FARM MECHANIZATION PLANNING

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TSUKUBA INTERNATIONAL CENTRE

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

TSUKUBA INTERNATIONAL CENTRE of JICA has opened the new course named as [Agricultural Mechanization for Sustainable Farming System] in 2002.

The Agricultural Mechanization for Sustainable Farming System Course was designed to systematically introduce scientific knowledge and technology on farm mechanization (such as effective selection, introduction and utilization of farm machinery), and to plan the appropriate farm work system for each country.

Farm mechanization planning is one of the most important and basic lectures in this course.

Therefore, this textbook was edited for understanding of following items:

1. Farm work series of rice cultivation
2. Farm machinery abilities
3. Cost analysis
4. Planning of the optimal farm work system

from the viewpoint of farm mechanization for sustainable farming system.

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INTRODUCTION

Machinery management has increased in importance in today's farming operations because of its direct relation to the success of management in using land, labor and capital to return a satisfactory profit.

The importance of machinery in the total farming operation is indicated by the machinery costs in relation to the total costs.

Typically, machinery costs overshadow all other crop production costs except land.

Machinery costs in Japan often account for more than twenty percent of total production costs, and can run as high as 28,000 Yen per 0.1 hectare per year for rice cropping systems. (See reference-12 and Table 0-1.)

Machinery costs in USA often account for fifty percent of total production costs, and can run as high as $200 per acre ($500 per hectare) per year for intensive cropping systems on irrigated land. It is not unusual to find that the difference in profit from one farm to another is due solely to differences in the machinery selected and the way it is managed. (See referece-3)

Table 0-1. Machinery cost in farm management

Production Cost of Agricultural Products in Japan, 1998-2000

Unit : Yen per 0.1ha

	Paddy field rice · Brown base: 1998		Paddy field rice · Brown base: 2000		Wheat ·husked: 1998	
Term	House-hold	%	House-hold	%	House-hold	%
Material and others	44,697	32.4	44,364	33.6	29,763	59.6
Land improvement, water utilization	7,913	5.7	7,224	5.4	702	1.4
Agricultural implements	**28,754**	**20.8**	**27,528**	**20.8**	**8,957**	**17.9**
Labour	56,986	41.3	53,103	40.2	10,479	21.0
Total cost	138,050	100.0	132,219	100.0	49,901	100.0

Source: "Survey of Production Cost" by the Ministry of Agriculture, Forestry & Fisheries.

1. MEANING AND PURPOSE OF MECHANIZATION

1-1. Effect of Mechanization

1) Saving cost in labor shortage

2) Stabilization farm system by work timeliness

3) Improvement of farm work by high efficiency of machine

4) Increase yield by working precisely

5) Make multi-crop system feasible for farm management etc.

6) Improvement of health by release from heavy work and improvement of living conditions

7) Release from gender gap by saving time spent to farm work of woman

8) Level up rural development by spreading of engineering knowledge

1-2. Farm Mechanization

Farm mechanization is based on total agricultural system, which is deeply connected to socio-economic environment of each country. So farm mechanization problem should be discussed from the point of view of, not only farm mechanization itself, but also socio-economic background.

For establishment of better farm work system, it is necessary to analyze and make a plan of them.

Systems engineering is one of the most powerful techniques how to apply the farm machinery for taking optimal actions to solve these complex and difficult mechanization problems.

First, the mathematical models should be built in from the original prototype systems, which are, in these cases, the farming systems.

$$Z = g(Y1, Y2, Y3, ---) \qquad \text{Eq. 1-1}$$

where,

symbol	term	unit
Z	Total model	-
Y1	Economical part	-
Y2	Ecological part	-
Y3	Cultural part	-
Y4	Social part (Gender, rural development etc.)	-

See fm-12.xls

1-2-1.Farm Mechanization Planning

On Farm Mechanization Planning, it is essential that the fundamental idea of farm mechanization is to find the conditions to make the objective function, that is, "total benefit" maximum in certain farming system.

$$B = M - D \qquad \text{Eq. 1-2}$$

where,

symbol	term	unit
B	Total benefit	-
M	Merit, something plus	-
D	Demerit, something minus	-

Generally in farm mechanization planning problem, we discuss to make the economic benefit maximum by increasing the production income and by decreasing the cost.

It is important to make economic benefit maximum, but we should also consider the total benefit from the point of wide view of other factors by evaluating of energetic benefit, healthy benefit and social matter etc. at same time.

Another point is to make clear that in what area we want to optimize the system. At the beginning we should define to plan the optimal system for the world level, or for the country level, or for farm enterprise, or for land owner, or for tenant farmer, or for farm laborer.

1-2-2.Economic Analysis

$$B = S - C \qquad \text{Eq. 1-3}$$

where,

symbol	term	unit
B	Economic benefit (profits or net return)	\$
S	Gross return or income (amount of production)	\$
C	Total expenses (cost for production)	\$

$$S = P * Y * A \qquad \text{Eq. 1-4}$$

where,

symbol	term	unit
S	Gross return or income (amount of production)	$
P	Price per unit weight	$/kg
Y	Yield	kg/ha
A	Area of farm	ha

Amount of production S is calculated by multiplying the price P of a unit weight and the yield Y and the total area A. Therefore, the higher price, the more yield and the wider area, then the larger income.

$$C = FC + VC \qquad \text{Eq. 1-5}$$

where,

symbol	term	unit
C	Total cost	$
FC	Fixed cost	$
VC	Variable cost	$

Fixed cost is constant and variable cost increases, when annual working area increases.

1-3. Exercise

Exercise 1-1.

List up your feeling of farm mechanization target.

Term of benefit	weight example	%	your data	%
Economic	70	45.2		
Ecological	20	12.9		
Cultural	10	6.5		
Political	10	6.5		
Social	10	6.5		
Energetic	15	9.7		
Human healthy	20	12.9		
Total	155	100		

2. RATE OF WORK

Rate of Work or Farm work capacity (or efficiency) varies by equipment capacity, operator ability, and field and crop conditions.
Work abilities of machine or manual for field work, will be expressed by hours per area, or area per hour, which is called as area capacity.
Work abilities of machine or manual for stationary work, will be expressed by hours per weight, or weight per hour, which is called as material capacity.

In this textbook, Effective Field Capacity is commonly used as hectares or tons per an hour, in a block of field or a unit of material. In the case of farm work by machine, Effective Field Capacity will be expressed the value on a set of machine with operators. In manual farm work, Effective Field Capacity will be expressed the value by a worker.
Also, Work Capacity is defined the reciprocal of Effective Field Capacity, like as hours per a hectare or a ton.

2-1. Effective Field Capacity

Effective Field capacity is the actual rate of land or crop processed in a given time. Effective Field capacity is called as field capacity simply.

2-1-1.Effective Field Capacity for field work

$$EFC = A / T \qquad \text{Eq. 2-1}$$

$$WC = 1 / EFC = T / A \qquad \text{Eq. 2-2}$$

Where,

symbol	term	unit
EFC	Effective Field Capacity	ha/h
T	Total time required a farm work	h
A	Field area	ha
WC	Work Capacity	h/ha

a) Total time required a farm work

Field time is in ASAE defined like as; the time a machine spends in the field measured from the start of functional activity to the time the functional activity for the field is completed.

b) Field area

Field area for effective field capacity is a field block as minimum unit.

c) Example

See Table A-211., A-212., A-213. Standard value of effective field capacity in appendix.

Exercise. 2-1, 2-2, 2-3

2-1-2. Effective Field Capacity for stationary work etc.

$$\mathbf{EFC = (P / Y) / T} \qquad \textbf{Eq. 2-3}$$

$$\mathbf{WC = T / (P / Y)} \qquad \textbf{Eq. 2-4}$$

Where,

symbol	term	unit
EFC	Effective Field Capacity	ha/h
T	Total time required a farm work	h
P	Weight of production, grain etc.	t
Y	Yield or amount per hectare	t/ha
WC	Work Capacity	h/ha

a) Weight of production, grain etc.

Weight of production, grain etc. should be in a certain unit expression.

b) Example: Table A-214. Standard Capacity of Grain Dryer in appendix.

Exercise. 2-4

2-1-3. Total operating time

$$\mathbf{T = ta + tb + tc + td + te + tf + tg + th + ti} \qquad \textbf{Eq. 2-5}$$

Where,

T	Total operating time
ta	Actual operating time
tb	Turning time
tc	Moving time
td	Regulating time
te	Rest time
tf	Loading or unloading time
tg	Transporting time
th	Waiting time
ti	Supplementing time

Total operating time will be measured by time study. See 2-2-2.

Exercise. 2-5

2-1-4. Theoretical field capacity

Theoretical field capacity is the rate of performance obtained if a machine performs its function 100% of the time at a given operating speed using 100% of its theoretical width. (See ASAE S495)

a) Theoretical field capacity

The theoretical field capacity will be led from the following equation.

TFC = Wt * Vt * K **Eq. 2-6**

Where

symbol	term	Unit: 1	Unit: 2
TFC	Theoretical field capacity	ha/h	ha/h
Wt	Theoretical operation width	m	m
Vt	Theoretical operation speed	km/h	m/s
K	Constant	0.1	0.36

We use unit-1 system normally, therefore theoretical field capacity is shown as follows.

TFC = Wt * Vt * 0.1 **Eq. 2-7**

See fm-215.xls

Exercise. 2-6

b) Theoretical work capacity

Theoretical work capacity is a reciprocal number of theoretical field capacity.

TWC = 1 / TFC **Eq. 2-8**

Where, TWC: Theoretical work capacity: (h/ha)

See fm-215.xls

2-1-5. How to obtain theoretical operation width and speed

a) How to obtain theoretical operation width

Theoretical operation width is the measured width of the working portion of a machine. For row crop machine, it is the average row width times the number of rows.

(i) The width of implement (machine width)

It is defined by using machinery standard (usually shown by catalogue).

(ii) Actual operation width (effective operation width)

This is the actual operation width in the field, obtained by the width of the field divided by the number of actual strokes in operation.

(iii) Planned operation width

This operation width is used for making the utilization plan of farm machinery under given detail work circumstances.

For example, in the spraying operations with two stokes on 30 meters width of field, its operation width is estimated as 15m, even if the possible width of the swath sprayer is 20 meters.

We will use above mentioned operation width (W) shown in next table as theoretical operation width (Wt).

Exercise. 2-7

b) How to obtain theoretical operation speed

Field speed is defined in ASAE like as; Average rate of machine travel in the field during an uninterrupted period of functional activity. For example, functional activity would be interrupted when the implement is raised out of the soil.

Operation speed is indicated with speed of straight movement of work.

The travel speed is varied by the following facts:

1. Condition of soil texture, moisture contents, shape and inclination of the field.
2. The level or rate of operator's skill
3. The size of tractor and machine

Standard operation speed is shown in Table 215a.

General operation speed is shown in Table A-215b in appendix.

We will use these rated or actual operation speed (V) as theoretical operation speed (Vt). Therefore, theoretical field capacity is shown as follows.

TFC (ha/h) = W (m) * V (km/h)* 0.1 **Eq. 2-9**

Also, theoretical field capacity is simply obtained by actual operating time (Ta) for the area (A) as follows, if there is no overlapped in operating width.

