A comparative study of two-wheel and four-wheel tractor operation and performance in the dry zone

M. GEORGE PILLAINYAGAM

Farm Machinery Research Centre, Mahailluppallama, Sri Lanka

(Received May, 1972)

MECHANIZATION of agriculture in Sri Lanka and the dry zone in particular commenced in the mid-forties. Most of the import of tractors and equipment was done by the Government, but some where during 1949/50, the private sector entreed this field. The first large scale introduction appeared to have been the Massey Ferguson TE-20 model with tyne tiller. The population of four wheel tractors in 1945 was approximately 60, in 1949 the number increased to 650 and in 1965 it stood at 10,000. Today it is in the region of 13,900. Two wheel tractors appeared to have come into the island in 1960, with "Mitsubishi", which is one of the heavy duty Japanese make, and the Land-Master which is a part assembled Garden Tractor in Sri Lanka. It was not until 1968 that this range of tractors made any impression in local agriculture. The population of two wheel tractors today stands at 6,354.

Despite the fact that there are 13,867 four wheel and 6,354 two wheel tractors there is yet an unsatisfied demand for tillage facilities. There appears to be a great deal of confusion at the moment with regard to the farmers choice of the class of tractor most suited for his needs. The main objective of this article is to serve as a guide in the choice of the proper class of tractor.

COST ANALYSIS

The following notations are used in the discussion on cost analysis :—

D	—	Depreciation of Machinery	(Rs/hr)
F	—	Fuel cost	(Rs/hr)
H	—	Housing Insurance and Management expenditure ...	(Rs/hr)
I	—	Interest on capital investment	(Rs/hr)
L	—	Lubrication cost	(Rs/hr)
N	—	Life span	(years)
P	—	Purchase price	(Rupees)
R	—	Repair, spares & Maintenance	(Rs/hr)
T	—	Work span	(hours)
W	—	Operators wages	(Rs/hr)
t	—	Annual hourly use	(hours)

I 13085 (5/72)

A cost analysis of land preparation with various types of tractors and implements used for agricultural purposes would aid the selection of a suitable tractor power unit. Generally it is impossible to state accurately the cost of machine power in a farm as it is influenced by a wide range of factors which include :—

(1) Weather condition during cultivating period.
(2) Type and condition of soil (specially soil moisture condition)
(3) Skill of the machinery operator,
(4) Annual hourly use in the field.

The cost of machine power for mechanization of agriculture can be divided into two main groups, namely : fixed costs and running costs.

A. Fixed Costs

Fixed cost is the expense incurred when the tractor is in the farmer's possession irrespective of the number of hours for which such a machine is used annually. Fixed cost consists of :—

(i) Depreciation of the machine
(ii) The interest on capital investment
(iii) The housing, insurance and management expenditure, etc.

(i) *Depreciation.*—Depreciation of a tractor depends on its total working hours (*i.e.* its work span) which is determined by two factors. One is the time taken for the tractor to wear out and become unfit for further use, and the other is the obsolescence due to new technical improvements. The life period of a tractor (2, 3 and 4) estimated from its annual hourly rate of working is presented in Table I. The salvage value of the tractor and its implements is estimated as 10 percent of the purchase price.

$$\text{The hourly rate of depreciation} = \frac{0.9 \times \text{Purchase price}}{\text{Total hours of use.}}$$

$$\textit{ie. } D = \frac{0.9 \times P}{T} \text{ Rs/hr.}$$

(ii) *Interest on capital investment.*—Average annual interest paid on loaned capital is 10 percent.

$$\text{The hourly rate of interest} = \frac{0.1 \times \text{Purchase Price}}{\text{Annual hourly use}}$$

$$= \frac{0.1 \times P}{t} \text{ Rs/hr.}$$

(iii) *Housing, Insurance and Management Expenditure* (3), (4).—It is essential for the tractor to be sheltered when it is not in use. The construction and maintenance of this shelter is considered as a part of the fixed cost.

The Motor Traffic Act requires that all 4 wheel tractors be insured against accidents, at least against 3rd party risks.

The expenditure on management and care of tractors hired for services such as ploughing, haulage, etc. is taken as additional costs incurred.

These annual rates are estimated as follows :—

Housing	...2.5%	Of the Purchase price
Insurance	...0.5%	
Management Expenditure	... 3%	

$$\text{The hourly cost} = \frac{0.06 \times \text{Purchase price}}{\text{Annual hourly use}}$$

$$H = \frac{0.06 \times P}{t} \text{ Rs/hr.}$$

Note.—Since two wheel tractors are not registered as road vehicles, being utilized by the owner operator, insurance and management costs are not applicable.

$$\therefore \quad H = \frac{0.025 \times P}{t} \text{ Rs/hr.}$$

B. Running cost (Variable cost)

Running cost may be defined as the cost incurred in utilizing the machine for various operations. This cost is made up for of the following :—

(i) Repair, spares and maintenance
(ii) Fuel consumption
(iii) Oil and Lubricant
(iv) Operators wages.

