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Feasibility of Vegetable Production in the Mad River Valley of Ohio

D. H. DOSTER

E. T. SHAUDYS

H. L. STEELE

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
Wooster, Ohio

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Feasibility of Vegetable Production in the Mad River Valley of Ohio

D. H. DOSTER, E. T. SHAUDYS, and H. L. STEELE[1]

INTRODUCTION

Significant technological changes in the production of vegetable crops have altered their profitability relative to corn, soybeans, small grains, and meadow crops. Varieties adapted to a wider range of growing conditions and mechanical harvesting techniques are being developed. Advances have been made in planting precision, tillage techniques, insect and weed control, irrigation, harvesting methods, and processing. Changes have also occurred in marketing and consumer demand.

As recently as 5 years ago, vegetable production required large amounts of hand labor for planting, thinning, weeding, irrigating, and harvesting vegetables. In the foreseeable future, production and processing of vegetables will be accomplished with significantly smaller quantities of unskilled labor.

The effects of this technological revolution in terms of vegetable production areas, land use patterns, land ownership, and control of the production and processing activities are difficult to predict. Economies of scale and capabilities for better environmental control in larger specialized production areas, along with the application of expert management, will undoubtedly result in drastically changed production patterns.

In the spring of 1967, an interdisciplinary committee initiated an intensive study to determine the influence of foreseeable technological changes on vegetable production and processing in Ohio. In the initial phase, a geographic area was selected for intensive study. The Mad River Valley of west central Ohio was selected as the geographic locus as it appeared to have many desirable characteristics for growing vegetables for processing.

Some reasons for selection of the Mad River Valley area were: (1) an abundant supply of underground water; (2) soil parent material has much of the needed nutrients for growing vegetables; (3) climatic conditions are satisfactory for those vegetables considered; (4) population pressures from Dayton to the southwest and from Springfield to the immediate south, while of importance, were not considered to be limiting or restrictive upon the land use patterns; and (5) the area is proximal to primary transportation routes (east-west Interstate 70 and north-south Interstate 75), to major population centers, and to other potential vegetable production areas.

An important but small acreage of vegetable crops is grown in the area at present. During the past 50 years, sizeable acreages of potatoes have been produced. A few other vegetables, mostly for the fresh market, are currently produced. Corn for grain, soybeans, and other crops associated with the Corn Belt dominate the agriculture of this area.

OBJECTIVES

The objectives of this project were:

- To assemble production cost and return information for processing vegetable crops, corn, and soybeans.
- To determine the profitability of using land and labor resources for the production of processing vegetable crops, corn, and soybeans in the Mad River Valley area of Ohio.

METHOD OF STUDY

Crop budgets were developed based on current input-output relationships expected to exist for the resources analyzed. The analysis includes costs of growing vegetables, corn, and soybeans using modern production methods. Some practices and equipment considered in the analysis are not yet in general commercial use. Costs for tillage, planting, harvesting, and hauling were charged on a custom rate basis. Direct labor was charged at $2.00 per hour.

No attempt was made to differentiate between costs of production for farms of different sizes. It was assumed that specialized equipment would be used up to the limit of time available in a planting or harvesting season. The equitability of landlord-tenant contractual agreements was not considered, nor was the processor-grower contract evaluated.

Supply-Demand Relationships

This analysis does not include the marketing or merchandising of processing vegetable crops. For purposes of the study, it was assumed that:

1. The processing vegetable demand schedule has a national geographic character.
2. The amount of vegetables grown in the Mad River Valley area will not appreciably affect the basic national supply-demand relationships. Therefore, prices paid to farmers producing vegetables for processing in the

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[1] Assistant Professor, Dept. of Agricultural Economics, Purdue University; Professor and Associate Professor, Dept. of Agricultural Economics and Rural Sociology, The Ohio State University and the Ohio Agricultural Research and Development Center.

area can be estimated without regard for their impact on the available supply.

Average seasonal prices were used for each crop. No attempt was made to differentiate prices between surplus and deficit production periods. Seed and fertilizer prices are typical of charges paid in 1967 by commercial vegetable growers.

Programming Models

Two basic linear program models were developed to demonstrate the profitability of the relationships for selected crops. Linear programming techniques have been used in economic adjustment studies and in farm planning. Linear programming is an appropriate tool for this type of analysis provided the components of the problem—the objective, alternative methods for obtaining the objective, and the resource restrictions —can be expressed quantitatively.

The linear programming solution as developed refers to action which an economically oriented decision maker ought to seek. However, the solution is in terms of the objective and is subject to the restriction as formulated. The linear program solution does not explain what is but rather what ought to be, based on the conditions stated in the problem.[2]

The objective of each model in this analysis is to maximize profit based on labor and land restrictions.

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[2] Heady, Earl O. and Wilfred Candler. 1958. Linear Programming Methods. Iowa State College Press, Ames.

FIG. 1.—The Mad River Valley of Ohio, Vegetable Feasibility Study, 1967.

A total of 127 production alternatives in the form of single and double-crop budgets were considered. A fixed labor supply was determined for each of 16 periods during the planting season.

Model A

This model was designed to evaluate the production profit potentials of the selected vegetable crops, corn, and soybeans on the basis of the planting labor restrictions. The assumption made in choosing planting labor as the limiting restriction is that an operator will arrange other tillage jobs so that he can devote full time to the planting activity during the desirable time period. With the higher opportunity cost associated with time spent planting, it is to be expected that an operator might hire or contract the tillage work done and devote his energies to supervising the critical planting operation.

