Handling Fertilizer in Bulk, A Study in Costs
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A STUDY IN COSTS

Handling Fertilizer IN BULK

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FOREWORD

Bulk handling of fertilizer is becoming increasingly important in Michigan. Though this method of distribution may continue to expand, there are certain limitations which should be kept in mind by individual business managers who are contemplating the addition of a bulk fertilizer enterprise. These limitations are as follows:

A. Top dressing is not recommended for crops where placement of the fertilizer in relation to the seed is important.*

B. The quantity sold for top dressing will depend in large part upon the amount of forage livestock farming that is in existence in any particular area.

C. Often, spreading may be restricted because of the weather. In some years this may limit the use of specialized delivery equipment.

D. Fertilizer spreading probably will not result in direct cash savings to farmers but will increase farm efficiency by eliminating a task which the farmer has hereto performed himself.

E. Bulk selling of fertilizer, when farmers come to the plant and haul it themselves, can result in savings and greater convenience to farmers. However, farm storage may be difficult.

F. Granular fertilizer is better suited to bulk handling than common pulverized fertilizer.

G. In many cases, bulk facilities to handle bulk fertilizer can be added with relatively little cost. However, where cost is expected to be greater (particularly in cases where consideration is being given to purchasing delivery and spreading equipment), market potential should be carefully evaluated to provide a basis for estimating the amount that can reasonably be invested in facilities, and to determine what delivery charges should be.

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* See Extension Bulletin 159, "Fertilizer Recommendations for Michigan Crops." Prepared by the Departments of Soil Science and Horticulture, Michigan State University.

HANDLING FERTILIZER IN BULK

A Study of Costs

By VERNON L. SORENSON *and* CARL W. HALL

INTRODUCTION

BULK HANDLING has developed along several lines in Michigan. Fertilizer is spread directly on farmers' fields from large mixing plants. One local mixing plant sells bulk fertilizer either on a delivered basis or at the plant to be loaded on farmers' trucks or trailers. Retail distributors handle bulk fertilizer which is received from large manufacturers.

Three local retail distributors who handle bulk fertilizer were contacted in making this study. Two of these local handlers provided delivery and spreading service, and one did not. Two of the three use existing storage facilities with no additional investment, and the other stores fertilizer in newly-constructed concrete silos. These silos have loading spouts at a height of about 12 feet above the ground which permit gravity flow for loading into trucks or trailers as long as fertilizer is above that level. Fertilizer in the bottom of the silos is elevated by means of continuous bucket elevators and dispensed into load-out spouts.

The primary question investigated in this study is — under what circumstances can local businessmen afford to install facilities needed to handle fertilizer in bulk? Less labor will be required as a result of the elimination of bag handling, but this reduction in cost may be offset by the additional investment required to provide facilities needed for bulk handling. If bulk spreading services also are provided, a substantial investment in a truck and spreading unit will be required or these services must be hired from an independent operator.

One of the important problems facing business managers is to estimate the relationship between prices, costs, and volume with sufficient accuracy to minimize the risk involved in a new venture. Expected volume for any individual business serving farmers will depend on the kind of farming area, competitive conditions, the ability of the manager, and many other factors. Because of the variety of conditions under which farm supply businesses operate in Michigan, no effort has been made to determine expected volume for any individual or groups of local distributors. Some costs, on the other hand, may be relatively the same for all plants if operations are sufficiently standardized.

Probably the most feasible approach for most farm supply businesses operating in Michigan is to use existing facilities or relatively inexpensive buildings for storage.

A small farm tractor with bucket attachment can be used for handling and loading. Using a small farm tractor appears to be an efficient and timesaving method of loading, adaptable to large or small loads. The only apparent disadvantage to this method is that the exact weight of fertilizer loaded cannot be determined except by weighing on a platform scale. With experience, however, very close estimates can be made, thus eliminating the need to adjust the load after weighing.

Total investment in facilities will not be large unless delivery equipment is purchased. Since many operators will want to consider the possibility of providing delivery service, these costs have been developed separately.

Costs can be classified as either variable or fixed. Variable costs are those which change in some fairly direct relationship to the volume of product handled. These usually include labor, power, fuel, etc. Fixed costs, on the other hand, are those which remain relatively constant over fairly wide ranges of volume. These usually include depreciation on facilities, insurance, taxes, etc. If a truck is purchased, for example, it can be used extensively or very little during the first year, but depreciation will be approximately the same in either case. Depreciation, therefore, is a fixed cost of owning the truck whereas gasoline costs are variable with use.

The principal variable costs incurred in bulk handling of fertilizer are for labor and fuel, tires, and repairs on mechanical equipment. Gasoline and other variable costs will not be incurred except as fertilizer is loaded and delivered or loaded on farmers' trucks and wagons.

Though labor costs may not always vary directly with volume for the business as a whole, it can be considered a variable cost for the fertilizer enterprise if a good alternative use for the labor is available whenever it is not employed in the bulk fertilizer operation. In most Michigan elevator farm supply businesses where fertilizer sales represent a relatively small part of the total sales, this seems to be a valid assumption.

Fixed and variable costs have been separated because it is possible — through time study techniques and by use of engineering data — to determine variable costs per ton for bulk and bag handling. Once these costs have been determined, they can be used to estimate the amount of funds which will be available to cover the cost of the additional facilities required for bulk handling and to provide a profit.

BULK HANDLING AT MANUFACTURING PLANTS

Two large manufacturers in Michigan were asked about the possible savings if fertilizer were distributed from their plants in bulk. At one of the plants bagging costs, including loading cars or trucks, amount to approximately 99 cents per ton. Ten to eleven men are employed in the bagging operation with an average hourly wage rate of $1.57 and average production of 25 tons per hour. With a similar rate of output, loading labor costs would be reduced to 18 cents per ton and bag costs eliminated if fertilizer were distributed in bulk.