(i) *Repairs, spares and maintenance.*—Total amount of repair cost on a tractor is directly proportional to its total use. The cost is low when the machine is new and increases as the machine becomes older. Tractor spares are very costly being subjected to import control. Repair and service facilities are not available or are generally unsatisfactory in remote villages. In general, farmers do not maintain an accurate record of repair cost incurred on their machines.

From the popular makes widely used for agricultural purposes, one 45-HP (Diesel) 4—wheel tractor and one 7 H.P. (diesel) 2—wheel tractors were selected for this study and a record of maintenance, service and operation is being maintained at the Farm Machinery Research Centre, Maha Illuppallama. These records together with whatever information obtained from farmers were used to develop emporical estimates of the total accumulated repair cost during the entire life of the tractors (fig. 1). The hourly rate of repair cost of tractor and implements corresponding to their annual use calculated from Fig. 1 is given in Table 2.

(ii) *Fuel Consumption.*—Various makes and models of tractors were tested at the Farm Machinery Research Centre, Maha Illuppallama, to estimate their capacity and quality performance under local conditions. From the test results for continous operation of 8 hrs/day the specific fuel consumption per acre and corresponding tilling capacity were estimated (1). In addition the following factors were considered.

(1) Different and irregular field sizes.
(2) Variation in the type of soil and its moisture content across the field.
(3) Obstructions (Boggy plots, hidden stones, roots, etc. in the field).
(4) Reduced efficiency due to wear and tare.
(5) Operators rest period.

In consideration of the above factors an additional allowance of 33 percent had to be made on the test values of fuel consumption, and 75 percent of the estimated tilling capacity (2, 4) were used for the derivation of fuel cost given in table—3.

Hourly cost of fuel consumption (F) could be calculated for different categories of tractors.

Average price of fuel :

		Rs.	*c.*	
Diesel ...	...	... 1	84	Per gallon
Petrol ...	...	... 3	56	
Kerosene	...	... 1	0	

(iii) *Oil and Lubricant* (*L*).—It was estimated from the records of different tractors that the cost of oil and lubricant was proportional to the fuel consumtion and was determined as 30 percent of the fuel cost

Therefore hourly cost of oil and lubricant.

$$L = 0.3.\ F\ \text{Rs/hr.}$$

(iv) *Operator's wages (W).*—From district to district the tractor operators wages vary with the season (*Viz.* Maha & Yala)

The average wages are :—

4—wheel tractor operator—10 Rs./day or 1.25 Rs./Hr.
2—wheel tractor operator—7.5 Rs./day or 0.95 Rs./Hr.

Purchase price.—Average prices given in Table—4 for tractors of same horse power class but of different makes were calculated on the market prices prevailing in 1970 and are therefore subject to change.

ESTIMATION

A. Maximum operational capacity :—

Assuming 40 days (320 working hours) are available for preparatory land operation per season and using Table 3, the maximum operational capacity of the machines could be evaluated.

Examples :

If a 45 HP tractor is used for tyne tilling operation for the whole period in single cropping season then from Table 3 hourly capcaity of the tractor .. .. = 0.63 acres

∴ for 40 days (320) hours capacity .. .. = 0.63 × 320
≃ 200 acres.

Similarly when the tractor is used for two cropping seasons (80 days 640 hours) per year the operational capacity will be = 400 acres

B. Cost per acre for preparatory land operation

With different horse power class of tractors the cost per acre for various operations involved in land preparation were calculated for their corresponding annual hourly use Fig. 2, 3 & 4. These figures could be used to estimate the cost involved for different hourly use of implements to suit the need of individual farms.

Example :

If a 45 HP tractor is used for 1,000 hours annually of which tyne tilling include 320 hours, rotary tilling 320 hours, and its remaining period of 360 hours for transport work:—

Then from Fig. 2, cost of tractor power (1,000 hours annual use) .. = 11.60 Rs/hr
From Fig. 3, cost of tyne tilling implement and operation (320 hours) = 6.50 Rs/hr
∴ Total operational cost .. .. .. = 18.10 Rs./hr
From Table 3 the tyne tilling capacity of 45 HP tractor = 06.3 ac/hr

$$\therefore \text{ Cost per acre fo rtyne tilling } = \frac{18.10}{0.63}$$

= 29.00 Rs./-

Similarly from Fig 2, 3 and Table 3 cost per acre for rotavating (320 hours per year) .. .. = 37.40 Rs./acre

6—K 13085 (5 72)

Using the above methods of analysis, the maximum operational capacity and the cost per acre with different categories of tractors for different operations are given in Table 5, both in relation to one cropping season and two cropping seasons per year.