Planting rates (or planting supervision rates since a labor charge is included in the custom planting cost) for each crop are reported in Table 3. A 10-hour working day was assumed.

In Model A, planting rates for one planter are considered the restricting factor. Thus, if both corn and peppers can be planted on the same day in May, the linear program permits the ratio of the planting rates of the two crops to be compared to the ratio of the respective net incomes per acre to determine which crop is planted in the available time. The crop associated with the greater planting-income ratio will be planted. For example, a planting ratio of 3 acres of corn to 1 acre of peppers indicates that an operator can plant 3 acres of corn in the same time that he can plant 1 acre of peppers. In like manner, a net income ratio can be derived. In the case of peppers and corn, the pepper net income per acre is 10 times the corn net income per acre. The income ratio of peppers to corn is greater than the planting ratio of corn to peppers. Therefore, the land is planted to peppers. Various double-crop combinations complicate the selection but the principle of ratio comparison is the maximizing criterion.

Possible planting time from April 1 to September 10 is divided into 16 periods of 10 days each. Labor availability for each period is based on information reported in Table 2. Land and operating capital are not limiting except that land must at least yield an opportunity cost of $40 per acre and operating capital must return at least 6 percent per annum for the time period in which it was used.

Operating capital includes the material and custom tillage costs up to harvest, as shown in the crop budgets (Table 1). For purposes of this analysis, the operating capital was assumed to be used for a period of 4 months. For double crops, interest was charged to the crop having the greater operating capital need. All crops were sold at harvest and operating capital used for the first crop was available for the second crop.

Double-crop combinations were developed whenever time was available in the growing season for the second crop to mature if it was planted in the labor period immediately following the harvest of the first crop. Fixed irrigation costs of $15.46 per acre were charged annually for either the single or double-crop system. Variable irrigation costs were charged on the basis of acre-inches applied.

Model B

Model B compares the production profit potential of the selected crops based on criteria similar to Model A, except for three additional restrictions. First, all of the tillage operations must be performed by one man; second, the number of acres was limited by the size of farm which one man could handle if devoted to the production of corn and soybeans; third, all land for vegetable crops planted after May 31 must be plowed, tilled, and planted in the same 10-day labor period.

Farm size was determined as the acreage of corn and soybeans one man could produce (except harvest). From the crop budgets, it was ascertained that irrigated corn was more profitable than irrigated soybeans for the three planting periods: April 21-30, May 1-10, and May 11-20, which have 100 hours of available planting time. Discing and planting 435 acres of corn during these periods could be accomplished with the labor, equipment, and production techniques employed. Further, 273 acres of soybeans could be seeded after two discings during the May 21-June 10 period. Thus, 708 acres of corn and soybeans could be produced provided the plowing was completed before April 21.

The plowing of 231 acres could be accomplished during the April 1-20 period, which means that 477 acres must be plowed prior to April 1. It was assumed that this would be done during the fall and winter, since the operator has no responsibility for harvesting any of the crops. Therefore, the farm size was limited to 708 acres.

The restriction requiring land for summer vegetable crops to be plowed, tilled, and planted in the same 10-day period was made in order to prevent having fall-plowed ground planted to vegetables after May 31 without being re-plowed. This was considered a necessary cultural practice for satisfactory crop production,

TABLE 1.—Costs, Returns, and Net Income per Acre of Vegetable Crops, Corn, and Soybeans in Mad River Valley, Ohio, 1967.

	Snap Beans	Cabbage	Carrots	Corn Irrigated	Corn Non-irrigated	Cucumbers	Peppers	Irish Potatoes
Gross Returns per Acre								
Yield (Lb.)	6,000	60,000	50,000	9,240	7,560	5000-16000	15,000	36,000
Value at Packing House Door	$270.00	$480.00	$450.00	$166.65	$136.35	$604.00	$897.00	$666.00
Costs per Acre								
Irrigation								
Fixed	$ 15.46	$ 15.46	$ 15.46	$ 15.46	—	$ 15.46	$ 15.46	$ 15.46
Variable	2.70	3.60	1.80	2.70	—	1.80	1.80	3.60
Materials								
Seed	35.00	25.00	13.00	5.00	$ 5.00	35.00	10.00	90.00
Fertilizer	19.00	32.00	35.00	30.00	30.00	19.00	60.00	40.00
Insecticides and herbicides	10.00	17.00	23.00	10.00	10.00	22.00	23.00	25.00
Applications								
Custom plow, disc, plant, spray	18.00	20.76	17.48	9.50	9.50	24.76	22.76	18.01
Custom harvest	25.00	10.00	25.00	16.00	13.00	25.00	20.00	41.00
Custom hauling*								
Local	10.50	60.00	50.00	8.09	6.62	18.00	26.25	36.00
75 miles	15.00	178.50	112.50	—	—	35.70	63.75	81.00
150 miles	22.50	294.00	170.00	—	—	61.20	101.25	108.00
Net Income per Acre								
Crop processed locally	$134.34	$296.18	$269.26	$ 69.90	$62.23	$442.98	$717.73	$396.93
Crop hauled 75 miles	129.84	177.68	206.76	—	—	425.28	690.23	351.93
Crop hauled 150 miles	122.34	62.18	149.26	—	—	399.78	645.73	324.93

