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Chapter 12

Selecting Fertilizer Programs by Activity Analysis

THE central notion of activity analysis or linear programming is that of an activity or a process. In the usual type of production planning problem employing activity analysis, an activity may be described in terms of its resource requirements and the product, or products, it generates. Thus in a farm planning problem, e.g., cattle feeding or haymaking are considered to be activities. The product of each activity is assumed to be a linear function of the resources used in its production. Although the assumption of linearity or fixed technical coefficients for a given process or activity may seem unduly restrictive, such is not the case. For example, activities may be added to correspond to different points on a production surface. Thus, feeding cattle to the same weight and quality by three different methods may represent three points on a conventional isoquant. These three methods may be represented by three separate activities. Likewise, several rates of fertilizer application may be treated as distinct corn-growing activities or processes. Lowering of per-unit labor requirements, as the size of an enterprise increases, can be treated in the same fashion.

The economic problem is, of course, one of selecting optimum activity levels. This is accomplished by maximizing or minimizing a linear criterion relation (4), usually some type of profits or costs, subject to such restraints as resource supplies, product requirements, and definitional restrictions that may be appropriate.

The particular application of activity analysis that is treated in this paper might best be termed farm planning or budgeting.[1] Activity analysis has an advantage over less formalized budgeting techniques in that it assures that there is no better organization possible within the set of restrictions considered. Activity analysis is more appropriate than conventional budgeting in relatively complex planning situations where it may be desirable to consider many alternative activities with a large number of restraints on profit maximization. Accordingly, activity analysis is more likely to be useful in selecting a fertilizer program when, for example, outlays for fertilizer must compete with many other

[1] For an application of activity analysis in problems of selecting a minimum-cost fertilizer to meet a given set of requirements at the farm level, cf., G. A. Peterson (6). Another application is that of mixing ingredients, cf., E. R. Swanson (9).

enterprises of the farm business for a limited amount of capital. On the other hand, farm problem situations with only a single crop and few alternative methods of production may best be handled by conventional budgeting.

The model that is to be presented in this chapter, along with the results, should be viewed only as an illustration of the technique. Thus, the model serves chiefly as an expositional device to suggest the usefulness and the limitations of activity analysis in selecting fertilizer programs. It will be noted that several of the properties of the model are not as realistic as desirable, or perhaps even presently possible. Some of these simplifying assumptions are due to the inadequacy of data while others are made for computational convenience. However, it is not believed that these characteristics of the model seriously interfere with our central purpose, i.e., to indicate the general methodology of selecting fertilizer programs by activity analysis.

Farm Situation

An owner-operator is located on 200 acres of Muscatine silt loam, a highly productive level soil found in Illinois and Iowa. He is interested in selecting a farm plan starting in 1955. He presently has no livestock. Soil tests indicate that potash is adequate, but that three tons of lime per acre is needed for satisfactory legume stands and that the available phosphate is low (5). Barn space is available for feeding cattle, but equipment will be needed. Hog houses and equipment will need to be purchased if hogs are to be included in the farm plan. Adequate power and machinery investment have already been made for this acreage. Three hundred hours of labor per month is assumed to be available during peak labor periods.

Activities Considered

Cropping Systems

Six cropping systems are considered as separate activities. Cropping systems are defined as a combination of a rotation (2, 7), or crop sequence, and a fertilizer plan. Thus we attempt to account for the interdependence of the rotation and the fertilizer treatments. Two alternative rotations are considered: (a) three-year rotation of corn-corn-oats (clover catch crop), and (b) four-year rotation of corn-corn-oats-clover. For each of these two rotations three different fertilizer plans are considered, thus giving the total of six cropping systems. The fertilizer plans presented in table 12.1 are based on the "build-up" and "maintenance" concepts of a soil fertility program (8).[2] Thus, it can be seen that the various plans for a given rotation constitute points on

[2]The yield estimates and fertilizer requirements were furnished to the author by E. H. Tyner, Department of Agronomy, University of Illinois.

iso-yield curves for each year. Ideally, other yield levels should be included as alternatives. Adequate experimental data are not presently available to estimate other yield levels as alternatives. Although the analysis was simplified by using one yield level, additional activities for other yield levels could have been employed had the data been available.