These results were obtained for a tractor with 1,000 hours (total) annual use, wherein implement use for single and double cropping amounted to 40 days of 320 working hours and 80 days of 640 working hours respectively. The calculations are based on the use of a particular implement exclusively throughout the period of tillage corresponding to 40 days in single cropping and 80 days in double cropping.

Management and Maintenance

The efficiency of management will largely influence the cost structure of mechanization, particularly in our developing country where imported machinery, are used for field operation under extreme conditions. For successful mechanization the machinery operator should be acquanited with the principle functions of the machinery and necessary care to maintain it efficiently. The personal attention and supervision by the farmer (owner of the land where the machinery is used) is an important factor determining the efficiency of mechanized operation. The farmer should bear in mind the following points in the use of machinery for agriculture :

(1) Selection of correct power unit capacity for his requirements.
(2) Awareness of proper cultivation practices in relation to soil conditions at the time of land preparation.
(3) Utilization of proper gear for optimum performance of the machinery and maximum economy of fuel consumption.
(4) Attend to the scheduled system of service, maintenance and adjustments that are required for easy and trouble free operation.
(5) Field supervision of the machine to ensure efficient operation.

DISCUSSION

In working out the economics of tractor operation the two main variables include fixed cost and running cost. The fixed cost which constitute depreciation, interests and other expenditures involving housing, insurance and management is largely a percentage of the capital cost of equipment which is not affected by the working condition. On the other hand, running cost which include expenditures on repair, fuel, oil and lubricants and operator's wages influence the working cost to a great extent and therefore it is in this area that maximum care is needed in the exercise of skills.

It will be noticed that 45 HP. is about the ideal among four wheel tractors. Four wheeler below or above the 45 HP. range appear to be uneconomical. It will also be observed that for optimum returns this class of machine should be in use for at least 1,000 hours a year. From the operational point of view it

will be noticed that, of the three operations namely rotavating, ploughing and tyne tilling the cost of tyne tilling is the least, followed by rotavation, whereas ploughing costs are high. In double cropped areas, these operational costs are a little lower than in single cropped areas, mainly due to the longer period of machinery used. It would therefore become apparent that unless the machine is in use for at least 1,000 hours per year the investment will not give a desirable margin of profit. However the advantages in having more than 1,000 hours of work per year is that, the income will be greater but at the expense of a shorter life period of the machine.

The factors which influence fixed and running cost of four wheel tractors are also used in the estimation of working cost for two wheel tractors, except insurance and managent expenditure. The three classes of two wheelers are the diesel, kerosene and petrol machines which possess a horsepower range of 6—7. The tests carried out indicate that the diesel tractors of this horse power range gave the highest field performance resulting in reduced cost per acre though the investment cost of the diesel tractor is high. It was also observed that the diesel engine is relatively free from troubles particularly when operated under wet and muddy field conditions.

As far as paddy cultivation is concerned rotary tilling with the two wheel tractor appears to meet the requirement of the farmer and is cheaper than ploughing, except in instances of land heavily infested with weeds and stubbles as in fallow rice fields where ploughing is essential. In order to obtain the maximum benefit from the two wheel tractors it must be utilized for 1,000 hours on preparatory land operation (rotavating). However the owner of this class of tractor may be able to use his tractor for subsequent operations such as ridging, seeding, intercultivating and harvesting, and as stationary power source for operating water pumps, threshing machines, hulling machines, etc. which brings him additional income.

CONCLUSION

The power unit on which a programme of mechanization of paddy is to be based has become a controversial issue today. The two protoganists being those who favour the use of two wheel power tillers and those who support the use of the conventional four wheel tractors. While it must be admitted that both types have their place in the mechanization of agriculture in Sri Lanka, the relatively new idea of the two wheel power tiller demand examination, from both the technical and economical points of view.

The use of either categories of tractors will depend largely on the size of holdings. Some suggestions can be made on the selection of power sources for land preparation in the developed paddy land (1962). There are in Sri Lanka approximately 30,000 acres under small holdings of less than $\frac{1}{2}$ acre, which can be cultivated with animal power. The extent of 600,000 acres in holdings between $\frac{1}{2}$ and 5 acres, where the effective power sources which can be used are the hired services of both two wheel tractors and four wheel tractors. Owned

two wheel tractors or hired services of four wheel tractors can be efficiently used in the 50,000 medium size holdings between 5 and 25 acres covering an extent of 350,000 acres of land. For the remaining areas where the individual land holdings exceed 25 acres the four wheel tractor is recommended.