	Fall Spinach	Soybeans Irrigated	Soybeans Non-irrigated	Late Soybeans Irrigated	Late Soybeans Non-irrigated	Spring Spinach	Sweet Corn	Tomatoes
Gross Returns per Acre								
Yield (Lb.)	18,000	3,000	2,400	2,400	1,920	18,000	14,000	40,000
Value at Packing House Door	$216.00	$127.00	$101.60	$101.60	$ 81.28	$196.00	$134.00	$700.00
Costs per Acre								
Irrigation								
Fixed	$ 15.46	$ 15.46	—	$ 15.46	—	$ 15.46	$ 15.46	$ 15.46
Variable	1.80	1.80	—	1.80	—	1.80	3.60	1.80
Materials								
Seed	5.00	4.00	$ 4.00	4.00	$ 4.00	5.00	5.00	39.00
Fertilizer	22.00	6.00	6.00	6.00	6.00	22.00	20.00	41.00
Insecticides and herbicides	13.00	10.00	10.00	10.00	10.00	13.00	15.00	22.00
Applications								
Custom plow, disc, plant, spray	17.48	12.00	12.00	12.00	12.00	17.48	24.00	24.76
Custom harvest	40.00	9.00	8.00	8.00	7.00	40.00	5.00	200.00
Custom hauling*								
Local	31.50	2.63	2.10	2.10	1.78	31.50	14.00	60.00
75 miles	—	—	—	—	—	—	—	80.00
150 miles	—	—	—	—	—	—	—	130.00
Net Income per Acre								
Crop processed locally	$ 69.76	$66.11	$ 59.50	$ 42.24	$ 40.50	$ 49.76	$ 31.94	$295.98
Crop hauled 75 miles	—	—	—	—	—	—	—	275.98
Crop hauled 150 miles	—	—	—	—	—	—	—	225.98

*Based on information provided by Larry Traub and Chan Connolly, Agricultural Economists, Marketing, Ohio Agricultural Research and Development Center.

Note: Local processing costs are shown for crops subject to severe quality deterioration or crops having an existing market.

Model C

Model C was based on the restrictions presented in the Model B description, except only corn and soybean crops were grown. This farm model represents the maximum acreage of corn and soybeans which one man can operate provided he has plowed 477 acres prior to April 1, based on the production coefficients used for the corn and soybean budget.

DISCUSSION

Selection of Processing Vegetable Crops

Production cost budgets were developed for the following crops: sweet corn, snap beans, Irish potatoes, carrots, cucumbers, tomatoes, cabbage, peppers, spring spinach, fall spinach, asparagus, green peas, lima beans, celery, sweet potatoes, cauliflower, strawberries, beets, onions, muskmelons, broccoli, and turnips. The first 10 crops listed were selected for intensive study.[3] Based on experience and observation, it was suggested that the first 10 crops listed had the most promise for development and growth in terms of a processing industry in the Mad River Valley. Growers and processors were visited in Ohio and Michigan to develop crop production coefficients for these 10 crops.

Budgets for the 10 vegetable crops selected, plus corn and soybeans produced for sale as cash grains, were presented to the Vegetable Production Feasibility Committee. Some adjustments in coefficients were made in accord with the experience of this committee. Particular attention was directed toward generating comparable crop production input and yield coefficients in terms of present knowledge and management skills.

The budgets used for the analysis, except for asparagus, are presented in Table 1. Based on a yield of 4,000 lb. per acre and a price of $300 per ton, asparagus was determined to have a net income of $368 per acre when delivered to a local processor. However, asparagus was omitted because of the long period of time required for establishment and production; thus it was not comparable with annual vegetable crops.

Crop Production Coefficients

Labor procurement and the scheduling of work present the most important input considerations for tillage and planting operations. Available skilled labor must be used in the most productive manner possible during the seeding period.

A six-bottom, 16-inch plow requiring .26 hour per acre was budgeted for all plowing operations. A 21-foot disc pulled by a six-bottom tractor operating at the rate of .10 hour per acre was used for fitting operations. Several commercial planters were used for the seeding. These were selected as the largest available commercially manufactured planting equipment capable of seeding a particular crop.

In the analysis, the use of each item of machinery was assumed sufficient to spread the fixed costs over an adequate acreage for efficient employment. Variable costs of operating tractors for plowing and discing were essentially the same per acre, regardless of the unit size.

Particular attention was given to the planting operation as the most critical production activity. Great strides have been made in the past few years and additional technological advances such as precision planters, more precise seed sizing, better seed grading, better seed placement and coverage, and other techniques to assure adequate germination are being developed. These include such techniques as applying vermiculite above the seed to prevent crustting and light applications of overhead irrigation water to insure proper moisture-soil relationships immediately after seeding.

It is important to note that thinning, blocking, and hand-weeding operations were not allocated any time in the program budgets. The importance of high germination rates, uniformity, and precise spacing cannot be overemphasized because of the labor involved with hand-seeding, hand-thinning, and hand-blocking operations. The competitive operator will rely upon precision seed placement and guaranteed seed germination.

All crops selected can be weeded with chemical herbicides and would not require mechanical cultivation. Thus, no time was included for mechanical cultivation.

Spray application time was programmed at the uniform rate of .14 hour per application per acre. The number of applications was varied, depending upon the season and the crop involved. This must be modified in accordance with prevailing conditions from year to year.