All three of the fertilizer plans are similar in their limestone and nitrogen applications for a given rotation during the "build-up" phase of the program. They differ in the type of phosphate materials and annual rates of application of the phosphate materials. Plan A of fertilizer treatment relies solely upon superphosphate as a source of phosphate; the "build-up" is accomplished very slowly; seven years is required for the three-year rotation, and nine years is required for the four-year rotation. However, initial outlays for capital are not as great as for the other two fertilizer plans.

Plan B uses rock phosphate as the sole source of phosphate. Large applications are made in the initial years. These supplies are depleted down to the level at which a "maintenance" program may be initiated after seven years in the case of both rotations. In order to make the plans comparable in terms of ending in the same year, a "maintenance" program of superphosphate was started in the eighth year of Plan B. This procedure avoided the problem of placing values on the unexpended rock phosphate that would normally have been applied that year. Hence, all plans have the same asset valuation at the end of the nine-year period.

Plan C, the third alternative fertilizer plan, consists of a combination of rock phosphate and superphosphate. Under this scheme the "build-up" program is completed in four years for the three-year rotation, and after six years for the four-year rotation. "Maintenance" requirements are the same as for the other plans for their respective rotations. Note in table 12.1 that in the initial years of each plan relatively heavy applications of nitrogen are made. This is done to bring the yields up to the specified level prior to procurement of full legume nitrogen effects.

Livestock Enterprises

Only two livestock enterprises are considered as alternatives: (a) a two-litter hog system and (b) a feeder-cattle enterprise. Thus, opportunity is provided for competition from livestock for limited resources to affect the fertilizer plan adopted. Further, the inclusion of livestock provides a means for implicity solving the question of whether legumes are a cheaper source of nitrogen than commercial fertilizers. Taking this problem out of the context of the farm business may prove to be misleading because of the joint-product characteristics of legume production. The appropriate value of legume roughage produced must include consideration of its marginal value productivity in livestock production. In activity analysis, the problem of placing explicit values on such intermediate inputs may be by-passed and the "built-in" pricing mechanism may be relied upon to yield the optimal total farm plan. Finally, another relation between livestock and fertilizer programs is that

TABLE 12.1. Lime and Fertilizer Requirements for "Build-Up" and "Maintenance" (Pounds per Rotation Acre) Muscatine Silt Loam, Starting with "Low" Phosphate Test, a 3-Ton Limestone Requirement, and Adequate Potassium (Treatments for Each Specific Crop Appear in the Appendix

Year	Materials	Rotation					
		Corn-Corn-Oats (Clover)			Corn-Corn-Oats-Clover		
		(Plan A)	(Plan B)	(Plan C)	(Plan A)	(Plan B)	(Plan C)
1955	Limestone	2,000	2,000	2,000	1,500	1,500	1,500
	Rock phosphate	-	1,300	333.3	-	975	250
	0-20-0	300	-	133.3	250	-	150
	N	80	80	80	50	50	50
1956	Limestone	2,000	2,000	2,000	1,500	1,500	1,500
	Rock phosphate	-	-	333.3	-	325	250
	0-20-0	300	-	116.7	250	-	125
	N	73.3	73.3	73.3	50	50	50
1957	Limestone	2,000	2,000	2,000	1,500	1,500	1,500
	Rock phosphate	-	-	333.3	-	-	250
	0-20-0	300	-	100	250	-	87.5
	N	70	70	70	45	45	45
1958	Limestone	-	-	-	1,500	1,500	1,500
	Rock phosphate	-	-	-	-	-	250
	0-20-0	300	-	100	-	-	87.5
	N	70	70	70	45	45	45
1959	Limestone	-	-	-[a]	-	-	-
	Rock phosphate	-	-	-	-	-	-
	0-20-0	300	-	130	250	-	150
	N	63.3	63.3	39	37.5	37.5	37.5
1960	Limestone	-	-	-	-	-	-
	Rock phosphate	-	-	-	-	-	-
	0-20-0	300	-	130	250	-	127.5
	N	56.7	56.7	39	37.5	37.5	20.5
1961	Limestone	-	-	-	-	-	-[a]
	Rock phosphate	-	-	-	-	-	-
	0-20-0	133.3	-	130	250	-	105
	N	56.7	56.7	39	37.5	37.5	14
1962	Limestone	-[a]	-[a]	-	-	-[a]	-
	Rock phosphate	-	-	-	-	-	-
	0-20-0	130	130	130	250	105	105
	N	39	39	39	37.5	14	14
1963	Limestone	-	-	-	-	-	-
	Rock phosphate	-	-	-	-	-	-
	0-20-0	130	130	130	125	105	105
	N	39	39	39	37.5	14	14

