses are the percentages to the total cropped area.

TABLE V—CROPPING PATTERN: LARGE FARMS (TRACTOR OPERATED)

(*acres*)

Crops	Existing plan	Optimal plans	
	At existing fertilizer supply	With multiple cropping and unrestricted capital	
		At existing fertilizer supply	At half of existing fertilizer supply
(1)	(2)	(3)	(4)
Bajra *desi*	6.00 (11.75)	—	1.25 (1.81)
Bajra HB-4	—	—	—
Jowar	8.00 (15.69)	20.64 (29.91)	19.75 (28.62)
Maize *desi*	3.00 (5.88)	0.36 (0.52)	—
Paddy BC-5	4.00 (7.85)	—	—
Cotton	1.00 (1.96)	—	—
Kharif vegetables	—	2.00 (2.90)	2.00 (2.90)
Tall wheat	—	—	1.25 (1.81)
Dwarf wheat	19.00 (37.25)	21.00 (30.43)	13.26 (19.22)
Barley	4.00 (7.84)	—	6.49 (9.40)
Rabi vegetables	—	2.00 (2.90)	2.00 (2.90)
Zaid vegetable	—	2.36 (3.42)	2.00 (2.90)
Jowar *Ghari* (zaid)	4.00 (7.85)	20.64 (29.92)	21.00 (30.43)
Mung (*zaid*)	2.00 (3.93)	—	—
Total cropped area	51.00 (100.00)	69.00 (100.00)	69.00 (100.00)
Net cultivated area	23.00	23.00	23.00
Cropping intensity (per cent)	221.74	300.00	300.00

Note:—Figures in parentheses are the percentage to the total cropped area.

compared to those on large farms. The decline in net returns was more on large farms as compared to those on small farms if the small farms were provided with adequate credit facility. But when capital was not made freely available and multiple cropping was used the picture was entirely different. The decline in net returns was more on small farms as compared to those on large farms.

Effects of Resource Optimization and Multiple Cropping

Comparison of figures in columns (3) and (6) in Table 1 indicated the combined effect of resource optimization and multiple cropping. It was observed that the small farms had the largest potential for increasing their farm returns, where the farm returns could be increased by Rs. 3,098.34 (68.47 per cent) due to resource optimization and multiple cropping. On medium and large farms, the potential was about half of that on small farms, *viz.*, Rs. 7,133.07 (39.90 per cent) and Rs. 9,922.05 (20.82 per cent) respectively. The effect of multiple cropping alone was observed by comparing columns (4) and (6). Here again the largest potential existed on small farms (53.76 per cent increase) followed by large farms (28.66 per cent increase) and medium farms (16.90 per cent increase).

Effects of Credit

The effects of credit facilities on farm returns were observed by comparing the data in columns (6) and (8) and data in column (7) with those in column (9) in Table I. The small farmers in the sample were already using capital to the needed extent in their existing plans. The medium and large farmers, however, were not utilizing the capital to the needed extent and additional credit facilities could increase the net returns by about 12 to 14 per cent at full supply of fertilizer and by 0.10 per cent to 3.20 per cent at half the fertilizer supply.

Overall Net Effect on Farm Returns

Comparison of data in columns (3) and (9) indicated the net positive effect of resource optimization, multiple cropping and credit facilities on farm returns. On small farms the returns could increase by 58 per cent even after the reduction of the fertilizer supply by 50 per cent. Thus the positive effect of resource optimization and multiple cropping were several times greater than the absolute negative effect of reduction of fertilizer on farm returns. As already indicated, resource optimization and multiple cropping could increase the farm returns on small farms by 68 per cent whereas the decrease in returns due to reduction in the supply of fertilizer was only 10 per cent leaving a net positive effect of 58 per cent increase in farm returns.

On medium farms, the returns could increase by 53 per cent due to resource optimization, multiple cropping and credit facilities if the full quantum of fertilizer as in the year 1971-72 was made available. The decrease in farm returns due to reduction in the fertilizer supply to half of its level was 9

per cent, thus leaving a net positive effect of 44 per cent increase in farm returns due to resource optimization, multiple cropping, and credit facilities.

On large farms also, the net effect on farm returns was positive. The farm returns could increase by about 43 per cent due to resource optimization, multiple cropping and credit facilities, if there were no cut in the fertilizer supply. The cut in the fertilizer supply reduced the returns by 14 per cent. The net overall effect as shown by comparison of data in columns (3) and (9) was, therefore, an increase of 29 per cent in farm returns.