The number of irrigation applications for each crop was based on estimates by E. C. Wittmeyer[4] and takes into consideration the use of an overhead sprinkler system capable of distributing fine spray particles immediately after planting and for use whenever the soil-moisture relationship drops below 75 percent of soil-moisture field capacity. An overhead portable self-propelled irrigation system requires less labor than a manually moved sprinkler system. Therefore, irrigation can be utilized sooner than possible with the "hand move" portable sprinkler system.

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[3] Consultation with E. C. Wittmeyer, Dr. W. N. Brown, and W. M. Brooks, Dept. of Horticulture, The Ohio State University.

[4] Extension Horticulturist, Ohio Cooperative Extension Service.

Planting Dates

Planting periods for each crop were based on minimum temperature limitations as listed in the *Handbook for Vegetable Growers* by James E. Knott and adjusted for Ohio by E. C. Wittmeyer (Table 2). The overlapping of seasons has particular significance in the analysis because the different crops compete directly for the time of the skilled operator during these periods.

Weather data for central Ohio was used as the basis for the labor restrictions by 10-day periods from April 1 through July 20. Using precipitation information from the Columbus Weather Station for the years 1938-1957, the number of days suitable for selected crop operations on poor, average, and well-drained land was ascertained.[5] The number of available working days as listed in Table 2 represents the minimum number of days likely to be favorable for crop work 16 years out of 20.

Crop Planting Rates

The entire analysis is dependent upon the time relationship of planting rates for the various crops. The largest commercially available planter was used for each crop. All planters were assumed to operate at 3 miles per hour and at 70 percent efficiency for 10-hour days. For example, the rate for corn was computed as follows:

$$\frac{360 \text{ inches} \times 3 \text{ m.p.h.} \times .70}{100} = 7.56 \text{ acres/hour}$$

$$\frac{1}{7.56} = .13 \text{ hour per acre}$$

Table 3 indicates planting rates assumed for five planter sizes.

Harvest Dates

Harvest dates were based on the expected number of days from planting to harvest for each crop (Table 4). The second crop of a double-crop rotation was assumed to be planted in the first labor period following harvest of the original crop.

No labor time was indicated in the budgets for harvesting operations as harvesting was considered to be included as a processor's contractual responsibility. This conforms with the processor's desires to control harvested crop quality and with the maintenance of a uniform and desired quantity delivered to the proc-

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[5] Sitterley, John H. and Richard Bere. 1960. The Effect of Weather on the Days Available to Do Selected Crop Operations, Central Ohio, 1938-57. Ohio Agri. Exp. Sta., Dept. Mimeo A.E. 313.

TABLE 2—Planting Dates and Number of Available Working Days by 10-Day Periods for Selected Vegetable Crops in Mad River Valley Area, 1967.

	April 1 11 21 May 1 11 21 June 1 11 21 July 1 11 21 August 1 11 21 Sept. 1 11 21 Oct. 1 11 21
Number of Available Working Days*	3 3 3 4 3 4 5 5 5 5 5 7 7 7 7 6
Spring Spinach	(April 1—May 10)
Potatoes	(April 1—June 1)
Carrots	(April 11—May 31)
Sweet Corn	(April 11—July 10)
Cabbage	(April 21—July 10)
Field Corn	(April 21—May 20)
Early Soybeans	(April 21—May 20)
Peppers	(May 11—31)
Tomatoes	(May 11—June 10)
Cucumbers	(May 11—July 20)
Snap Beans	(May 11—July 31)
Late Soybeans	(May 21—June 10)
Fall Spinach	(June 10—Sept. 10)
Asparagus	(April 11—May 10)

*In each 10-day period.

Based on data interpolated from Handbook for Vegetable Growers by James E. Knott and The Effect of Weather on the Days Available to Do Selected Crop Operations, Central Ohio, 1938-57, by John H. Sitterley and Richard Bere.

TABLE 3.—Planting Rates for Selected Crops for Various Planters.

	Planter Size				
	12-row 30-inch	10-row 16-inch	4-row 40-inch	4-row 34-inch	4-row 30-inch
Crop	Soybeans Sweet Corn Corn - Soybeans	Carrots Spinach	Cucumbers Tomatoes	Potatoes	Cabbage Peppers
Hours per Acre	.13	.30	.30	.35	.40

essing plant. With the processor accepting the harvesting responsibilities, the operator can begin tillage operations for the next crop, whether it be the second of a double-crop sequence or the first tillage for crops to be seeded the following season. This permits the operator to plow and till an adequate acreage in the fall so that spring planting operations can be handled in a most desirable manner.

Transport Costs

Hauling methods for transporting vegetables from the field to the processing plant require skilled labor. The charges used for local and long-distance rates represent current costs employing bulk handling methods.

Risk

It is entirely possible that no one farmer will be willing to plant his entire acreage to peppers or to cucumbers or to a combination of two or three vegetables. This suggests that ownership of vegetable lands by processors, leasing land, or guaranteed minimum payments per acre by processors may need to be considered. The risk associated with yield variation on a large acreage by one farmer is extremely great. A processor interested in several thousand acres may be in a better position to manage or handle a part of the risk cost associated with production of vegetable crops.