TFC (ha/h) = A (ha) / Ta (h) **Eq. 2-10**

Table 215a. Theoretical operation width and standard operation speed

Farm work	Field	Work	Machine	Theoretical operation width	Standard operation speed
					(km/h)
Tillage, land preparation	Paddy	Tillage	Bottom-plow, Japanese plow	Shear width	6.0
	Paddy	Tillage	Rotary(<20PS)	Machine width	2.0
	Paddy	Tillage	Rotary(>30PS)	Machine width	2.5
	Paddy	Harrow and puddling	Rotary	Machine width	3.0
	Paddy, upland	Leveling	Tooth harrow	Machine width	7.0
	Paddy	Puddling	Paddy harrow	Machine width	4.0
	Paddy, upland	Harrow and leveling	One-way harrow	Machine width	6.0
	Paddy, upland	Pressing	Culti-packer	Machine width	6.0
	Paddy	Pan braking	Sub-soiler	Planning width	3.6
Fertilizing, Seeding	Paddy, upland	Manure spreading	Manure spreader	Planning width	7.0
	Paddy, upland	Fertilizing	Broad caster	Planning width	6.0
	Paddy, upland	Ridging	Ridge	Row width x Row number	5.0
	Paddy, upland	Fertilizing and seeding	Seed drill	Row width x Row number	6.0
	Paddy	Fertilizing and seeding	Fertilize seeder	Row width x Row number	2.0
	Paddy, upland	Fertilizing and seeding	Fertilize seeder	Row width x Row number	2.5
Trans-planting	Paddy	Rice transplanting	Rice transplanter	Row width x Row number	2.3
	Paddy	Rice transplanting	Rice transplanter (rotary type)	Row width x Row number	3.0
Harvesting	Paddy, upland	Chemical application	Wide swath sprayer	Rated working width	2.5
	Paddy, upland	Chemical application	Boom sprayer	Nozzle interval x its number	5.0
	Paddy, upland	Harvest (rice)	Combine	Cutting width	2.5
	Paddy, upland	Harvest (wheat)	Combine	Cutting width	4.2
	Paddy, upland	Pick and baling	Hay baler	Windrowing width	6.0
	Paddy, upland	Reaping	Binder	Cutting width	6.0

Source: JSAM: Handbook of Bioproduction Machinery, 1996

2-1-6.Field Efficiency: (or Functional Efficiency)

a) Field Efficiency

Actual effective field capacity is different from theoretical field capacity. For example, actual field operation is including loss times of turning, feeding etc. Therefore, actual effective field capacity might be smaller than theoretical field capacity.
The following equation shows to find field efficiency.

$$ef = EFC / TFC \qquad \text{Eq. 2-11}$$

or,

$$EF = EFC / TFC * 100 \qquad \text{Eq. 2-12}$$

Also, Field Efficiency is obtained from Eq. 2-1 and Eq. 2-10 as follows.

$$ef = Ta / T \qquad \text{Eq. 2-13}$$

or,

$$EF = Ta / T * 100 \qquad \text{Eq. 2-14}$$

Where,

symbol	term	unit
EFC	Effective Field Capacity	ha/h
TFC	Theoretical Field Capacity	ha/h
ef	Field Efficiency in decimal	
EF	Field Efficiency in percentage	%
Ta	Actual operating time	h
T	Total operating time	h

Exercise. 2-8, 2-9

b) Functional efficiency

Functional efficiency is the ratio of the actual effectiveness of a machine to its theoretical effectiveness, expressed in percent. Threshing efficiency of a combine is an example of a functional efficiency.

See Table A-216. Field Efficiency in appendix

2-2. How to obtain the Effective Field Capacity

Actual effective field capacity will be estimated by calculation using theoretical field capacity and field efficiency, when no data of effective field capacity is directly obtained.

2-2-1.Daily experience or Past data-base

Farmers know how many hours required for certain farm work by certain machines in their own field. This is Effective Field Capacity.
Data-base is powerful to find the useful data for planning.
Simple data-base will be build up by spread-sheet software, instead of the data-base software like "ACCESS". See fm-211.xls db-efc-1.

2-2-2.Time Study

Motion-and-time study is defined as determining the time necessary to perform motions required for a particular job.

a) Work time for certain farm work

Farm Work will be operated with a certain farm facilities set, and it includes certain machine set and workers.

Example a: A = 0.1 ha, Number of workers = 3 in harvesting

	Term	Machine (min)	Labor (min)	Time required of a set (h)	EFC (ha/h)
ta	Actual operating time	47			
tb	Turning time	9			
td	Regulating time	4			
T	Total time	60	180	1.0	0.1

b) Machine or implement

Operating time of machine should be measured, even if it is automatic machine or farm robot.
If more than 2 machine sets are used for a farm work, then accumulated time should be counted for total time. After that, the value should be converted to it on a set.

c) Operator and Labor

Total time of manual work without machinery should be the accumulated time of all workers. And the value of time on a worker is shown as Effective Field Capacity of manual work.

MH = T * Nw **Eq. 2-15**

EFC = A / MH **Eq. 2-16**

Where,

symbol	term	unit	Example
	Farm Work	-	Manual weeding
A	Field area	ha	0.1
Nw	Number of workers	-	2
T	Time required	h	1.5
MH	Labor required (Man hours)	h	3.0
EFC	Effective Field Capacity	ha/h	0.033

2-2-3.Estimation by calculation

Effective Field capacity and work capacity are estimated by following equation normally.

EFC = TFC * ef **Eq. 2-17**

Or,

EFC = TFC * EF / 100 **Eq. 2-18**

EFC = (W * V * 0.1) * ef **Eq. 2-19**

Or,

EFC = (W * V * 0.1) * EF / 100 **Eq. 2-20**

Also, from Eq. 2-2.

WC = 1 / EFC

Example:

a) Effective field capacity in case of tillage by power tiller

symbol	term	unit	Example
W	Width	m	0.7
V	Speed	km/h	1.2
TFC	Theoretical Field Capacity	ha/h	0.084
EF	Field Efficiency	%	90.0
EFC	Effective Field Capacity	ha/h	0.0756
WC	Work capacity	h/ha	13.23

See fm-22.xls

b) Effective field capacity in case of manual weeding

EFC-manual = Area / Time required by one worker

c) Effective field capacity in case of automatic grain dryer

Effective field capacity will be explained in detail, as of machine working time, or as of time required for operator.

Exercise. 2-10, 2-11, 2-12

2-3. What factors affect on the Effective Field Capacity

Even if the area is the same, the field efficiency of plowing varies. The higher ratio of the long side to the short side has larger value of the field efficiency.
As field efficiency varies with shape, size operation method and operator's skill, the numbers in Table A-232 will be the standard to field the actual effective field capacity form the theoretical field capacity.

2-3-1. Machinery

a) Width

b) Speed

c) Power

2-3-2. Field condition

a) Size of field

b) Shape of field

The filed size and shape will affect effective field capacity and work capacity, like as shown following equations (Table 23.).

See Table A-232. (fm-232.xls): Relationships between Field Efficiency and Field Size, in appendix.

Exercise. 2-13

Table 23. Effect of field size and shape etc. in upland field

Machinery	Operating method	Analytical equations	
Rotary	Continuous, turn at each end	T = (x*y)/(v*w) + (x/w) * t1 + tc + td + te	
Mount type drill seeder		T = (x*y)/(v*w) + (x/w) * t1 + tc + td + te + tf	tf = (qf*x*y*t4f)/Qf + (qs*x*y*t4s)/Qs
Mount type boom sprayer		T = (x*y)/(v*w) + (x/w) * t1 + tc + td + te + tf + tg	tf + tg = (t4 + t5)*(q*x*y)/Q
Bag unloading type combine		T = (x*y)/(v*w) + (x/w) * t1 + tc + td + te + th	

where,

symbol	term	unit
T	Total operating time	h, s
x	Width of field	m
y	Length of field	m
w	Effective operating width	m
v	Effective operating speed	m/s
ta	Actual operating time	h, s
tb	Total turning time	h, s
tc	Moving time in field	h, s
td	Regulating time	h, s
te	Rest time	h, s
tf	Total loading or unloading time	h, s
tg	Total transporting time	h, s
th	Waiting time	h, s
t1	U type turning time	s
t2	Δ type turning time	s
qf	Spreading quantity of fertilizer per unit area	kg/m^2
qs	Spreading quantity of seed per unit area	kg/m^2
Qf	Fertilizer hopper capacity	kg
Qs	Seed hopper capacity	kg
t4f	Fertilizer loading time	s
t4s	Seed loading time	s
t4	Loading or unloading time	s
t5	Transporting time	s

Example (a): Rotary tillage

In case of plow, total time will be shown as followings:

T = (x*y)/(v*w) +(x/w) * t1 + tc + td + te

where,

symbol	term	unit	Example
x	Width of field	m	49.5
y	Length of field	m	107
w	Operating width	m	1.55
v	Operating speed	m/s	0.38
tc	Moving time in field	s	90
td	Regulating time	s	500
te	Rest time	s	0
t1	U type turning time	s	20
t2	Δ type turning time	s	50

$$T (s) = 1.698 * x * y + 12.9 * x + 590 \quad \text{Eq. 2-21}$$

$$T (h) = 0.000472 * x * y + 0.00358 * x + 0.164 \quad \text{Eq. 2-22}$$

$$T = 0.000472 * A * 10000 + 0.00358 * 100 * SQRT (A / m) + 0.164 \quad \text{Eq. 2-23}$$

$$T = 4.72 * A + 0.358 * SQRT (A / m) + 0.164 \quad \text{Eq. 2-24}$$

$$EFC = A / [4.72 * A + 0.358 * SQRT (A / m) + 0.164] \quad \text{Eq. 2-25}$$

where,

symbol	term		unit
m	Ratio of length and width of field	y / x	-
A	Size of a field	x * y	ha
EFC	Effective Field capacity	A / T	ha/h

Fig. 23. shows how the effective field capacity is varied with size and shape of field, which is expressed by the above equation 2-25.

See Table A-23b. and fm-23.xls

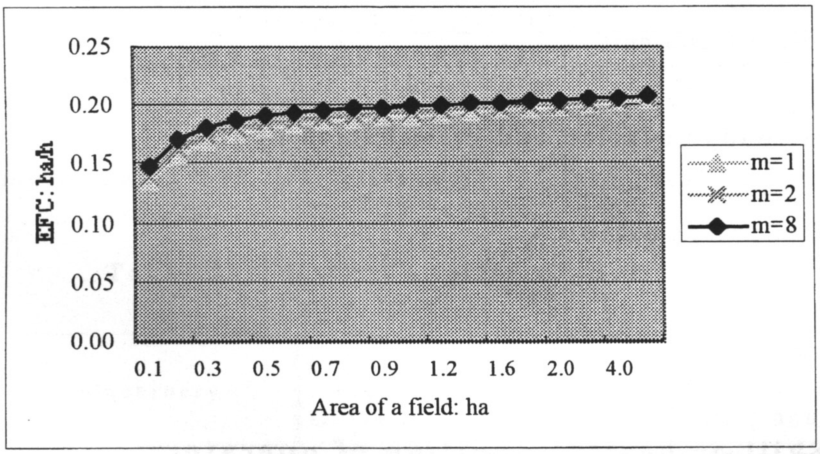


Fig. 23. Effective Field Capacity vs. area of a field in Rotary tillage

See Table A-23b. and Fig. A-23 for plowing in appendix.

c) Head land

d) Inclination of field

e) Soil condition [1]

(i) Soil texture
(ii) Soil hardness
Cone penetrometer, Falling cone, Footprint depth, Hardpan
(1) SR-2 Soil resistance tester
(2) Depth of human footprint

Table 232e. Depth of human footprint in paddy field
Standard judgement for trafficability of tractor and combine

	Tractor			Combine clearance		
	Rotary	Bottom plow	Bottom plow with girdle	<10cm	10-20cm	>20cm
Footprint depth	cm			cm		
easy	<2	0	<1	<2	<3	<4
limit of possible	2-5	0-2	1-5	2-5	3-7	4-10
impossible	>5	>2	>5	>5	>5	>10

(iii) Moisture contents

f) Farm road, Location and distribution of fields

2-3-3.Crop condition

a) Variety

b) Yield

2-3-4.Skill or health condition of operator

If the field small and operators and unskilled, 'low' or between 'low' and 'standard' are used.
If the field is large and operators are well skilled, 'high' or between 'high' and 'standard' are used in Table A-216. in appendix.

1 Soil physical properties

2-4. Daily Capacity

Daily Capacity will be expressed the value on a farm work by several sets of machine with operators in the several field blocks on a day. In manual farm work, Daily Capacity will be expressed the value by a group of several workers.