Labor costs in the other plant would be reduced from 93 cents per ton (using identical wage rates) to approximately 23 cents per ton. In addition, some savings occur on storage. At the present time, most of the bulk fertilizer which leaves these plants is for immediate delivery to farms — bypassing the retail level. However, management of both of these manufacturing units estimates that savings to retailers, if large quantities of bulk fertilizer were distributed through them, should amount to $3.50 to $4.00 per ton.

RETAILING BULK FERTILIZER WITHOUT FARM DELIVERY OR SPREADING

A ton of fertilizer can be loaded on a truck with a small farm tractor and a one-third ton scoop in approximately 3 minutes. Variable costs amount to approximately 10 cents per ton. Labor costs for bag handling amount to about 26.5 cents per ton. This represents a savings in variable costs of 16.5 cents per ton.

This means that for every ton of fertilizer handled in bulk, there will be 16.5 cents available to cover fixed costs and to increase earnings from the business. If a small tractor with a scoop costs $1,500 and is depreciated over a 10-year period, the depreciation charge will average $150 per year. The savings in variable cost from the sale of 1,000 tons of fertilizer will amount to $165 and is little more than enough to cover depreciation costs. If depreciation on storage facilities is added to this, the reduction in variable costs may be inadequate, even to cover depreciation charges.

It is apparent, therefore, that the principal cost saving in bulk distribution will occur at the manufacturing plant. If all of the savings to manufacturers are passed on to retailers, the total from this source and from lower variable handling costs at the retail level will amount to about $4.00 per ton. On 1,000 tons this amounts to $4,000. These savings can be used to cover the cost of additional facilities, for profit, or to reduce the price to farmers.

Price reduction to farmers will be governed by competitive conditions, investment required in facilities, wage rates, and other factors, all of which may vary between localities. In most cases, however, it should be possible to cover all costs, realize a reasonable profit, and still pass some savings on to farmers.

A number of farmers were contacted by mail questionnaires to determine what advantages and disadvantages they saw in handling their fertilizer in bulk as compared with bag. They indicated that the major reasons they would prefer to handle fertilizer in bulk were convenience and lower cost. The major disadvantages mentioned were that farm storage is not feasible and that it is difficult to estimate application per acre until all fertilizer has been used.

RETAILING BULK FERTILIZER WITH FARM DELIVERY AND SPREADING

DELIVERY EQUIPMENT

Delivery equipment most commonly used is of the type shown in Fig. 1. The truck boxes have one to several compartments. A continuous conveyor carries fertilizer to the rear of the truck where it is dropped on two rapidly rotating spreader disks and broadcast on either side and behind the truck.

Fig. 1. This type of equipment is commonly used to load and spread bulk fertilizer. The spreading width is usually from 20 to 25 feet.

A hood covers the spreading disks and extends to either side of the truck. This hood has a metal top and a canvas which reaches to the ground. In spite of this protection, one of the complaints registered by farmers who have had fertilizer spread is that some blowing occurs on windy days. The width of spread on these units is equal to the overall length of the hood which may vary on different size spreaders but is usually from 20 to 25 feet.

Unless expensive storage equipment is required, delivery equipment will represent the largest investment required for a complete bulk handling and spreading service. Since this is specialized equipment and will not ordinarily be used for other purposes, the amount of money which can be invested in it will depend on the volume of bulk fertilizer which will be delivered to farmers and spread on fields.

VARIABLE COSTS

The variable costs incurred in delivering and spreading bulk fertilizer include labor expenses and variable truck expenses. These will depend on the size of load delivered, the distance to point of delivery, and the rate at which fertilizer is spread on farmers' fields. The remainder of this manuscript is devoted to determining what these costs will be under different delivery situations.

Cost combinations are calculated for load sizes from 2 to 7 tons for selected distances from 3 to 30 miles, and for spreading rates from 200 to 1,000 pounds per acre. Time study techniques were used to determine labor costs, and engineering data were used to obtain variable truck costs.

IN-TRANSIT LABOR COSTS

Labor costs will be incurred to load, deliver, and unload fertilizer. Each of these operations usually requires the time of one man. In-transit costs per ton will vary with the distance traveled and the number of tons delivered per load (Table 1).

Table 1 — Sample calculations of in-transit labor costs per ton in dollars

Size of load tons	Miles						
	3	5	10	15	20	25	30
7	.039	.059	.107	.157	.206	.256	.304
6	.045	.068	.125	.183	.240	.298	.355
5	.054	.082	.150	.220	.288	.358	.426
4	.068	.102	.188	.275	.360	.448	.532
3	.090	.137	.250	.367	.480	.597	.710
2	.135	.205	.375	.550	.720	.895	1.06

Fig. 2 illustrates total in-transit labor cost for distances from 2 to 30 miles. Costs per ton can be obtained by dividing total labor costs by the size of the load in tons.[1]

The labor cost varies from 3.9 cents per ton where 7 tons are delivered 3 miles, to $1.06 per ton where 2 tons are delivered 30 miles (labor rates at $1.35 per hour). These costs arise with an expected travel time of about 20 minutes to travel 6 miles (3 miles each way) and 1 hour and 35 minutes to travel 60 miles (30 miles each way).

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1 The relationship between distance traveled and in-transit labor cost was found to approach linearity very closely and is expressed by the formula $C = .061 + .069\ (D)$, where C is the total in-transit labor cost and D is the distance traveled. Labor costs per ton can be calculated by dividing the C value for any distance by the size of load hauled. For example, suppose a 7-ton load is transported 10 miles. The cost is calculated as follows:

$$\frac{.061 + .069\ (10)}{7} = \frac{.751}{7} = \$.107$$

The C value or total in-transit labor cost is 75.1 cents. When spread over 7 tons, this amounts to 10.7 cents per ton.

