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where Z_S is the change in output that would have taken place if there was a mere change in area and no change in cropping pattern, Z_C is the change due to cropping pattern and A_O and A_I are respectively the changes in the total sown area under all crops at the first and second point of time.

This does not, however, explain the effect of cropping pattern changes associated with the interaction effect of changes in the area. This can be further estimated by another assumption that the effect of changes in the cropping pattern is in the same proportion as that of the pure effect. The total effect of cropping pattern changes can then be estimated as :

$$Z_C + \frac{(Z_{A.Y} + Z_{A.P} + Z_{A.YP})\ Z_C}{Z_A} .$$

P. V. JOHN*

ECONOMIC POTENTIALITIES OF VEGETABLE CULTIVATION ON SULLAGE WATER FARMS IN PUNJAB (A CASE STUDY)

Increasing industrialization and urbanisation in India is generating more and more purchasing power in the urban centres, which along with shortage of foodgrains is bringing about some shifts in the food consumption patterns, in favour of vegetables—a more nutritive and protective food. This increase in the demand for vegetables has led to a considerable increase in the area and production of vegetable crops. But vegetable crops are highly perishable and require immediate market. The vegetable area, therefore, increased near the cities mainly and in the suburbs of most of cities the farmers have shifted to vegetable cultivation.

The availability of sullage water around the cities has also played a great role in promoting vegetable cultivation due to the richness of sullage water in plant nutrients. Ordinary crops like wheat, maize, rice would not stand to heavy concentration of plant nutrients and would lodge. Since sullage water supplies are continuous, growing of crops other than vegetables would not use the available nutrients fully due to low intensity. Vegetables have good potential to increase intensity even upto 400 to 500 per cent. This high intensity of cropping makes full use of the supply of plant nutrients through sullage water.

Vegetable crops are short duration crops, allowing enough scope for increasing the intensity of cropping. Around the city some progressive farmers are raising 4 to 5 crops in a year. There is thus much of a flexibility in adjusting vegetable crop rotations. Within the vegetable crops group, some crops are more income bright and the others less. Keeping in view the high fertility of suburban land and some complementary and supplementary effect of vegetable crops, these crops can be fitted into profitable rotations resulting in increasing farm income, and production planning on vegetable farms should be based on these rotations rather than individual crop enterprises.

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This study attempts to examine the economic potentials of different vegetable crop rotations on a representative farm in the vicinity of Ludhiana city, served with the sullage water.

The specific objectives of the study are : (1) to estimate the optimum combination of different vegetable crops (rotational basis) so as to maximize the returns to fixed farm resources; (2) to work out the marginal value productivity of different farm resources, so as to spot out the bottleneck resources and locate surpluses.

One of the demonstration farms operated by the Department of Economics and Sociology, growing vegetable and served with sullage water was selected purposively for this study. The data on resource availability, input-output coefficients for different vegetable crop enterprises were obtained through conference with the cultivator and records maintained by the Department. Linear programming technique of farm management analysis was used to optimize the returns to fixed farm resources.

For the purpose of the analysis, land was classified according to land use capabilities after surveying the farm and discussion with the cultivator. Land was classified under six categories: (1) Summer arable crops and fodder land; (2) Summer vegetable and fodder land; (3) Autumn fodder and arable crops land; (4) Autumn vegetable land; (5) Spring arable crops and fodder land; and (6) Spring vegetable land.

Selection of Rotations

In order to locate the optimum production pattern for the farm all possible vegetable rotations were examined. The farmer was already following the rotations having 400-500 per cent intensity. It was, therefore, preferred to include the rotations already followed by the farmer. The different rotations selected were as shown in Table I.

TABLE I—COSTS AND RETURNS OF DIFFERENT CROP ROTATIONS ON THE SELECTED FARMER FIELDS, LUDHIANA SUBURBAN AREA: 1966-67

	Rotations	Variable costs (Rs.)	Returns to fixed farm resources (Rs.)
1.	Maize fodder→Potatoes Autumn→Sarson green→Potatoes Spring→Maize fodder	2,441.67	4,998.33
2.	Cauliflower→Potatoes Autumn→Sarson green→Potatoes Spring→Maize fodder	3,501.35	4,938.65
3.	Cauliflower early→Cauliflower Autumn→Potatoes Spring→ Maize fodder	3,609.38	4,190.62
4.	Maize fodder→Cauliflower Autumn→Potatoes Spring→Maize fodder	2,319.34	3,480.66
5.	Maize fodder→Potatoes Autumn→Tomatoes+Coriander, etc.	2,988.12	4,011.88
6.	Cauliflower early→Potatoes Autumn→Tomatoes+Coriander, etc.	4,047.80	3,952.20

(Contd.)