2-4-1.Daily Capacity

DC = EFC * Dn **Eq. 2-26**

Dn = Dt * NWR / 100 **Eq. 2-27**

From above two equations,

DC = EFC * Dt * NWR / 100 **Eq. 2-28**

Where,

symbol	term	unit
DC	Daily Capacity	ha/d
EFC	Effective Field Capacity	ha/h
Dn	Net Work hours per day	h/d
Dt	Working hours per day	h/d
NWR	Daily net working rate	%

a) Example: Table 241. Daily Capacity of farm work: fm-241.xls

Table 241. Daily Capacity of farm work

Work Name	Machinery	Effective Field Capacity	Work capacity	Work hour per day	Net Work rate	Net Work hours	Daily Capacity
		EFC	WC	Dt	NWR	Dn	DC
	unit	ha/h	h/ha	h/d	%	h/d	ha/d
Land preparation	Walking Tractor + Rotary	0.083	12.0	8.0	75	6.0	0.50
Weeding	Manual	0.009	111.1	8.0	80	6.4	0.06
Sowing	Walking Tractor + 2-Row Seeder	0.126	7.9	8.0	65	5.2	0.66
Trans-planting	Rice transplanter	0.036	27.8	10.0	73	7.3	0.26
Chemical application	Boom sprayer	0.273	3.7	8.0	75	6.0	1.64
Harvesting	Head-feeding combine	0.052	19.2	8.0	68	5.4	0.28

Exercise. 2-14

2-4-2. Daily working hours

$$Dt = Dn + Dp + Ds + Dc + Df + Da + Dm + Dr + Db \qquad \text{Eq. 2-29}$$

Where,

symbol	term	unit
Dt	Total daily working hours	h
Dn	Net working hours	h
Dp	Preparation time of work	h
Ds	Time for setting	h
Dc	Time for cleaning of farm machines	h
Df	Time for feeding	h
Da	Adjustment time	h
Dm	Moving or traveling time	h
Dr	Repairing time	h
Db	Short brake time or time for non operation or lunch time	h

a) Example: Table 242.and fm-242.xls

Table 242. Actual survey of daily work hours (Harrowing by disk harrow, and plowing)

Items	Clock Time			Items of required hours									Area	Remarks
				Working hours: Dn		Other extra hours								
	Starting time	Ending time	Net hours	Plow	Disk harrow	Dp	Db	Ds	Dc+Df	Da	Dm	Dr		
	h.min												ha	ha/h
Garage-Field 1	7.02	7.19	17					2	10		5			
Field 1	7.19	9.53	2.34	2.31		3							0.445	0.178
Field 2	9.53	11.15	1.22	1.07		3	10				2		0.164	0.15
Field 2-Garage	11.15	11.44	29			4	9		10		6			fueling
Lunch Time	11.44	13.31	1.47				1.47							
Garage-Field 3	13.31	13.39	8			1					4	3		
Field 3	13.39	17.00	3.21	3.19		2							0.5	0.151
Field 3-Garage	17.00	17.12	12					7			4	1		
Garage-Field 1	17.12	17.21	9								5	4		
Field 1	17.21	18.34	1.15		1.14							1	0.445	0.361
Field 1-Garage	18.3	18.53	17					2	10		5			
Total (min)	7.2	18.53	711	417	74	13	126	11	30		31	9	1.11	0.16
Rate (%)			100	58.6	10.4	1.8	17.7	1.5	4.2		4.4	1.3		
	Daily net working rate								69.0 %					

Where, Dt: Total daily working hours

Dn: Net working hours

Dp: Preparation time of work

Ds: Time for setting

Dc: Time for cleaning of farm machines

Df: Time for feeding

Da: Adjustment time

Dm: Moving or traveling time

Dr: Repairing time

Db: Short brake time or time for non operation or lunch time

Exercise. 2-15

2-4-3. Daily net working rate

$$NWR = Dn / Dt * 100 \qquad \text{Eq. 2-30}$$

Where,

symbol	term	unit
NWR	Daily net working rate	%
Dn	Net working hours	h
Dt	Total daily working hours	h

a) Example: Table 243a.and fm-243a.xls

Exercise. 2-16

Table 243a. Standard Value of Daily Net Working Rate

Name of operation	Daily Net Working Rate (%)						Main equipment
	One operator			Two operators			
	Distribution of field			Distribution of field			
	Small	Mid.	Large	Small	Mid.	Large	
plowing	66	69	72	78	81	84	Suki, Bottom plow, Rotary
Harrowing & leveling	68	71	73	80	83	85	Disk harrow, Rotary tooth harrow
Pressing	70	73	76	81	84	86	Roller, Culti- packer
Puddling	63	66	70	75	78	80	Rake, Puddling-rotor. Rotary
Fertilizer & sowing	55	60	65	70	74	77	Manure spreader, Lime sower, Broad-caster, Grain drill
Rice transplanting	59	63	67	70	75	80	Rice transplanter
Chemical spray (liquid water)	62	64	66	69	73	75	Power mist sprayer
Chemical spray (duster)	69	73	75	73	78	82	Power duster
Chemical spray (granule)	72	76	80	80	84	88	Knapsack type power duster, Manual broad-caster
Reaping	62	65	68	72	76	80	Power reaper
Reaping & binding	60	63	66	70	74	78	Reaper binder
Harvesting & threshing	58	62	65	68	72	76	Head feeding combine.
Threshing	70	75	80	75	80	85	Self feeding thresher (Threshing in the field)
Husking	85	85	85	85	85	85	Automatic husker (in-door operation)
Transporting	75	73	80	80	83	85	Trailer

Table 243a was estimated by following condition.

(1) If two operator, it can reduce in time for attaching equipment to tractor, cleaning time, adjustment and repair time.

(2) Small, Mid and Large means distribution of field, Large means 100 ha with 5 distribution plots, middle means 50 ha with 3 distribution plots, small means 30 ha with one plots. Traveling speed of tractor in 8 km/hr and others are 5 km/hr.

(3) These net work rates are calculated in Japanese condition.

b) Example: Table A-243b. Example of calculation for Net Work Rate in appendix: fm-243b.xls

2-4-4.What factors affect on the daily capacity

a) Farm work type (Crop and customs of farmer etc.)

b) Weather condition (Length of daytime, temperature etc.)

Table 244b. Working hours per day in Japan

month North latitude (name of place)	January	February	March	April	May	June	July	August	September	October	November	December
26.13 (Naha, Okinawa)	8.8	8.4	9.0	9.9	10.5	10.8	10.6	10.0	9.3	8.5	7.8	7.5
35.30 (Tokyo, Ibaraki)	7.1	7.9	9.0	10.1	11.0	11.5	11.3	10.6	9.4	8.4	7.5	6.9

See Table A-244b. for other place of Japan in appendix: fm-244b.xls
Remarks: This average monthly operation hours are decided from monthly average sun shining hours deduct 3 hours for lunch time and lest time.

c) Labor Standard Law: 8 hours per day in Japan

d) Scattering of fields
Field map

e) Farm road

Table 244e. Farm road conditions

Effective width	machine width + 1 m	Standard
	>2.5 m	Tractor (30PS)
	>3.0 m	Tractor (40-80PS)
	>4.0 m	Tractor (>90PS)
Junction width	>3 m	
Height between paddy field and road	<30cm	Tractor
	<20cm	Combine(0.8-1.2m)
	<25cm	Combine(1.2-3.5m)
	<40cm	Combine(>3.5m)

2-5. Exercise

Exercise 2-1.
When field area=2 ha, total time required a farm work=5 h, obtain Effective Field Capacity and Work Capacity.

Exercise 2-2.
When field area=20a, total time required a farm work=50min, obtain Effective Field Capacity and Work Capacity.

Exercise 2-3.
When field area=1.2 ha, actual operating time required a farm work=1.5 h, Obtain Effective Field Capacity and Work Capacity.

Exercise 2-4.
When rice grain 800kg was produced in 30min by thresher. Yield of rice was 4t/ha. Obtain Effective Field Capacity of this thresher.

Exercise 2-5.
In plowing of the field (40*30 m), data of times required was as follows.

		min: second
ta	Actual operating time	13: 36
tb	Turning time	8: 46
tc	Moving time	0: 30
td	Regulating time	1: 06
	Other time	0

Obtain Total operating time, and Effective field capacity.

Exercise 2-6.
When Wt and Vt were as follows, obtain theoretical field capacity.

Wt	Theoretical operation width	0.6 m
Vt	Theoretical operation speed	3 km/h

Exercise 2-7.
Obtain theoretical operation width of weeding by rotary weeder (width=45cm), when row width is 70 cm.

Exercise 2-8.
Obtain Field Efficiency in percentage, when EFC=1.3, TFC=1.7 (ha/h).

Exercise 2-9.
Obtain Field Efficiency in percentage, in problem 2-4.

Exercise 2-10.

Obtain Total time of labor and Effective Field capacity of a set of threshing, when A = 0.2 ha, time required of machie=0.7 h, number of workers=3.

Exercise 2-11.

Obtain Effective Field capacity of manual weeding, when A = 0.2 ha, time required =0.6 h, number of workers=5.

Exercise 2-12.

Obtain Effective Field capacity and Work capacity in case of tillage by power tiller, when W=0.6m, V=1.8km/h, EF=70%.

Exercise 2-13.

Show the effect of size of field (A=0.1, 0.3, 0.5, 1.0 ha),and the effect of shape of field (m=1, 2, 3.3) in the rotary tillage in upland as follows. Use next equation. EFC = A / {4.72*A 0.358* SQRT(A/m) + 0.164}

x	Width of field	50	m
y	Length of field	100	m
w	Operating width	1.6	m
v	Operating speed	0.4	m/s
tc	Moving time in field	100	s
td	Regulating time	530	s
te	Rest time	0	s
t1	U type turning time	30	s
t2	Δ type turning time	60	s

Exercise 2-14.

Obtain Daily Capacity and Net Work hours per day, when Dt=8h, NWR =70% and EFC=0.2 ha/h.

Exercise 2-15.

Show working hours per day in your countries.

month North latitude (Name of place)	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Your country												
35.30 (Tokyo, Ibaraki)	7.1	7.9	9.0	10.1	11.0	11.5	11.3	10.6	9.4	8.4	7.5	6.9

Exercise 2-16.

Obtain Daily Net Work Rate (NWR) using following data.

Items	Needed Time		Items of required hours									
	Starting time	Ending time	Working hours		Other extra hours							
			Plow	Disk harrow	Dp	Db	Ds	Dc+Df	Da	Dm	Dr
	h. min	h. min	min	min	min	min	min	min	min	min	min
Garage-Field 1	7.00	7.20					3	10	7		
Field 1 (0.5ha)	7.20	9.55	151		4						
Field 2 (0.16ha)	9.55	11.19	66		5	10			3		
Field 2-Garage	11.19	11.45			4	9		7	6		
Lunch Time	11.45	13.30								105	
Garage-Field 3	13.30	13.40			1				6		3
Field 3 (0.6ha)	13.40	17.00	198		2						
Field 3-Garage	17.00	17.15					10		4		1
Garage-Field 1	17.15	17.20							4		1
Field 1: Disk harrow	17.20	18.40		77							3
Field 1-Garage	18.40	18.55					2	8	5		

3. COVERAGE

3-1. Coverage (Covered area)

Coverage (Covered area) will be used for certain farm work ability of certain period, which is a seasonal period of for a crop.
Coverage is simply obtained by following process.

CA = DC * AWD * M / N **Eq. 3-1**

CAS = DC * AWD / N **Eq. 3-2**

CAS = EFC * ANWH / N **Eq. 3-3**

where,

symbol	term	unit
CA	Coverage (Covered area)	ha
CAS	Coverage of one set	ha
DC	Daily capacity	ha/d
AWD	Available work days	d
EFC	Effective field capacity	ha/h
ANWH	Available net working hour	h
M *	Number of machine set	-
N *	Number of operation times	-

* : normally M and N = 1

Example: Next table and See fm-311.xls and fm-33.xls.

Table 311. Example of Covered Area

Item		Effective Field Capacity	Daily Capacity				Available work days				No. operation	Covered area
Work Name	Implement		Work hour	Net Work rate	Net Work	Daily Capacity	Operation Period	Days of work period	Rate of available work day	Available work days		
	symbol	EFC	Dt	NWR	Dn	DC	WP	DWP	ADR	AWD	N	CAS
	unit	ha/h	h/d	%	h/d	ha/d	date	d	%	d	-	ha
Tillage	Rotary 1.8m	0.266	10.0	72	7.2	1.92	Apr.1-May 20	50	74	37.0	1	71.0
Harrowing	Paddy harrow	1.132	10.5	70	7.4	8.32	May.1-May 20	20	73	14.6	2	60.7
Trans-planting	Rice transplanter 2-row	0.036	10.5	67	7.0	0.26	May.1-May 20	20	73	14.6	1	3.7
Herbicide	Knapsack power sprayer	1.800	11.0	80	8.8	15.84	July 1-July 5	5	60	3.0	1	47.5
Harvest	Head-feeding combine	0.052	8.5	65	5.5	0.29	Sep.25-Nov.10	47	65	30.6	1	8.8

