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THE RELATIONSHIP BETWEEN PLOT GEOMETRY AND INPUTS REQUIRED FOR FARM MACHINE OPERATION IN KOREA

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ABSTRACT

The rapid industrial growth, the consequent shortage of farm labour and increase in their wage level have facilitated more capitalized agricultural mechanization pattern in Korea. The efficiency of capital intensive machine is highly dependent on farm land structure. This paper describes a model explaining the relationship between farmland structure and required inputs for machine operation and to estimate required inputs for machine operation on the national basis for Korea for its paddy production system.

The machine cost is closely related to operation area, but the required labour-hours are more related to machine type adopted. From the technology introduction point of view, if capital intensive machine is introduced, less labour-hours are required but machine kW-hours increase rapidly. From the plot geometry point of view, on good geometry plots, machine kW-hour and labour-hour required are less than that on the poor geometry plots. The kW-hour per hectare of mechanical energy input id better indicator of mechanization level than kW per hectare or number of machines. If the adopted technology is more capital intensive and plot geometry is good, the cost reduction effect is highly significant.

Key Word : Korea, Farm, Machine, Operation, Plot, Geometry

INTRODUCTION

The shortage of labour and increasing wage level have facilitated more capitalized mechanization pattern. The efficiency of capital intensive machine is highly dependent on farm land structure (Ahn, 1992). The aims of this paper are: (a) to describe a model explaining the relationship between farmland structure and required inputs for machine operation; (b) to estimate required inputs for machine operation on the national basis; and (c) to investigate changes required in inputs according to changes in plot geometry through application of the model to Korean paddy production system.

LIST OF SYMBOLS

i	Plot geometry
j	Machine type
k	Operation area
AREA	Total area
AWT	Actual working time of a machine
HP	Required hp of machine
HPH	Required hp of the machine per ha
NOM	Required number of machines
OA	Operation area
RHP	Required hp of the machine for all areas
RHPH	Required hp-hours of the machine type for all area
RNO	Required number of operators
TRHP	Total required hp of the machine based on operation area
TRHPH	Total required hp-h of the machine based on operation area
TRNMO	Total required number of operators for machine type based on the operation area

STEPS OF MODELLING

(A) Input data required for the model are taken from Ahn (1992).
- (i) Area of paddy lands based on each plot geometry type.
- (ii) Relationship between machine size and machine power determined by regression method.
- (iii) Optimal machine type and size for a given machine operation area and plot geometry. The optimal machine size is converted into number and size of machines.

(B) Number of required inputs per hectare for each machine operation based on different operation area and plot geometry are calculated. Then, the required inputs, on the national basis for area of about 1 million ha under single paddy crop, such as total required number of machines, machine power (kW), energy (kW-hour), and labour-hours are estimated as the sum of required inputs for the area of each plot geometry.

Equations for calculation of required inputs:

(a) Required number of j^{th} type of machines per ha on i^{th} plot geometry and for k^{th} operation area (NMH_{ijk})

$$NMH_{ijk} = \frac{NOM_{ijk}}{OA_k} \quad (1)$$

(b) Required number of j^{th} machine type for all area of i^{th} plot geometry, based on k^{th} operation area (RNM_{ijk})

$$RNM_{ijk} = AREA_i \times NMH_{ijk} \tag{2}$$

(c) Total required number of j^{th} machine type based on k^{th} operation area ($TRNM_{jk}$)

$$TRNM_{jk} = \sum_{i=1}^{21} RNM_{ijk} \tag{3}$$

Similarly, HPH, RHP and TRHP can be calculated.

(d) Required hp-hours of the j^{th} type of machine per ha for i^{th} plot geometry based on k^{th} operation area ($HPHH_{ijk}$)

$$HPHH_{ijk} = \frac{HPH_{ijk} \times AWT_{ijk}}{OA_k} \tag{4}$$

Similarly, RHPH and TRHPH can be calculated.