From the above evaluation it can be concluded that the two classes of tractors namely the four wheel tractors and two wheel tractors have specific roles to play in the mechanization of agriculture in Sri Lanka. The popular falacy that the two wheelers can replace the four wheelers and vice versa is not based on any scientific evaluation.

ACKNOWLEDGEMENT

I express my sincere gratitude to Mr. R. Sathasivampillai, Agricultural Officer, Farm Machinery Research Centre, for providing the facilities and guidance in carrying out this study and in the drafting of the script. I acknowledge with thanks the assistance of Messers. P. Velauthapillai and K. Cyril in the field tests.

REFERENCES

Test Reports. Agricultural Machinery Designs & Testing Centre, Maha-Illuppallama. Publication No. 2, 1969.

I. Agr. E. Data Performance of Equipments for various operations. Institution of Agricultural Engineers Year Book 1969–70.

A. S. A. E. Data. A. S. A. E. D. 230. Farm Machinery Cost and Use. Agricultural Engineers Year Book 1969.

Masayuki Kisu. Economical Studies on Tractor Size. Institution of Agricultural Machinery Technical Report 1967.

TABLE 1

Annual hourly use and estimated life period (2, 3, 4)

A.—4-WHEEL TRACTOR (20—25—35—40—45—60 HP)

Annual hourly use—t hours	500	600	750	1,000	1,250	1,500
Useful life—N years	15	14	12	10	8	7
Workspan T = Nt hours	7.500	8,400	9,000	10,000	10,000	10,500

B.—4-WHEEL TRACTOR IMPLEMENTS (ROTARY, PLOUGH & TINE TILLER)

Annual hourly use—t hours	100	200	300	400	500	600
Useful life—N years	12	10	8	7	6	5
Workspan T = Nt hours	1,200	2,000	2,400	2,800	3,000	3,000

C.—2-WHEEL TRACTORS WITH IMPLEMENTS

Annual hourly use — t hours	300	450	600	750	900	1,000
Useful life—N years	8	7	6	5	4.5	4
Workspan T = Nt hours	2,400	3,150	3,600	3,750	4,000	4,000

TABLE 2

Repair costs on tractors and implement (Figure I)

A.—4-WHEEL TRACTOR (20—25—35—40—45—60 HP)

Annual use—t hours	500	600	750	1.000	1,250	1,500
Repair cost R = $\times 10^{-4}$ P Rs/hr	2.7	2.38	2.20	2.0	2.0	1.95

B.—4-WHEEL TRACTOR IMPLEMENTS

Annual use—t hours	100	200	300	400	500	600
Repair cost R = $\times 10^{-4}$ P Rs./hr	8.1	5.0	4.20	3.58	3.33	3.33

C.—2-WHEEL TRACTOR WITH EQUIPMENT

Annual use—t hours	300	450	600	750	900	1,000
Repair cost R = $\times 10^{-4}$ P Rs/hr	4.2	3.14	2.8	2.70	2.65	2.65

TABLE 3

Estimation of practical operational capacity and fuel consumption for different land preparation (I)

Machinery details (H.P. class)	*Operational capacity acres per hour*	*Fuel consumption gallon/per hour*
I—ROTARY TILLING (WET)		
(*a*) 4-*wheel tractor*		
60 HP Diesel	0.75	1.76
45 HP Diesel	0.63	1.80
40 HP Diesel	0.60	1.80
35 HP Diesel	0.48	1.80
25 HP Diesel	0.46	0.86
20 HP Diesel	0.35	1.20
15 HP Diesel	0.26	0.89
(*c*) 2-*wheel tractor*		
7 HP Diesel	0.16	0.28
6 HP Kerosene	0.10	0.36
6 HP Petrol	0.10	0.42
II—PLOUGHING (DRY)		
(*a*) 4-*wheel tractor*—		
60 HP Diesel	0.4	0.85
45 HP Diesel	0.4	0.96
35 HP Diesel	0.31	0.98
25 HP Diesel	0.28	0.70
(*c*) 2-*wheel* tractor		
7 HP Diesel	0.10	0.24
6 HP Kerosene	0.08	0.33
6 HP Petrol	0.08	0.28
III—TINE TILLING (DRY)		
(*a*) 4-*wheel tractor*		
60 HP Diesel	0.63	1.50
45 HP Diesel	0.63	1.43
25 HP Diesel	0.36	0.74
IV—TRANSPORTING (ON LEVEL ROAD)		
(*a*) 4-*wheel tractor*		
45 HP Diesel	—	0.74

TABLE 4

The average purchase price (P) for different catagories of tractors, implements, etc. (1970 market price subject to change)