[a]Indicates first year that all fields under a given cropping system are on "maintenance" program.

of the effect of manure. In the illustration presented in this chapter, capital outlays are reduced in the succeeding year by the value of the manure produced in any given year.

Other Activities

Hay-making activities are employed to process pasture into hay. In addition, corn-buying and corn-selling activities are introduced to permit both purchase and sale of corn. Since the model embraces several time periods, it is necessary to make some provision for transfer of income from one period to a later one. This transfer is accomplished by what might be called "saving" activities. The levels of the saving activities represent the dollars of income in each year (1955 through 1963) above a given amount specified for fixed costs and household withdrawals. This particular model does not permit transfer of income to any period beyond the one immediately following its generation. More complex assumptions could be made at the expense of added computational burden.

Criterion for Selection of Farm Plan

The criterion for selecting a farm plan for a period of time requires a dating of each outlay and income. Accordingly, cash outlays are assumed to be made on January 1 of each year, and the income from production during that year is assumed to occur on December 31. After specifications of the dates of the outlays, incomes, and given price expectations[3] (including the interest rate, r), the present value of a stream of net income over the relevant horizon is constructed as the criterion equation. In this case the present value (P V) of the plan is maximized and is denoted for a nine-year horizon as follows:

$$(1) \qquad P\,V = \sum_t \sum_i P_{it}\, x_1 \frac{1}{(1 + r_t)t} \qquad \begin{matrix} t = 0, 1, 2, 3 \ldots 9 \\ i = 1, 2, 3 \ldots 13 \end{matrix}$$

The 13 activities or processes entering into the criterion equation are as follows:

x_1 = acres of C-C-O (C1) with superphosphate build-up program (Plan A)

[3]Price expectations for all periods were assumed to be at the following levels: corn, $1.48 per bushel; oats, $0.74 per bushel; March hogs, $19.25 per cwt.; September hogs, $21.00 per cwt.; feeder calves, $23.00 per cwt.; choice steers, $26.10 per cwt.; rock phosphate, $24.00 per ton (spread); limestone, $4.50 per ton (spread); 33-0-0, $104.00 per ton (spread); 0-20-0, $46.00 per ton (spread); protein supplement, $88.00 per ton; cash costs other than fertilizer (fuel, repairs, seed, etc.): for three-year rotation, $8.60 per acre; for four-year rotation, $7.85 per acre; cash costs for livestock (equipment, protein feed, veterinary and medicine, original outlay for gilts, annual purchase of feeder calves): hogs, $13 for the first year and $4.50 for each of the subsequent years; cattle $105 for the first year and $100 for each of the subsequent years; manure credits: hogs, $3.80 per animal; cattle, $16.70 per animal.

x_2 = acres of C-C-O (C1) with rock phosphate build-up program (Plan B)

x_3 = acres of C-C-O (C1) with combination superphosphate and rock phosphate program (Plan C)

x_4 = acres of C-C-O-C1 with superphosphate build-up program (Plan A)

x_5 = acres of C-C-O-C1 with rock phosphate build-up program (Plan B)

x_6 = acres of C-C-O-C1 with combination superphosphate and rock phosphate program (Plan C)

x_7 = number of hogs produced

x_8 = number of good-to-choice feeder calves fed

x_9 = tons of hay produced in period May 15-June 14

x_{10} = tons of hay produced in period July 15-August 14

x_{11} = tons of hay produced in period August 15-September 14

x_{12} = bushels of corn equivalent sold

x_{13} = bushels of corn equivalent purchased.