The advantages of large acreages and large-scale production practices tend to favor specialization by farmers. A processor may profit by contracting with fewer large farmers instead of obtaining his vegetable supply from many small operators. Raw product quality may be improved and expenses for processor field staff may be reduced. If the effect of yield risk would be felt less by the processor than by the farmer, both may improve their positions by having the farmer accept a slightly lower product price in exchange for having the processor accept part of the yield risk.

TABLE 4—Harvesting Dates for Selected Vegetable Crops in Mad River Valley Area, 1967.

Crop	May 1 11 21 · June 1 11 21 · July 1 11 21 · August 1 11 21 · Sept. 1 11 21 · Oct. 1 11 21 · Nov. 1 11 21 30
Spring Spinach	(May 15—June 30)
Potatoes	(July 21—Oct. 20)
Carrots	(July 21—Nov. 10)
Sweet Corn	(July 21—Sept. 10)
Cabbage	(July 11—Oct. 31)
Field Corn	(Oct. 11—Nov. 30)
Early Soybeans	(Sept. 25—Oct. 15)
Peppers	(July 25—Sept. 30)
Tomatoes	(Aug. 5—Sept. 30)
Cucumbers	(July 11—Sept. 10)
Snap Beans	July 1—Sept. 25)
Late Soybeans	(Sept. 25—Oct. 15)
Fall Spinach	(Aug. 15—Oct. 31)
Asparagus	(May 1—June 15)

Production Costs

Ohio custom rates,[6] where applicable, were used for corn and soybean planting, harvesting, and grain hauling; for all plowing, discing, and spraying; and for sweet corn and snap bean planting. Planting costs for the other crops were assumed as indicated, taking into account initial planter cost, planting rates, length of planting season, tractor costs, and labor. In addition, the anticipated useful life of these new planters may be shorter than for machines now in use.

It was assumed that each planter would be fully utilized within the time available. In the budgets, amount of use was computed from the weather data indicating number of favorable 10-hour days for planting each crop.

Irrigation Systems

The self-propelled system was selected because of the low labor requirement per acre irrigated, the uniformity of water coverage, and the adaptability of the unit to gently undulating land. The system is more expensive in initial cost than portable pipe sprinklers and less expensive than solid-set systems.

Liquid fertilizer, particularly nitrogen, has been successfully applied through the use of a precise metering device which is now available commercially. It may be possible to apply insecticides and herbicides with the irrigation system at a future date.

Because the system has small nozzles and a fine mist spray pattern, it can benefit the establishment of uniform stands. The proper soil-moisture-seed contact can be made with the aid of a light application of water immediately after seeding.

The fixed cost of the irrigation pipe, well, and pump constitutes the major expense. Variable costs of pumping and operating the system are relatively small. Thus, it may be advantageous to begin using the self-propelled system when there is still considerable water available in the soil-root zone, provided adequate drainage exists. Other more labor-demanding systems would not normally be started profitably until the available water in the root zone was approximately 60 percent of field capacity. The conventional portable sprinkler requires about 1 hour of labor per acre inch of water applied; the self-propelled system requires about 1/10 as much labor. This means that one man can apply 1 acre-inch of water per week to approximately 40 acres using a portable sprinkler system, while one man doing much less strenuous physical work could handle 400 acres with a self-propelled system. Labor for irrigation is charged at $2.00 per hour (.20 hour per acre-inch) and the irrigation fuel charge is $.70 per acre-inch.

FINDINGS

Optimal Farm Program Solution

Model A: With no restriction on land and operating capital, except that the net returns must be sufficient to more than cover rent and interest, a total of 2,215 acres was used (Table 5) and no available planting labor was left unused. Five crops were included in the optimal solution, with a total of 2,817 acres grown. Returns to land, operating capital, and management averaged $353.69 per acre of land.

This model is not intended to necessarily represent a realistic situation but rather it is intended to indicate an upper limit and demonstrate a maximum capacity for one man based on the stated assumptions.

Model B: The optimal Model B land area was limited to 708 acres—the maximum size of the sample corn-soybean farm. All 708 acres were planted and with double cropping, 1,014 acres of six crops were raised during the year.

Not all of the available labor was used. A total of 95 hours of late July to early August labor could have been used to plant additional snap beans and spinach, except for the land limitation. Nevertheless, all of the available labor in 13 of the 16 labor periods was utilized.

Model C Comparison: Compared to the sample corn-soybean farm (Model C), the Model B solution made a more complete use of the available labor from April 1 to September 10 for seedbed preparation and planting, although the operator of the corn-soybean farm was able to plant more acres between April 21 and June 10 than the operator of the Model B farm. Corn required less seedbed preparation and corn or soybeans could be planted at the rapid rate of 7.56 acres per hour. Most of the vegetable crops required considerably more time to plant and, in the case of the double crops, to perform additional land preparation, but this work was spread over a longer labor season.

Model B yielded an optimum net return to land, operating capital, and management of $453.10 per acre. This was a larger per acre income return than Model A. Nevertheless, the total net income of Model B was much less than Model A. This suggests that the manager, capable of acquiring additional land, should attempt to hire seedbed preparation done by others whenever he can devote his own labor time to planting or supervising planting operations. The preceding statement is tempered, of course, by any reduction in net income per acre associated with a manager spreading himself "too thin".

