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ECONOMIC ASPECTS OF HAND TRACTOR OWNERSHIP AND OPERATION

Bert Orcino

International Rice Research Institution

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The first section contains a technical description of hand tractors used on Philippine rice farms. Information on why the tractors were bought and what criteria were used in choosing them are given in the second section. The third section is devoted to a comparative economic evaluation of power tillers and the fourth is an attempt to establish the conditions under which hand tractor repayments can be made. The last section examines the impact of devaluation on hand tractor use. Materials for the paper are primarily drawn from a survey of 140 tractor owners conducted by the Department of Agricultural Engineering, IRRI, in Laguna province in November 1969 to December 1970.

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ECONOMIC ASPECTS OF HAND TRACTOR OWNERSHIP AND OPERATION

Bert Orcino*

INTRODUCTION

In the less developed countries, where increasing food production is the goal, the question of whether power and equipment inputs are needed to achieve and sustain growth in output is a tautology. It is only a question of what kind and how many.

The introduction of the new high-yielding varieties brings the need for improvements in cultural techniques sharply into focus. The shorter growing season of these varieties and their ability to mature regardless of daylength make possible double or multiple cropping, where sufficient water is available. Thus as soon as the first crop is harvested, another may be planted, to be followed by still another. As an example, in a cooperative field experiment held in the Philippines, a three-crop total production of 23,553 kg/ha was obtained in 315 days.[1/]

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* Research assistant, Agricultural Engineering Department, IRRI, Los Baños, Philippines.

1/ The IRRI Reporter, Vol. 6 No. 3, May-June 1970.

Only 50 days were thus available to prepare the land for the three crops, or roughly two weeks per crop. While there is no evidence of a yield increase as a result of mechanization, the availability of machinery for rapid land preparation and harvest may determine whether individual farmers can realize this potential gain in production.[2/] The governments of the Southeast Asian countries, to varying degrees, are accepting the thesis that mechanization of part or all of the crop production processes is one of the essential elements of agricultural development. This is evidenced in the Philippines where capital at reasonable interest rates has been made available to many of the farmers to provide for the purchase of machines.

A substantial increase in the number of hand tractors on lowland rice farms has occurred during the last few years. The continued adoption of these machines has meant increases in capital investments and the costs of owning and operating them have become an important and rapidly increasing part of farm costs. As machinery costs increase the decision to purchase tractors become more and more significant because of the increased risks from price fluctuations, vagaries of weather, higher costs of other farm inputs, and other uncertainties. Increased

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[2/] Deomampo's study, for example, shows that it takes 3 days for the carabao to accomplish what a hand tractor can do in one day and that better yields are obtained on tractor-plowed plots due to better tilth. If the same number of horsepower hours is used per hectare, however, the quality of the job should be the same. CF. N.R. Deomampo, Comparative economic analysis of experimental data on the use of tractor and carabao in lowland rice farming. Phil. Agric. Jan. 1969. pp. 535-546.

vulnerability is particularly apparent in cases where the purchase of tractors is financed from loans on which amortizations must be regular periodic payments.

This paper addresses itself to the economics of hand tractor ownership and operation. The objectives are to analyze input-output data on various types of hand tractors and to define the relationship between tractor use and costs via average cost curves.

The first section contains a technical description of hand tractors used on Philippine rice farms. Information on why the tractors were bought and what criteria were used in choosing them are given in the second section. The third section is devoted to a comparative economic evaluation of power tillers and the fourth is an attempt to establish the conditions under which hand tractor repayments can be made. The last section examines the impact of devaluation on hand tractor use. Materials for the paper are primarily drawn from a survey of 140 tractor owners conducted by the Department of Agricultural Engineering, IRRI, in Laguna province in November 1969 to December 1970.

HAND TRACTOR CLASSIFICATION

Hand tractors currently used in the Philippines can be classified into three types. These are: single-axle power tillers (type I), general power tillers (type II) and double-axle power tillers (type III). Figure 1 illustrates these general categories while their general specifications are shown in Table 1.

Single-axle power tillers (type I)

These power units are lightweight, usually with 4 to 6 hp

gasoline engines. Rotary tiller blades are mounted on a transverse main axle which is directly driven by the engine through chain and sprocket. These tractors can often be equipped with pneumatic tires for dryland work or haulage application. There is no differential mechanism in the axle and no provision for steering clutches.

General power tillers (type II)

This type of hand tractor is usually equipped with an aircooled gasoline engine of up to 8 hp capacity. It is equipped with wheels and can perform several farm operations by adapting conventional draft-dependent farm implements such as plows, harrows, cultivator, etc. Tillers under this type have provisions for steering clutches, reverse drive, and multi-speed shifting transmission.

Double-axle power tillers (type III)

These have two drive wheels and the tilling mechanism consists of a series of knives attached to a rotating shaft installed behind the main wheel axle. Although these tillers are not as versatile as the other two types, they are well suited to tilling heavy clay paddy fields because of their sturdier construction and larger sized engines. Generally, these tractors are equipped with diesel engines of 6 to 14 hp capacity.

HAND TRACTOR ADOPTION

Nearly all the tractors (92 percent) included in the survey were found on irrigated, two-crop farms, most of which were operated by tenants and lessees (Table 2). Note that average tractor size tends to increase with increases in farm size. There are, perhaps, two reasons

for this. Larger farms produce a larger volume of income which is necessary for repayment. Second, larger farms are under greater time and labor pressure with respect to the completion of the land preparation task.