Restraints

Capital

The restraints on maximization of the present value of the total farm plan is considered. Initial capital available for cash outlays will constitute the first restraint. In the solutions presented, this quantity will vary to note the effect on optimum farm organization. Since the focus is on the time shape of capital outlays for various fertilizer programs, the annual cash outlay for lime and fertilizer for each of the six cropping systems is presented in table 12.2. Expenses for the livestock enterprises are presented in a previous footnote referring to prices. Letting α_{1i} be the 1955 capital requirements of the various activities, the first restraint is:

$$\sum_i \alpha_{1i} x_i \leqslant \text{capital available January 1, 1955.} \tag{2}$$

In order to make income available for investments in subsequent periods, the savings activities are utilized as previously mentioned. The levels of these activities are denoted as x_{14} through x_{21}. Writing these capital requirements and supply relationships for the year 1956 through 1963, the second through the ninth restraints are:

$$\sum_i \alpha_{2i} x_i - \beta_{2,14} x_{14} \leqslant 0 \tag{3}$$

$$\sum_i \alpha_{3i} x_i - \beta_{3,15} x_{15} \leqslant 0 \tag{4}$$

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(10) $$\sum_i \alpha_{9i} x_i - \beta_{9,21} x_{21} \leqslant 0.$$

The α's refer to the capital requirements of each activity in each year. The fraction of income above a specified level available for spending by the firm in the following year is designated as β. An arbitrary value of 0.6 was selected for β.

TABLE 12.2 Total Capital Outlays for Lime and Fertilizer Required for Various Phosphate "Build-Up" Programs (per Rotation Acre)

	Rotation					
	Corn-Corn-Oats (Clover)			Corn-Corn-Oats-Clover		
Year	Plan A	Plan B	Plan C	Plan A	Plan B	Plan C
	(In Dollars)					
1955	23.10	32.60	24.00	16.90	22.90	17.60
1956	22.10	15.90	22.60	16.90	15.10	17.10
1957	21.60	15.40	21.70	16.15	7.00	15.40
1958	17.00	10.90	14.00	15.00	5.90	14.00
1959	16.00	9.90	8.90[a]	11.60	5.90	9.30
1960	15.00	8.90	8.90	11.60	5.90	5.90
1961	12.00	8.90	8.90	11.60	5.90	4.60[a]
1962	8.90[a]	8.90[a]	8.90	11.60	4.60[a]	4.60
1963	8.90	8.90	8.90	9.30	4.60	4.60

[a]Denotes first year all fields under a given cropping system are on a "maintenance" program.

Income

The minimum level of income required in any year is specified in the next set of restraints. These restrictions may be viewed in terms of a further description of the time shape preference of the income stream. A minimum requirement for fixed costs and household withdrawals of 4,000 dollars was specified for this problem. These restraints were handled as equalities:

(11) $$\sum_i \alpha_{10i} x_i - x_{14} = \$4{,}000 \text{ (1955)}$$

(12) $$\sum_i \alpha_{11i} x_i - x_{15} = \$4{,}000 \text{ (1956)}$$

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(18) $$\sum_i \alpha_{17i}x_i - x_{21} = \$4{,}000 \text{ (1962)}$$

α's indicate dollars of income per unit of activity level, and activities 14 through 21 act to transfer income to their respective subsequent years.

Labor

In addition to the capital and income restrictions on the choice of a high-profit program, other resources were considered. Labor in three periods during the year was considered fixed at 300 hours. These were considered to be periods when the labor supply would be critical and also when the hay-making operation would be performed. The crop and livestock labor requirements were secured from *Illinois Farm and Home Development Reference Book* (3).