(e) Required number of operators for j^{th} type of machine per ha of i^{th} plot geometry based on k^{th} operation area (NMO_{ijk})

$$NMO_{ijk} = NMH_{ijk} \times RNO_j \tag{5}$$

(f) Required number of operators for j^{th} machine operation for all areas of i^{th} plot geometry based on k^{th} operation area ($RNMO_{ijk}$)

$$RNMO_{ijk} = RNM_{ijk} \times RNO_j \tag{6}$$

Similarly, TRNMO can be calculated.

(g) Required number of labour per ha for j^{th} type of machine operation having i^{th} plot geometry based on the k^{th} operation area ($RNLH_{ijk}$)

$$RNLH_{ijk} = \frac{RNL_{ijk}}{OA_k} \tag{7}$$

(h) Required number of labour for j^{th} type of machine operation for all area of i^{th} plot geometry based in k^{th} operation area (RNL_{ijk})

$$RNL_{ijk} = AREA_i \times RNLH_{ijk} \tag{8}$$

(i) Total required number of labour of j^{th} machine type based on k^{th} operation area ($TRNL_{jk}$)

$$TRNL_{jk} = \sum_{i=1}^{21} RNL_{ijk} \quad (9)$$

RESULTS AND DISCUSSION

Required Total Inputs on the National Basis

Required inputs for whole paddy land of Korea on the national basis are shown in Fig. 1. As machine operation areas increase up to about 7-10 ha, the required number of machines, power and operation cost per ha decrease rapidly. Up to 7 ha, the required labour-hours are very high, because most of farm machinery used are labour intensive. For machine operation areas from 7-16 ha, the required labour-hours decrease rapidly because of the introduction of labour saving machines such as combine. This indicates that machine cost is more related to operation area whereas required labour-hours are more related to machine types adopted.

As the machine kW-hour per ha increases because of substitution of machine power for labour power, the machine kW-hour curve and labour-hour curve show opposite trends. Machine efficiency of capital intensive large machine, especially on small and scattered plots, is lower than that of labour intensive small size machine (Ahn, 1992). Also the energy use efficiency is rather low due to traction and transmission losses. It means that for the same job, higher kW-hour is needed for capital intensive machines than that for the labour intensive machines.

If machine operation area exceeds 20 ha, required inputs per ha remain nearly the same. This implies that if paddy land structure does not improve, there are some limitations in terms of reduction of required inputs and thereby the costs of machine operations.

Required Inputs by Type of Plot Geometry

Plots of 100 x 20m, 100 x 40m and 150 x 40m sizes were selected as samples to investigate the effects of plot geometry on required inputs for machine operation. The results are illustrated in Fig. 2 and discussed below:

(i) As shown in Fig. 2, if the operation area is smaller than 7 ha, in spite of differences in plot geometry, the required number of machines and kW per ha remain very large for all plot geometries. If the machine operation area exceeds 7 ha, on a good geometry plot, slightly less number of machines and kW per ha are required than those on a poor geometry plots.

(ii) On big plots with good geometry, machine power substitutes labour efficiently. As a result, the required labour-hours, machine kW-hour and machine operation cost per ha are significantly smaller than those on poor geometry plot (Figs. 2b and 2c).

Based on the above results, it can be said that the number of machines or kW per ha are not good indicators of the degree of mechanization. The reason is that when a large number of machines or higher kW per ha are used on a small machine operation area or poor geometry

plots, machine operation cost is very high. The kW-hour per ha is a better index on a homogeneous farmland structure, but this index also does not explain the effects of farm land structure. In other words, machine operation on the small farms with small scattered plots, for example the Korean agriculture, requires large amount of machine kW-hour or labour-hour per ha.

Required Inputs for Field Operation

Required inputs for each field operation were further examined as shown in Fig. 3. According to the results, land preparation requires the longest machine operation time and machine kW-hour. Because the puddling and transplanting operations have to be carried out simultaneously, it is expected that available operation period will become a serious constraint. For harvesting, especially, binder thresher combination case, a lot of labourers are required. As a result, available labour will become a serious constraint for harvesting. In general, harvesting is the most expensive operation, followed by land preparation and then transplanting.

CONCLUSIONS

(i) The machine cost is more related to operation area, whereas the required labour-hours are more related to the machine types adopted.