Reasons for buying a hand tractor

The sample farmers were asked to give their reasons for buying a hand tractor. Table 3 summarizes the range of answers given together with the number of respondents citing each reason. Of the 140 respondents, 80 (57 percent) reported that their decision to buy a hand tractor was in fact partly influenced by the widespread rustling of carabaos. A majority indicated, however, that the nuisance associated with the care and maintenance of a carabao was one of the major reasons for shifting to the power tiller. This is a highly subjective factor and may vary widely from one farmer to another depending on local conditions. For example, farmers who have the income potential to buy a hand tractor may place a high opportunity cost on the time and nuisance attendant to keeping a carabao. Those who have limited financial and land resources, on the other hand, can maintain a carabao and raise the replacement with a minimum, if any, cash expenditure.[3/]

A somewhat smaller percentage of farmers gave a direct economic reason - faster land preparation (savings in time). This is, perhaps, the more significant reason, especially in cases where the periodicity

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[3/] Comparing the cost of using tractors vs carabaos is not likely to prove useful either as a basis for explaining tractor adoption or for making recommendations.

of rains control farming operations; thereby setting a limit to the period between plowing and seeding. The use of hand tractors, owing primarily to their faster rate of work, often results in greater hectarage being prepared in time for seeding.

Other farmers were motivated by the potentials for renting out the machine to other farmers or opportunities for custom work. The influence of psychological factors on hand tractor adoption is very difficult to ascertain. In the course of the survey, however, it was observed that hand tractors tended to be concentrated in particular neighborhoods. This seems to indicate that "keeping up with the Jones" has had an important effect.

Apparently the adoption of hand tractors is influenced as much by economic as well as non-economic reasons. This implies that the pattern of mechanization of Philippine agriculture, where small-scale farming enterprises consisting of a household economy and business predominate, will be quite different from that of large-scale farms found in the more advanced countries. Machines may be actually brought into use because farmers' incomes may have increased. It has been pointed out that there is a strong likelihood that the seed-fertilizer revolution will give an impetus to premature tractor mechanization.[4/] The widespread adoption of hand tractors in Japan has in fact been explained on the basis of, among other factors, increased incomes,

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4/ J. Cownie, B.F. Johnston and Bart Duff, The quantitative impact seed-fertilizer revolution in West Pakistan: an exploratory study. Food Research Institute Studies in Agricultural Economics, Trade and Development, Vol. IX, No. 1, 1970. Food Research Institute, Stanford University.

increased leisure valuation and demonstration effect.[5/]

Criteria for choice of hand tractor type

Varied responses were elicited regarding the choice of a particular hand tractor type. These are shown in Table 4. Perusal of the table reveals that simplicity[6/] and lightness are the two major factors behind the choice of type I tractors. Farmers who bought types II and III tractors, on the other hand, wanted relatively more powerful machines. Note also that the influence of other tractor owners is quite significant on the choice of power tiller type. This stresses the importance of owner satisfaction in the selection of the machines. Undoubtedly some of the respondents were trained by working first as helpers. It was observed that almost all the tractor owners interviewed employed helpers to do as much of the work as possible. The helper, rapidly trained, then becomes an operator and repeats the cycle. This indicates that machine operators will become available relatively quickly as machines are introduced; and partially reduces the conviction of argument that a lack of trained operators is one of the major deterrents to mechanization in the less developed countries.

Problems of tractor ownership

The problems attendant to hand tractor ownership and mainten-

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5/ K. Tsuchiya, The role and significance of mechanization in Japanese agriculture. Journal of the Faculty of Agriculture, Kyushu University, Vol. 18, No. 2, July 31, 1970.

6/ Simplicity as used here mean minimal number of parts.

ance are shown in Table 5. The procurement of, and high cost of spare parts are the two major problems confronting farmers. It is important that parts which are likely to wear out first can be easily and cheaply replaced if a satisfactory level of operation is to be maintained. This is of crucial importance because the speed and timeliness of operations made possible by these machines is one of their main advantages over older methods. The best machines can be put out of use for trivial reasons if adequate spares are not available, and work may be seriously delayed and heavy financial losses incurred. Long delays at critical periods may destroy any economic advantage which mechanization might otherwise confer. Observations made on 118 farm sites in Central Luzon, Philippines, for example, indicate that an additional 1 to 3 weeks extra crop season would probably have increased average yields 80 to 600 kg per hectare.[7/] This extra time would be practical if extra power were available when needed.

Frequent breakdown and weak parts are also problems of major significance. Tractor units low in initial cost may be costly to operate if frequent renewals requiring costly parts are required. Greater standardization of parts and fittings is an important aspect in design which should contribute greatly to the ease of operation and repair of machines and, hence, to reduced operating costs.

[7/] S. S. Johnson, Terminal Report on the general engineering and economic research portion of Contract No. AID/csd-334 for research on farm and equipment power requirements for production of rice and associated food crops in Far East and South Asia. The International Rice Research Institute, Los Baños, Laguna, Philippines, pp. 10-11.

HAND TRACTOR COSTS

Machinery costs are usually classified in two groups - fixed costs and variable costs. Variable costs are those that vary with use and are estimated on the basis of a unit of work. Cost per hectare is the final figure needed for farm budgeting. It is more convenient, however, to express all variable costs on an hourly basis and this is the basic measure used in this paper. Costs per hectare is then derived by knowing the field capacity of the particular machine.

Operating costs

Table 6 shows the fixed and variable costs of using the three hand tractor types. As none of the respondents was able to produce records of machine and labor performance rates, fuel and oil consumption, and repair and maintenance costs, reliance had to be placed on their recollections and estimates. 'On-farm' prices were used to convert the fuel and oil consumption figures given in Table 7 into monetary terms.

Depreciation was calculated over 8 years for types I and II tractors and 10 years for type III power tillers assuming each unit would have a real value of 10 percent of its original price at the end of this time. The estimated service life was obtained by adding the farmers' estimate of remaining life to present age. Interest was charged at 12 percent on the average value of the tractors during their 8- and 10-year lives.

Two men usually combined to operate one tractor. Table 7 shows the average labor requirements and machine performance for each type of power tiller. Labor was charged at ₦0.50 per man-hour. There did not

seem to be any clear pattern in the repairs and maintenance figures so a simple average for each tractor type was taken. A note of caution should be sounded in interpreting this information. The averages should not be taken to imply the relationship between the three tractor types. Based as they are on owners' recollections, they represent only the general level of repairs and maintenance costs.