(19) $$\sum_i \alpha'_{18i}x_i \leqslant 300 \text{ May 15-June 14}$$

(20) $$\sum_i \alpha_{19i}x_i \leqslant 300 \text{ July 15-August 14}$$

(21) $$\sum_i \alpha_{20i}x_i \leqslant 300 \text{ August 15-September 15}$$

Land

The land available for cultivation also needs to be added as a restraint

(22) $$\sum_i \alpha_{21i}x_i \leqslant 200$$

where $\alpha = 1$ for each of the six cropping systems and $\alpha = 0$ for other activities.

Grain and Hay

A grain relation is also added to permit feeding or sale of grain produced as well as purchase of grain. No beginning inventories are assumed, hence:

(23) $$\sum_i \alpha_{22i}x_i = 0$$

where the α's indicate the production, consumption, purchase, and sale coefficients of their respective activities.

A set of three relations concerning pasture is specified which permits the direct consumption of pasture by animals or its transformation into the intermediate product of hay. Again, no beginning inventories are assumed; however, surplus pasture days are permitted, i.e., more pasture days produced than consumed.

$$\sum_i \alpha_{23i} x_i \geqslant 0 \tag{24}$$

$$\sum_i \alpha_{24i} x_i \geqslant 0 \tag{25}$$

$$\sum_i \alpha_{25i} x_i \geqslant 0 \tag{26}$$

Finally, a relation is specified which accounts for the hay production in each of the three hay-making periods and its consumption by the two classes of livestock. No hay is assumed to be available at the beginning of the period and none will be produced unless it is necessary for consumption by the livestock enterprises.

$$\sum_i \alpha_{26i} x_i = 0 \tag{27}$$

Results

Proceeding directly to the results (table 12.3) of maximizing equation 1 subject to the relations 2 through 27, it is noted that the fertilizer programs selected depend on the levels at which some of the assigned constants are arbitrarily set. The method of computation may be found in Charnes, et al. (1). Situations I through IV show the effect of various amounts of initial capital on the optimum farm plan. A nine-year horizon is considered in the discounting procedure in order to make the various fertilizer plans comparable without placing values on unexpended nutrients. This does not mean that the farmer is committed to a single plan once it is adopted for 1955. It merely means that the 1955 plans are dependent upon expectations of incomes and outlays in the eight succeeding years as well as the expectations for 1955.

A discount rate, r, of 5 percent is used in the first four situations. As the starting capital available for cash outlays decreases from $13,000 (Situation I), to $11,000 (Situation II), a shift is made from cropping systems employing rock phosphates as the sole source (Plan B) to a combination rock phosphate-superphosphate plan (Plan C). Also, hog numbers decrease and a shift is made toward more acres in the three-year rotation as beginning capital decreases. The effective restraints (i.e., limiting resources) level of $13,000 is land and labor. In the remaining situations, starting capital and land are the effective restrictions. Thus, surplus capital for cash outlays in 1955 exists only in Situation I.

This general pattern of increased acres in catch crops and decreased livestock numbers continues as beginning capital decreases (Situations III and IV). Only 34 hogs remain in the farm plan in the $7,000 beginning capital situations. Obviously, these plans would need a certain degree of adjustment in their adaptation to a specific farm situation. For example, small fields in a rotation may not be feasible. Additional restraints on profit maximization may be imposed to prevent more than one rotation from being chosen. Such restraints were not considered in this problem.

In Situation V the discount rate is changed from Situation IV. A

TABLE 12.3. Optimum Cropping and Livestock Systems for Various Situations on a 200-Acre Muscatine Silt Loam Farm

Situation	Available Capital Jan. 1, 1955	Relevant Horizon	Discount Rate	Cropping System		Hogs	Beef Cattle
	(Dollars)	(Years)	(Percent)	(Rotation and Fertilizer Plan)	(Acres)	(Head)	(Head)
I	13,000	9	5	C-C-O-(Plan B)	116	395	4
				C-C-O-Cl-(Plan B)	84		
II	11,000	9	5	C-C-O(Plan C)	137	376	-
				C-C-O-Cl-(Plan C)	63		
III	9,000	9	5	C-C-O-(Plan C)	174	173	-
				C-C-O-Cl-(Plan C)	26		
IV	7,000	9	5	C-C-O-(Plan C)	195	34	-
				C-C-O-Cl-(Plan C)	5		
V	7,000	9	20	C-C-O-(Plan C)	195	34	-
				C-C-O-Cl-(Plan C)	5		
VI	7,000	9	5	C-C-O-(Plan B)	50	(no livestock considered)	
				C-C-O-(Plan C)	150		
VII	9,000	2	5	C-C-O-(Plan A)	168		
				C-C-O-Cl-(Plan A)	32	217	-

change from 5 percent to 20 percent does not alter the optimum organization. Outlays in the original year still appear to dominate the program selection at this level of beginning capital ($7,000).