Exercise. 3-1, 3-2

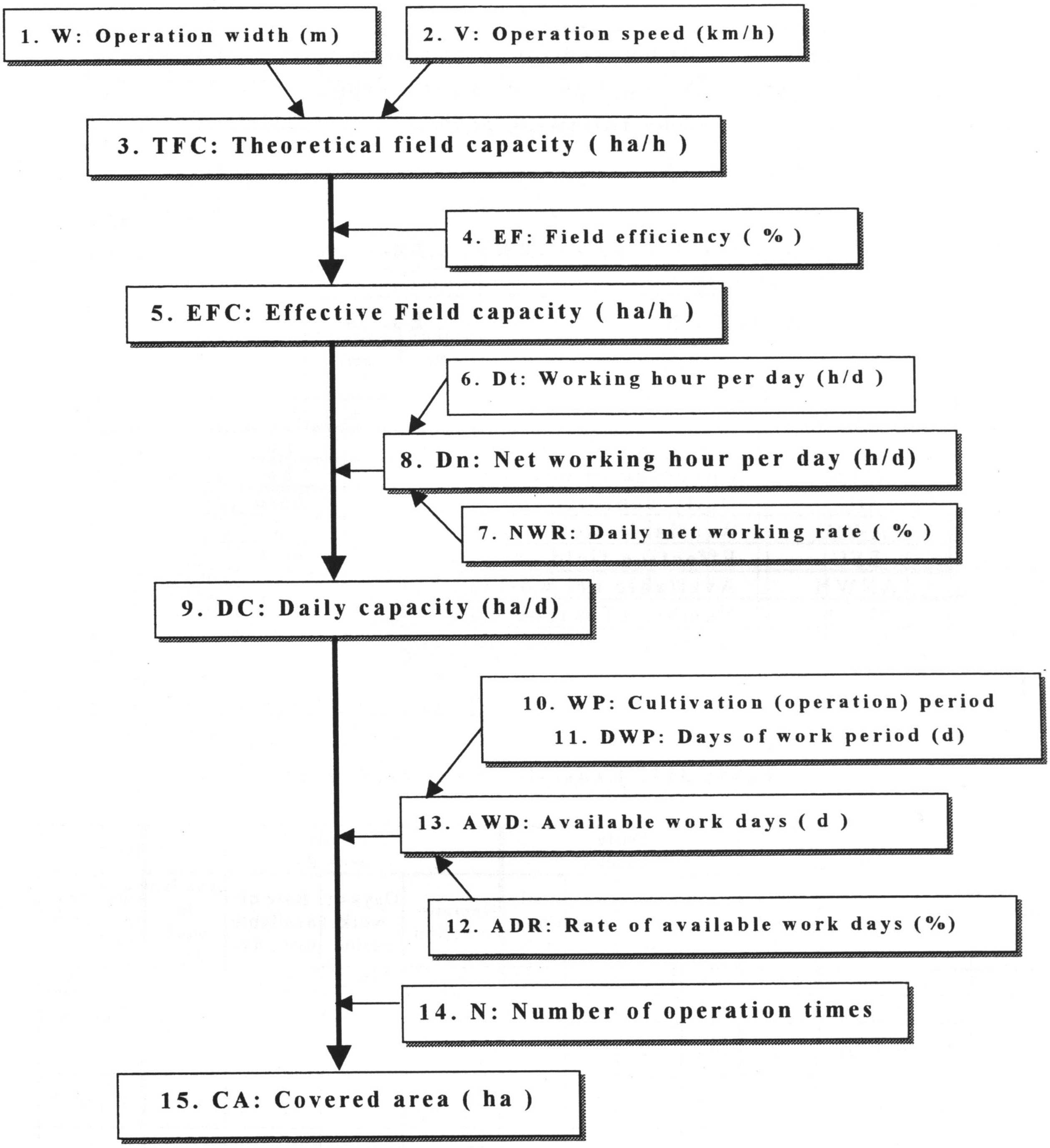


Fig. 3 Flow chart to obtain coverage

3-2. Available Work Days

Available work days means actual days available to work.
Freezing temperatures, precipitation, excessive deficient soil moistures, and other weather related factors may limit field machines operations. As weather variability is great, any prediction of the number of future working days can only be made probabilistically.
The number of working days in any time period is a function of: climatic region, slope of soil surface, soil type, drainage characteristics, operation to be performed, and traction devices.

AWD = DWP * ADR **Eq. 3-4**

Where,

symbol	term	unit
AWD	Available work days	d
DWP	Days of work period	d
ADR	Rate of available work days	%

Table 32. Example of Available work days See fm-311.xls

Work Name	Implement	Effective Field Capacity	Net Work hours	Daily Capacity	Working period	Days of work period	Rate of available work day	Available work days
		EFC	Dn	DC	WP	DWP	ADR	AWD
		ha/h	h/d	ha/d	date to date	d	%	d
Tillage	Bottom plow 14"x2	0.224	7.2	1.61	Apr.1-May 20	50	74	37.0
Tillage	Rotary 1.8m	0.266	7.2	1.92	Apr.1-May 20	50	74	37.0
Harrowing	Paddy harrow 20	1.132	7.4	8.32	May.1-May 20	20	73	14.6
Trans-planting	Rice trans-planter 2-row	0.036	7.0	0.26	May.1-May 20	20	73	14.6

Exercise. 3-3

3-2-1. Available net working hour

ANWH = AWD * Dn **Eq. 3-5**

Where,

symbol	term	unit
ANWH	Available net working hour	h
AWD	Available work days	d
Dn	Net working hours	h/d

3-3. Rate of Available Work Days

In the work period, machines are not available for use due to the precipitation and periodical machine maintenance etc. Therefore, these unavailable days are deducted from total work days of the period.
The weather condition and its suitability to out side work can be get in the weather chart for agriculture which was gathered by meteorological agency.

Table 33a shows the rate of monthly available work day based on the data of "available work days at outside".

Table 33a. The Rate of Monthly Available Days for Machinery Work with Judging from Weather (%)

Area	Place \ Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Hokkaido	Sapporo	0	0	0	73	73	70	71	69	75	61	57	0
Kanto	Kumagaya	90	88	84	75	73	62	71	82	67	74	87	94
Okinawa	Naha	77	75	77	68	60	52	74	65	73	74	82	77

rainfall less than 10mm/d

See fm-33a.xls (for upland work see ASAE-D497: ASAD4971.xls)

Exercise. 3-4

3-4. Coverage of a Farm Work, or a Farm Work System

3-4-1. Coverage of combined work

See 5-1-6. Coverage of plural farm works

3-5. Machinery capacity

3-5-1. Machinery capacity from Coverage

How to obtain the optimal machinery capacity, when farm scale or coverage of farm system is given?

DC = CA * N / AWD **Eq. 3-6**

EFC = DC / Dn **Eq. 3-7**

TFC = EFC / EF * 100 **Eq. 3-8**

Where,

symbol	term	unit	tillage 1	tillage 2
TFC	Theoretical Field Capacity	ha/h	0.315	0.360
EF	Field Efficiency	%	71.0	74.0
EFC	Effective Field Capacity	ha/h	0.224	0.266
Dn	Net working hours	h/d	7.2	7.2
DC	Daily Capacity	ha/d	1.61	1.92
AWD	Available work days	d	37	37
N	No. of operation	-	1	1
CA	Coverage	ha	59.6	71.0

Example: Obtaining EFC, TFC from Coverage in above case.

Exercise. 3-5, 3-6

3-5-2. Selection of machine

From equation 2-9,

W = (TFC / V) * 10 **Eq. 3-9**

Table 352 Example: Obtaining machine width from TFC

symbol	term	unit	Example	
	Work name		Tillage 1	Tillage 2
	Implement		Bottom plow	Rotary
TFC	Theoretical Field Capacity	ha/h	0.315	0.360
V	Speed	km/h	4.5	2.0
W	Width	m	0.7	1.8

See fm-351.xls

Exercise. 3-7

3-6. Exercise

Exercise 3-1.

When Daily capacity =0.48 ha/d, Available work days =21 d, obtain Coverage of one set.

Exercise 3-2.

When Effective field capacity =0.009 ha/h, Number of workers = 5, Available work days =21.9 d, Net work hour=6.4h/d , obtain Coverage of this manual weeding.

Exercise 3-3.

When Days of farm work period =(April 10 to 24), Rate of available work days = 75%, obtain Available work days.

Exercise 3-4.

Pick up a farm work in your country (Example: tillage). Select a machine and list up width and speed.

1. Obtain Theoretical Field capacity (TFC) and Effective Field capacity (EFC).
2. Obtain Daily capacity (DC) by using working hour per day (Dt) and Daily net working rate (NWR).
3. Obtain coverage (CA) of the farm work using operation period (DWP) and rate of available work days (AWDR).
4. Submit paper and FD.

Exercise 3-5.

When Coverage (CA)=3.7ha, Number of operation times (N) =1, Available work days (AWD) =14.6d, Net working hours (Dn) =7.0 h/d, Field Efficiency (EF) =55.0%, obtain Daily Capacity (DC), Effective Field Capacity (EFC) and Theoretical Field Capacity (TFC) of this farm work.

Exercise 3-6.

When Coverage (CA)=60.7ha, Number of operation times (N) =2, Available work days (AWD) =14.6d, Net working hours (Dn) =7.4 h/d, Field Efficiency (EF) =82.0%, obtain Daily Capacity (DC), Effective Field Capacity (EFC) and Theoretical Field Capacity (TFC) of this farm work.

Exercise 3-7.

When Theoretical Field Capacity (TFC) =0.135 ha/h, Speed(V) =1.8km/h , obtain Width(W) of machine for this farm work.

4. COST ANALYSIS

4-1. Accounting Method

Cost analysis, or cost accounting is a system of accounting in which records of all cash and non-cash costs as well as returns. They are kept for the purpose of preparing an account to show costs of production, returns, and net profit or loss on the enterprise. Examples are labor, power, machinery use, building use, fuel, and interest charges.

When we will examine economical evaluation of farm mechanization, we should evaluate the profit of the farm management system. Generally, the profit is the difference between the income and expenditure. Machinery cost is the major expenditure of farm management system; therefore we will examine it in this chapter.

Accounting methods of machinery cost are two different ways, which are (1) Cost accounting method and (2) Expenses accounting method.

4-1-1. Cost accounting method

This method is to express capital, material and labor for production, e.g. rice production, in terms of money irrespective of whether or not actual payment is made in cash.

For instance:

a) The same machine purchased on subsidy aid or at a reduced price is calculated at the same price.

b) When a son operates a tractor, the wages are calculated as an employed operator.

This method is used for accurate comparison on unified assessment. This is adopted for;

(i) comparison with others for improvement and analysis of management
(ii) to study adaptable newly introduced machinery, and
(iii) development and establishment of new mechanization in the research work for the comparison of economy with that of a conventional method.

4-1-2. Expenses accounting method (management expenses)

In spite of purposes, all actual payment and expenditure will be counted in Expenses accounting method, which is called management expenses, too. In this way, when a subsidy is received, it is calculated cheaper accordingly. This method of accounting will reflect the actual condition of incoming and outgoing in the use of machinery, and therefore, has a merit of making many obvious for the management. On the other hand, it is unfit for comparison with machinery service in other management and consideration for a long-term improvement of management.

Exercise 4-1.

Table 4-1. Contents of Expenses

Contents of expense to be involved in		
Expense accounting	Expense & cost accounting	Cost accounting
Included in expense accounting but not in cost accounting, e.g. neutral expense	Purchase expense or fundamental expense	Expenditure included in cost accounting but not in expense accounting: additional cost
Example		
1. Expenses unrelated to production directly, like as machine depreciation not in present use 2. Special depreciation of machinery damage by natural disaster, like floods, fires and earth-quake 3. Besides, cash outcomings and outgoings not directly related production	1. Depreciation 2. Repair cost 3. Fuel cost 4. Lubricant cost 5. Wages 6. Besides purchase expenses for production	1. Estimated wages for family labor 2. Estimated interest on self-capital 3. Machine obtained free of charge because of a sample or for an experiment 4.Subsidy to machinery and installation purchased subsidized by the National Treasury 5. Beside, estimated price of self-supplies used for production, e.g. home-gathering compost 6. Landowner cost

4-2. Fixed Cost

Total cost for the accumulated use of a machine divided by the number of accumulated time units. Usually the time units are years or hours. Total cost is the sum of fixed (ownership) and variable (operating) costs. One of the most important costs influencing profit in farming operations is the cost of owning and operating machinery. There are two main types of machinery costs, as follows;

1. Fixed (Ownership) Costs
This is the cost, which is depend more on how long a machine is owned rather than how much it is used. Ownership costs is defined in ASAE like as; the costs which do not depend on the amount of machine use. Examples are depreciation, interest on investment, taxes, insurance, and storage.

(See ASAE-P496: ASAE-SD.htm: asp496-4)

2. Variable (Operating) Costs.

Variable cost is called operating costs, which is the cost varying in proportion to the amount of machine use. Operating costs are defined in ASAE like as; the costs which depend directly on the amount of machine use. Examples are labor, fuel, lubrication, and repair and maintenance costs.

(See ASAE-P496: ASAE-SD.htm: asp496-4)

Fixed cost is needed whether machinery is used or not, as follows:

1) Depreciation, 2) Taxes, 3) Garage, 4) Insurance, and 5) Interest and 6) Repairing cost sometimes.

The distinction between fixed costs and operating costs is clear for all items listed except depreciation and repairs. While depreciation is more a fixed cost than an operating cost, it is somewhat affected by the amount a machine is used, particularly if the annual use is unusually high or low.

On the other hand, repairs usually vary according to amount of use, but the need for some repairs seems to result from deterioration due to the age of a machine as well as how much it is used.