Relationship between costs and annual use

The amount a machine is used materially affects total costs of operation per unit of measurement. Total costs per hour decreases as annual utilization is increased (Fig. 2). This results from spreading overhead costs over more hours.

Because of the seasonal pattern of cropping which cannot be markedly influenced, the farmer can use his tractor for only short periods. Furthermore, owing to the small size of farms, the farmer is not usually in a position to make full use of the capacity of the machines, thus work outside the farmer's field becomes desirable as a source of additional income and to ensure that the tractor is effectively utilized at or near its capacity.

Tractor contract costs vary from ₱25 to ₱35 per 8-hour day. The latter is typical of rates in which meals of two men who combine to operate the tractor are not paid for by the customer. Under this cost, the breakeven point in terms of annual use is 230 hours for single-axle tillers and general power tillers, and 491 hours for double-axle power tillers. Applying this work load to the annual use of the tractors reveals that more than 50 percent of the power tillers are used economically.

Except for double-axle tillers, scale economies almost disappear at 800 hours of use. After this there are only marginal cost reductions resulting from the spreading of overhead costs over more hours. Apparently type III tractors are uneconomical vis-a-vis the other two types for low levels of utilization.

Gasoline vs diesel hand tractors

To the extent that ₱4 is not the true opportunity cost of labor per day, the cost curves in Fig. 2 require alteration. If in fact the operators' time are worth more than ₱8/day, the cost curves will be raised and, therefore, the break-even points increased.

When the gasoline-engine tractor is compared with the diesel engine tractor in relation to different wage rates, Figure 3 is obtained. This shows the critical line between the two kinds of tractors i.e., the situations under which using the gasoline tractor instead of diesel tractor, or vice versa, is the less costly alternative.[8/] Any combination of labor cost and annual use to the right and above the line favors the use of diesel tractor. Conversely, gasoline tractor is the less costly alternative for all combinations below the line. A ₱2 increase in the wage rates (from ₱4 to ₱6 reduces the break-even hectarage from 50 to 28 hectares.

[8/] The formula used is $V_1 + \frac{F_1}{A} = V_2 + \frac{F_2}{A}$ where: V_1 = variable costs for gasoline tractors, V_2 = variable costs for diesel tractors, F_1 = fixed costs for gasoline tractors, F_2 = fixed costs for diesel tractors, A = area in hectares.

Relative importance of individual cost factors

This portion of the paper explores the relative significance of individual cost items as each affects the economics of hand tractor use. The cost items considered are:

a) custom rate (pesos/day)

b) wage rate (pesos/day)

c) price of fuel (pesos/liter)

d) price of oil (pesos/liter)

e) interest rate (percent/year)

The method used was to compute a ratio of the overhead costs per year to the variable profit per hour of operation. The ratio is:

$$B/E\ (hrs) = \frac{\text{Fixed cost (FC)}}{\text{Total revenue-variable cost}}$$

This ratio shows the work load needed to cover the annual fixed charges of depreciation and interest on average investment.

Results were obtained by varying each factor above and below its baseline value while holding all others constant at their respective average or baseline levels. The net effect of such changes are shown in Figs. 4 and 5. The horizontal dashed lines represent the baseline levels of the factors considered. Results are read as the net effect of varying one factor (holding others constant) on the annual use needed to break-even. A ₱5 increase in the custom rate, for example, reduces the break-even by 43 hours for type I tractors and 103 hours for type III tractors. This is equivalent to a 50 percent reduction in the opportunity cost of the capital investment. Note that the break-even

point is extremely sensitive to these factors, particularly with respect to changes in custom, wage and interest rates.

HAND TRACTOR REPAYMENTS

A substantial number of the farmers interviewed indicated that purchase of their hand tractors were financed from loans extended by Rural Banks under the CB:IBRD Farm Mechanization Program.[9/] It is therefore important to establish the conditions under which tractor repayments can be made because credit availability should go hand in hand with repayment capacity.

"Rules of thumb" have been developed by some product planners to define these conditions. One such rule states that the gross value of the crop produced should be about three times the value of the tractor. Using this as a rough guide, budgets were established in Tables 8 and 9 for type I and III tractors, respectively. The tables show the work load required of each tractor type to achieve a gross income equal to approximately three times their respective values.

Budgets were run at five different yield levels ranging from about 5 to 8 tons per hectare per year. On the assumption that the

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9/ The Central Bank of the Philippines entered into agreement with the World Bank (IBRD) on November 2, 1965, to obtain a credit line of US$5 million to finance medium and long term loans for the acquisition of farm machinery and equipment and small private irrigation pumps and equipment. The loans were extended through rural banks. Most of the capital, however, was used to finance tractor purchases due to the delay and difficulty in establishing water rights for irrigation pumps. The first credit line was exhausted in May 1968. A second credit line of US$12.5 million was implemented in September 1969.

price of paddy is ₱0.36/kg, a substantial amount of income must be earned from custom work if yield is quite low. Table 8, for example, shows that ₱3800 must be earned from custom work if total income is going to be high enough to meet repayments for type I tractors. This means operating the tractor over 1000 hours per year. Only a few of the tractors, however, are utilized to this extent. Most of them are operated about 500 hours per year. Income increases from higher yields would enable more and more farmers to meet the projected income requirement by following the pattern described in the fourth column.

Table 9 presents the conditions for type III tractors. The assumptions with respect to prices and yields are the same as in Table 8. Note that even under the most favorable assumptions with respect to yield, a substantial amount of revenue must still be earned from custom work. As mentioned earlier, the periodicity of rain sets a limit to the time available for preparing the land, in effect setting a limit to the area that can be effectively covered by a machine. Under such conditions, therefore, larger farms and higher yields are required. This indicates that double-crop irrigated farms of larger-than-average size represent the greatest potential market for hand tractor sales.