In Model B, the total net and net per acre are considerably greater than the comparable figures for the Model C unit. The difference is of such magni-

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[6] Shaudys, E. T. and R. H. Baker. August 1967. Farm Custom Rates Paid in Ohio, 1966. Ohio Cooperative Extension Service. Columbus.

TABLE 5.—Optimal Linear Program Solutions for Three Hypothetical Farms in the Mad River Valley, Ohio, 1967.

	Models		
Crop	Model A	Model B	Model C (Corn-Soybean Farm)
	Acres	Acres	Acres
Potatoes	371	208	—
Snap Beans	538	54	—
Peppers	175	117	—
Fall Spinach	900	280	—
Cucumbers	833	329	—
Cabbage	—	26	—
Irrigated Corn	—	—	435
Irrigated Late Soybeans	—	—	273
Total Acres of Crops	2817	1014	708
Total Acres of Land Used	2215	708	708
Total Net Income (return to land, operating capital, management)	$783,424.96*	$350,529.87*	$ 41,938.02
Net Income per Acre	353.69	495.10	59.23
Less rent at $40 per acre	40.00	40.00	40.00
Less interest on operating capital at 6 percent	2.00	2.00	2.00
Net Return per Acre to Management	$ 311.69	$ 453.10	$ 17.23

*Fixed irrigation costs of $15.46 per acre were charged only once for each acre which was double cropped.

tude that this vegetable rotation would appear to be optimal with considerable variation in yields and prices of the crops involved.

If land rent and interest are charged at $40.00 per acre and 6 percent for the time period in which operating capital was used, the residual return to management is only $17.23 per acre for the corn-soybean farm compared to $453.10 per acre for the optimal vegetable models.

A change in any crop budget, the inclusion of new crops, or the exclusion of any of the present crops may affect the optimum farm program. For example, farm producers in the area may not have the opportunity to sell certain of these crops to a local processor, a processor may demand that a farmer grow a crop in periods other than when it is optimal for the farmer, or a processor may require other crops to be grown.

The great difference in income between Model B and Model C, the sample corn-soybean farm, suggest the potential of processed vegetable production.

Crop Income

Net income per acre for the various crops sold to a local processor was used for comparing crops (Table 1). The cost of hauling the crops to processors varies as influenced by weight, perishability, and handling difficulties.

On a per-acre basis, peppers return the greatest net income to land, operating capital, and management. Technology of pepper production is changing rapidly and problems caused by surplus production may emerge unless additional markets are found in the near future.

Asparagus yielded the second highest net return per acre. Asparagus is the only perennial crop included in the analysis. All others are annuals. Stands of asparagus are relatively easy to maintain for 15 years and, if placed on well-drained soil, can be mechanically harvested every third day during the harvest season to assure an adequate quality product for processing.

To maintain quality, asparagus must be processed soon after harvest. Because it is harvested in May and June, asparagus production may be encouraged by processors because it permits an extended processing season.

Sweet corn for processing was not found to be a profitable crop for farmers in Ohio based on the yields and prices used in the budgets. However, sweet corn for processing has been produced and processed in Ohio in the past. Research may enable Ohio farmers to produce competitively in the future.

Field corn and soybeans were included in the analysis as benchmark crops. These are the principal crops presently produced in the Mad River Valley. If vegetable production were expanded in the area, corn and soybean acreages would be reduced.

Irrigated field corn and irrigated soybeans were found to be more profitable than non-irrigated corn or soybeans as budgeted. For the April 21 to May 20 planting period, corn was slightly more profitable than soybeans. For the May 20 to June 10 planting period, only late-crop soybeans were included in the budgets.

Long Distance Transportation

To consider the impact of moving crops long distances, the consumption of gross income for transportation was evaluated (Table 6).

The transportation charges used represent costs in excess of those incurred in hauling to a local processor. The income sacrifice analysis was based on production costs, including transportation to a local processor. For example, if cabbage was transported 150 miles to a processor, the price would need to be increased 49 percent more than the amount indicated on the income sacrifice tables of the Optimal Crop Solutions before cabbage would be an optimum crop. Some crops are not suitable for long transport. Asparagus, spinach, and sweet corn must be processed locally because of rapid deterioration of raw product quality if the crop is not processed soon after harvest.

The relationship of gross income to transportation cost is different for each crop included. For example, snap beans can be hauled 150 miles for a cost of $12.00 per acre in addition to the basic charge for delivery to a local processor. The extra charge for the 150-mile haul represents only 4 percent of the gross income per acre. Extra charges for hauling cucumbers and peppers 150 miles represent about 7 to 8 percent of gross income. These three crops are often moved several hundred miles before being processed.

TABLE 6.—Long Distance Transportation Charges per Acre for Selected Crops as a Percent of Gross Income.

Crop	Gross per Acre	Transportation Charges as a Percent of Gross	
		75 Miles	150 Miles
		%	%
Snap Beans	$ 270	2	4
Cabbage	480	25	49
Carrots	450	14	27
Cucumbers	604	3	7
Peppers	897	4	8
Irish Potatoes	666	7	11
Tomatoes	700	3	10

If a northern Ohio processor can obtain quantities of one of these crops from a southern Ohio grower with a slightly different growing season, it may be profitable to pay the additional transportation costs because of the extended processing season. Alternatively, since long-distance transportation costs represent such a small percent of net income, a farmer grower is not dependent on selling to a local processor.