4-2-1. Depreciation

The service life of a machine is needed to estimate depreciation. Service life in turn depends on the feasibility of repairing or replacing worn parts.

The economic life of a machine is a more pertinent measure of the period of time for which depreciation should be estimated. Economic life is defined as the length of time from purchase of a machine to that point where it is more economic to replace with a second machine than to continue with the first.

As a cost, depreciation means a loss in the value of a machine due to time and use. Often, it is the largest of all costs. Machines depreciate, or have a loss of value, for several reasons, including

1. Life, 2 Wear, 3. Obsolescence. See in reference 3)

Economic Life of machine is defined in ASAE like as; The useful service life of a machine before it becomes unprofitable for its original purpose due to obsolescence or wear. (See ASAE S495)

Table 421. shows the economic life of machine in Japan. (See Table A-426. in appendix)

Table 421. Economic life (Years of Durability) of Farm Machinery

Machinery	Name of machine	Economic life (Years of Durability)
Prime mover	Motor	10
	Gasoline engine, Diesel engine	8
Riding type tractor		8
Plow & leveling equipment	Plow, Rotary, Harrow, Puddling machine,	5
Seeder, Cultivator	Manure spreader, Fertilizer & seeder, Rice transplanter, Power sprayer	5
Irrigation & Drainage equipment		8
Harvesting machine	Combine, Thresher	8
Post-harvesting machine	Milling machine, Flour machine	10
	Box for crop after harvesting	3
Processing Machine	Rush grass harvester, Straw rope machine	5
Equipment of animal husbandry	Forage harvester, Hay mower, Hay baler, Milker	5
	Self-propelled forage harvester etc.	8
Transporting Machine	Trailer, Wagon	4
	Vehicle (less than 2000 cc)	3
	Vehicle (more than 2000 cc)	5
Other farm equipment	Snow remover	4
	Machinery mainly made by steel	10
	Others	5

References: Ministry of Agriculture, Forestry & Fishery in Japan

There are two different ways mainly to calculate depreciation, as follows:

1. Straight-line depreciation (Constant amount each year)
2. Declining-balance depreciation (Constant rate each year)

a) Straight-line depreciation (Constant amount each year)

With the straight-line depreciation method, an equal reduction of value is used for each year over the economic life of a machine. This method can always be used to estimate costs over a specific period of time, provided the proper salvage value is used for the life of the machine.

Straight-line depreciation can be computed by the following formula:

$$D = (P - S) / L \qquad \text{Eq. 4-1}$$

Where,

symbol	term	unit	Example
D	Annual depreciation	$/year	90
P	Purchase price	$	1,000
S	Salvage value	$	Purchase Price * 0.1 = $100
L	Economic life	year	10
L	(Durability Year)	year	10

See fm-421b.xls

This method is the simplest as it charges an easily calculated, constant amount each year.

Durability hours (Total service hour) will show more actual value shown in Table A-426 in appendix.

Exercise 4-2.

b) Declining-balance depreciation (Constant rate each year)

A uniform rate is applied each year to the remaining value of the machine at the beginning of the year. The depreciation amount is different for each year of the machine's life.
Following equations express the relationships by formulas.

$$R_{i+1} = Ri * (1 - r) \qquad \text{Eq. 4-2}$$

$$S = P * (1 - r) **L \qquad \text{Eq. 4-3}$$

$$S / P = (1 - r) **L \qquad \text{Eq. 4-4}$$

Or,

$$P - S = P * r + P *(1-r)* r + P *(1-r)**2 * r + \quad + P *(1-r)**(L-1)* r \qquad \text{Eq. 4-5}$$

Where,

symbol	term	unit
Ri	Remained value of i year	$
P	Purchase price	$
S	Salvage value, normally P * 0.1	$
L	Economic life	year
r	Constant depreciation rate	in decimal

Actually constant depreciation rate r will be obtained by solving 0.1*P = P * (1 - r) **L
from Eq. 4-3. r = 1 - (S/P)**(1/L) and r = 1- 0.1**(1/L).
See fm-421b.xls: get-r

Annual depreciation charge for i year will be as followings;

$$Di = [P * (1 - r) ** (i - 1)] * r \qquad \text{Eq. 4-6}$$

or,

$$Di = R_{i-1} * r \qquad \text{Eq. 4-7}$$

symbol	term	unit
Di	Depreciation charge for i year	$

Table 421b. Remaining Values of Machines Expressed as Percentages of Purchase Price for Each Year of Life
(10 yr. Life and 10% salvage value assumed for depreciation methods)

	Year										
	0	1	2	3	4	5	6	7	8	9	10
Straight-line	100	91	82	73	64	55	46	37	28	19	10
Declining-balance	100	80	63	50	40	32	25	20	16	13	10

where r = 0.2057

See in fm-421b.xls, reference 3) and reference 13

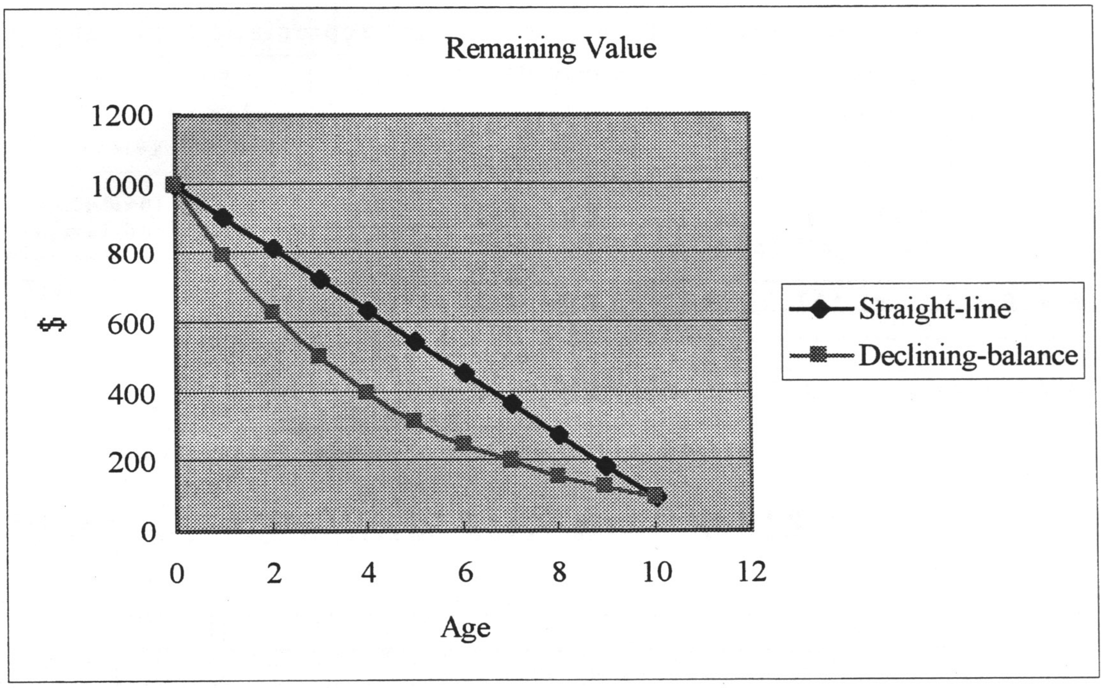


Figure 421. Remaining Value

Exercise 4-3. , 4-4.

4-2-2. Taxes

Taxation caused by the purchase and use of machines is limited to the municipal property tax, the light car tax, the local farm machinery tax as special automobiles.

There are the registration fee, inspection fee, and the number plate fee of the tractor, but not uniform by local. The foundation for integration, strictly speaking, is considerably complicated, so it is expressed in terms or rate to initial cost. In cost calculation, approximately 0.5 % is taken into account.

Generally yearly taxation and its sum are calculated as follows.

AT = P * rtax Eq. 4-8

Where,

symbol	term	unit	Example
AT	Annual taxes	$	5
P	Initial price	$	1,000
rtax	Tax rate (0.5%)	in decimal	0.005

Exercise 4-5.

4-2-3. Garage(Housing or Shelter)

Housing expense will be obtained from the following equation.

AG = P * rgc Eq. 4-9

Where,

symbol	term	unit	Example
AG	Annual garage cost	$/year	56
P	Initial price	$	10,000
rgc	Garage cost rate	in decimal	0.0056

Area required for housing is calculated on full length and full width in the standards of farm machinery, considering the interval of machines (tractors and combines are 2 meters long and 1.5 meters wide, and working machines 1.4 meters long and 1.3 meters wide). This is a rough standard because of the difference up to brands even in the same model.

Garage cost rate is calculated as following.

rgc = AG / P Eq. 4-10

AG = AGt * (Sg / St) Eq. 4-11

Where,

symbol	term	unit	Example
AG	Annual garage cost	$/year	56
AGt	Total garage cost per year	$/year	1671.6
P	Initial price	$	10,000
rgc	Garage cost rate	in decimal	0.0056
Sg	Garage space of machine	m**2	6.7
St	Total garage space of house	m**2	200.0

See Table A-423 in appendix

4-2-4. Insurance

Insurance is necessary against the risk of accident or disaster. In the calculation of insurance fee, it is expressed in the rate of insurance fee to initial price and generally 0.25- 0.5 % is estimated and is obtained from the following equation.

AP = P * rp Eq. 4-12

Where,

symbol	term	unit	Example
AP	Annual insurance fee	$/year	25
P	Initial price	$	10,000
rp	Premium rate	in decimal	0.0025

4-2-5. Interest

A large expense item for agricultural machinery is interest. It is a direct expense item on borrowed capital. Even if cash is paid for purchased machinery, money is tied up that might be available for use elsewhere in the business. Interest rates vary but usually will be in the range of 5 to 12 percent.

Capital interest decreases according as machinery gets old and assessment falls. Actually, however, it is convenient to know it as yearly mean interest like as depreciation.

AI = [(P + R) / 2] * ri Eq. 4-13

Where,

symbol	term	unit	Example
AI	Annual interest	$/year	275
P	Initial price	$	10,000
R	Remaining value	$	1,000
ri	Yearly interest rate	in decimal	0.05

Exercise 4-6.

4-2-6. Repairing cost

Maintenance and repair costs vary depending on (i) how to use machinery, (ii) attention an operator skill, (iii) age of the machine, (iv) service hours, and (v) service environments, naturally resulting in a difference each.

But for mechanization planning, yearly mean repair cost including economic life (years of durability) will be used. In the calculation of repair cost in mechanization plan generally overall repair cost from purchase to disuse is shown at the rate to purchase price.

AR = P * er / L Eq. 4-14

RCh = P * erh Eq. 4-15

symbol	term	unit	Example
AR	Annual repair cost	$/year	417
P	Initial price	$	5,000
er	Overall repair cost coefficient	in decimal	0.5
L	Economic life	year	6
RCh	Mean repair cost per hour	$/h	2.1
erh	repair cost coefficient per hour	/h	0.00042

Repair cost coefficient will show more actual value shown in Table A-426. in appendix.

See in reference 13: M-mng208.doc

4-2-7. Annual fixed cost (annual ownership cost)

Other ownership costs: Taxes, housing, and insurance can be estimated as percentages of the purchase price. If the actual data are not known, the following percentage can be used:

-- taxes 1.00;
-- housing 0.75;
-- insurance 0.25;
-- total 2.00% of purchase price

Total annual ownership costs: A simple estimate of total annual ownership costs is given by multiplying the purchase price of the machine by the ownership cost percentage.

AFC = AD + AT + AG + AP + AI + AR **Eq. 4-16**

RAF = RD + RT + RG + RP + RI + RR **Eq. 4-17**

AFC = P * raf **Eq. 4-18**

AFC = P * RAF / 100 **Eq. 4-19**

Where,

symbol	term	unit
AFC	Annual fixed costs	$/year
AD	Annual depreciation	$/year
AT	Annual taxes	$/year
AG	Annual garage cost	$/year
AP	Annual insurance fee	$/year
AI	Annual interest	$/year
AR	Annual repairing cost	$/year
RAF	Annual fixed cost rate	%
RD	Annual depreciation rate	%
RT	Annual taxes rate	%
RG	Annual garage cost rate	%
RP	Annual insurance rate	%
RI	Annual interest rate	%
RR	Annual repairing cost rate	%
P	Initial price	$
raf	Annual fixed cost rate	in decimal

(See reference-7 ASAE-P496: ASAE-SD.htm)

Example: Table 427 and fm-427.xls

Exercise 4-7.