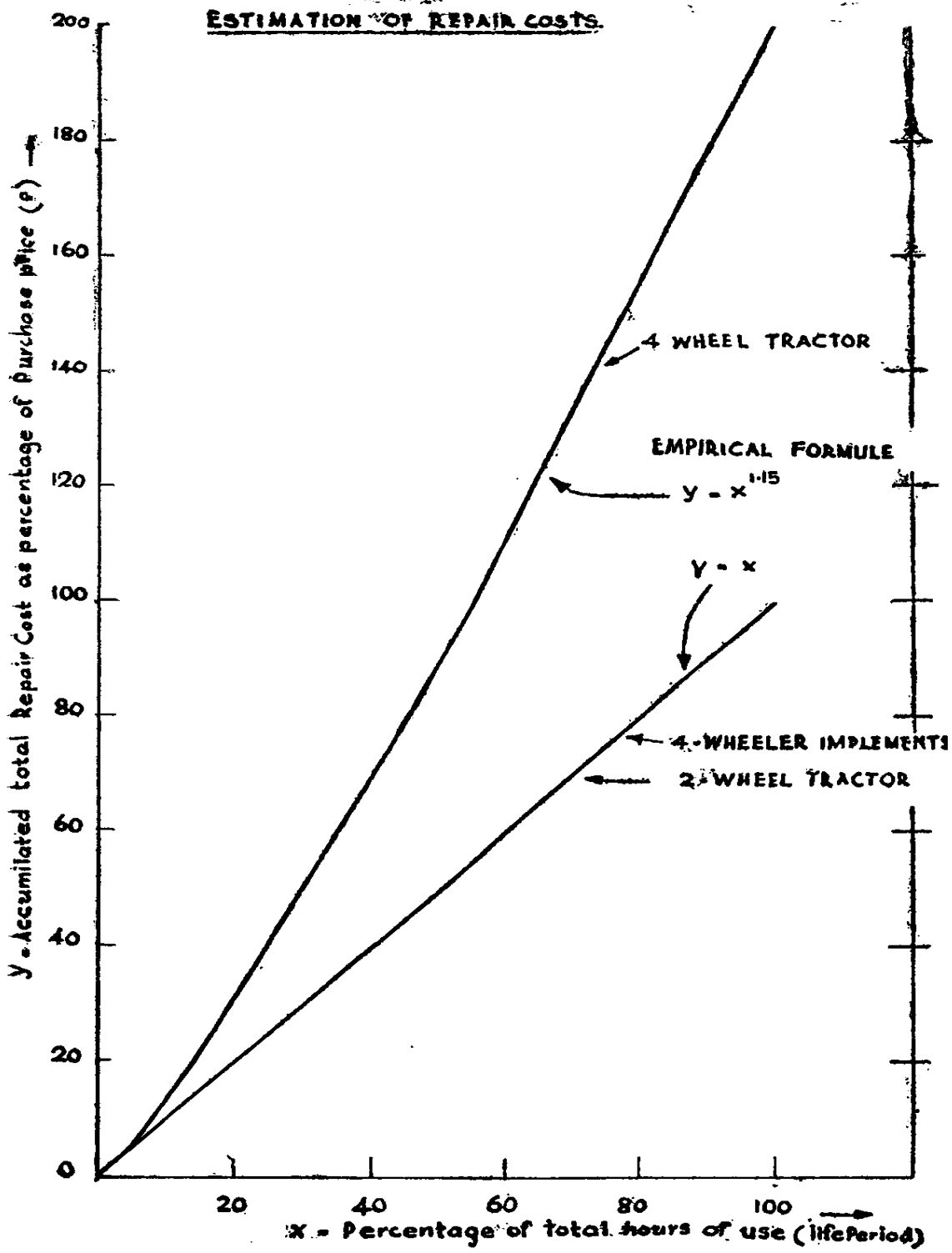
Machinery details	*Price Rs.*
(*a*) 4-*wheel tractor*	
60 HP Diesel	28,000
45 HP Diesel	23,000
40 HP Diesel	21,000
35 HP Diesel	18,750
25 HP Diesel	16,350
20 HP Diesel	15,750
15 HP Diesel	15,275
(*b*) 4-*wheel tractor implement*	
Howard Rotavator (RMK 40/50) ..	5,500
Disc plough (2 furrow)	4,500
Tine tiller (9 points)	2,500
Trailer (3-ton capacity)	6,700
(*c*) 2-*wheel tractor*	
7 HP (Diesel)) Rotary and wet wheel ..	6,400
6 HP (Kerosene) Rotary and wet wheel ..	5,160
6 HP (Petrol) Rotary and wet wheel	5,330
7 HP (Diesel) Mould plough and wheel ..	5,300
6 HP (Kerosene) Mould plough and wheel ..	4,450
6 HP (Petrol) Mould plough and wheel ..	4,500