THE IMPACT OF DEVALUATION ON THE ECONOMICS OF HAND TRACTOR USE

This section examines the possible impact of the floating rate of exchange (CB Circular 289)[10/] on the economics of hand tractor use.

Price changes

Following devaluation of the peso, the price of new hand tractors and standard attachments increased by an average of 30 percent. This led to a significant decline in sales. Compared with over a thousand units per year sold in the late 60's, sales dipped to only 959 units sold during the past two years. Poor sales are largely attributed to the devaluation which led to pricing of the power units beyond the financial capabilities of most farmers. The cost of spare parts increased by 30 percent, the price of gasoline by 18.5 percent, and the price of diesel fuel by 29 percent. During 1970 the minimum legal daily wage for agriculture also rose. In the face of these price and wage increases, custom tractor operators in Laguna increased the contract cost of land preparation by an average of ₱10 for a day's work. This is an increase of 28 percent over the rate before devaluation.

Aggregate change in average costs

The effect of devaluation on average costs of ownership and operation of hand tractors may be examined from two perspectives:

10/ The Central Bank of the Philippines adopted the floating rate of exchange on Feb. 21, 1970 as a remedial measure to alleviate the chronic balance of payments problem plaguing the economy. The peso has since then sunk from ₱3.90 before devaluation to ₱6.05 - ₱6.745 to the US dollar after devaluation.

the effect on those who purchased tractors prior to devaluation and the effect on those who obtained machines after devaluation.

Annual fixed costs are a constant determined by initial purchase price and the useful life of a machine. This means that for those who purchased tractors prior to devaluation, changes in variable costs are the only relevant consideration in assessing changes in total average costs. Given the average annual use of 492 hours (Table 10) the cost to tractor owners who purchased machines prior to devaluation went up by ₱0.59/hr. Those who bought tractors after devaluation suffered an increase of ₱1.07/hr (Table 11), 32 percent over the pre-floating rate level. Undoubtedly, the higher investment costs resulting from devaluation account for a major portion of this increase. Efforts aimed at decreasing the initial investment requirement, such as the work being done at IRRI, would enhance the economic desirability of tractor use. As an example, a new 4-6 hp power tiller designed at the Institute is now being manufactured by two firms in the Philippines and is currently selling for about one-half the cost of comparable imported power tillers. The design minimizes the use of imported components and makes maximum use of readily available local materials.

The possible outcomes of increased fixed and variable costs and the concomitant impact on annual-use requirements are presented in Figure 6. Taking type III tractors as an example, annual use must increase from 490 before devaluation to 996 hours after devaluation to justify investment in this type of machine. This simply means that if no corresponding increase in custom rate is made in the face of rising

costs, power tillers must be used more intensively to justify their ownership. Custom operators, however, have raised the contract rate by ₱10/day and it appears that this more than compensates for the increase in costs. Based on these normative calculations, it is apparent that farmers who had purchased machines prior to devaluation are in a relatively advantageous position following devaluation.

Actual post-devaluation conditions

The arbitrary nature of the assumptions used in arriving at the above conclusion prompted us to resurvey 45 of the original 140 respondents. The objectives were to determine actual post-devaluation farm level prices and to ascertain the response of farmers to changes in costs brought about by devaluation.

Table 12 summarizes the post-devaluation price situation. Note that all costs have increased appreciably as a result of the devaluation. As noted earlier, the initial response of tractor owners was to raise the custom rate from ₱35 to ₱45/day. This represented, however, a short-run disequilibrium and the custom rate soon stabilized at ₱40/day. Table 13 shows that the tractor work load has increased by 12 percent and that current average costs are actually higher than those of the estimates presented earlier. A rise in repair costs accounted for the major portion of the total increase (Table 14).

Using data contained in Table 13, a series of calculations were made to determine the increase in custom rates necessary to offset the recent increase in costs. The results indicate that most custom operators are charging slightly more than is necessary to offset the

cost increases (Table 15). With the increased utilization already noted, it is apparent that most machines covered in the survey are being used efficiently and profitably.

Comparing alternative techniques of land preparation, it is evident that animal power remains a viable economic alternative on small farms up to 4.2 hectares. Over a range of 4 to 50 hectares, the use of hand tractors remains the least-cost alternative above which larger four-wheel tractors are the preferred method (Figure 7). Empirical surveys of hand tractor use in Laguna Province indicate that the average size of farm employing a hand tractor is about 4.5 hectares. In Central Luzon, where the use of four-wheel tractors is extensive, over 50 percent of the farmers owning and using four-wheel tractors own more than 50 hectares. In addition, more than 83 percent of the rice farmers who own tractors use them for custom services which effectively increases the total area covered by an individual tractor.

CONCLUSION

Rice farms in the Philippines are basically small with an average size of 2 to 3 hectares. The histograms shown in Figure 8, for example, indicate that 55 percent of the total farms and 65 percent of the total farm area under paddy cultivation fall within the range of 2 to 10 hectares. On this basis alone, there appears to be a substantial potential demand for power tillers. This is further accentuated by the development of irrigation projects permitting expansion of the double-cropped area (Table 16). The time constraints of double cropping require rapid tillage operations.

Hand tractors or power tillers were first introduced in 1960, and are used almost exclusively as substitute for the carabao in preparing rice land. Majority of the units are owned by tenant farmers operating about 4.5 hectares of double-cropped rice land. Their adoption is influenced as much by economic as well as non-economic reasons. Shifts in government policy has had in the past, and will likely continue to have more effect on the growth in tractor use than the seed-fertilizer technology. The continuing demand for tractor services, as evidenced by the increased utilization of the power units, indicates that a premium is being placed on faster and better land preparation. Partly because of this and the conditions described above, power tillers will continue to be employed.

Table 1. General specifications of hand tractors.

