Agriculture - Econ. aspects - Taiwan

PROCEEDINGS OF
AGRICULTURAL ECONOMICS SEMINAR, Taipei, Taiwan, SEPTEMBER 16—20, 1958

HELD AT THE COLLEGE OF AGRICULTURE
NATIONAL TAIWAN UNIVERSITY

TAIPEI, TAIWAN, CHINA
MARCH 1959

OPTIMUM RESOURCE ALLOCATION AND ENTERPRISE COMBINATION OF SINGLE-CROPPING PADDY FARMS IN TAINAN REGION OF TAIWAN

——Application of Linear Programming——

Ching-yuan Chao

Associated Professor of Farm Management
National Taiwan University

SUMMARY

I. Purpose, Method and Sample of the Study

The purposes of this study are to (1) determine optimum farm plans for single-cropping paddy farms in Tainan region, and (2) demonstrate how linear programming technique can be applied to the study of farm management problems in Taiwan.

The analysis was made by using the simplex method of linear programming technique—a mathematical technique permitting simultaneous consideration of many possible plans with estimates of input-output coefficients and prices used. It allows the practice of the most profitable plan, under the limitations of land, capital, labor and other factors on the farm.

This study covered 125 single-cropping paddy farms in 31 townships in the prefectures of Yunlin, Chiayi and Tainan in southern Taiwan.

II. Conditions of Sample Farms

1. Resources

The average available resources of sample farms are 2 hectares (200 ares*) of land, 2 males and 2 females of family labor and NT$7,000.00 of capital for cash expenses including seed and seedling, fertilizer, material and animal labor.

2. Crop Enterprises and Their Combination

Four groups of crops are grown in the region according to their planting seasons.

a. Spring planted crops—Hu-tze** sweet potato, peanut, 1st upland rice, jute, sesame, sweet potato and beans.

b. Fall planted crops—2nd rice, 2nd upland rice, sweet potato and tomato.

c. Year planted crops—Spring ratoon sugarcane.

* "Are" is a unit of surface measure in the metric system, equal to 100 square meters or 0.01 hectare.

** "Hu-tze" is an interplanting method to plant a crop in the field a few weeks before the harvest of the previous crop. For instance, spring planted Hu-tze sweet potato is planted in late October before the harvest of the 2nd rice crop.

d. Over one year planted crops—Hu-tze sugarcane and fall sugarcane.

As the average size of sample farms in the region is only 2 hectares, the only way for operators to increase their farm income is to make intensive use of their paddy field. Hence, two or more crops are usually grown on the same field in a year. The main crop combinations or cropping systems are Hu-tze sweet potato—2nd rice, spring peanut—2nd rice, spring sweet potato—2nd rice, jute—2nd rice, spring peanut—fall sweet potato, spring sweet potato—fall peanut, 1st upland rice—2nd rice, jute—fall sweet potato, spring ratoon sugarcane, fall Hu-tze sugarcane and fall sugarcane.

III. Input-Output Coefficients

The linear programming technique requires input-output coefficients and prices for each crop to be produced on the farm. Input-output coefficients can be defined as the quantity of resources required to produce one unit of a specified crop or to cultivate one hectare of land under a specified cropping system. Input-output coefficients were computed from the raw data of sample farms by crop, by cropping system and by prefecture in the region. For instance, the input requirements or coefficients in Yunlin prefecture are shown in tables 1 and 2 indicating the amounts of resources required per kilogram of each crop or per hectare of each cropping system. For example, it requires 0.00578 ares of land, NT$0.11889 of capital expense and 0.00188 days of labor to produce one kilogram of spring sweet potato; or it requires NT$4,308.63 of capital expense and 79.95 days of labor to cultivate one hectare of spring sweet potato and 2nd rice crop.

Table 1 Input-output Coefficients of Crops in Yunlin

Item	Spring ratoon sugarcane	Spring sweet potato	Hu-tze sweet potato	Spring peanut	2nd rice	Fall peanut
I. Yield per are (kg.)	758.76700	173.05720	147.35110	11.43010	41.11710	13.45950
Per are requirement of:						
Capital expense (NT$)	35.29830	20.57470	17.29490	21.13290	20.85730	19.50130
Spring labor (days)	1.01240	0.32530	0.55990	0.76820	0	0
Fall labor (days)	0.33080	0	0	0	0.80060	0.68590
II. Amount of resource required per unit of crop (Input Coefficients)						
Spring land (are)	0.00132	0.00578	0.00679	0.08749	0	0
Fall land (are)	0.00132	0	0	0	0.02432	0.07430
Capital expense (NT$)	0.04652	0.11889	0.11737	1.84888	0.50727	1.44889
Spring labor (days)	0.00133	0.00188	0.00380	0.06721	0	0
Fall labor (days)	0.00044	0	0	0	0.01947	0.05096
III. Price per unit (NT$)	0.15	0.41	0.35	5.01	2.28	5.20

Table 2 Input-output Coefficients of Cropping Systems in Yunlin

Item	Spring ratoon sugarcane	Hu-tze sweet pota-to—2nd rice	Spring sweet pota-to—2nd rice	Spring peanut —2nd rice	Spring sweet pota-to—Fall peanut
I. Value of products and by-products per ha (NT$)	12,201.69	16,084.58	17,780.72	15,934.36	14,919.89
II. Per ha. requirement of: (Input Coefficients)					
Capital expense (NT$)	3,529.83	3,835.97	4,308.63	7,271.23	4,180.38
Feb. labor (days)	25.27	1.31	8.06	16.34	11.25
Aug. labor (days)	8.86	32.51	34.22	36.06	16.80
Nov. labor (days)	10.58	53.95	37.67	25.01	1.66