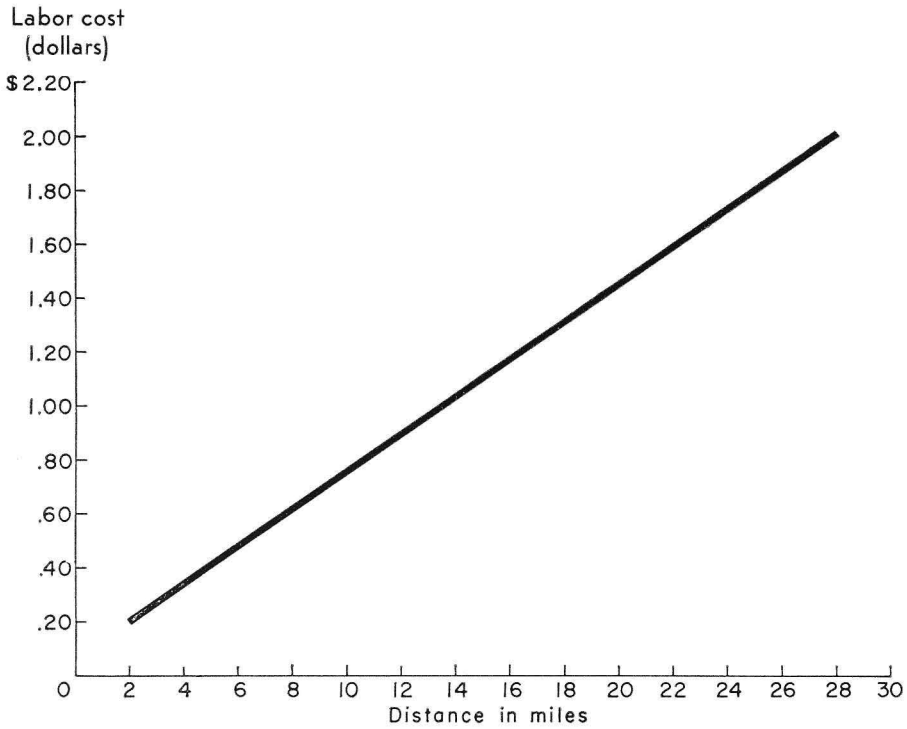

Fig. 2. Total in-transit labor cost related to distance traveled.

IN-TRANSIT TRUCK COSTS

Since variable truck cost will change with the weight being transported, it is necessary to determine the cost of the outward and return trip separately. Outward costs are calculated on the basis of net loads of from 2 to 7 tons plus truck weight. Cost per ton mile with different load sizes are shown in Fig. 3.[2]

The two lower lines show these costs separately.[3]

Total variable truck costs for selected distances from 3 to 30 miles for the outward and return trips are shown in Table 2.[4]

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2 All truck costs were calculated from engineering data obtained from the following three published reports: Willet, Howard Jr. (1953). How long should you run a truck to get the lowest combined depreciation and maintenance costs. Reprint of paper presented at SAE International West Coast Meetings, Vancouver B.C., August 17-19; Sall, Carl (1951). Truck road performance — actual vs. computed. SAE Quarterly Transactions, 5 (1); and Sall, Carl (1951). Gasoline consumption and travel time of trucks. SAE Quarterly Transactions, 5 (1).

3 The cost per ton mile curves converge toward the left side of the figure because the difference between gross weight on the outward and return trip diminishes as load sizes become smaller. Both these curves rise rapidly as load size decreases and become infinite as load size diminishes toward zero. Technical limitations define their possible range at increasing load sizes.

4 These values and any others which are desired can be obtained by taking any point on the total truck cost curve and multiplying this value by the number of miles traveled. Separate costs for the outward and return trips can be obtained by the same procedure, using the cost lines shown for each.

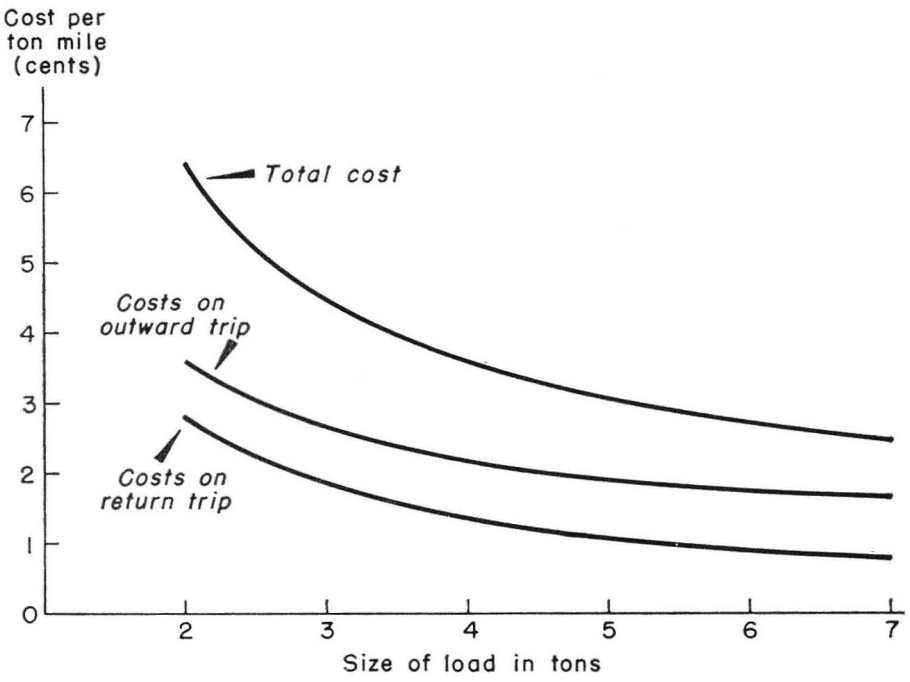


Fig. 3. Variable truck cost per ton-mile with loads from 2 to 7 tons.