Item	Type I	Type II	Type III
Rated hp	6	7.5	14
Engine	Gasoline; aircooled	Gasoline; aircooled	Diesel
Weight average (kg)	80	135	300
Tilling attachment	(Tiller on axle) Moldboard plow Comb harrow	Moldboard plow Comb harrow	Rotary tiller
Steering clutch	None	Has	Has
Speed control	Belt-pulley change & throttling	Gear shift & throttling	Gear shift & throttling
Reverse drive	None	Has	Has

BO:21

Table 2. Hand tractor ownership patterns, Laguna, Philippines, 1969.

Item	Hand tractor type			All types
	Ia/	IIb/	IIIc/	
		Tenure		
Share tenant	27 (57)*	35 (51)	5 (20)	67 (48)
Lessee	14 (30)	21 (31)	3 (12)	38 (27)
Part-owner	2 (4)	6 (9)	1 (4)	9 (6)
Owner-operator	4 (9)	6 (9)	16 (64)	26 (19)
		Farm characteristics		
Rain-fed	--	2 (3)	1 (4)	3 (2)
Irrigated 1-crop	1 (2)	4 (6)	3 (12)	8 (6)
Irrigated 2-crop	46 (98)	62 (91)	21 (84)	129 (92)
Average size (ha)	4.04	4.35	4.82	4.33
		Tractor characteristics		
Operators (no)	2	2	2	2
Power (Avg.hp)	5.3	5.5	7.5	5.8

a/ 47 observations b/ 68 observations c/ 25 observations

*Numbers in parentheses are percentages.

Table 3. Reasons for buying a hand tractor, 140 farmers, Laguna, Philippines, 1969.

Reasons	Number reporting	
	Number	Percent
Rampant carabao rustling	80	57
Faster land preparation	91	65
Easier to maintain than carabao	92	66
Deep mud	19	14
Better puddling	6	4
To keep pace with other farmers	7	5
Income from custom work	4	3
Custom service not available when needed	3	2

BO:23

Table 4. Criteria for choice of hand tractor type.

Item	Hand tractor type		
	I	II	III
No. of respondents	47	68	25
	Number reporting		
Initial cost	4 (9)	12 (18)	---
Weight	31 (66)	12 (18)	2 (8)
Simplicity	25 (53)	---	---
Durability	10 (21)	11 (16)	8 (32)
Popularity	9 (19)	10 (15)	---
Power	---	20 (29)	15 (60)
Demonstration	3 (6)	11 (16)	---
Fuel type	---	---	7 (28)
Experience with type		13 (19)	
Other farmers' advice	3 (6)	13 (19)	5 (20)

Note: Numbers in parentheses are percentages.

Table 5. Problems of ownership and maintenance of hand tractor, Laguna, Philippines, 1969.

Item	Hand tractor type			All
	I	II	III	types
	Number reporting			
High initial cost	13 (28)*	26 (38)	6 (24)	45 (32)
Spare parts procurement	28 (60)	36 (53)	5 (20)	69 (49)
Costly spare parts	13 (28)	16 (24)	3 (12)	32 (23)
Frequent breakdown	1 (2)	5 (7)	4 (16)	10 (7)
Weak axle	- - -	12 (18)	2 (8)	14 (10)
No ready cash with which to buy spares	1 (2)	5 (7)	- - -	6 (4)
No problem	21 (45)	19 (28)	13 (52)	53 (38)

*Numbers in parentheses are percentages.

BO:25

Table 6. Average costs of ownership and operation, Laguna, Philippines, 1969.

Item	Hand tractor type I	Hand tractor type II	Hand tractor type III	All types
Estimated service life (yr)	8	8	10	8
Average annual use (hr)	486	442	641	492
		Pesos *		
Ave/purchase price	3367.35	3419.54	7318.80	4098.32
Overheads:				
Depreciation 1/	378.83	384.70	658.69	461.06
Interest 2/	222.24	225.69	483.04	270.49
Total	601.07	610.39	1141.73	731.55
Variable costs/hr.				
Fuel	0.32	0.32	0.18	0.29
Lubricants	0.09	0.11	0.11	0.10
Repairs	0.35	0.29	0.76	0.39
Labor	1.00	1.00	1.00	1.00
Total	1.76	1.72	2.05	1.78

*US$1 = ₱3.90

1/ Straight-line; salvage value = 10% of purchase price.

2/ 12% per annum.

Table 7. Labor requirements and machine performance (plowing plus harrowing*).

Item	Hand tractor type			All types
	I	II	III[1/]	
No. of operators	2	2	2	2
Total man-hr/ha	88.20	88.38	63.10	83.80
Machine-hr/ha	44.10	44.19	31.55	41.90
Average tractor rhp	5.34	5.53	7.46	5.81
Rhp-hr/ha	235.49	244.37	235.36	243.44
Fuel consumption (lit/hr)	1.18	1.18	1.06	1.16
Lubricants	0.06	0.07	0.07	0.07

* Each harrowing requires 2 passes of the comb harrow.

1/ Two passes of the rotavator only.

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Table 8. Alternative means of achieving income capacity needed to maintain a Type I tractor valued at ₱3400 on a 4-hectare double-cropped farm.[a/]

Item	Yield per hectare per year (tons)				
	4.4	5.3	6.2	7.0	7.9
Effective crop area	8	8	8	8	8
Yield (kg)	4,400	5,280	6,160	7,040	7,920
Custom hectare	19.7	13.1	6.4	0	0
Total hectare[1]	27.7	21.1	14.4	8	8
Hours/tractor[2]	1,221.5	930.5	635.0	352.8	352.8
Gross farm income[3]	6,400	7,680	8,960	10,240	11,520
Gross custom income[4]	3,800	2,520	1,240	0	0
Total gross income[5]	10,200	10,200	10,200	10,200	10,200

[a/] Based on the "rule of thumb" that gross income should be three times the value of the tractor.