Hauling charges, in addition to costs for local delivery, for moving potatoes and tomatoes 150 miles are 10 and 11 percent of gross income. These crops are occasionally moved this distance to a processor.

Labor

Increases in gross income per acre needed to cause crops to enter the optimal solution for each of the 16 labor periods are reported in Appendix Tables I and II. The solutions indicated are based on the assumption that the crops considered are production alternatives and would be sold to a local processor. If any of the crops are not production alternatives, or if a local processor is not available, a different solution would evolve.

The term *gross income* is the amount received per acre for a crop delivered to the packinghouse. The term *net income* refers to gross income minus operating expenses as listed in Table 1. Operating expenses include seed, fertilizer and spray materials; custom charges for all tillage, harvesting, and local hauling; and fixed and variable irrigation expenses. No charge is made for land rent, interest on operating capital, or management. However, an opportunity cost of $40.00 per acre for rent and 2 percent (6 percent for 4 months) for operating capital (seed, fertilizer, spray, variable irrigation expenses, and custom tillage) were included in the linear program function.

Other Crop Returns

For the Model A solution, the income sacrifice is the amount that net income would be reduced by using planting labor in any labor period to plant 1 acre of another crop instead of using the same amount of time to plant the optimum profit crop. The amount of acreage of the optimum crop which is sacrificed in order to plant another crop depends upon the ratio of the planting rates. For Model B, the income sacrifice ratios are affected by discing and summer plowing labor, as well as planting time. In addition, total acreage is a limiting factor and thus affects these ratios.

The income sacrifice can be divided by the budgeted gross income per acre for that crop to determine the percent increase in gross income per acre (from price and/or yield) in order to get an acre of the crop into the optimum solution, assuming constant coefficients for all other crops. For April 1 to 10 spinach, the income sacrifice of $341 divided by the gross of $196 equals 1.74. This may be interpreted as meaning that the gross income must be increased by 174 percent to make this the optimal crop (see Appendix Tables I and II.) For the April 1 to 10 spinach and June 1 to 10 cabbage double crop, the income sacrifice of $563 divided by the gross income of $676 equals .83. Therefore, the double crop would appear in the optimum solution with an increase in gross of 83 percent but spinach would not appear alone unless gross was increased by at least 174 percent. The percent increase in gross necessary to make a non-optimal crop appear in the optimal solution is listed for each crop in Appendix Tables I and II.

Where two or more crops are included in the optimal solutions for a 10-day period, the income sacrifice comparison is based on the optimal crop having the lower returns per unit of labor required.

The crop having the lower income per unit of labor in the solution is the marginal crop in the solution which would be replaced if the necessary time were allotted to the non-optimal solution crop.

One use of the "shadow prices" (the sacrifice in income amounts) is in price negotiation on the part of a processor with farmers. Given the assumptions of the model, a processor can determine necessary price increases in the form of increased gross income per acre he needs to offer to farmers in order to get particular crops grown in certain labor periods. For example, a processor can determine how much lower the price can be in each labor period and still have the optimal crops produced.

To the extent that a model could be developed which accurately represented the resource restrictions and the alternative crop activities of an area, a processor would be able to use the optimal solutions and the shadow prices in conjunction with the fixed and variable costs of his plant to determine the maximum he could afford to pay to get a particular crop produced in any labor period. By a similar procedure, each individual farmer could determine the minimum price at which he could afford to sell each crop produced in any labor period.

The model used in this analysis is greatly oversimplified. The optimal solution and the shadow prices are merely suggestive of profitability relationships among the various crops which were considered.

CONCLUSIONS

This study sought answers to two questions. First, what is the profit potential of corn, soybeans, and selected processing vegetable crops? Second, what is the competitive capability of vegetable crops in the Mad River Valley? Based on the assumptions of Models A and B, net income per acre from peppers, asparagus, cucumbers, Irish potatoes, cabbage, tomatoes, carrots, and snap beans exceeded irrigated corn and soybeans. Net income from spinach was similar to corn and soybeans but net income from sweet corn was less than field corn and soybeans on a per acre basis.

Precision planting equipment and high-germinating, uniform sized seed were assumed in order to eliminate the need for employing stoop labor. In addition, extra expenditures could be justified for a self-propelled irrigation system instead of a less expensive portable sprinkler because of the reduced labor required to operate the self-propelled system.

The cost per acre for hauling vegetable crops to a processor is greatest for cabbage. In fact, only farmers with very few production alternatives can afford to haul this crop a greater distance than to a local processor. Other crops with large hauling costs per acre are carrots, tomatoes, and potatoes. Snap beans, cucumbers, and peppers have low tonnages and hauling costs per acre. These crops can be produced profitably, even though a local processing market is not available.

The second major question in this analysis referred to the competition of vegetable crops with corn and soybeans for land and labor resources in the Mad River Valley. A linear program profit maximization model was developed. Land and labor restrictions were set by the acreage of corn and soybeans one man could produce based on current farming practices. The planting season was divided into 16 10-day labor periods and opportunity rates for using labor on each crop in the appropriate periods were determined.

Time spent on potatoes, snap beans, peppers, fall spinach, cucumbers, and cabbage returned the maximum income for the 16 labor periods. Returns to land and labor for this combination of crops greatly exceeded returns from irrigated corn and soybeans.

Time spent in seedbed preparation and planting of peppers returned the greatest income per hour. Corn and soybeans competed directly with peppers for planting labor. Income from these crops is less than one-half of the amount necessary for them to be more profitable than peppers.