(ii) From the plot geometry point of view, on good geometry plots, machine kW-hour and labour-hour required are less than that on the poor geometry plots.

(iii) Number of machines and horse-power per ha does not represent the true level or quality of mechanization. The mechanization must be measured in terms of kWh/ha of mechanical energy input and its contribution to reduce production cost.

(iv) The effects of economic scale vary according to the type of mechanical technology introduced and farmland structure. If the adopted technology is more capital intensive and plot geometry is good, the cost reduction effect is highly significant.

REFERENCE

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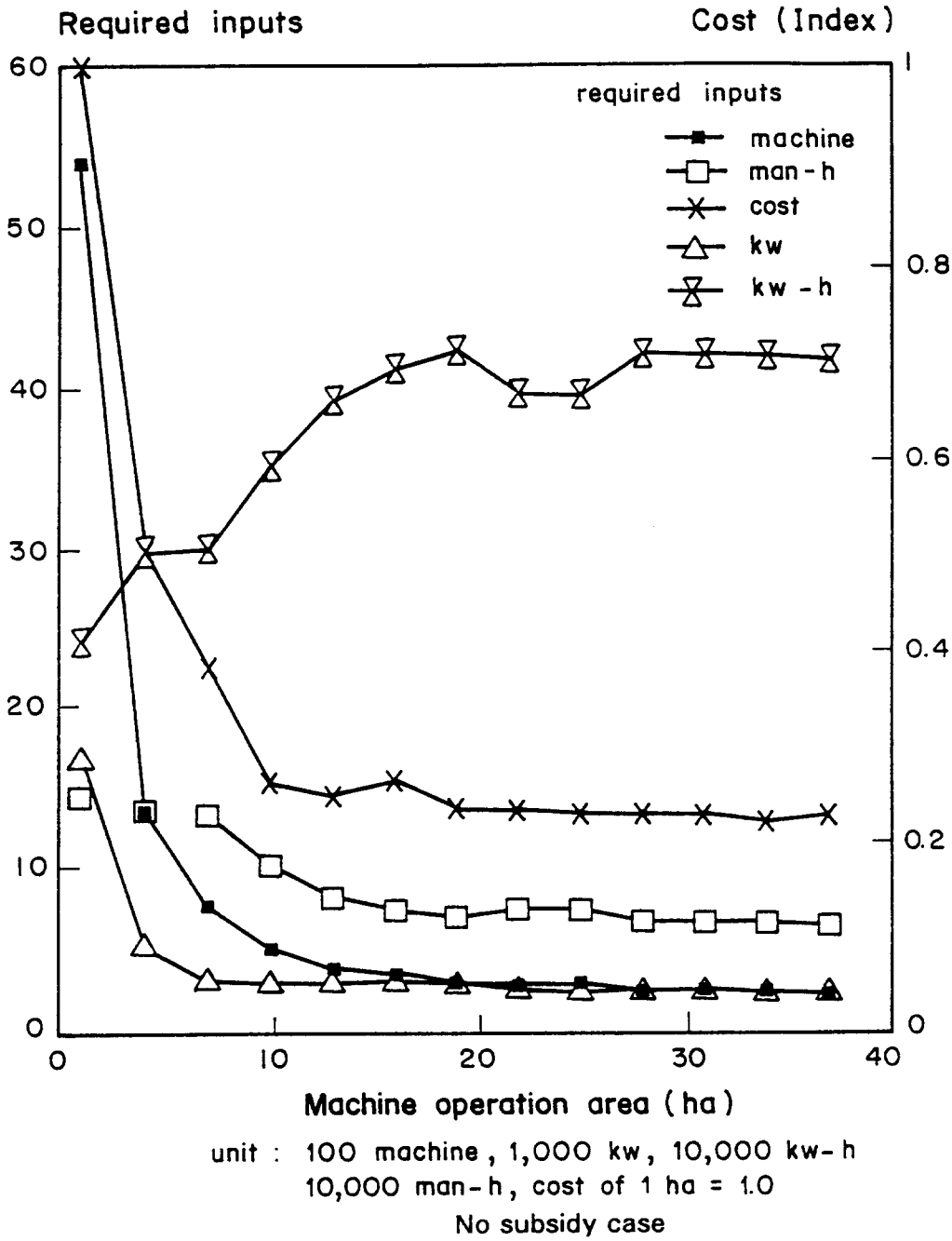