TABLE 5

Estimation of cost per acre for rotary tilling, ploughing and tine tilling operations in relation to single cropping areas and double cropping areas (assuming 4-wheel tractor is used 1,000 hours (total) annually, irrespective of implement use)

Tractor details	*Single cropping season (Yala or Maha) 40 days per year*		*Double cropping season (Yala or Maha) 40 days per year*	
	Maximum operational capacity (acre/yr.)	*Cost per acre* Rs. c.	*Maximum operational capacity (acre/yr.)*	*Cost per acre* Rs. c.
I—ROTARY TILLING (WET)				
(a) 4-wheel tractor				
60 HP Diesel	240	34 50	480	31 20
45 HP Diesel	200	37 40	400	33 40
40 HP Diesel	190	37 80	380	33 60
35 HP Diesel	150	45 40	350	40 0
25 HP Diesel	145	42 50	290	40 0
20 HP Diesel	110	54 0	220	46 50
15 HP Diesel	70	68 60	140	60 0
(c) 2-wheel tractor				
7 HP Diesel	50	57 50	100	39 0
6 HP Kerosene	40	73 0	80	51 0
6 HP Petrol	40	83 0	80	59 0
II—PLOUGHING (DRY)				
(a) 4-wheel tractor				
60 HP Diesel	125	54 0	250	49 70
45 HP Diesel	125	50 0	250	42 70
35 HP Diesel	100	59 0	200	53 60
25 HP Diesel	90	61 0	180	54 80
(c) 2-wheel tractor				
7 HP Diesel	32	77 0	64	54 0
6 HP Kerosene	25	85 0	50	56 0
6 HP Petrol	25	95 0	50	67 0
III—TINE TILLING (DRY)				
60 HP Diesel	200	32 35	400	30 0
45 HP Diesel	200	29 0	400	27 0
25 HP Diesel	200	43 0	400	39 0

figure 1


ESTIMATION OF REPAIR COSTS.
y = Accumilated total Repair Cost as percentage of purchase price (P)
200
180
160
140
120
100
80
60
40
20
0
4 WHEEL TRACTOR
EMPIRICAL FORMULE
y = x^1.15
Y = x
4-WHEELER IMPLEMENTS
2 WHEEL TRACTOR
20
40
60
80
100
x = Percentage of total hours of use (lifeperiod)