It is also of interest to investigate the effect of considering no livestock alternatives. Accordingly, in Situation VI livestock are not considered. With beginning capital at $7,000, the optimum plan calls for the three-year rotation on the total acreage and a mixed fertilizer plan. Had sufficient capital been available in this cash-grain situation, the cropping system of the three-year rotation and fertilizer Plan B would have been selected. This would have required about $8,200. Since only the $7,000 was available, Plan C (combination rock phosphate-superphosphate) was selected for three-fourths of the farm. An alternative plan lying between B and C might have been chosen, had such a plan been considered.

Finally it is of interest to examine the effect of a shorter horizon. Accordingly, if the relevant period is reduced from nine years to two years, Plan A, or the straight superphosphate program, appears to be the optimum solution. It should be mentioned that no account was taken of the differences among plans in the valuation of soil nutrient assets in considering the two-year horizon. It will be recalled that in the nine-year horizon the levels of fertility for each cropping system were assumed to be identical at the end of the nine-year period.

12A.1. Field Treatments per Acre for Various Cropping Systems

Year	Materials	Corn-Corn-Oats (Clover) with Fertilizer Plan A		
		Field 1	Field 2	Field 3
		Oats	Corn	Corn
1955	Limestone	3 T	-	-
	Rock phosphate	-	-	-
	0-20-0	300 lbs.	300 lbs.	300 lbs.
	Elemental N	40 lbs.	100 lbs.	100 lbs.
		Corn	Oats	Corn
1956	Limestone	-	3 T	-
	Rock phosphate	-	-	-
	0-20-0	300 lbs.	300 lbs.	300 lbs.
	Elemental N	80 lbs.	40 lbs.	100 lbs.
		Corn	Corn	Oats
1957	Limestone	-	-	3 T
	Rock phosphate	-	-	-
	0-20-0	300 lbs.	300 lbs.	300 lbs.
	Elemental N	100 lbs.	80 lbs.	30 lbs.
		Oats	Corn	Corn
1958	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	300 lbs.	300 lbs.	300 lbs.
	Elemental N	30 lbs.	100 lbs.	80 lbs.
		Corn	Oats	Corn
1959	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	300 lbs.	300 lbs.	300 lbs.
	Elemental N	60 lbs.	30 lbs.	100 lbs.
		Corn	Corn	Oats
1960	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	300 lbs.	300 lbs.	300 lbs.
	Elemental N	80 lbs.	60 lbs.	30 lbs.
		Oats	Corn	Corn
1961	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	100 lbs.	150 lbs.	150 lbs.
	Elemental N	30 lbs.	80 lbs.	60 lbs.

1962 Maintenance program with following requirements per rotation acre: Elemental N 39 lbs. 0-20-0 130 lbs.

12A.2. Field Treatments per Acre for Various Cropping Systems

Year	Materials	Corn-Corn-Oats (Clover) with Fertilizer Plan B		
		Field 1	Field 2	Field 3
		Oats	Corn	Corn
1955	Limestone	3 T	-	-
	Rock phosphate	1,300 lbs.	1,300 lbs.	1,300 lbs.
	0-20-0	-	-	-
	Elemental N	40 lbs.	100 lbs.	100 lbs.
		Corn	Oats	Corn
1956	Limestone	-	3 T	-
	Rock phosphate	-	-	-
	0-20-0	-	-	-
	Elemental N	80 lbs.	40 lbs.	100 lbs.
		Corn	Corn	Oats
1957	Limestone	-	-	3 T
	Rock phosphate	-	-	-
	0-20-0	-	-	-
	Elemental N	100 lbs.	80 lbs.	30 lbs.
		Oats	Corn	Corn
1958	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	-	-	-
	Elemental N	30 lbs.	100 lbs.	80 lbs.
		Corn	Oats	Corn
1959	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	-	-	-
	Elemental N	60 lbs.	30 lbs.	100 lbs.
		Corn	Corn	Oats
1960	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	-	-	-
	Elemental N	80 lbs.	60 lbs.	30 lbs.
		Oats	Corn	Corn
1961	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	-	-	-
	Elemental N	30 lbs.	80 lbs.	60 lbs.