IV. Optimum Resource Allocation and Enterprise Combination

1. Optimum plans by crops

Crop enterprises and their input-output coefficients in the region are outlined on previous pages. Now we can apply linear programming technique to determine profit-maximizing farm plans for operators. It is assumed that operator of farm A in Yunlin wants to select one spring planted crop among three crops, Hu-tze sweet potato, spring sweet potato and spring peanut, and one fall planted crop between fall peanut and 2nd rice for the purpose of maximizing profit for the farm. He has the following "fixed" amounts of resources to use on the two crops: 200 ares of spring and fall land respectively, NT$7,000 of capital expense, and 190 working days of spring and fall labor respectively. The per are (a) yields and (b) capital and labor requirements are shown in Table 1. Requirements of land, capital and labor per kilogram of crop or input coefficients are shown in Table 1. Now we apply linear programming technique to help the operator to determine an optimum farm plan. The details are to produce 23,790.92 kilograms of spring planted sweet potato and 8,223.72 kilograms of 2nd rice, leaving 62.58 ares of spring land, 145.22 working days of spring labor and 29.88 working days of fall labor unused. The gross return is NT$28,504.38.

It is further assumed that farm A increases its capital input (a) from NT$7,000 to NT$8,000 and (b) to unlimited capital with all other resources remaining constant. What are the optimum farm plans for the three capital levels of farm A? We can also apply linear programming method and get the results in the following table:

Table 3 Optimum Resource Allocation and Crop Combination of Farm A with Different Quantities of Available Capital in Yunlin

Plan	Capital expense level (NT$)	Gross return (NT$)	Crops	Yield (kg.)	Area (are)	Limiting resources
1.	7,000	28,504.38	Spring sweet potato	23,790.93	137.51	Fall land
			2nd rice	8,223.73	200.00	Capital expense
2.	8,000	31,953.06	Spring sweet potato	32,202.56	186.13	Fall land
			2nd rice	8,223.73	200.00	Capital expense
3.	unlimited (8,285.68)	32,937.95	Spring sweet potato	34,604.53	200.00	Fall land
			2nd rice	8,223.73	200.00	Spring land

A summary of the farm plans for three capital levels is given in Table 3. With NT$7,000 the most profitable plan is plan 1 as described above.

When capital is increased to NT$8,000, the most profitable plan (plan 2) includes: 32,202.56 kilograms of spring sweet potato and 8,223.73 kilograms of 2nd rice. The gross return for this plan is NT$31,953.06. The limiting resources are fall land and capital expense.

With capital not limiting, the most profitable plan (plan 3) produces 34,604.53 kilograms of spring sweet potato and 8,223.73 kilograms of 2nd rice. The gross return is NT$32,937.95. Land is the only limiting resource.

2. Optimum plans by cropping system

The same technique will be applied to work out optimum plans for farm B in Table 4. It is assumed that operator of farm B in Yunlin wants to select cropping systems among spring ratoon sugarcane, Hu-tze sweet potato—2nd rice, spring sweet potato—2nd rice, spring peanut—2nd rice and spring sweet potato—fall peanut. He has the same amounts of resources as farm A except labor which is 65 working days in February, August and November respectively. The capital levels are NT$7,000, NT$8,000 and unlimited capital with all other resources remaining the same. Input-output coefficients of cropping systems are indicated in Table 2.

Table 4 Optimum Resource Allocation and Selection and Combination of Cropping System for Farm B with Different Quantities of Available Capital in Yunlin

Plan	Capital expense level (NT$)	Gross return (NT$)	Cropping system	Area (ha.)	Limiting resources
1.	7,000	28,934.82	Hu-tze sweet potato —2nd rice (P_2)	0.18613	Capital expense
			Spring sweet potato —2nd rice (P_3)	1.45894	Nov. labor

2.	8,000	32,683.85	Spring sweet potato —2nd rice (P_3)	1.71927	Capital expense
			Spring sweet potato —Fall peanut (P_5)	0.14169	Nov. labor
3.	unlimited (8,580.41)	34,900.00	Spring sweet potato —2nd rice (P_3)	1.71286	Land
			Spring sweet potato —Fall peanut (P_5)	0.28714	Nov. labor

A summary of the farm plans for the three capital levels is given in Table 4. With NT$7,000 the most profitable plan (plan 1) includes: 0.18613 ha. of P_2 cropping system and 1.45 ha. of P_3 cropping system. Capital expense and labor in November are limiting resources. The gross return is NT$28,934.82.

Plan 2, with a capital level of NT$8,000, includes P_3 and P_5 cropping systems. It includes 1.71 ha. of P_3 cropping system and 0.14 ha. of P_5 cropping system. Some ares of land and some working days of labor in February and August are not used in this plan. The gross return is NT$32,683.85.

With capital not limited, the most profitable plan is plan 3 in which land and labor in November become limiting. It includes 1.71 ha. of P_3 cropping system and 0.28 ha. of P_5 cropping system. The gross return is NT$34,900.00.