TABLE I—(*Concld.*)

	Rotations	Variable costs (Rs.)	Returns to fixed farm resources (Rs.)
7.	Maize fodder→Cauliflower Autumn→Tomatoes+Coriander, etc.	2,874.09	3,125.91
8.	Cauliflower→Cauliflower Autumn→Tomatoes+Coriander, etc.	4,164.13	3,835.87
9.	Maize fodder→Potatoes Autumn→Tomatoes + late Cauliflower or Cabbage	2,378.79	4,821.21
10.	Cauliflower→Potatoes Autumn→Tomatoes +late Cauliflower	3,438.57	4,761.43
11.	Cauliflower→Cauliflower Autumn→Tomatoes+Cabbage ..	3,628.83	3,971.17
12.	Cauliflower→Cauliflower Autumn→Cucurbit→Maize fodder	3,155.92	3,144.58
13.	Cauliflower→Potatoes Autumn→Cucurbits→Maize fodder ..	3,039.59	3,260.41
14.	Maize fodder→Potatoes→Cucurbits→Maize fodder ..	1,979.91	3,320.09
15.	Maize fodder→Cauliflower→Cucurbits→Maize fodder ..	1,865.88	2,434.12
16.	Paddy T.N. 1→Wheat Mex.→Maize fodder	493.26	3,152.74
17.	Paddy→Berseem	445.35	1,930.65

Capital Borrowing Activities

Capital borrowing activities were introduced for all the three vegetable growing seasons with a view to assess the additional needs of the farm. Interest was charged at the prevalent rate of 12 per cent per annum.

Fixed Farm Activities

Fodder for farm animals and vegetable nursery were considered as fixed activities for this programming analysis. As the fodder is required in all the seasons, the area required for the purpose was put under the following two rotations in order to obtain fodder continuously throughout the year.

1. Maize fodder→Potatoes→Potatoes→Maize fodder.
2. Paddy→Berseem.

The area required for raising fodder and nursery was decided in consultation with the cultivator keeping in view the number of milch and draft animals kept.

Resource Restrictions

The most limiting factor of production with the farmer were (i) land and (ii) capital. Restrictions in respect of these resources were therefore introduced in all the three seasons, Considering the risky nature of the vegetable crops and market conditions, the farmer was not in favour of growing any single crop beyond a certain limit. The crop area restrictions were, therefore, imposed as follows :

1.	Cauliflower early maximum	15 acres
2.	Potatoes autumn crop†	15 acres
3.	Potatoes spring crop†	10 acres
4.	Cauliflower autumn crop	15 acres
5.	Cabbage	5 acres
6.	Late cauliflower+cabbage maximum	5 acres
7.	Tomatoes and brinjals maximum	10 acres
8.	Cucurbits maximum	2 acres

† These limits are over and above the acreage included in fixed rotation.

Net Availability of Limited Farm Resources

Net availabilities of different limited resources for commercial crop enterprises were worked out after deducting the resources requirement of the fixed activity rotations such as maize—potato—potato and paddy—berseem. The net availability of the farm resources is shown in Table II.

TABLE II—NET AVAILABILITY OF FARM RESOURCES

Category	Total availability	Reserved for fodder rotations (fixed activity)	Reserved for nursery raising	Net available for commercial crops
A. Land (acres)				
1. Summer arable crops and fodder crops land	31.81	2.4 + 1.6 = 4.0	0.75	27.06
2. Summer vegetable and fodder land	19.62	2.4	0.75	16.47
3. Autumn arable crops and fodder land	31.81	1.6 + 2.4	0.75	27.06
4. Autumn vegetable land	19.62	2.49	0.75	16.47
5. Spring arable crops and fodder land	31.81	1.6 + 2.4	0.75	27.06
6. Spring vegetable land	19.62	1.6	7.75	16.47

	Total availability	Required for cattle rearing	Required for nursery raising	Required for fodder growing rotations	Net availability
B. Capital (Rupees)					
1. Summer season capital	10,430	119.24	276.00	566.40	9,468.36
2. Autumn season capital	13,245	118.30	273.00	1,512.52	11,341.50
3. Spring season capital	17,000	236.60	546.00	3,546.00	13,129.40

Comparative Enterprise Budgets

The enterprise budgets for different vegetable crops and combinations of different vegetable crops were prepared on the basis of expected yields and prices based on previous records and experience of the cultivator. These enterprise budgets of individual crops and their combinations were adjusted into different rotations to work out the costs and returns of different rotations as shown in Table I.

Results and Discussion

The existing farm organization for the year 1966-67 included 12.31 acres under cauliflower, 5 acres under maize fodder, 11 acres under paddy, 1.62 acres under pasture and 0.82 acre under spinach in the summer season. In the previous years

more area was left under pasture. But with the introduction of new heavy yielding varieties of paddy, *viz.*, Taichung Native I the area under pasture was decreased. Pasture was planned to be eliminated from the production plan for the next year.