Table 427. Annual fixed cost rate

Name of machine	Years of durability*	Annual fixed cost rate	Annual fixed cost rate (%)			
			Depreciation	Repair cost	Garage cost (housing)	Capital interest, Tax, and Insurance fee
symbol	L	RAF	RD	RR	RG	RI+RT+RP
	Year	%	%	%	%	%
Riding type tractor	8	24.6	12.50	7.00	1.5	3.55
Bottom plow	5	33.1	20.00	4.00	5.5	3.55
Rotary	5	33.8	20.00	6.25	4.0	3.55
Disk harrow	5	32.6	20.00	4.00	5.0	3.55
Teeth harrow	5	31.1	20.00	2.00	5.5	3.55
Sub-soiler	5	28.6	20.00	2.00	3.0	3.55
Trencher	5	30.6	20.00	5.00	2.0	3.55
Roller	5	30.6	20.00	1.00	6.0	3.55
Culti-packer	5	30.6	20.00	1.00	6.0	3.55
Puddling machine	5	30.2	20.00	1.67	5.0	3.55
Manure-spreader	5	28.7	20.00	3.10	2.0	3.55
Lime-sower	5	31.1	20.00	2.00	5.5	3.55
Broad-caster	5	29.1	20.00	2.00	3.5	3.55
Drill-seeder	5	29.6	20.00	4.00	2.0	3.55
Rice-transplanter	5	35.4	20.00	8.33	3.5	3.55
Power sprayer	5	29.6	20.00	4.00	2.0	3.55
Power duster	5	29.6	20.00	4.00	2.0	3.55
Speed sprayer	5	29.3	20.00	3.78	2.0	3.55
Head-feeding type Combine	5	30.1	20.00	5.00	1.5	3.55
Standard-type Combine	8	22.6	12.50	5.00	1.5	3.55
Forage-harvester	5	31.1	20.00	4.00	3.5	3.55
Self-propelled type forage harvester	8	22.1	12.50	4.00	2.0	3.55
Potato harvester	5	32.1	20.00	5.00	3.5	3.55
Self-propelled type potato harvester	8	23.1	12.50	5.00	2.0	3.55
Beat harvester	5	31.1	20.00	4.00	3.5	3.55
Self-propelled type beat harvester	8	22.1	12.50	4.00	2.0	3.55
Trailer	4	33.6	25.00	2.00	3.0	3.55
Truck	5	30.1	20.00	5.00	1.5	3.55

* Ministry of Agriculture

Remarks: Annual fixed cost rate of each items are average base on Japanese condition.

(for upland work see ASAE-D497: ASAE-SD.xls asd497-5)

4-2-8. Calculation of Annual fixed cost

Calculation of Annual fixed cost will be varied by following conditions.

A: This machine used only in this farm work
B: This machine used not only in this work but also other work
(use yearly hour : Ha)
C: Share % of this work: Sp
D: Contract work
E: Transportation work or Post-harvest work etc.

AFCi = FC * sp **Eq. 4-20**

VCF = FC / Ha **Eq. 4-21**

where,

symbol	term	unit	Example
AFC	Annual fixed cost	$	. 300
FC	Fixed cost	$	1,000
sp	Share of the work	in decimal	0.30
VCF	Variable cost per hour originated from fixed cost in case of B.	$/h	2.0
Ha	Annual operation hour	h/year	500

Exercise 4-8.

4-3. Variable Cost

Variable cost is needed in actual operation, as follows:
1) Fuel, 2) Lubrication, 3) Maintenance, 4) Repairs, and 5) Labor cost.

4-3-1. Fuel

Fuel cost is the cost of average fuel consumption for tractors or machinery. Annual average fuel requirements for tractors or machinery may be used in calculating overall machinery costs for a particular enterprise. However, in determining the cost for a particular operation such as plowing, the fuel requirement should be based on the actual power required.
Estimate fuel consumption is shown in Table A-431 in appendix.
Average annual fuel consumption for a specific make and model tractor can be approximated from the Nebraska Tractor Test Data.
(See reference-7 ASAE-P496: ASAE-SD.htm)

Exercise 4-9.

4-3-2. Lubrication

There are two ways to consider regarding lubricant cost.

(1) One is to measure actual engine oil, and grease to be fed when at work, and calculate of lubricant cost actually.

(2) The other is to calculate fuel costs including lubricant, engine oil, and grease collectively multiplying given rate. Cost calculation method can be use 30 % of fuel cost.

4-3-3. Repairs

See 4-2-6.

4-3-4. Labor cost

The cost of labor (wage) varies with region or location. For owner-operators, labor cost should be determined from alternative opportunities for use of time. For hired operators, a constant hourly rate is appropriate. In no instance should the charge be less than a typical, community labor rate.

4-3-5. Material cost

Material cost (Seed, Fertilizer, Chemicals etc.) is calculated from actual price of the material consumed in farm work.

4-3-6. Total variable cost

$$VC = VF + VL + VR + VW + VM \qquad \text{Eq. 4-22}$$

Where,

symbol	term	unit
VC	Total variable cost of a farm work	$
VF	Fuel cost of a farm work	$
VL	Lubricant cost of a farm work	$
VR	Repairing cost of a farm work	$
VW	Labor cost of a farm work	$
VM	Material cost of a farm work	$

$$VCh = VFh + VLh + VRh + VWh + VMh + VCF \qquad \text{Eq. 4-23}$$

Where,

symbol	term	unit
VCh	Total variable cost per hour of a farm work	$/h
VFh	Fuel cost per hour of a farm work	$/h
VLh	Lubricant cost per hour of a farm work	$/h
VRh	Repairing cost per hour of a farm work	$/h
VWh	Labor cost per hour of a farm work	$/h
VMh	Material cost per hour of a farm work	$/h
VCF	Variable cost per hour originated from fixed cost	$/h

4-4. Summary of Accounting Methods and its Standard

Table 4-4. Accounting Method and its Standard

<table>
<tr><td rowspan="2" colspan="2">Item</td><td colspan="2">Accounting methods</td></tr>
<tr><td>Cost accounting (Operation cost)</td><td>Expense accounting</td></tr>
<tr><td colspan="4">Fixed costs (Ownership cost)</td></tr>
<tr><td></td><td>Depreciation</td><td>Yearly mean depreciation
D= (P - S) / L</td><td>Machine cost should be actual price without subsidize.</td></tr>
<tr><td></td><td>Garage (Housing) cost</td><td>Annual garage cost
AG = P * rgc</td><td>Annual garage cost
In planning stage, cost accounting method will be used.</td></tr>
<tr><td></td><td>Capital interest</td><td>Yearly mean interest
AI = [(P + R) / 2] * ri</td><td rowspan="3">Actual expenses should be accounted.
In planning stage, cost accounting method will be used.</td></tr>
<tr><td></td><td>Taxes</td><td>Annual taxes
AT = P * rtax</td></tr>
<tr><td></td><td>Insurance</td><td>Annual insurance fee
AP = P * rp</td></tr>
<tr><td></td><td>Repairing cost</td><td>Yearly mean repair cost
AR = P * er / L

Mean repair cost per hour
RCh = P * erh</td><td>Repair cost should be actual cost in a year.
In planning stage, cost accounting method will be used.</td></tr>
<tr><td></td><td>Annual fixed cost</td><td>Annual fixed cost
AFC = P * raf</td><td>In planning stage, cost accounting method will be used.</td></tr>
<tr><td colspan="2">Variable cost</td><td></td><td></td></tr>
<tr><td></td><td>Fuel cost</td><td>Fuel cost per hour
= Fuel consumption per hour * Fuel price</td><td rowspan="2">Actual expenses should be accounted.
In planning stage, cost accounting method will be used.</td></tr>
<tr><td></td><td>Lubricant cost</td><td>30% of Fuel cost</td></tr>
<tr><td colspan="2">Labor cost</td><td>Wage per hour of Operator, or assistant worker.</td><td>Actual expenses should be accounted.
Family labor will be omitted.</td></tr>
<tr><td colspan="2">Management cost</td><td colspan="2">Management cost will include administration cost, meeting fee, training fee of operator and so on.
In planning stage, 10 to 20% of hire charge will be used normally.</td></tr>
<tr><td colspan="2">Custom cost (Contract fee) (Hiring fee)</td><td colspan="2">Custom cost is the amount paid for hiring equipment and operator services to perform a certain task.
Custom costs normally include a charge for the operation of the basic machine, and may or may not include supplemental labor and equipment for such tasks as seed or fertilizer to the field, etc.
Charges may be determined on the basis of area, time, transport distance or quantity of crop processed.</td></tr>
<tr><td colspan="2">Lease cost (Contract or Rental)</td><td colspan="2">A lease is a contract for the use of machinery for an agreed period of time in return for periodic payments.
Ownership remains with the lessor. The lessee acquires the right of temporary possession and use.</td></tr>
</table>

4-5. Annual Cost Per Hectare

We will discuss the total cost of a farm work comparing with custom charge of it in this chapter. And economical evaluation of the farm work system will be done in chapter 5.
For the economic analysis of farm work, it is most important to estimate the annual cost per hectare. Annual cost per hectare of a machine or of a farm work will be obtained as follows.

4-5-1. Annual (total) cost

ATC = AFC + AVC **Eq. 4-24**

Where,

symbol	term	unit
ATC	Annual (total) cost	$/year
AFC	Annual (total) fixed cost	$/year
AVC	Annual (total) variable cost	$/year

Sample

1. Land preparation: AFC = 1,350 $, AVCa = 61 $/ha

Annual Operation Area (ha/year)	Annual Fixed Cost ($/year)	Annual Variable Cost ($/year)	Annual Total Cost ($/year)
Aa	AFC	AVC	ATC
0.5	1,350	30	1,380
1	1,350	61	1,411
2	1,350	122	1,472
3	1,350	183	1,533
4	1,350	244	1,594
5	1,350	305	1,655
6	1,350	366	1,716
7	1,350	426	1,776
8	1,350	487	1,837
9	1,350	548	1,898
10	1,350	609	1,959

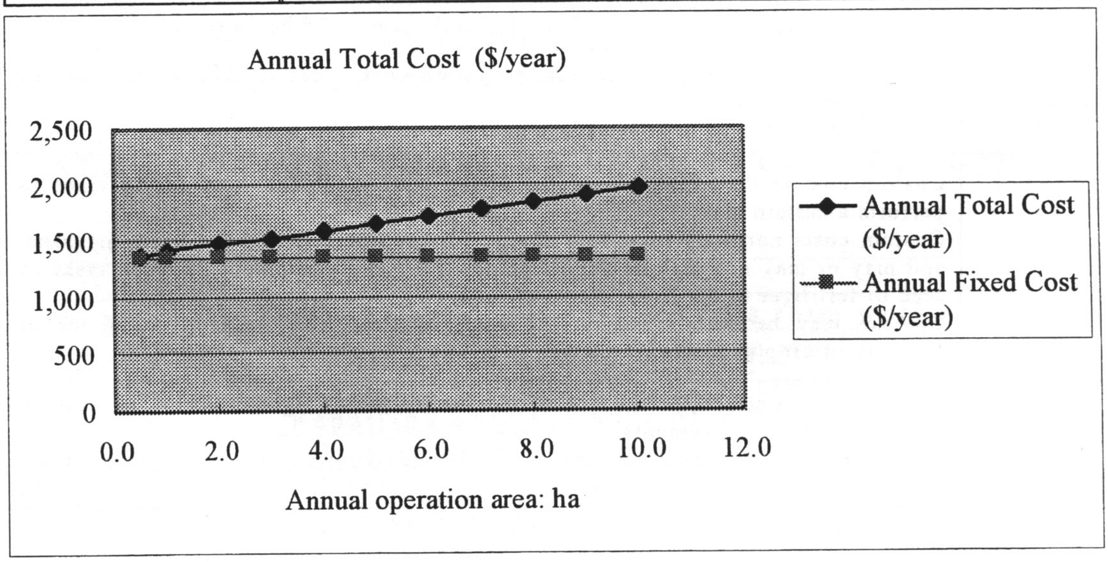


Fig. 451A Annual Total Cost vs. Annual operation area

See fm-451p.xls total-cost-1

4-5-2. Annual cost per hectare

$$ACa = ATC / Aa \quad \text{Eq. 4-25}$$

$$ACa = AFC / Aa + AVC / Aa \quad \text{Eq. 4-26}$$

$$ACa = AFC / Aa + AVCa \quad \text{Eq. 4-27}$$

Where,

symbol	term	unit
ACa	Annual cost per hectare	$/ha
Aa	Annual operation area	ha/year
AVCa	Annual variable cost per ha	$/ha

Annual variable cost per ha (AVCa) is independent from Annual operation area (Aa), therefore it is constant when Aa is changed.