Spinach and snap beans were determined to be profitable crops when grown as a double crop with certain other vegetables. The double crops utilized land and labor otherwise virtually idle for the period.

This analysis was developed by synthesizing production coefficients based on research findings, grower experiences, and estimations of application of mechanical innovations not yet in commercial use.

APPENDIX

TABLE I.—Model A—Optima Crops and Percent Income Increases Required for Non-optimal Crops to Replace Optimal Crops by Labor Periods.

Crop	April 1-10	April 11-20	April 21-30	May 1-10	May 11-20	May 21-31	June 1-10	June 11-20	June 21-30	July 1-10	July 11-20	July 21-31	Aug. 1-10	Aug. 11-20	Aug. 21-31	Sept. 1-10
					(Percent Income Increase Required for Crop to Become Optimum)											
Snap Beans					47	47	30	30	30	30	30	Opt.				
Cabbage			31	31	88	88	58	58	58	58						
Carrots		28	17	17	62	62	39	39	39							
Corn, Irrigated			62	62	115											
Corn, Non-irrigated			81	81	146											
Cucumbers					18	18	Opt.	Opt.	Opt.	Opt.	Opt.					
Peppers					Opt.	Opt.										
Irish Potatoes	9	9	1	1	36	36										
Spring Spinach	174	174	149	149												
Fall Spinach								172	172	172	172	86	Opt.	Opt.	29	29
Early Soybeans, Irrigated			83	83	153											
Early Soybeans, Non-irrigated			111	111	198											
Late Soybeans, Irrigated						214	168									
Late Soybeans, Non-irrigated						270	214									
Sweet Corn		121	105	105	171	171	137	137	137	137						
Tomatoes					37	37	21									
Spinach—Cucumbers	35	35	29	29			35	35	29	29						
Spinach—Carrots	71	71	63				71	71	63							
Spinach—Snap Beans	78	78	68	68			78	78	68	68						
Spinach—Cabbage	83	83	76	76			83	83	76	76						
Spinach—Sweet Corn	141	141	126	126			141	141	126	126						
Spinach—Irr. Soybeans	153						153									
Spinach—Soybeans	170						170									
Potatoes—Spinach	Opt.	Opt.	Opt.	Opt.									Opt.	Opt.	Opt.	Opt.
Carrots—Spinach		10	11	11										10	11	11
Sweet Corn—Spinach		30	40	40										30	40	40
Cabbage—Snap Beans			12									12				
Cabbage—Spinach			40	13	52	61	40					40	13	52	61	40
Cucumbers—Spinach					6	6	Opt.	Opt.					6	6	Opt.	Opt.
Snap Beans—Spinach					91	53	5	5	17	17	91	53	5	5	17	17

Opt.=optima crops for the period.

TABLE II.—Model B—Optima Crops and Percent Income Increases Required for Non-optimal Crops to Replace Optimal Crops by Labor Periods.

Crop	April 1-10	April 11-20	April 21-30	May 1-10	May 11-20	May 21-31	June 1-10	June 11-20	June 21-30	July 1-10	July 11-20	July 21-31	Aug. 1-10	Aug. 11-20	Aug. 21-31	Sept. 1-10
					(Percent Income Increase Required for Crop to Become Optimum)											
Snap Beans					119	119	96	87	87	87	87	Opt.				
Cabbage			31	26	88	88	45	39	39	39						
Carrots		40	28	23	78	78	44	39	39							
Corn, Irrigated			141	132	231											
Corn, Non-irrigated			178	167	288											
Cucumbers					30	30	4	Opt.	Opt.	Opt.	Opt.					
Peppers					Opt.	Opt.										
Irish Potatoes	13	13	4	1	41	41										
Spring Spinach	202	202	174	163												
Fall Spinach								172	172	172	172	30	Opt.	30	58	69
Early Soybeans, Irrigated			188	176	305											
Early Soybeans, Non-irrigated			241	227	388											
Late Soybeans, Irrigated						404	343									
Late Soybeans, Non-irrigated			161			509	432									
Sweet Corn		231	204	193	315	315	269	255	255	255						
Tomatoes					46	46	25									
Spinach—Cucumbers	34	31	24	21			34	31	24	21						
Spinach—Carrots	69	65	56				69	65	56							
Spinach—Snap Beans	108	104	92	87			108	104	92	87						
Spinach—Cabbage	68	64	56	53			68	64	56	53						
Spinach—Sweet Corn	184	178	161	154			184	178	161	154						
Spinach—Irr. Soybeans	200						200									
Spinach—Soybeans	221						221									
Potatoes—Spinach	Opt.	Opt.	Opt.	Opt.									Opt.	Opt.	Opt.	Opt.
Carrots—Spinach		14	15	15										14	15	15
Sweet Corn—Spinach		64	72	74										64	72	74
Cabbage—Snap Beans			Opt.									Opt.				
Cabbage—Spinach			9	5	48	57	31					9	5	48	57	31
Cucumbers—Spinach					11	11	Opt.	Opt.					11	11	Opt.	Opt.
Snap Beans—Spinach					112	48	36	32	44	49	112	48	36	32	44	49

Opt.=optima crops for the period.

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Southeastern Branch, Carpenter, Meigs County: 330 acres

Southern Branch, Ripley, Brown County: 275 acres

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