In Autumn season 13 acres were put under potatoes, 3.94 acres under cauliflower, 6.44 acres under berseem, 6.19 acres under Mexican wheat and 1.19 acres under coriander. After potatoes, sarson green was cultivated in 3.94 acres. Earlier no sarson green crop was taken after Autumn potatoes crop. It is only during 1966-67 that this new crop was introduced in between two crops of potatoes which increased the intensity of cropping to 500 per cent (rotation being maize→potato→sarson→potato→maize). The acreage under this rotation would be increased next year.

In Spring season 10.50 acres of the area was put under potatoes to be followed by maize fodder crop. Tomatoes and late cauliflower crop and cabbage occupied 2.87 acres. Tomatoes + coriander accounted for 1.06 acres, brinjals + coriander 0.50 acre, brinjals + onions 0.50 and brinjals occupied 0.75 acre. Berseem, wheat and coriander crop occupied the land in Spring season also, accounting for 6.44 acres, 6.19 acres and 1.19 acres respectively.

In all the three seasons, 1.06 acres were left for raising of nursery for various vegetable crops. In certain periods (such as February, March) when no nursery for any crop was needed, this area was diverted to some short duration vegetables which could be used for home consumption.

Based on the existing cropping plan, the returns to fixed farm resources were calculated at Rs. 90,816.65. The returns to fixed farm resources per acre thus worked out to be Rs. 2,854.97.

Optimum Farm Organization

The final iteration of simplex solution indicated that the following three rotations were the most profitable ones.

(i) Maize fodder→Potatoes→Sarson→Potatoes→Maize fodder.
(ii) Maize fodder→Potatoes→Tomatoes + late Cauliflower or Cabbage.
(iii) Paddy→Wheat→Maize fodder.

The analysis suggests that 10 acres should be put under rotation (i), 5 acres under rotation (ii), and 12.06 acres under rotation (iii). Besides these rotations, 1.6 acres would need to be put under rotation paddy→berseem and 2.4 acres under maize→potatoes→potatoes→maize fodder as fixed activities to produce fodder for farm animals.

The break-down of these rotations gave the following optimum plan. The optimum farm plan suggests that in Summer season it would pay to increase the maize fodder acreage to 17.40 as against 5 acres in the existing plan. Paddy crop would be sown on 13.66 acres as against 11 acres in the existing plan. Cauliflower, pasture and spinach is discouraged in the optimum plan and their cultivation is not suggested.

In Autumn season, area under potatoes would increase to 17.40 acres. It would include 10 acres under potatoes followed by sarson and 7.40 acres under potatoes followed by any other Spring crop. Due to higher income from Mexican

wheat, its area would increase to 12.06 acres. Wheat would be followed by maize fodder in May-June. Berseem would be discouraged and only 1.60 acres under berseem required for fodder would be included in the optimum plan.

In Spring season, optimum plan suggested 12.4 acres to be put under potatoes to be followed by maize fodder; 5 acres got allotted to tomatoes intercropped with late cauliflower or cabbage. Wheat and berseem would continue from Autumn season on 12.06 and 1.60 acres respectively.

The analysis showed that the optimum plan so outlined yielded higher returns to the fixed farm resources, compared to returns from the existing farm plan. Net absolute gains and percentage increase in the farm income were obtained as under :

	Rs. P.
Returns to fixed farm resources in the existing plan	90,816.65*
Returns to fixed farm resources in the optimum plan	1,17,907.92*
Gain	27,091.27
Percentage gain	29.83
Returns per acre in the optimum plan	3,706.63

* As vegetable crops are more risky ones and much affected by the adverse weather conditions, insect pests and diseases attack, these returns are liable to be reduced by 25 per cent under such conditions.

This increase came through changes in product mix, which included more area of maize fodder, paddy, potatoes Autumn, tomatoes and late cauliflower or cabbage.

Resource Use Pattern and Demand for Additional Resources

The resource use pattern of the farm brought out that land and Spring season capital were the most limiting farm resources. Land was fully utilized in all the seasons. Land fit for vegetables was however surplus to the extent of 1.47 acres which was put under arable crops. This showed that vegetable farms would be essentially small farms, because of more risky nature of vegetable crops and heavy capital input. The Summer season capital and Autumn season capital were in surplus to the tune of Rs. 5,898.25 and Rs. 4,015.24 respectively.

The introduction of capital borrowing activities indicated that the farmer would need to borrow Rs. 7,560.49 in Spring season as a short term seasonal loan or he should utilize the surplus capital of other two seasons.

The analysis showed that the overall capital requirement and gross availability of capital for the whole year were as shown in Table III.