[1] Hectares plowed and harrowed for wet and dry seasons.

[2] 44.10 hrs/ha.

[3] Based on the price of paddy of ₱0.36/kg.

[4] Based on ₱35/day.

[5] US$1.00 = ₱3.90.

Table 9. Alternative means of achieving income capacity needed to maintain a Type III tractor valued at P7300 on a 4.8-hectare double-cropped farm.[a/]

	Yield per hectare per year (tons)				
	4.4	5.3	6.2	7.0	7.9
Effective crop area	9.6	9.6	9.6	9.6	9.6
Yield (kg)	4,400	5,280	6,160	7,040	7,920
Custom hectare	101.9	91.0	80.0	69.0	58.1
Total hectare[1]	111.5	100.6	89.6	78.6	67.7
Hours/tractor[2]	3,214.9	2,871.0	2,524.0	2,177.0	1,833.0
Gross farm income[3]	7,680	9,216	10,752	12,288	13,824
Gross custom income[4]	14,276	12,740	11,204	9,668	8,132
Total gross income[5]	21,956	21,956	21,956	21,956	21,956

a/ Based on the "rule of thumb" that gross income should be three times the value of the tractor.

1 Hectares rotavated for wet and dry seasons.

2 31.55 hr/ha.

3 Based on the price of paddy of P0.36/kg.

4 Based on P35/day.

5 US$1.00 = P3.90.

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Table 10. Changes in average total costs, Laguna, 1970.

Tractor	Average annual use (hrs)	Average total cost per hour (pesos)[a]		
		Before devaluation	devaluation	Percent increase
Type I	486	3.00	3.46	15.33
Type II	442	3.10	3.71	19.68
Type III	641	3.83	4.52	18.02
All types	492	3.26	3.85	18.09

[a] Fixed cost held constant at pre-devaluation level.

Table 11. Average cost for new tractors.[a]

Tractor	Average annual use (hrs)	Average cost per hour (pesos)		
		Before devaluation	After devaluation	Percent increase
Type II	442	3.10	4.12	32.90
Type III	641	3.83	5.05	31.85
Both types	495	3.30	4.37	32.42

[a] The distributor of Type I tractors has not imported any new units since devaluation, making it virtually impossible to determine an adjusted purchase price for this unit.

Table 12. Changes in input cost items for hand tractor operation in Laguna, 1969 to 1970.

Item	Tractor type I	Tractor type II	Tractor type III	All types
Fuel, ₱/lit	0.31(14.81)*	0.31(14.81)	0.24(14.18)	0.29(16.00)
Oil, ₱/lit	2.10(40.00)	2.10(40.00)	2.10(40.00)	2.10(40.00)
Spare parts, %	58.50*	105.70*	70.70*	78.30*
Labor, ₱/8-hr-day	6.00(50.00)	6.00(50.00)	6.00(50.00)	6.00(50.00)
Custom rate, ₱/8-hr-day	40.00(14.28)	40.00(14.28)	40.00(14.28)	40.00(14.28)

*Percentage increase over the pre-floating rate level.

Table 13. Average costs of operation, 45 hand tractors, Laguna, 1970.

Item	Tractor type I	Tractor type II	Tractor type III	All types
No. of observations	15	15	15	45
Annual use, hr	431(-11.32)**	601(35.97)	644(<1)	559(11.99)
Variable costs/hr				
Fuel	0.36(12.50)	0.36(12.50)	0.25(38.89)	0.32(10.34)
Oil	0.13(44.44)	0.15(36.36)	0.15(36.36)	0.14(40.00)
Repairs	0.79(125.71)	0.49(68.96)	0.75(-1[illegible]3)	0.68(74.36)
Labor	1.50(50.00)	1.50(50.00)	1.50(50.00)	1.50(50.00)
Total	2.78(57.95)	2.50(45.35)	2.65(45.35)	2.64(48.31)
Average total cost/hr*	4.17(39.00)	3.52(13.55)	4.42(15.40)	4.13(26.30)

*Fixed cost held constant at pre-devaluation level.

**Percentage increase over pre-devaluation level.

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Table 14. Changes in repair costs for hand tractors in Laguna, 1969 to 1971.

Item	Repair costs in 1971[a]		
	More	Less	Same
Type I tractors:			
No. reporting	10	4	1
Factors behind change:			
Frequent breakdown	5	-	-
High cost of spare parts	7	-	-
Better care	-	4	-
No answer	-	-	1
Type II tractors:			
No. reporting	8	4	3
Factors behind change:			
Frequent breakdown	5	-	-
High cost of spare parts	4	-	-
Better care	-	1	3
No answer	-	1	3
Type III tractors:			
No. reporting	8	2	5
Factors behind change:			
Frequent breakdown	3	-	-
High cost of spare parts	3	-	-
Better care	-	2	-
No answer	-	-	5

[a] Repair costs in 1969 as base.

Table 15. Custom rates and annual utilization required to break-even, 45 hand tractors, Laguna, 1971.

Tractor	Custom rate (₱/hr)		Annual use, hr	
	Actual	Needed	Actual	Needed
Type I	5.00	4.17	431	271
Type II	5.00	3.52	601	244
Type III	5.00	4.42	644	486
All types	5.00	3.95	559	310