Changes in Cropping Pattern for Maximizing Farm Returns under Fertilizer Constraint

An idea of the direction of change in the cropping pattern for maximizing farm returns under fertilizer constraint can be had by comparing figures in column (2) with those in column (3) in Tables III, IV and V. The needed changes in the cropping pattern for the three types of farms, *viz.*, small, medium and large farms are described below.

On small farms (with average size of 4 acres) the existing cropped area of 9 acres could be increased to 11.34 acres by putting more area under multiple cropping. In the existing plan, only one acre of land was put under *zaid* vegetables and *zaid* jowar *chari*. In the optimal plan with half of the existing supply of fertilizer, the farm returns could be maximized by putting 3.34 acres under *zaid* vegetables and *zaid* jowar *chari*. Such a change in the cropping pattern increased the cropping intensity from 225 per cent in the existing plan to 283.35 per cent in the optimal plan. Other suggested changes during the *kharif* season were shift of a portion of area from *desi* bajra to *kharif* vegetables. In *rabi* season, a shift was suggested from tall wheat and *rabi* vegetables to dwarf wheat. The above changes in the cropping pattern could increase the farm returns by 58 per cent in spite of a 50 per cent cut in the supply of fertilizer. It may be noted here that even at the lower doses of fertilizer, the dwarf wheat yielded higher production than tall wheat.

As regards the medium farms (with average size of 12 acres), Table IV indicated that the area under *zaid* vegetables and jowar *chari* crops could be increased from 2 acres in the existing plan to 4.5 acres in the optimal plan to increase the intensity of cropping and farm returns. Such an increase of area under multiple cropping was feasible with the existing resource even if the supply of fertilizer were cut to half of the existing level (supply level of 1971-72). It may be noted here from column (4), that with the existing supply of fertilizer the area under multiple cropping (with *zaid* vegetables and jowar *chari*) could be increased to 6.75 acres. The optimal cropping pattern under restricted supply of fertilizer (half of the existing supply level of 1971-72) suggested a shift of area from hybrid bajra to maize and *kharif* vegetables. In *rabi* season, a shift was needed from tall wheat and *rabi* vegetables to dwarf wheat, gram, *metra* and sugarcane crops. Gram and *metra* being leguminous crops did not use nitrogenous fertilizer in the existing or optimal

plan. In fact the inclusion of leguminous crops in crop rotations fixed the atmospheric nitrogen into the soil.

On large farms (with average size of 23 acres) also, much greater area could be put under multiple cropping by growing the crops in the *zaid* season. The area under *zaid* crops which was only 2 acres in the existing plan could be increased to 23 acres, *viz.*, 2 acres under *zaid* vegetable crops and 21 acres under *zaid* jowar *chari* crop and thus the intensity of cropping could be increased from 221.74 per cent in the existing plan to 300 per cent in the optimal plan and this could be possible at half the level of existing supply of fertilizer. As regard *kharif* season, a portion of the area was needed to be shifted from *desi* bajra and cotton to jowar and *kharif* vegetable crops for maximizing production. In the case of *rabi* crops, the optimal plan with half the supply of existing fertilizer suggested a shift of a portion of wheat crop to *rabi* vegetables and barley.

A. S. SIROHI AND B. M. SHARMA*

PRICE RESPONSIVENESS OF PUNJAB WHEAT YIELDS†

The introduction of Mexican varieties of wheat during the mid-sixties, along with complementary dosages of chemical fertilizers on areas provided with assured irrigation facilities led to 'wheat revolution' in Nothern India. A review of area, production and average yield of wheat over the past 26 years indicates a discernible improvement in wheat productivity beginning from 1967-68. The wheat production more than doubled during 1973-76 period over 1964-67, as compared to about 79 per cent increase brought about during an earlier period of 15 years (1949-52 through 1964-67).

The compound rate of increase per year for wheat in India for these two periods works out as under:

Period	Area	Yield	Production
1. Average of 1964-65 to 1966-67 over the average 1949-50 to 1951-52 (three-years' averages) (per cent)	1.97	1.94	3.95
2. Average of 1973-74 to 1975-76 over the average of 1964-65 to 1966-67 (three-years' averages) (per cent)	4.28	4.54	9.05

* Professor of Agricultural Economics and Head, and Scientist S-1 (Agricultural Economics) respectively, Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi-12.

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