Sample: 1. Land preparation: AFC = 1,350 $/year, AVCa = 61 $/ha, Custom charge = 300$/ha

Annual operation area (ha)	Fixed cost per ha ($/ha)	Variable cost per ha ($/ha)	Cost per ha ($/ha)
Aa	AFCa	AVCa	ACa
0.5	2,700	61	2,761
1	1,350	61	1,411
2	675	61	736
3	450	61	511
4	338	61	398
5	270	61	331
6	225	61	286
7	193	61	254
8	169	61	230
9	150	61	211
10	135	61	196

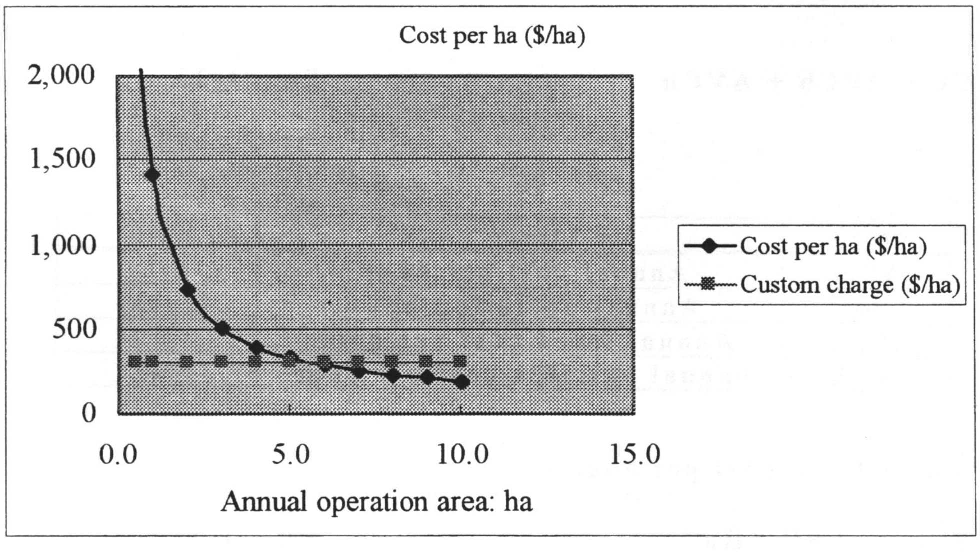


Fig.452 Annual cost per ha ($/ha) vs. annual operation area (ha)

See fm-451p.xls cost-ha-1

Exercise 4-10. , 4-11.

a) Annual fixed cost per ha

AFCa = AFC / Aa Eq. 4-28

AFCa = SUM (Pi * RAF / (Aa * 100)) Eq. 4-29

where,

symbol	term	unit
AFCa	Annual fixed cost per ha	Yen/ha or $/ha
Pi	Initial price	Yen or $
RAF	Annual fixed cost rate	%
AFC	Annual (total) fixed cost	$/year
Aa	Annual operation area	ha

b) Annual variable cost per ha

AVCa = AVC / Aa Eq. 4-30

AVCa = VCa1 + VCa2 + VCa3 + + VCan Eq. 4-31

Annual variable cost per ha is summation of variable cost per ha of each farm work.

4-5-3. Annual cost per hour

ACh = ATC / Ha Eq. 4-32

ACh = AFCh + AVCh Eq. 4-33

where,

symbol	term	unit
ACh	Annual cost per hour	$/h
Ha	Annual operation hour	h/year
AFCh	Annual fixed cost per hour	$
AVCh	Annual variable cost per hour	%

a) Annual fixed cost per hour

AFCh = AFC / Ha Eq. 4-34

AFCh = (Pi * RAF) / (Ha * 100) Eq. 4-35 where,

symbol	term	unit
AFCh	Annual fixed cost per hour	\$/h
Pi	Initial price	\$
RAF	Annual fixed cost rate	%
Ha	Annual operation hour	h/year
AFC	Annual (total) fixed cost	\$/year

b) Annual variable cost per hour

AVCh = AVC / Ha **Eq. 4-36**

Annual variable cost per hour (AVCh) is independent from Annual operation hour (Ha), therefore it is constant when Ha is changed.

AVCh = VCh1 + VCh2 + VCh3 + + VChn **Eq. 4-37**

Annual variable cost per hour is summation of variable cost per hour of each farm work.

4-6. Break-even Point

Service charge or farm work fee by machine will be decided as not higher than custom charge by manual so that farmer (user) will get profit by hiring machine.
Break-even Point: The point at which the line of cost intersects the line of earnings drawn against the quantity of production (or the quantity of sales). {JIS Z8121: Reference 17}
If the quantity of production or the quantity of sales is larger than the break-even point, the earnings are larger than the cost, and if the former is smaller, the result is reversed. In other words, this point is the turning point of loss and gain.

4-6-1. Break-even point or Cross point of income and expense

Break-even point or Cross point of custom charge and machinery cost is an important key-point for decision of service charge actually.
Custom charge is shown as Yen/ha ($/ha) or Yen/h ($/h). Therefore, Custom charge per hectare will be obtained by even point to machinery cost per hectare.
Machinery cost per hectare decreases when annual operation area of the machine increases normally. So, break-even point of area is calculated as follows.

$$AFC + AVCa * Abp = CC * Abp \qquad \text{Eq. 4-38}$$

or

$$CC = AVCa + AFC / Abp \qquad \text{Eq. 4-39}$$

$$Abp = AFC / (CC - AVCa) \qquad \text{Eq. 4-40}$$

where,

symbol	term	unit
Abp	Break-even point of area	ha/year
AFC	Annual fixed cost	$/year
CC	Custom charge	$/ha
AVCa	Variable cost per ha	$/ha

Example: Break-even point

How many hectares, Abp (ha), do you at least need to justify ownership of a head feed combine if the custom charge (CC) is 1800 $ per ha, assuming the fixed cost (AFC) is 4,500 $, the variable cost per ha (AVCa) is 267 $?

$$Abp = 4{,}500 / (1{,}800 - 267) = 4500 / 1533 = 2.9 \text{ (ha)}$$

a) Annual cost & custom charge vs. annual operation area

Aa	ATC = AFC + AVCa * Aa	TCC = CC * Aa
Annual operation area	Annual cost	Total Custom charge
(ha)	($)	($)
1	4,767	1,800
2	5,033	3,600
3	5,300	5,400
4	5,567	7,200
5	5,833	9,000
10	7,167	18,000

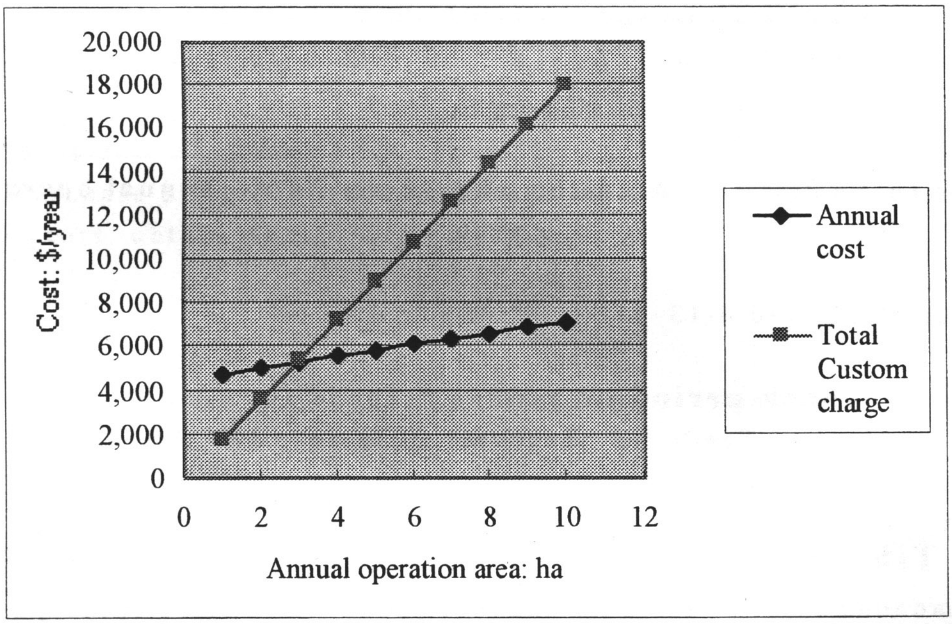


Fig. 461a Annual cost & custom charge vs. annual operation area

See fm-461.xls

b) Annual cost & custom charge per ha vs. annual operation area

Aa:	ACa=AFC/Aa+AVCa	CC
Annual operation area	Annual cost per ha	Custom charge
ha	$/ha	$/ha
1	4,767	1,800
2	2,517	1,800
3	1,767	1,800
4	1,392	1,800
5	1,167	1,800
10	717	1,800

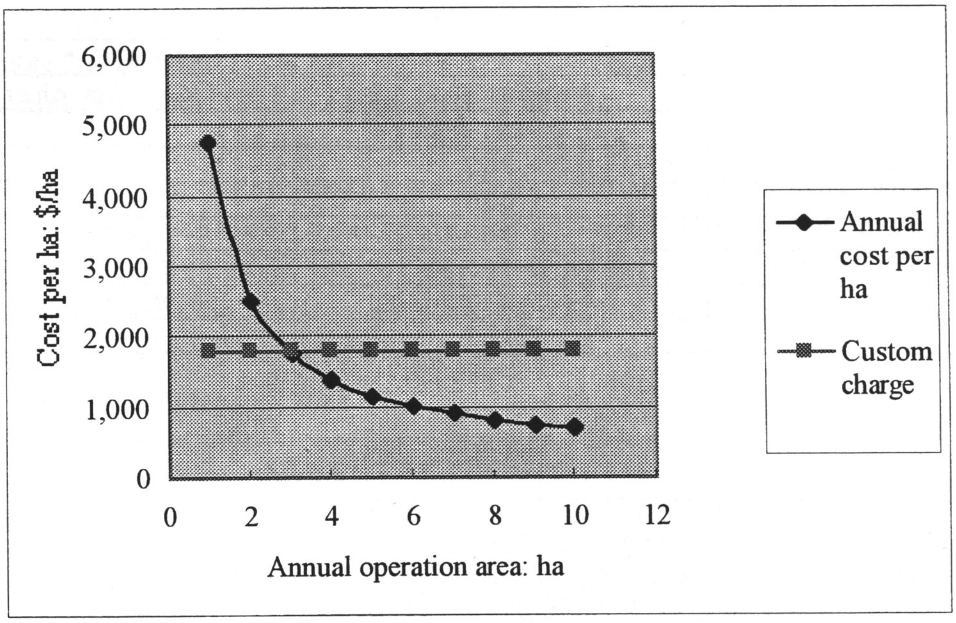


Fig. 461b Annual cost & custom charge per ha vs. annual operation area

Exercise 4-12. and 4-13.

4-6-2. Pay-back period or year

See 5-4-1. Recovery of the capital

4-7. Timeliness

Timeliness is the Ability to perform an activity at such a time that crop return is optimized considering quantity and quality of product.
Timeliness coefficient is defined like as; A factor used to estimated the reduction in crop return (quantity and quality) due to lack of timeliness in performing an activity.

(See ASAE S495 and ASAE D497: ASAE-SD.htm)

Delays in planting can reduce yields. Delays in harvest can reduce both quantity and quality of production. These losses are called timeliness losses. See in reference 3

4-8. Exercise

Exercise 4-1.

Select following items into three group, which are 1. Cost accounting method, or 2. Expenses accounting method, or 3. Both accounting method.

		1	2	3
1.	Depreciation			
2.	Fuel cost			
3.	Home-gathering compost			
4.	Interest on self-capital			
5.	Lubricant cost			
6.	Machine depreciation not in present use			
7.	Machine obtained free of charge because of a sample			
8.	Purchase expense			
9.	Repair cost			
10.	Special depreciation of machinery damage by floods			
11.	Subsidy to machinery purchase by government			
12.	Wages for family labor			
13.	Wages for hired workers			

Exercise 4-2.

When Purchase price (P) =800$, Salvage value (S) = 80$, Economic life (L) =6 years, obtain Annual depreciation.

Exercise 4-3.

When Purchase price (P) =800$, Constant depreciation rate (r) = 0.25, L = 8, obtain Depreciation charge for first year, and for next year.

Exercise 4-4.

When Purchase price (P) =800$, Salvage value (S) = 80$, Economic life (L) =6 years, obtain Constant depreciation rate. Use S = P * (1 - r) **L

Exercise 4-5.

List up tax rate of your country.

Exercise 4-6.
When Initial price (P) =800$, Remaining value (R) = 80$, Yearly interest rate (ri) = 0.05, obtain Annual interest .
And please let me know interest rate of your country.

Exercise 4-7.
When Initial price (P), and Annual fixed cost rate (RAF) are shown as next table, obtain Annual fixed cost (AFC) of farm work of transplanting.