Fig. 1: Required inputs for whole paddy land in Korea

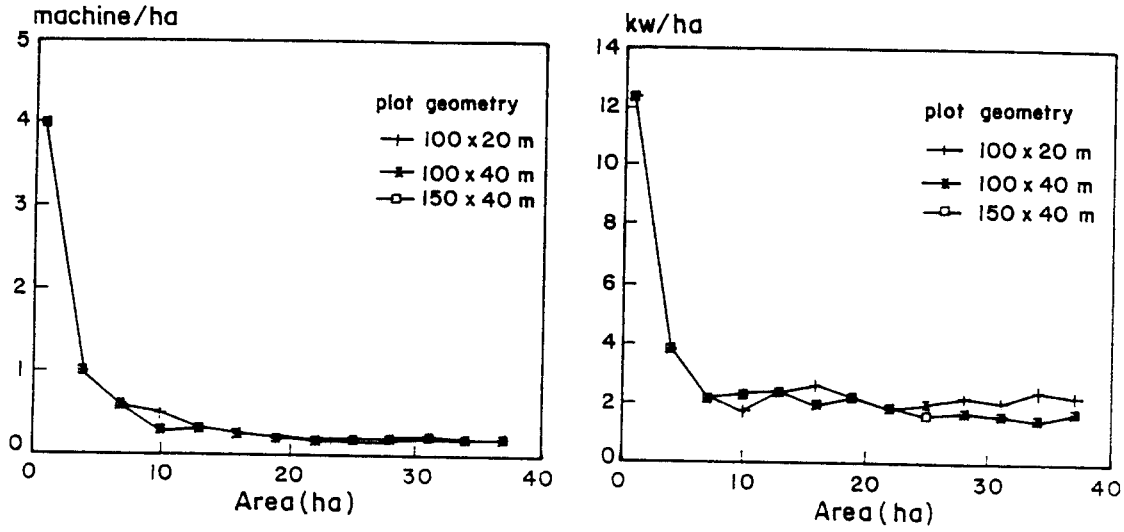

Fig. 2(a): Required number of machines and power