Table 2 — Sample calculations of the total variable truck cost per ton in dollars, (load sizes 2 to 7 tons and selected distances 3-30 miles)

Load size	Miles						
	3	5	10	15	20	25	30
7	.074	.123	.247	.370	.494	.617	.740
6	.080	.133	.267	.400	.534	.667	.799
5	.093	.101	.310	.465	.620	.775	.930
4	.108	.117	.360	.540	.720	.900	1.08
3	.137	.228	.456	.684	.912	1.14	1.37
2	.192	.320	.640	.960	1.28	1.60	1.92

Costs on the outward trip range from 5 cents per ton when 7 tons are delivered 3 miles, to $1.08 per ton when 2 tons are delivered 30 miles. Return costs range from 2.4 cents to 84 cents per ton.

TOTAL LOADING AND IN-TRANSIT COSTS

The separate costs which have been presented can be combined to obtain the total in-transit variable truck and labor costs incurred in delivering fertilizer to farmers' fields. In addition, a cost of approximately 10 cents per ton is incurred in loading. These represent all of the variable and allocable costs incurred up to the time spreading begins. These costs for different load sizes and distances are shown in Table 3.

Table 3 — Total variable truck cost, labor cost, and loading cost per ton in dollars (load sizes 2-7 tons and selected distances 3-30 miles)

Load size	Miles						
	3	5	10	15	20	25	30
7	.213	.282	.454	.627	.800	.970	1.14
6	.226	.301	.492	.683	.870	1.07	1.26
5	.247	.337	.560	.785	1.00	1.23	1.46
4	.278	.382	.648	.910	1.18	1.45	1.71
3	.326	.465	.806	1.15	1.49	1.84	2.18
2	.427	.625	1.11	1.61	2.10	2.60	3.08

SPREADING COSTS

The labor and variable truck cost incurred per ton in spreading fertilizer will depend largely on the spreading rate. Both the time required and distance traveled to spread a ton of fertilizer increase as the rate of application decreases. With a spreading rate of 200 pounds per acre, spreading a ton of fertilizer requires approximately 1 hour and 40 minutes and the distance traveled slightly more than 4 miles. If spreading rate is increased to 1,000 pounds per acre, the time required to spread 1 ton will be reduced to about 10 minutes; distance traveled will be reduced to .83 miles. These differences are marked and cannot be overlooked in determining expected costs. Variable truck and labor costs based on an average field travel speed of 5 miles per hour and a wage rate of $1.35 per hour are shown in Fig. 4.

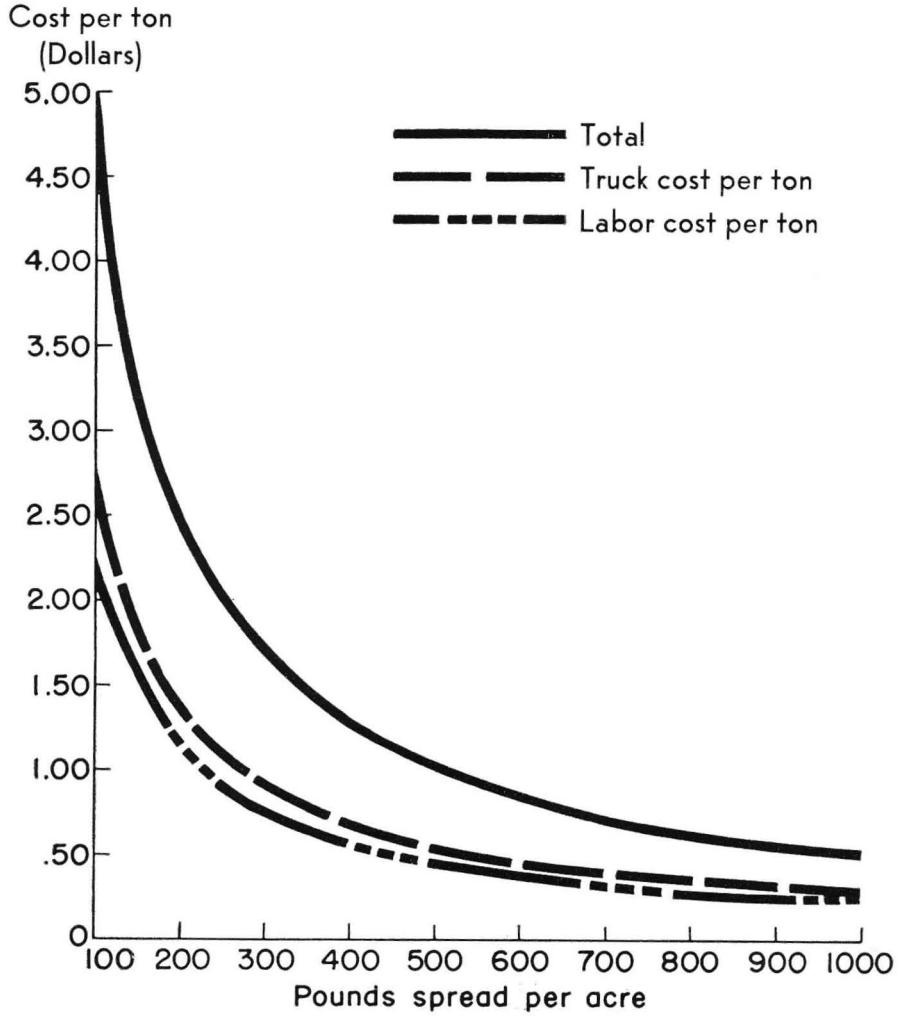


Fig. 4. Variable truck cost and labor cost per ton of fertilizer spread at a rate of 100 to 1,000 pounds per acre.

Variable truck costs range from $2.76 per ton when spread at a rate of 100 pounds per acre to 28 cents per ton when spread at a rate of 1,000 pounds per acre. Labor costs range from $2.24 per ton at 100 pounds per acre to 22 cents per ton at 1,000 pounds per acre. The total of these costs ranges from 50 cents to $5.00 per ton. Costs change rapidly at lower spreading rates and less rapidly at higher spreading rates.