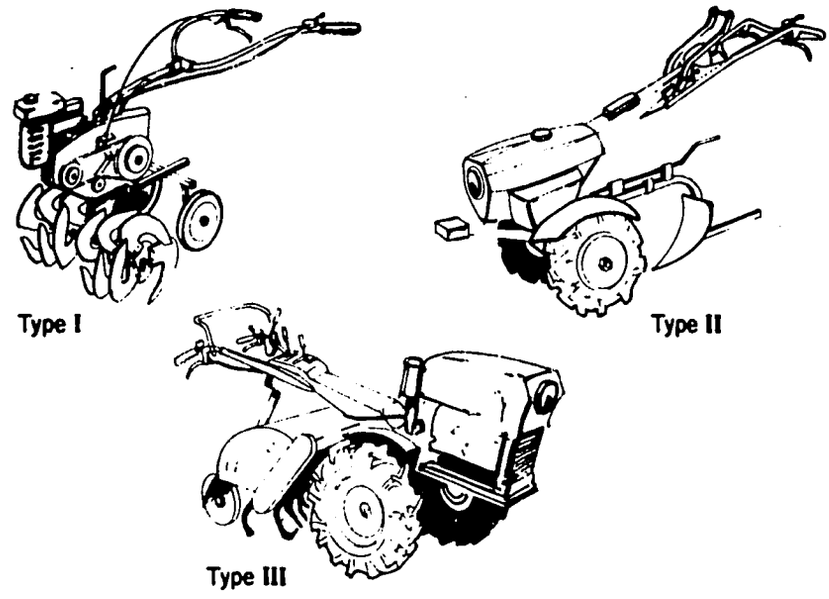

Fig. 1. Three types of hand tractor.

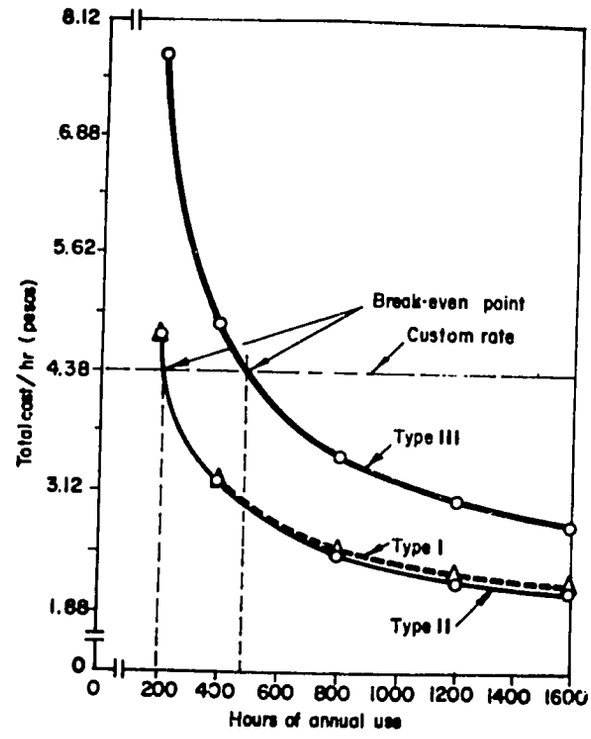

Fig. 2. Relationship between annual use and cost.

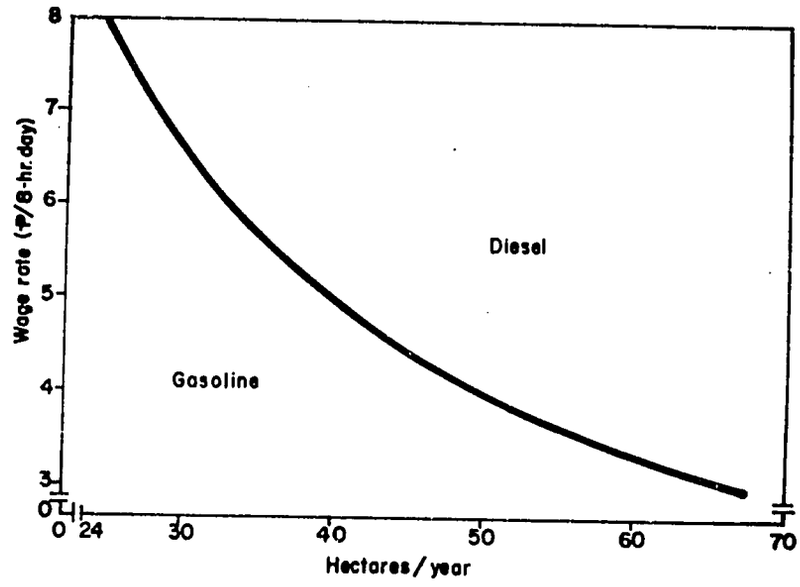

Fig. 3. Zones of cost advantage: gasoline vs diesel hand tractor.

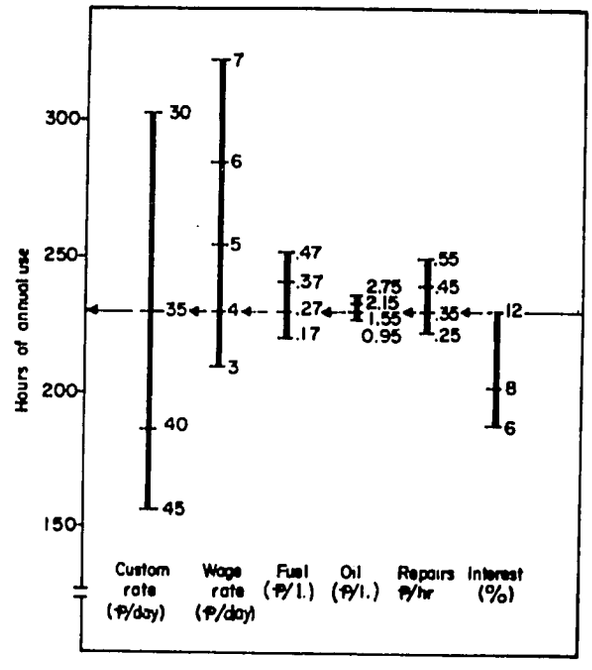

Fig. 4. Relative importance of cost factors, type I tractors.