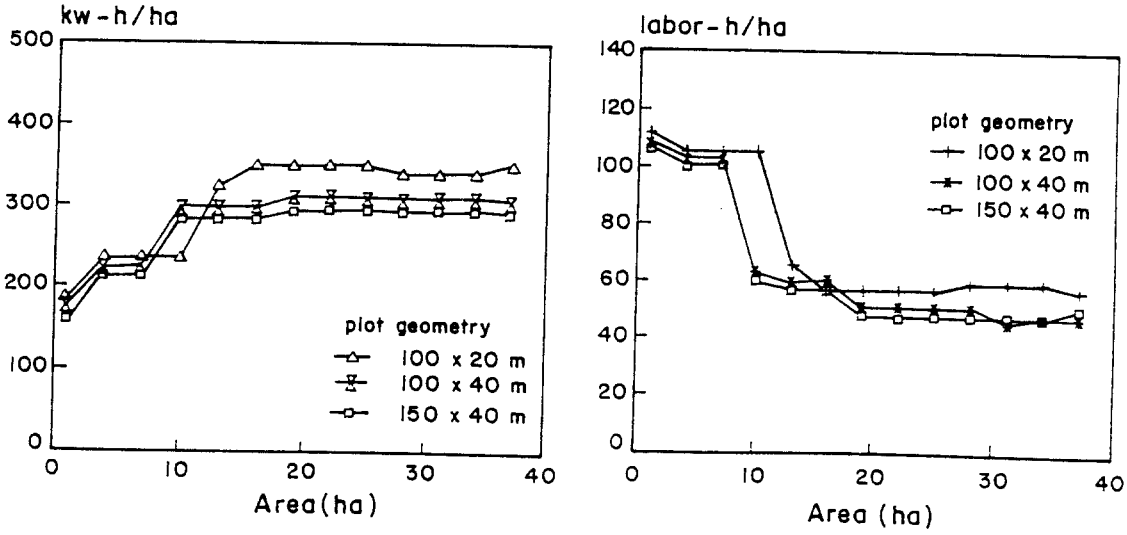

Fig. 2(b): Required energy and labour hour

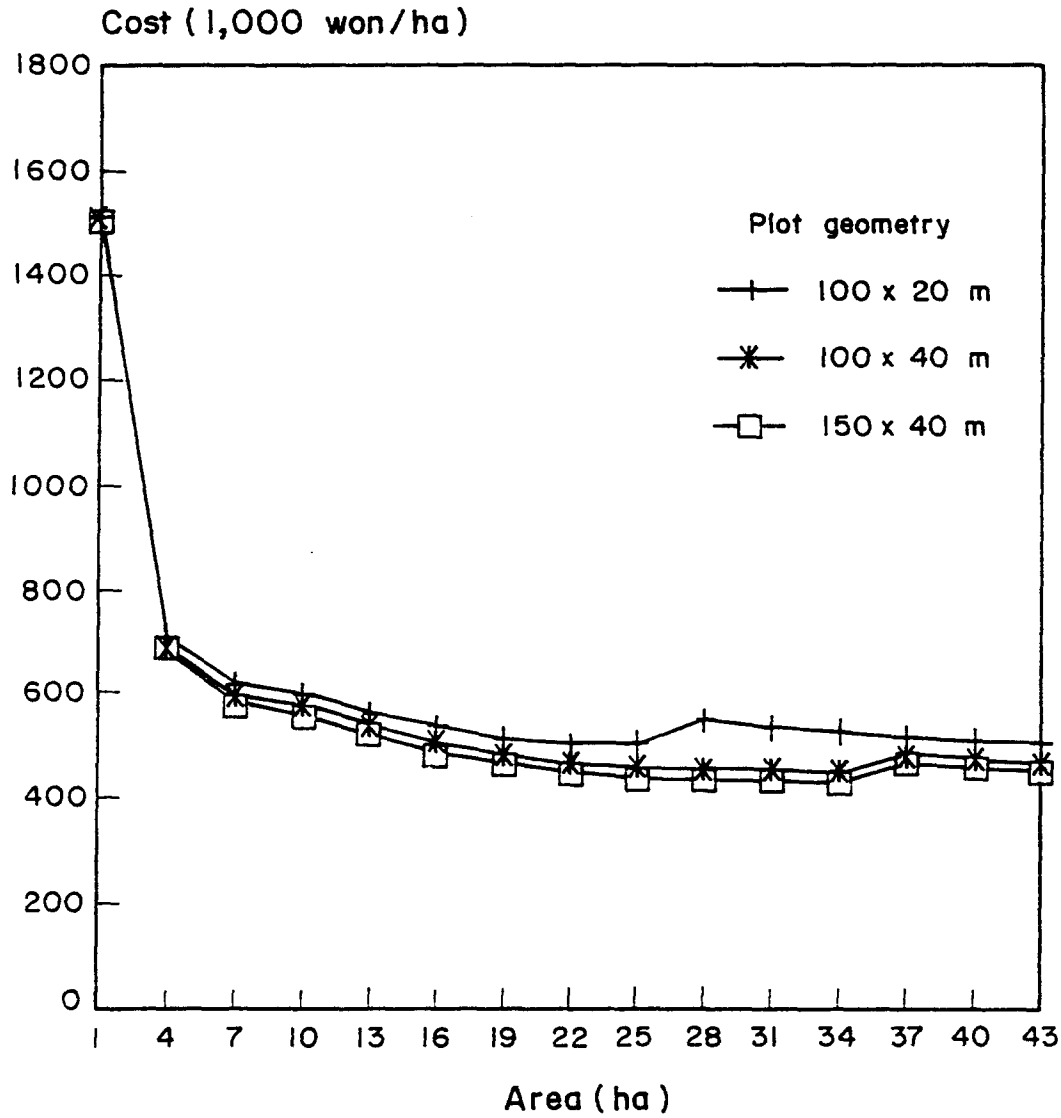