TABLE III—OVERALL REQUIREMENT AND GROSS AVAILABILITY OF CAPITAL

Category	Capital requirement	Gross availability (including capital required to raise fixed activities)	Surplus (+) or deficit (—)
1. Summer season capital (Rs.).. ..	4,531.75	10,430.00	+ 5,898.25
2. Autumn season capital (Rs.).. ..	9,229.76	13,245.00	+ 4,015.24
3. Spring season capital (Rs.)	24,460.49	17,000.00	— 7,460.49
Total ..	39,222.00	40,675.00	+ 1,453.00

Capital required in the optimum plan for the whole year thus amounted to Rs. 39,222 whereas capital available with the farmer was Rs. 40,675. This shows that capital was surplus with the farmer amounting to Rs. 1,453 which could be utilized for making some permanent investment on the farm such as purchase of labour-saving machinery.

Marginal Value Productivity of Different Farm Resources

The productivity of resource depends upon its supply relative to the supply of other resources on the farm, which are needed in combination for taking up an enterprise or combination of enterprises. The productivity of resources, therefore, is an outcome of a specific farm situation in respect of its resource mix and enterprise combination.

Column $Z_j - C_j$ of the answer iteration indicated the marginal value productivity of different farm resources. The marginal value productivity of Summer land fit for arable and fodder crops was Rs. 3,061.52 indicating a high rental value of land on this farm. It means, it pays to the cultivator to rent in an additional acre of land at Rs. 3,061.52. Similarly, opportunity costs of different crop maximum indicated that it would pay to the farmer to raise the acreage maximum of these crops with the following returns:

Crop maximum	Amount per acre (Rs.)
Autumn potatoes maximum	559.26
Late cauliflower or cabbage maximum	452.76

From the analysis of the marginal value productivity of different resources, it is evident that Summer season capital and Autumn season capital have zero opportunity costs and thus are in excess. It is thus profitable that this excess capital should be utilized in Spring season where capital is limited. The marginal value productivity of Spring season capital is Rs. 1.06, so the capital should be acquired at a rate not exceeding 6 per cent for this season or the surplus capital of Summer and Autumn season should be utilized in Spring season.

Conclusion

Based on this case study of a progressive sullage water vegetable farm, following conclusions can be drawn :

(1) As vegetable cultivation requires heavy capital input and is risky in nature, a vegetable farm could be essentially a small farm. If the farm is large in size, beyond certain area limits (say 18 acres) arable crops would enter the product mix.

(2) At the prevalent product and supplies prices, most profitable vegetable crop rotations would be :

(i) Maize fodder→Potatoes→Sarson green→Potatoes→Maize fodder.
(ii) Maize fodder→Potatoes→Tomatoes+late Cauliflower or Cabbage.

The rotation "paddy—wheat—maize fodder" is more paying compared with rotation "paddy—berseem," on arable crop lands.

(3) Maize fodder and paddy are more paying in Summer season. Cauliflower affects the returns from succeeding potato crop adversely to render it comparatively unprofitable. In Autumn season it pays to increase the acreage under potatoes and wheat. Cauliflower and berseem cultivation is not that profitable under such farm situations.

In Spring season potatoes followed by a maize fodder crop and tomatoes intercropped with late cauliflower or cabbage are comparatively more profitable enterprises.

(4) It is possible to enhance the returns to fixed farm resources to the tune of over 29 per cent over the returns from the existing production plan through rationalization of resource use alone even on progressive farms in the suburbs of the cities.

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AND
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EVALUATION OF INTENSIVE AGRICULTURAL DISTRICT PROGRAMME— A CASE STUDY FOR WHEAT IN LUDHIANA DISTRICT†

The Intensive Agricultural District Programme (I.A.D.P.) was initiated in seven districts of India in 1961 (later extended to cover one district in each State) with a view to attain a rapid rate of growth in agricultural production in these districts. An attempt has been made in this paper to suggest a model for evaluating the impact of the I.A.D.P. on the productivity of important crops. The model has been put to test with the help of data on wheat crop in Ludhiana district for the years 1962-63 to 1965-66.

There are many ways in which the impact of the I.A.D.P. activities could be studied. At the aggregate level, one could study changes in aggregate production in the district over time. Using some price weights one could generate estimates of aggregate income and study changes therein. Another measure could be to study changes in yield rates for the major crops grown in the districts. We have concentrated on the study of the yield rates over time in our analysis. Since the I.A.D.P. activities have primarily concentrated on the technical aspect of increasing yields of important crops, changes in yield rates provide a ready reckoner of the impact of the programme. Moreover, if the cropping pattern does not alter substantially over time, change in yield rates of important crops also reflects the trends in aggregate production.

The Model

The principal measures for bringing about an increase in yield rates can be grouped into two broad categories :

(*a*) Streamlining the supplies of modern inputs of production such as improved seeds, fertilizers, pesticides, etc., and

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† The views expressed are the personal views of the author.