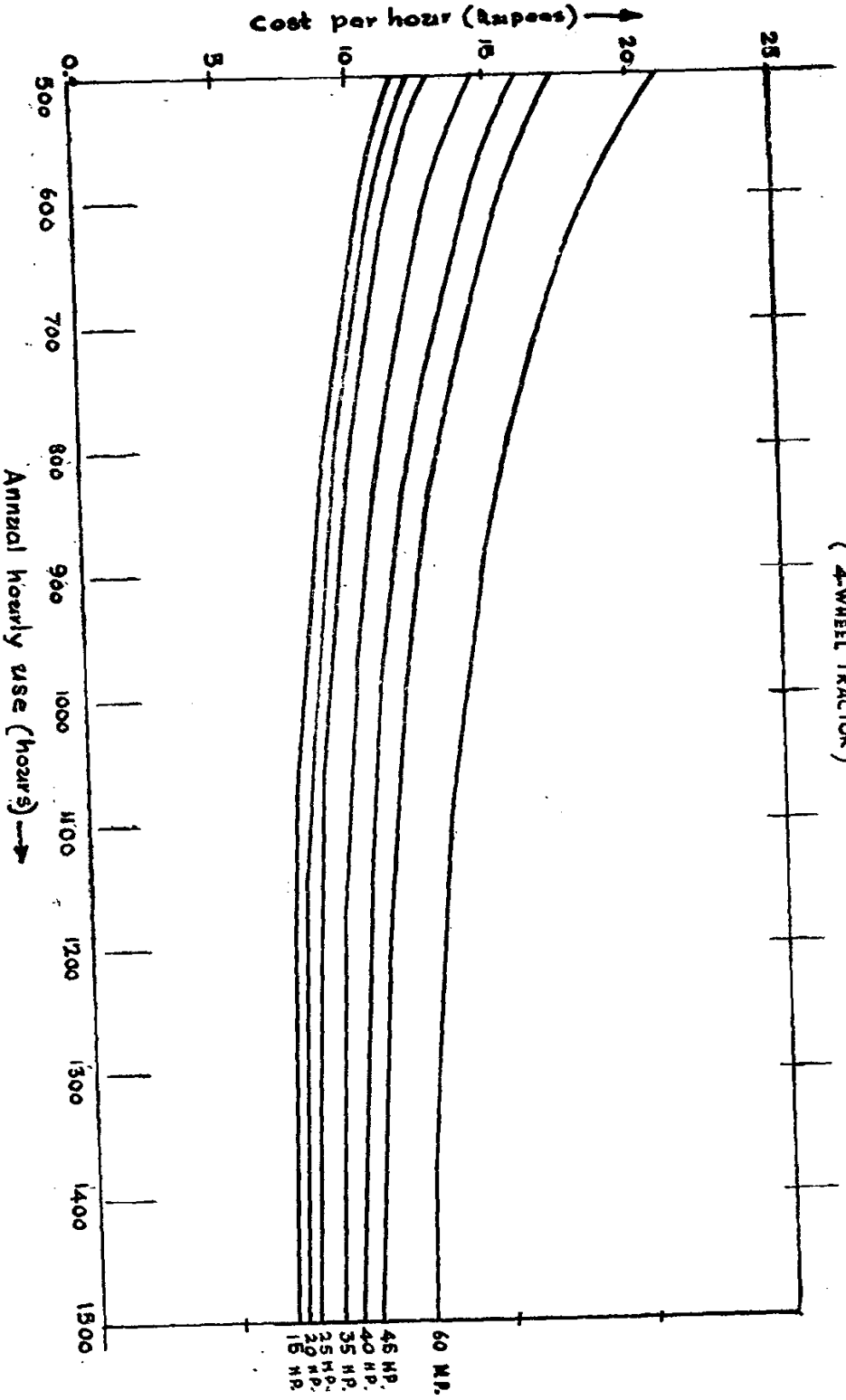


figure 2.

COST OF TRACTOR POWER

(4-WHEEL TRACTOR)