Fig. (2c): Machine operation cost and plot geometry

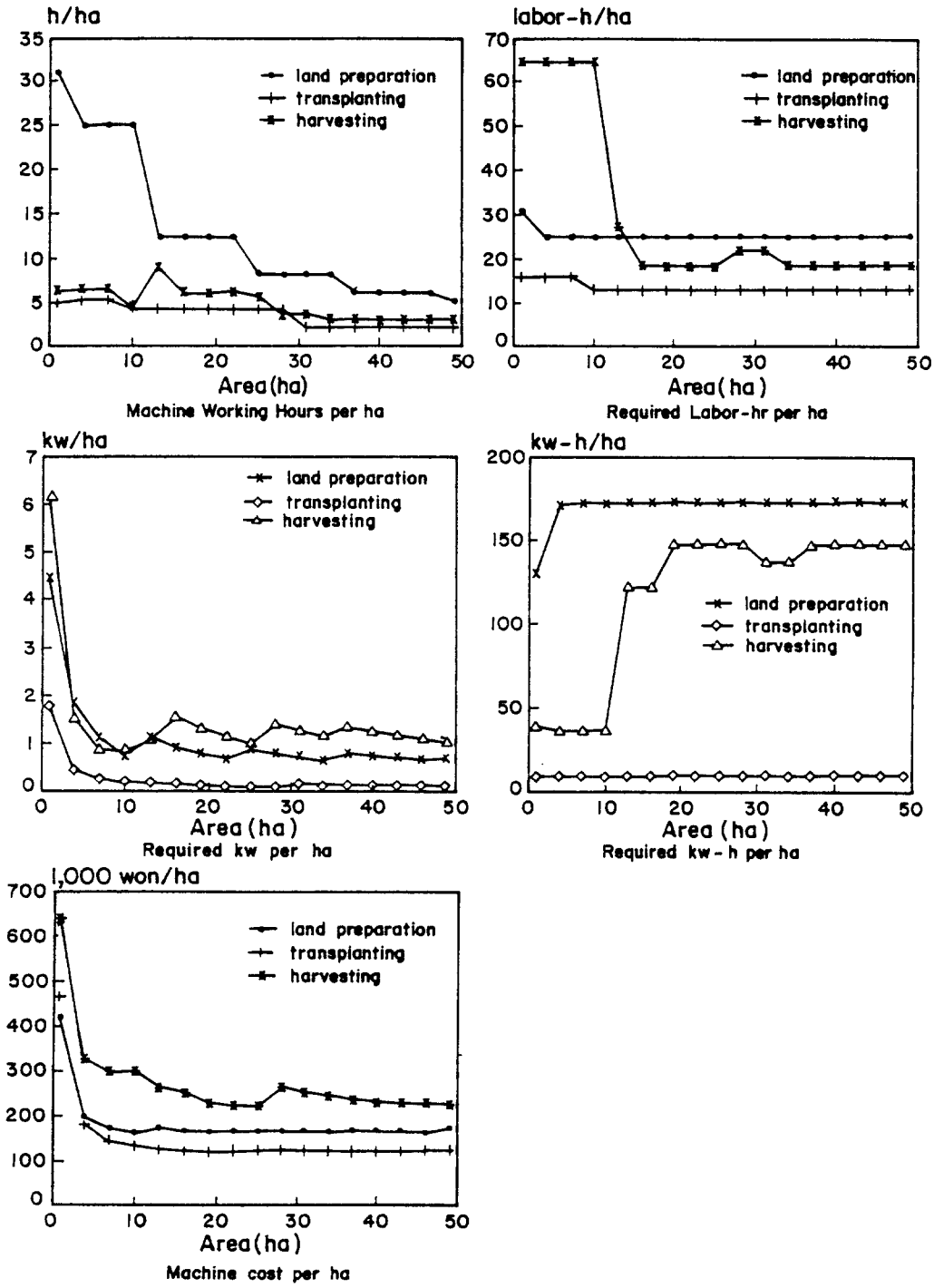

Fig. 3: Required inputs for each operation