TOTAL VARIABLE COSTS

The next step in developing variable cost relationships is to combine the three factors which affect variable truck and labor costs to obtain total variable costs as related to (1) distance traveled, (2) size of load, and (3) spreading rate. This has been done in Table 4. The ranges which have been developed are spreading rates from 100 to 1,000 pounds per acre, load sizes from 2 to 7 tons, and selected distances from 3 to 30 miles.

Table 4 should be used as follows. Load size and distance are shown along the bottom line, load size being the uppermost number in each cell. Spreading rate is shown in the left hand column of each table section. If average load size is expected to be 6 tons and average travel distance is expected to be 5 miles, find the cell along the bottom line which has the numbers 6T and 5M.

Table 4 — Labor cost, variable truck cost and loading cost per ton related to load size, distance traveled, and spreading rate

Spreading rate (lbs. per acre)	Spreading costs ($ per ton)	Total variable cost in dollars									
100	5.00	5.21	5.26	5.24	5.27	5.32	5.42	5.28	5.30	5.33	5.38
200	2.50	2.71	2.72	2.74	2.77	2.82	2.92	2.78	2.80	2.83	2.88
300	1.67	1.88	1.89	1.91	1.94	1.99	2.09	1.85	1.97	2.00	2.05
400	1.25	1.46	1.47	1.49	1.52	1.57	1.67	1.53	1.55	1.58	1.63
500	1.00	1.21	1.22	1.24	1.27	1.32	1.42	1.28	1.30	1.33	1.38
600	.83	1.04	1.05	1.07	1.10	1.15	1.25	1.11	1.13	1.16	1.21
700	.71	.92	.93	.95	.98	1.03	1.13	.99	1.01	1.04	1.09
800	.63	.84	.85	.87	.90	.95	1.05	.91	.93	.96	1.01
900	.56	.77	.78	.80	.83	.88	.98	.84	.86	.89	.94
1,000	.50	.71	.72	.74	.77	.82	.92	.78	.80	.83	.88
Loading, in-transit labor, and truck costs		.213	.226	.247	.276	.326	.427	.282	.301	.337	.382
Load size and distance traveled T = tons M = miles		7T 3M	6T 3M	5T 3M	4T 3M	3T 3M	2T 3M	7T 5M	6T 5M	5T 5M	4T 5M
100	5.00	5.46	5.62	5.45	5.49	5.56	5.64	5.80	6.11	5.62	5.68
200	2.50	2.96	3.12	2.95	2.99	3.06	3.14	3.30	3.61	3.12	3.18
300	1.67	2.13	2.29	2.12	2.16	2.23	2.31	2.47	2.78	2.29	2.35
400	1.25	1.71	1.87	1.70	1.74	1.81	1.89	2.05	2.36	1.87	1.93
500	1.00	1.46	1.62	1.45	1.49	1.45	1.64	1.80	2.11	1.62	1.68
600	.83	1.29	1.45	1.28	1.32	1.39	1.47	1.63	1.94	1.45	1.51
700	.71	1.17	1.35	1.16	1.20	1.27	1.35	1.51	1.82	1.33	1.39
800	.63	1.09	1.25	1.08	1.12	1.19	1.27	1.43	1.74	1.25	1.31
900	.56	1.02	1.18	1.01	1.05	1.12	1.20	1.36	1.67	1.18	1.24
1,000	.50	.96	1.12	.95	.99	1.06	1.14	1.30	1.61	1.12	1.18
Loading, in-transit labor, and truck costs		.465	.625	.454	.492	.560	.648	.806	1.11	.627	.683
Load size and distance traveled T = tons M = miles		3T 5M	2T 5M	7T 10M	6T 10M	5T 10M	4T 10M	3T 10M	2T 10M	7T 15M	6T 15M

Table 4, Con't

100	5.00	5.78	5.91	6.15	6.61	5.80	5.87	6.00	6.18	6.49	7.10
200	2.50	3.28	3.41	3.65	4.11	3.30	3.37	3.50	3.68	3.99	4.60
300	1.67	2.45	2.58	2.82	3.28	2.47	2.54	2.67	2.85	3.16	3.77
400	1.25	2.03	2.16	2.40	2.86	2.05	2.12	2.25	2.43	2.74	3.35
500	1.00	1.78	1.91	2.15	2.61	1.80	1.87	2.00	2.18	2.49	3.10
600	.83	1.61	1.74	1.98	2.44	1.63	1.70	1.83	2.01	2.32	2.93
700	.71	1.49	1.62	1.86	2.32	1.51	1.58	1.71	1.89	2.20	2.81
800	.63	1.41	1.54	1.78	2.24	1.43	1.50	1.63	1.81	2.12	2.73
900	.56	1.34	1.47	1.71	2.17	1.36	1.43	1.56	1.74	2.05	2.66
1,000	.50	1.28	1.41	1.65	2.11	1.30	1.37	1.50	1.68	1.99	2.60
Loading, in-transit labor, and truck costs		.785	.910	1.15	1.61	.80	.87	1.00	1.18	1.49	2.10
Load size and distance traveled T = tons M = miles		5T 15M	4T 15M	3T 15M	2T 15M	7T 20M	6T 20M	5T 20M	4T 20M	3T 20M	2T 20M