1962 Maintenance program with following requirements per rotation acre: Elemental N 39 lbs. 0-20-0 130 lbs.

12A.3. Field Treatments per Acre for Various Cropping Systems

Year	Materials	Corn-Corn-Oats (Clover) with Fertilizer Plan C		
		Field 1	Field 2	Field 3
		Oats	Corn	Corn
1955	Limestone	3 T	-	-
	Rock phosphate	1,000 lbs.	-	-
	0-20-0	-	200 lbs.	200 lbs.
	Elemental N	40 lbs.	100 lbs.	100 lbs.
		Corn	Oats	Corn
1956	Limestone	-	3 T	-
	Rock phosphate	-	1,000 lbs.	-
	0-20-0	150 lbs.	-	200 lbs.
	Elemental N	80 lbs.	40 lbs.	100 lbs.
		Corn	Corn	Oats
1957	Limestone	-	-	3 T
	Rock phosphate	-	-	1,000 lbs.
	0-20-0	150 lbs.	150 lbs.	-
	Elemental N	100 lbs.	80 lbs.	30 lbs.
		Oats	Corn	Corn
1958	Limestone	-	-	-
	Rock phosphate	-	-	-
	0-20-0	100 lbs.	150 lbs.	150 lbs.
	Elemental N	30 lbs.	100 lbs.	80 lbs.

1959 Maintenance program with following requirements per rotation acre:
Elemental N - 39 lbs.; 0-20-0 - 130 lbs.

12A.4. Field Treatments per Acre for Various Cropping Systems

Year	Materials	Corn-Corn-Oats-Clover with Fertilizer Plan A			
		Field 1	Field 2	Field 3	Field 4
		Corn	Corn	Oats	Clover
1955	Limestone	-	-	3 T	-
	Rock phosphate	-	-	-	-
	0-20-0	300 lbs.	300 lbs.	400 lbs.	-
	Elemental N	60 lbs.	100 lbs.	40 lbs.	-
		Corn	Oats	Clover	Corn
1956	Limestone	-	3 T	-	-
	Rock phosphate	-	-	-	-
	0-20-0	300 lbs.	400 lbs.	-	300 lbs.
	Elemental N	100 lbs.	40 lbs.	-	60 lbs.
		Oats	Clover	Corn	Corn
1957	Limestone	3 T	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	400 lbs.	-	300 lbs.	300 lbs.
	Elemental N	40 lbs.	-	40 lbs.	100 lbs.
		Clover	Corn	Corn	Oats
1958	Limestone	-	-	-	3 T
	Rock phosphate	-	-	-	-
	0-20-0	-	300 lbs.	300 lbs.	400 lbs.
	Elemental N	-	40 lbs.	80 lbs.	30 lbs.
		Corn	Corn	Oats	Clover
1959	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	300 lbs.	300 lbs.	400 lbs.	-
	Elemental N	40 lbs.	80 lbs.	30 lbs.	-
		Corn	Oats	Clover	Corn
1960	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	300 lbs.	400 lbs.	-	300 lbs.
	Elemental N	80 lbs.	30 lbs.	-	40 lbs.
		Oats	Clover	Corn	Corn
1961	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	400 lbs.	-	300 lbs.	300 lbs.
	Elemental N	30 lbs.	-	40 lbs.	80 lbs.
		Clover	Corn	Corn	Oats
1962	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	-	300 lbs.	300 lbs.	400 lbs.
	Elemental N	-	40 lbs.	80 lbs.	30 lbs.
		Corn	Corn	Oats	Clover
1963	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	150 lbs.	150 lbs.	300 lbs.	-
	Elemental N	40 lbs.	80 lbs.	30 lbs.	-