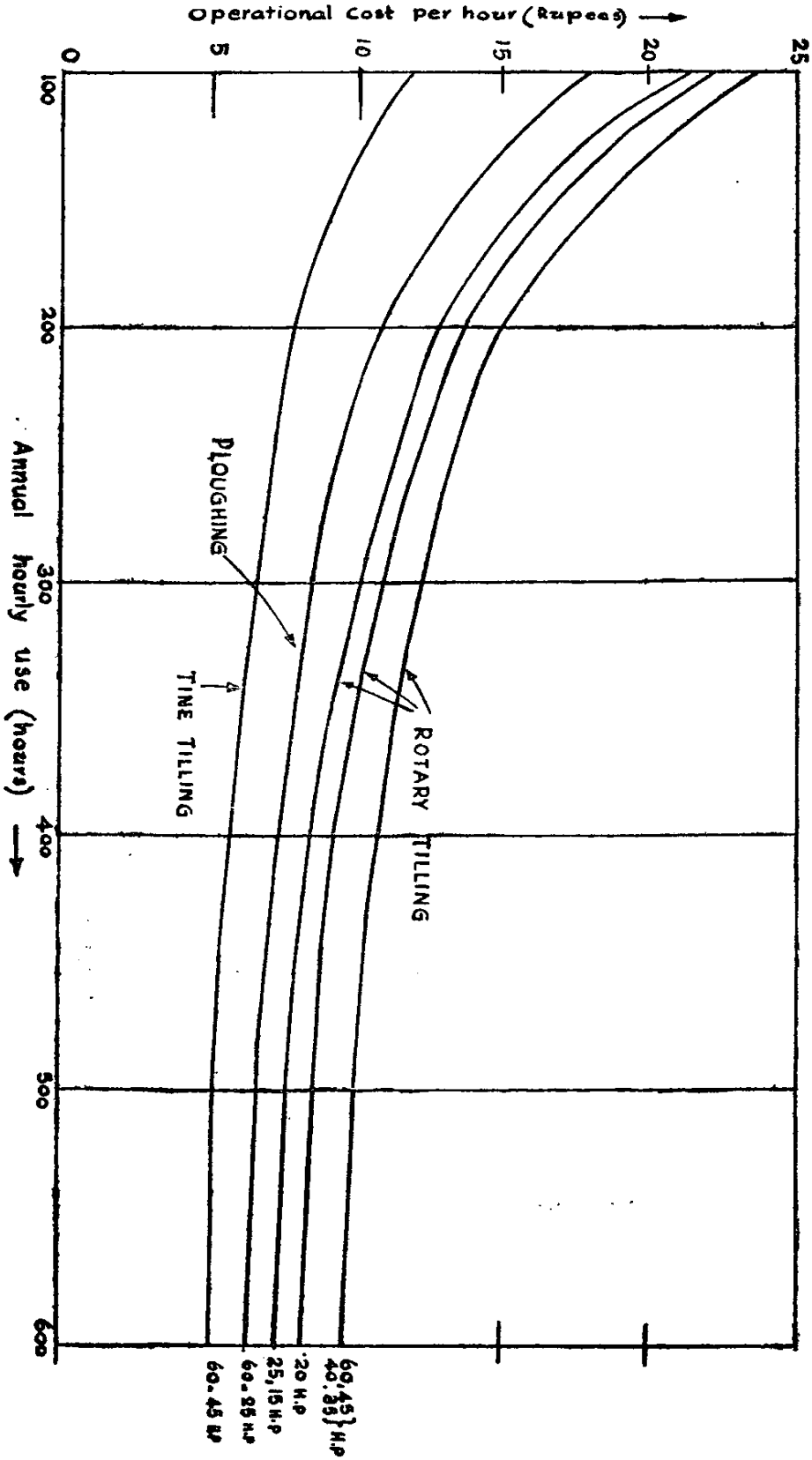


figure 3

4. WHEEL TRACTOR IMPLEMENTS AND OPERATIONAL COSTS.

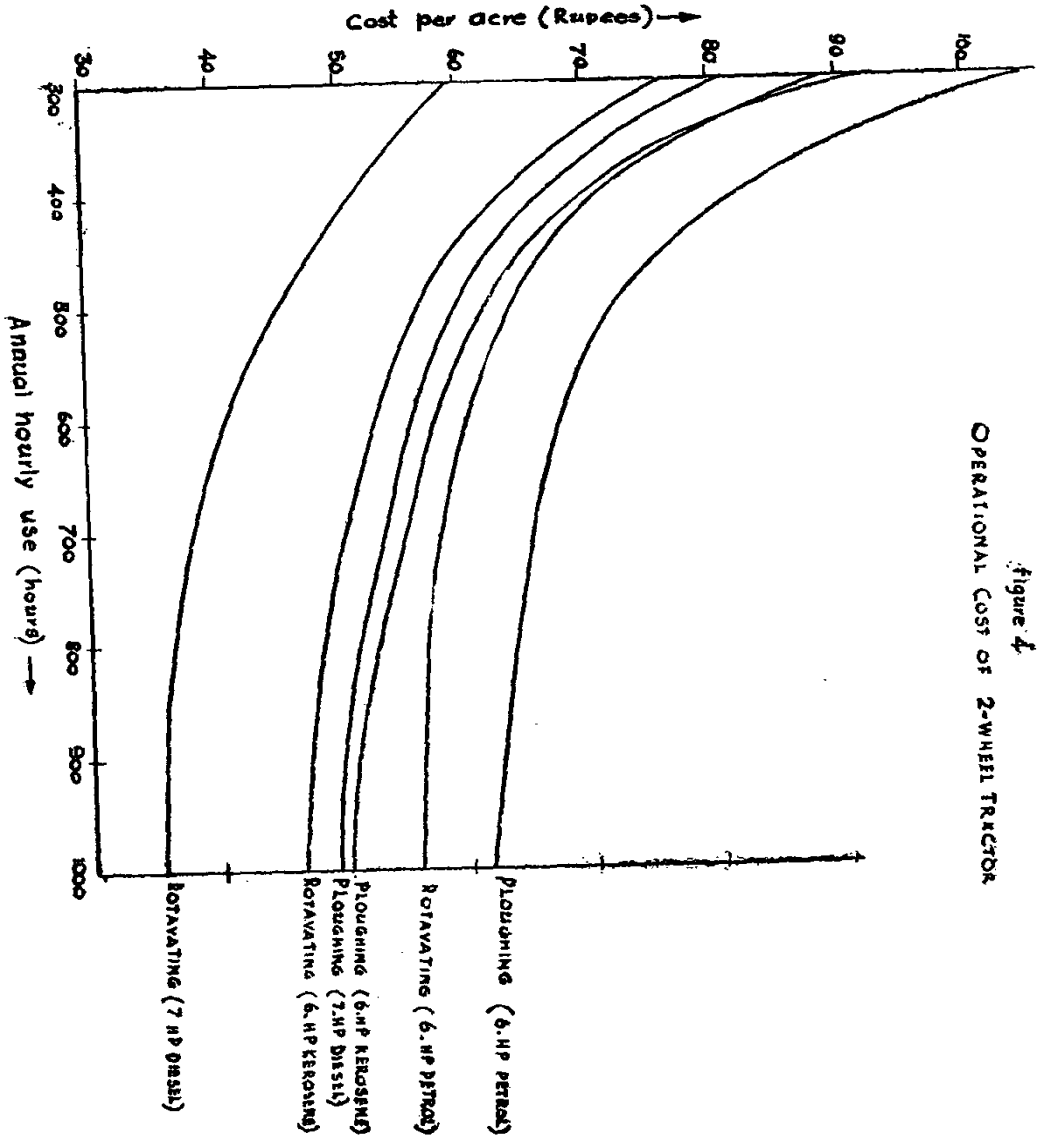


figure 4
OPERATIONAL COST OF 2-WHEEL TRACTOR