Spreading rate (lbs. per acre)	Spreading costs ($ per ton)	Total variable cost in dollars										
100	5.00	5.97	6.07	6.23	6.45	6.84	7.60	6.14	6.26	6.46	6.71	7.18	8.08
200	2.50	3.47	3.57	3.73	3.95	4.34	5.10	3.64	3.76	3.96	4.21	4.68	5.58
300	1.67	2.64	2.74	2.90	3.12	3.51	4.27	2.81	2.93	3.13	3.38	3.85	4.75
400	1.25	2.22	2.32	2.48	2.70	3.09	3.85	2.39	2.51	2.71	2.96	3.43	4.33
500	1.00	1.97	2.07	1.23	2.45	2.84	3.60	2.14	2.26	2.46	2.71	3.18	4.08
600	.83	1.80	1.90	2.06	2.28	2.67	3.43	1.97	2.09	2.29	2.54	3.01	3.91
700	.71	1.68	1.78	1.94	2.16	2.55	3.31	1.85	1.97	2.17	2.42	2.89	3.79
800	.63	1.60	1.70	1.86	2.08	2.47	3.23	1.77	1.89	2.09	2.34	2.81	3.71
900	.56	1.53	1.63	1.79	2.01	2.40	3.16	1.70	1.82	2.02	2.27	2.74	3.64
1,000	.50	1.47	1.57	1.73	1.95	2.34	3.10	1.64	1.76	1.96	2.21	2.68	3.58
Loading, in-transit labor, and truck costs		.97	1.07	1.23	1.45	1.84	2.60	1.14	1.26	1.46	1.71	2.18	3.08
Load size and distance traveled T = tons M = miles		7T 25M	6T 25M	5T 25M	4T 25M	3T 25M	2T 25M	7T 30M	6T 30M	5T 30M	4T 30M	3T 30M	2T 30M

With this load size and distance, if spreading rate is expected to be 400 pounds per acre, look upward in this column to the cost figure opposite 400 in the pounds per acre column. The value found there is $1.55. This is the total variable cost per ton for a 6-ton load of fertilizer delivered 5 miles and spread at the rate of 400 pounds per acre, where labor is charged at $1.35 per hour, and gasoline at 30 cents per gallon.

The charge per ton for delivering this load of fertilizer would have to be greater than $1.55 to cover non-variable costs such as depreciation, insurance, license, etc., on loading and delivery equipment, and to obtain a return on the investment in this equipment.

Whenever variable costs exceed the delivery charge, there will be no return to cover fixed expenses and profit; outlays for labor and truck expense will be greater than the delivery charge.

PRICE, COST, AND VOLUME RELATIONSHIPS

These cost figures provide the basis for estimating the amount of investment that can be made in facilities. Once variable costs have been determined, they can be related to any combinations of charges and total volume. In this case the charge will be on a per ton basis; volume will be the tons of fertilizer delivered in a year. Annual volume is used since this is the standard business accounting period; a per ton charge is used since costs were obtained on a per ton basis.

The amount left over as a return on investment is determined after variable costs and fixed costs have been deducted from total revenue. The amount left to pay for facilities and to provide a profit is the amount left after variable costs have been deducted. If $2.00 is charged to deliver a ton of fertilizer and the variable cost of delivery is $1.00, the remainder of $1.00 is available to cover fixed costs and to provide a profit. If 1,000 tons are delivered, total charges will be $2.00 x 1,000 or $2,000, and total variable cost will be $1,000.

The amount left to cover fixed costs (overhead) and to provide a profit is $1,000. If the charge is $3.00 and variable cost is $1.00, the amount left per ton is $2.00; the total amount that will be available for fixed costs and profit from 1,000 tons is $2,000.

It can be seen that if the delivery charge per ton, variable cost per ton, and total tonnage are known, the amount of money left to cover overhead (including depreciation, taxes, etc.) and to provide a return on investment can be easily calculated.

Assume that a charge of $4.00 per ton is planned to deliver and spread fertilizer, and that annual volume is expected to be 2,000 tons. Assume also that average load size is expected to be 6 tons, expected average travel distance is 5 miles, and expected average spreading rate is 400 pounds per acre. Referring to Table 4, variable costs per ton are $1.55. To obtain the amount left to cover overhead, multiply the expected tonnage by the difference between the charge and variable cost per ton, — in this case: 2,000 (4.00 — 1.55) = 2,000 x 2.45 or $4,900. The total amount available will be $4,900. With this price and assuming identical costs, the sale of 500 tons will provide $1,255 to cover overhead and provide a profit.

It becomes apparent, therefore, that the amount which can be invested in facilities with any set of price cost relationships is directly related to volume. Using Table 4, this calculation can be made for many combinations of prices and expected volumes. Some sample calculations, using charges of $4.00 per ton and $6.00 per ton, have been made and are shown in Tables 5 and 6. Each of these calculations was made by using a variable cost taken from Table 4 and relating it to delivery charge and expected volume in the above manner.

Table 5 — Gross amounts available to cover fixed costs and profit with specific variable costs and selected annual volumes from 200 to 10,000 tons (delivery charge = $4.00 per ton)

Annual volume (tons)	Returns in excess of variable costs — dollars							
10,000	$11,600	$30,300	$10,400	$29,100	$7,200	$25,900	$3,500	$22,200
4,500	5,220	13,635	4,680	13,095	3,240	11,655	1,575	9,990
3,500	4,060	10,605	3,640	10,185	2,520	9,065	1,225	7,770
2,500	2,900	7,575	2,600	7,275	1,800	6,475	875	5,550
1,800	2,088	5,454	1,872	5,238	1,296	4,662	630	3,996
1,400	1,624	4,242	1,456	4,074	1,008	3,626	490	3,108
1,000	1,160	3,030	1,040	2,910	720	2,590	350	2,220
600	696	1,818	624	1,746	432	1,554	210	1,332
200	232	606	208	582	144	518	70	444
Variable cost/ton	2.837	.967	2.965	1.095	3.285	1.42	3.65	1.78
Remainder after variable cost ($/ton)	1.16	3.03	1.04	2.91	.72	2.58	.35	2.22

Table 6 — Gross amounts available to cover fixed costs and profit with specific variable costs and selected annual volumes from 200 to 10,000 tons (delivery charge = $6.00 per ton)