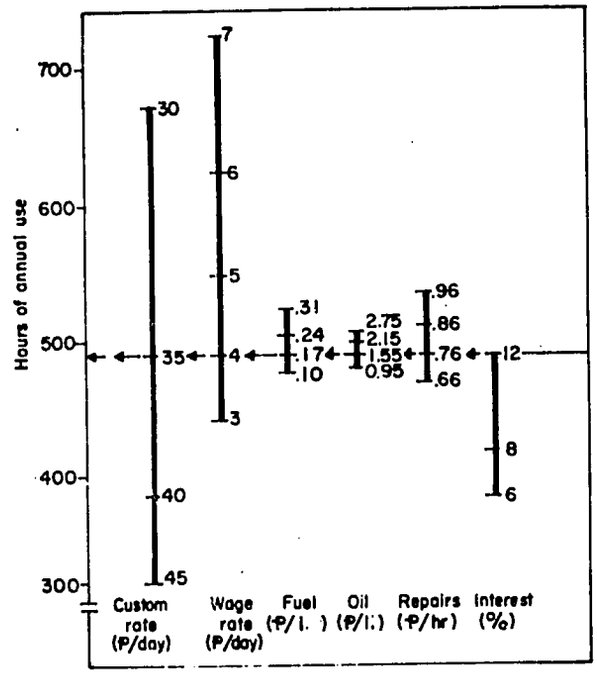

Fig. 5. Relative importance of cost factors, type III tractors.

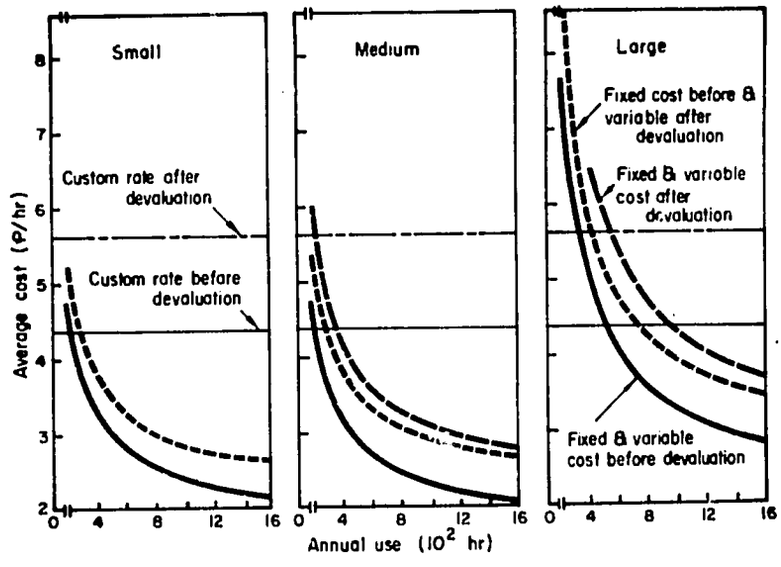

Fig. 6. Average cost of hand tractors as affected by devaluation.

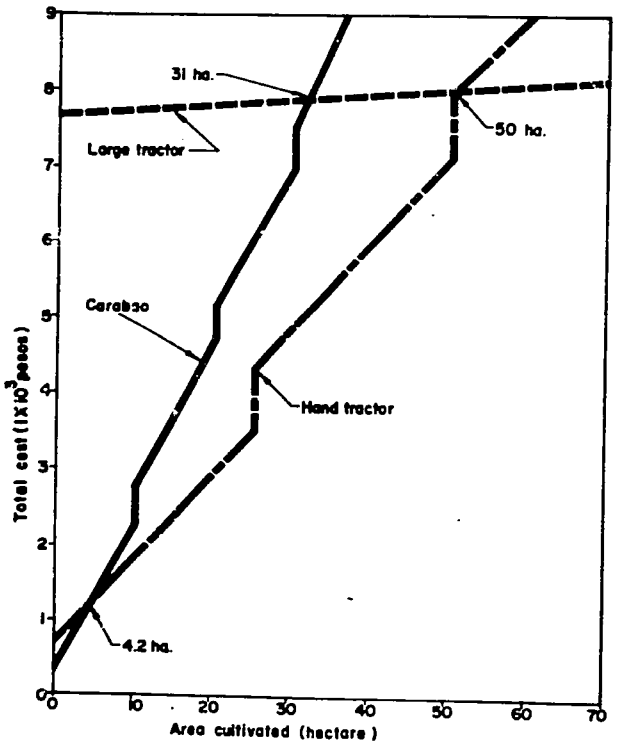

Fig. 7. Total cost curves for alternative methods of land preparation.

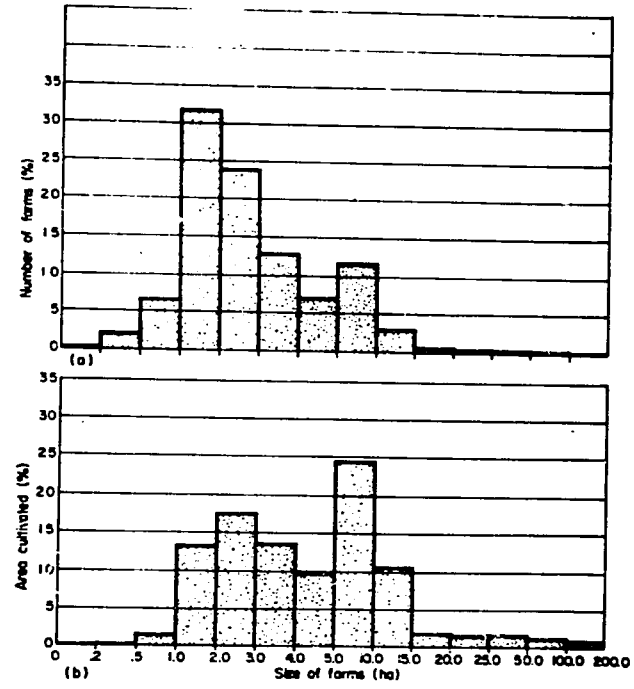

Fig. 8. Size distribution of farms by number (a) and area cultivated (b).