1964 Maintenance program with following requirements per rotation acre: Elemental N - 14 lbs; 0-20-0 - 105 lbs.

12A.5. Field Treatments per Acre for Various Cropping Systems

Year	Materials	Corn-Corn-Oats-Clover with Fertilizer Plan B			
		Field 1	Field 2	Field 3	Field 4
		Corn	Corn	Oats	Clover
1955	Limestone	-	-	3 T	-
	Rock phosphate	1,300 lbs.	1,300 lbs.	1,300 lbs.	-
	0-20-0	-	-	-	-
	Elemental N	60 lbs.	100 lbs.	40 lbs.	-
		Corn	Oats	Clover	Corn
1956	Limestone	-	3 T	-	-
	Rock phosphate	-	-	-	1,300 lbs.
	0-20-0	-	-	-	-
	Elemental N	100 lbs.	40 lbs.	-	60 lbs.
		Oats	Clover	Corn	Corn
1957	Limestone	3 T	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	-	-	-	-
	Elemental N	40 lbs.	-	40 lbs.	100 lbs.
		Clover	Corn	Corn	Oats
1958	Limestone	-	-	-	3 T
	Rock phosphate	-	-	-	-
	0-20-0	-	-	-	-
	Elemental N	-	40 lbs.	80 lbs.	30 lbs.
		Corn	Corn	Oats	Clover
1959	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	-	-	-	-
	Elemental N	40 lbs.	80 lbs.	30 lbs.	-
		Corn	Oats	Clover	Corn
1960	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	-	-	-	-
	Elemental N	80 lbs.	30 lbs.	-	40 lbs.
		Oats	Clover	Corn	Corn
1961	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	-	-	-	-
	Elemental N	30 lbs.	-	40 lbs.	80 lbs.

1962 Maintenance program with following requirements per rotation acre: Elemental N - 14 lbs.; 0-20-0 - 105 lbs.

12A.6. Field Treatments per Acre for Various Cropping Systems

Year	Materials	Corn-Corn-Oats-Clover with Fertilizer Plan C			
		Field 1	Field 2	Field 3	Field 4
		Corn	Corn	Oats	Clover
1955	Limestone	-	-	3 T	-
	Rock phosphate	-	-	1,000 lbs.	-
	0-20-0	300 lbs.	300 lbs.	-	-
	Elemental N	60 lbs.	100 lbs.	40 lbs.	-
		Corn	Oats	Clover	Corn
1956	Limestone	-	3 T	-	-
	Rock phosphate	-	1,000 lbs.	-	-
	0-20-0	200 lbs.	-	-	300 lbs.
	Elemental N	100 lbs.	40 lbs.	-	60 lbs.
		Oats	Clover	Corn	Corn
1957	Limestone	3 T	-	-	-
	Rock phosphate	1,000 lbs.	-	-	-
	0-20-0	-	-	150 lbs.	200 lbs.
	Elemental N	40 lbs.	-	40 lbs.	100 lbs.
		Clover	Corn	Corn	Oats
1958	Limestone	-	-	-	3 T
	Rock phosphate	-	-	-	1,000 lbs.
	0-20-0	-	150 lbs.	150 lbs.	-
	Elemental N	-	40 lbs.	80 lbs.	30 lbs.
		Corn	Corn	Oats	Clover
1959	Limestone	-	-	-	-
	Rock phosphate	-	-	-	-
	0-20-0	150 lbs.	150 lbs.	300 lbs.	-
	Elemental N	40 lbs.	80 lbs.	30 lbs.	-

1960 Maintenance program on Fields 1, 2, and 3 with following requirements per rotation acres: Elemental N - 14 lbs.; 0-20-0 - 105 lbs.
Field 4: Elemental N - 40 lbs.; 0-20-0 - 150 lbs.

1961 Maintenance program as above on all fields

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