Annual volume (tons)	Returns in excess of variable costs — dollars							
10,000	$31,600	$50,300	$30,400	$49,100	$27,200	$45,900	$23,500	$42,200
4,500	14,220	22,635	13,680	22,095	12,240	20,655	10,575	18,990
3,500	11,060	17,605	10,640	17,185	9,520	16,065	8,225	14,770
2,500	7,900	12,575	7,600	12,275	6,800	11,475	5,875	10,550
1,800	5,688	9,054	5,472	8,838	4,896	8,262	4,230	7,596
1,400	4,424	7,042	4,256	6,874	3,808	6,426	3,290	5,908
1,000	3,160	5,030	3,040	4,910	2,720	4,590	2,350	4,220
600	1,896	3,018	1,824	2,946	1,632	2,754	1,410	2,532
200	632	1,060	608	982	544	918	470	844
Variable cost/ton	2.84	.97	2.97	1.10	3.29	1.41	3.65	1.78
Remainder after variable cost ($/ton)	3.16	5.03	2.03	3.90	2.71	4.59	2.35	4.22

DECIDING ON INVESTMENT

To illustrate the simplest case possible, the assumption can be made that fertilizer will be priced so that markup on the combined volume of bag and bulk material will cover such non-direct costs as management, accounting expense, and other general overhead which must be allocated arbitrarily to the various departments of the business. Delivery charges, then, must be adequate to cover variable delivery and handling costs, to pay for the investment in specialized handling and storage facilities, and to provide a return on the investment. The required volume will depend on the amount that must be invested in facilities.

A sample calculation will illustrate the method of estimating the relationship between delivery charge, costs, and volume. If, as shown in the previous calculation, $2.45 is left from every ton to cover fixed costs, total annual fixed costs of $1,120 divided by $2.45 will give the number of tons that must be handled to cover fixed costs.

Facilities required	Purchase price	Fixed cost (depreciation, etc.)
Truck	$2,000	$ 400
Box and spreading equipment	1,800	200
Tractor and scoop	1.500	150
Storage	4,000	120
Building and truck insurance License, etc.	——	250
Total	$9,300	$1,120

The amount required is 457 tons. If variable cost per ton is $3.29 (as is shown in Table 4 where load size is 5 tons, distance is 15 miles, and spreading rate is 200 pounds per acre), the amount available from each ton to cover fixed costs is $.71 where $4.00 per ton is charged for delivery. The volume required to cover annual fixed charges of $1,120 in this case is 1,120 ÷ .71 or 1,578 tons.

Most businessmen will not adopt a new enterprise unless some return above costs is anticipated. Many rule of thumb procedures are followed. Some businessmen require that new facilities pay for themselves in one-third or one-half of their expected life. Others stipulate certain expected annual returns as a percent of investment. The level of expected returns usually will vary with the risk involved, including risk of obsolescence and other uncertainties which must be taken into account. Because of the many practical difficulties, the present value of expected future income from the asset being acquired is almost never used.

Experience indicates that a return of about 20 percent of the average investment in fixed facilities is reasonable in the operation of small businesses serving farmers. The value of facilities purchased in the above example was $9,300. The average investment will approximate one-half of this amount or $4,650. An annual return of 20 percent on this average value is $930.

Adding this to fixed costs of $1,120, the total annual revenue in excess of variable costs should be $2,050. Where $2.45 per ton is available for fixed costs and profits, this means that 837 tons must be sold. Where $.71 is available from each ton, 2,888 tons must be sold. This emphasizes the importance of the relationship between unit charges, costs, and volume. Even modest increases in costs require substantial increases in volume if earnings are to be maintained without increasing charges.

SUMMARY AND CONCLUSIONS

Bulk fertilizer can be handled at local country points on two bases: (1) By making it available to farmers who come to the plant and pick it up; and (2) by providing the added service of delivery and spreading.

Most local businesses can probably provide bulk fertilizer undelivered without making a large investment in facilities.

If spreading equipment is to be purchased, the investment in new facilities will be substantial. For this reason, a fairly large volume or a high delivery charge will be required for a profit. Since top dressing is recommended for only a limited number of crops (primarily grass and forage crops), careful analysis of potential volume should be made before deciding to purchase spreading equipment. Where only limited spreading services are requested by farmers, consideration should be given to custom hiring of the services rather than purchasing equipment.

APPENDIX

A method which businessmen can use to analyze a new enterprise is illustrated by Appendix Fig. 1.

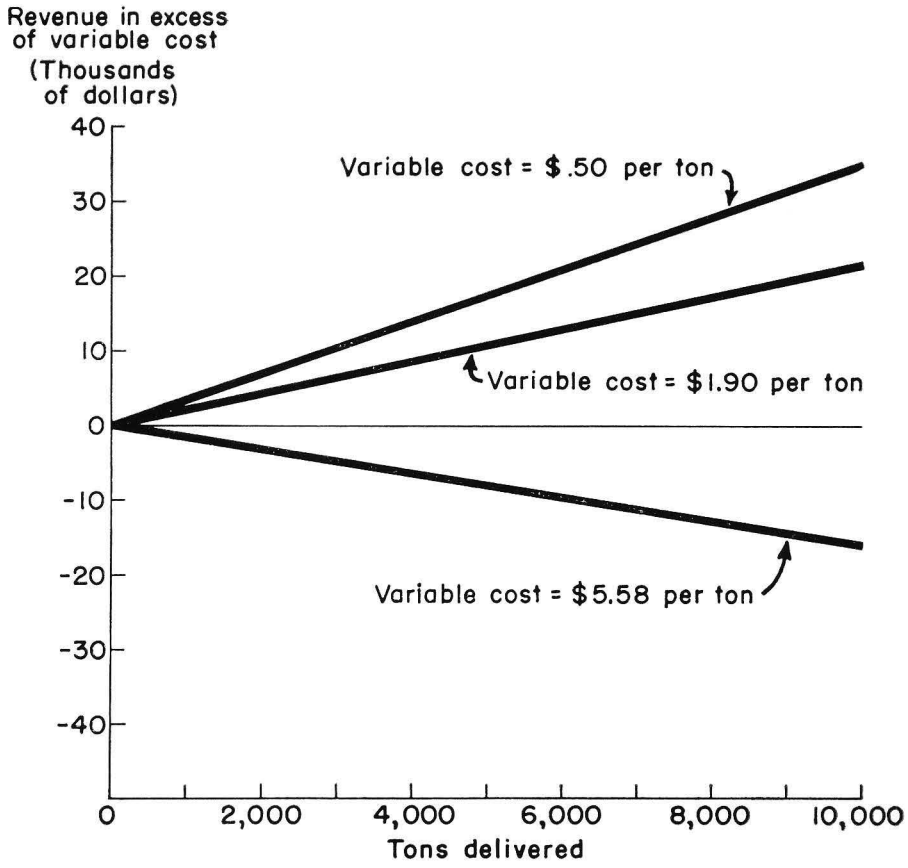
This figure illustrates three cases which were developed in the text of the study with total quantity varying from 0 to 10,000 tons. These cases are as follows:

Av. load size (tons)	Av. travel distance (miles)	Spreading rate (per acre)	Delivery charge (per ton)	Variable cost (per ton)
7	3	1,000	$4.00	$ .500
4	10	400	4.00	1.898
2	30	200	4.00	5.580

The amount available for profit and fixed costs is determined by the relationship between price (p), representing the amount available to cover fixed charges and profit, and variable cost (v) and quantity (q). The value on the vertical scale, for any given volume is equal to q (p-v). This is a residual value in the sense that it is computed from other values which have been determined empirically or are assumed for purposes of making the calculations.

For more complete analysis of the probable net revenue available from bulk fertilizer distribution, any of the situations covered in Table 4 can be accumulated. Suppose the situation confronting the businessman is the following. There are a number of farmers who use fertilizer quite heavily and others who use it lightly, all within an average range of 10 miles. Additional volume can be obtained only by going to greater distances where there are more farmers who use fertilizer quite heavily along with others who are light users.

It is estimated that heavy users will ordinarily call for large loads averaging 6 tons and spread at, say, 600 pounds per acre. The

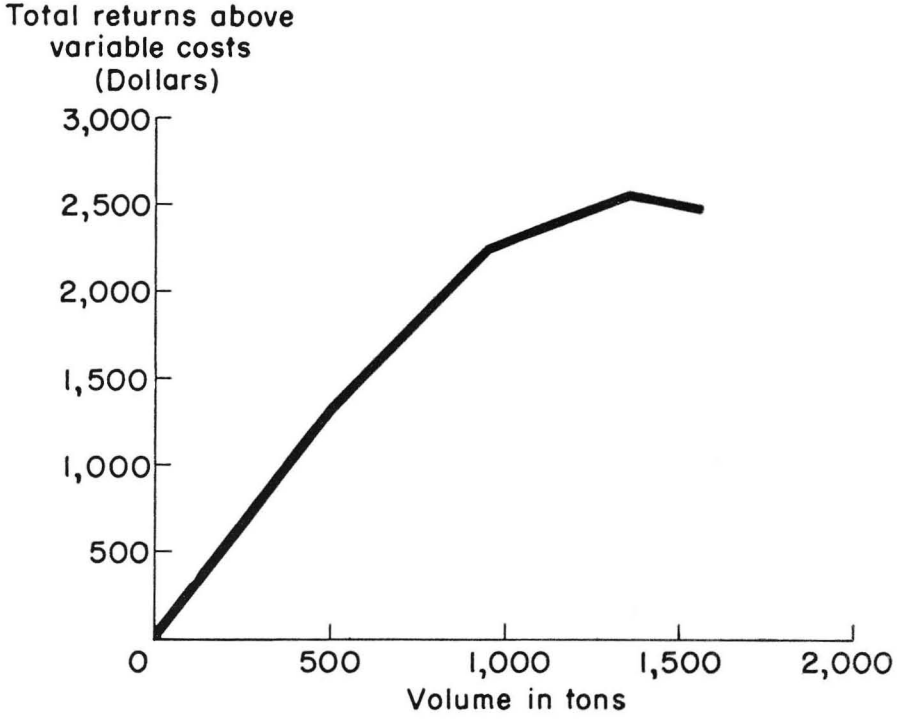


Appendix Fig. I. Revenue in excess of variable cost for three delivery situations. Delivery charge = $4.00 per ton.

remaining farmers will ask for 3-ton loads on the average, to be spread at 200 pounds per acre. The volumes and distances traveled might be as shown below and will be associated with variable costs as shown. As would be expected, the greatest return is available from the heavy users nearby. The next most profitable source of business is from heavy users located at greater distances with the nearby light users representing the final source of profitable business. Variable costs are not covered by a charge of $4.00 per ton when delivering to light users at greater distances.

Graphically, this situation can be represented as shown in appendix Fig. II. This procedure can be used to determine what approach should be taken in expanding volume or what adjustments should be made in delivery charges. As long as a situation is found where the

net return line rises (Appendix Fig. II), variable costs will be more than covered, and it will pay to increase the use of available fixed facilities. Whenever the net return line turns downward, revenues are less than variable costs.



Appendix Fig. II. Illustration of gross returns curve with different variable costs.

	Expected volume (tons)	Average distance (miles)	Variable cost per ton from Table 5	Return above variable cost (dollars)
To heavy users in normal trade territory	500	10	1.32	1,339
To light users in normal trade territory	400	10	3.30	276
To heavy users outside normal trade territory	450	25	1.90	945
To light users outside normal trade territory	200	25	4.34	—68

Any combination of situations can be added in this manner to approach the point where the additional revenue from new business just equals the additional cost of obtaining it. Given a complete ordering of possible delivery situations in terms of distance, load size, and spreading rate, and with costs calculated as continuous relationships, this point could be defined exactly.