Exercise 4-8.
When Initial price (P), Annual fixed cost rate (RAF), Share of work (Sp)=50% are shown as next table, obtain Annual fixed cost of 1: tractor and of farm work of land preparation.

Farm Work	Machine no.	Machine name	Purchase price	Annual Fixed cost rate	Fixed cost	Share of work	Code of how to use*	Annual fixed cost
			P	RAF	FC	Sp		AFC
			$	%	$	%		$
Land preparation	1	Tractor	18,000	25		50	C	
	2	Drive harrow	3,500	30			A	
	3	iron cage wheel	1,000	30			A	
Transplanting	4	Rice transplanter	13,500	30			A	

* : A: This machine used only in this farm work
C: This machine used not only in this work but also other work (use Share of work)

Exercise 4-9. When fuel consumption, oil, labor are shown as following table, obtain fuel cost per hour(VFh), oil cost per hour(VLh), labor cost per hour(VWh), and variable cost per hour(VCh) and per ha.(VCa) of farm work : land preparation and transplanting.

Work Name	fuel consumption						Oil	operator		Assistant worker		labor cost per hour	variable cost per hour	variable cost per ha
	FRh	EFC	FRa		Pf	VFh	VLh	Nw1	VWh 1	Nw2	VWh 2	VWh	VCh	VCa
	L/h	ha/h	L/ha	fuel	$/L	$/h	$/h	No.	$/h	No.	$/h	$/h	$/h	$/ha
Land preparation	3.8	0.30	12.7	D	0.32			1	8.0	0	0.0			
Transplanting	1.6	0.21	7.6	G	0.77			1	8.0	1	7.0			

Exercise 4-10.

When AFC, AVCa, CC are shown as following table, obtain ATC of farm work (rice transplanting) at Aa = 0.5, 1.0, 2.0, 9.0, 10.0.
And plot on graph (ATC vs. Aa) and compare it with total custom charge.

AFC	Annual fixed cost	$/year	4000
AVCa	Annual variable cost per ha	$/ha	80
Aa	Annual operation area	ha/year	0.5 ---10.0
CC	Custom charge	$/ha	500

Exercise 4-11.

When AFC, AVCa are shown as following table, obtain ACa of farm work (rice transplanting) at Aa = 0.5, 1.0, 2.0, 9.0, 10.0. And plot on graph (ACa vs. Aa) and compare it with custom charge.

Aa	Annual operation area	ha/year	0.5 ---10.0
ACa	Annual cost per hectare	$/ha	
AFC	Annual fixed cost	$/year	4050
AVCa	Annual variable cost per ha	$/ha	80

Exercise 4-12. .

How many hectares, Abp (ha), do you at least need to justify ownership of a rice transplanter if the custom charge (CC) is 500 $ per ha, assuming the fixed cost (AFC) is 4,000 $, the variable cost is 100 $ /ha?
And calculate Annual cost: AC and Total Custom charge: TCC at Aa = 1, 2, 3, 10 ha.

Exercise 4-13. .

How many custom charge (CC) of harvesting is reasonable, if a combine price (P) is $100,000, the fixed cost rate (RAF) is 30%, annual variable cost (AVCa) is 200$/ha and annual operation area (Aa) is 30ha?

5. PLANNING OF FARM WORK SYSTEM

Management phases are shown as follows:

1 Planning phase: Defining an objective for the system, selecting system components and predicting the expected performance of the system.

2 Scheduling phase: Determining the time when the various operations are to be performed. Availability of time, labor supply, job priorities, and crop requirements are some important factors.

3 Operating phase: Carrying out the operations with workers and machines. The operator of machinery will be self-supervised.

4 Improving phase: Utilizing productivity measures and standards to improve the system.

5-1. Farm Work System

Farm work system is an ordered sequence of farm work operations performed in producing and harvesting a particular crop.
Farm work system is a combination of the various subsystems required for culture of all crops grown on a particular farm.

5-1-1.Farm work system

Table 511. Arrangements of Farm work system

1.Pre-condition of farming	Case of precondition for farm mechanization system 1. Application area (topography, weather condition etc) 2. Management system and improvement target 3. Field condition (including farm road, size of field, shape) 4. Object of machinery utilization and total operation area 5. Actual condition of farm house hold. 6. Budget for purchase machinery and controlling the management of group farming system.

2.Preparation of farm works	Make out the schedule and plan for land utilization table	Make out the crop cultivation method	Make out the machinery operation schedule

3.Mechanization plan	Make out the cultivation plan of object crop and systematic mechanization table of each crop.

4.Examine of planning	Examine the coverage in calculation table.	Examine the working plan and required labor input	Examine the production cost

5-1-2.Precondition

Table 512. Precondition for Farm work system

Items		Precondition
1. Region and farming area		Location and area
2. Management system and its improvement target.		You must clear the following farmer's group such as full time farmer or individual farmer. Clear the improvement target of object crop and its management.
3. Cropping system		Select crops. Plan cropping system, one or two, cropping system or mixed farming
4. Field condition		Field size and shape. Soil conditions. Farm road etc.
5. Actual condition of farmers	Number of farm-house hold	We must arrange and to investigate actual situation of number of farm house hold, total cultivated area, total labour, condition and availability of labour and total farm machinery in planning area.
	Total cultivated area	
	Laborer available	
	Owned total farm machinery	
6. Capital available for buying machinery and its management.		At first, we must clear the cost calculation of machinery, capital available for buying machine, and management's fee etc.
7. Cultivation method		Name of crop, Variety Planting pattern, Estimate yield per ha Covered area
8. Machinery set		

Example:

1. Rice crop cultivation: Table 512a-1. is an example of North Kanto plain area in Japan.
2. Other examples: Wheat: Table A-512b., Corn: Table A-512c., Potato: Table A-512d., Soybean: Table A-512e. in appendix

Table 512a-1. Mechanization Planning for Rice Transplanting Method in Paddy Field (Example)

1. Pre-condition

Name of crop	Variety	Planting pattern	Yield per ha	Cultivated area	Size of field and shape	Covered area	Main farm machinery use
paddy rice	Akinishiki	rows 30 cm x 13 cm, 25.6 hills/m2, 3 to 5 plants/hill	(estimate) 4,500 kg	Kita-Kanto plain area. paddy field	30 a (100 m x 30 m)	10 ha	46 P.S. tractor, 6 rows Rice Transplanter, 4 row type combine

See fm-5-1a.xls and FS01R-Jm.xls: 1-1. Pre-condition

Table 512a-2. Mechanization Planning for Rice Transplanting Method in Paddy Field (Example)

2. Table for operation

Items	Cultivation standard			Operation standard			Operation hours per ha (h/ha)			Fuel consumption	
Name of operation	Period of operation	Materials use (per ha)	Prime mover	Name of farm Machinery	accuracy & method	Field capacity	Machinery	Workers	Total		
						ha/h	h/ha		h/ha		L/h
Preparation of seed	5.14-5.20	Seed 35 kg, salt 10 kg, Benlate-T 400 g, Sumithion 80 cc	Manual					2	1.90		
Nursery	5.20-6.25		Manual					2	37.50		
Tillage	6.12-6.19		Tractor	Rotary 1.8 m	depth 13 cm	0.267	3.74	1	3.74	D	6
Basal dressing fertilizer	6.12-6.19	comp. fertilizer, (10,18,16) 700 kg	Tractor	Broadcaster 300 L		1.515	0.66	2	1.32	D	4.3
Puddling	6 20-6 28		Tractor	puddling harrow 2.4 m width		0.549	1.82	1	1.82	D	5.5
Transporting seedling	6.20-6.29		Tractor	Trailer with seeding box shelves		0.21	4.77	2	9.54	G	4
Rice transplanting	6.21-6.29		Self-propel	Riding type 6 row Rice transplanter		0.172	5.81	2	11.62	D	0.7
Herbicide application	6.26-7.3	Saturn M 30 kg	Manual	Granule spreader *			2.28	1	2.28		
Top-dressing & spraying	7.5-7.10	ammonium sulfate 100 kg, Diazinon Granule 30 kg	Manual		mixed spray			1	2.62		
Pest & Disease control/											
Rice skipper, Sheath blight	8.3-8.7	Dipterex 1.0 L Neo-Asozin 0.7 L	Tractor	Tractor mount type sprayer, levee nozzle, mixed spray		1.852	0.54	6	3.24	D	3
						1.852	0.54	2	1.62	G	4
Stem borer Leaf hopper Leaf Blast	8.25-8.29	Sumithion 1.5 L Bassa 1.0 L Validacim 1.5 L Kitazin 1.5 L	Tractor	Tractor mount type sprayer, levee nozzle, mixed spray		1.235	0.81	6	4.86	D	3·
						1.235	0.81	2	1.62		4
Top-dressing	8.10-8.15	comp. fertilizer (17,0,16) 120 kg	Manual					1	6.00		
Water management	"6-9"		Manual					1	96.00		
Harvest/											
Harvesting & threshing	10.20-11.5		Self-propel	Head feeding type 4 row combine		0.115	8.66	2	17.32	D	3.9
Transporting	10.20-11.5		Truck	1 ton truck		0.654	1.53	2	3.06	G	4
Drying	10.20-11.6 Tempering (Circulated)		Motor	21 koku (3780L)	Moisture 21.3-14.0%		34.5	2	9.56	K	2.9
Husking	10.21-11.7		Motor	Husker roll width 76mm		0.24	4.17	3	12.50		
Rice straw turn over	10.23-11.8		Tractor	Tedder & rake (3.0m width)		1	1	1	1.00	D	6.1
Rice straw gathering	10.24-11.9		Tractor	Tedder & rake (3.0 m width)		0.909	1.1	1	1.10	D	5.5
Rice straw bale	10.24-11.9		Tractor	Baler (1.4m width)		0.68	1.47	2	2.94	D	10.4
Total							74.21		232.63		

D: Diesel ,G: Gasoline, K: Kerosene

5-1-3. Planning table for farm mechanization

After you decide the precondition of planning, you can make farm mechanization planning table.

Table 5-1-3. Planning table of rice cultivation:FS01R-J

Farm work		TOW	Main machine		M	Nw	Rate of work		Working period			Coverage
No	Name		No.	Name			EFC	DC	DATES	DATEE	DWP	CA
					-	-	ha/h	ha/d	-	-	d	ha
1	Tillage	M	1	Tractor	1	1	0.286	1.829	8.Feb	18.Apr	70	93.4
2	Puddling	M	1	Tractor	1	1	0.110	0.703	20.Apr	19.May	30	15.4
3	Nursery	C	99	None	0	0	-	-	2.Apr	21.May	50	-
4	Trans-planting	M	4	Rice trans-planter	1	2	0.134	0.860	22.Apr	21.May	30	18.8
5	Caring crop	M	5	Power Weeder	1	1	0.072	0.396	2.Jun	21.Jul	50	11.9
6	Chemical application	M	6	Power Sprayer	1	3	0.529	2.923	3.Jul	22.Jul	20	35.1
7	Harvest-1	L	99	None	0	1	0.500	2.763	12.Sep	11.Oct	30	49.7
8	Harvest-2	M	7	Head feeding combine	1	1	0.060	0.332	12.Sep	11.Oct	30	6.5
9	Drying	C	99	None	0	0	-	-	13.Sep	11.Nov	60	-
10	Husking	C	99	None	0	0	-	-	15.Sep	13.Nov	60	-
11	Water management	L	99	None	0	1	0.043	0.000	2.Apr	1.Oct	183	-

Where,

symbol	term	unit
TOW	Type of work: M= Machine, C= Contract, L= Manual	-
M, Nw	No. of machine set, workers	-
EFC	Effective Field Capacity	ha/h
DC	Daily Capacity	ha/d
DATES, -E	Starting date or Ending date	-
DWP	Days of working period	d
CA	Coverage	ha

5-1-4. Analysis on farm work system

a) Analysis of each farm work: FS01R-Jm.xls

(i) Effective Field Capacity, Daily Capacity, Coverage

(ii) Machinery cost, Variable cost, Cost per hour or ha

(iii) Graph of Cost per ha and Total cost vs. Annual operation area

b) Analysis of farm work system referring to Table 514.

Table 514. Summary of farm work system: Example

See FS01R-Jm.xls : 4-4. Summary of farm work system

No.	Work	TOW	M	Nw	WC	MH	AFC	VCa	CA	ACa-ca	CI-ca
					h/ha	h/ha	$	$/ha	ha	$/ha	-
1	Tillage	M	1	1	3.5	3.5	1,525	48	93.4	284	2.4
2	Puddling	M	1	1	7.2	7.2	2,720	94	19.5	515	4.3
3	Nursery	C	0	0	0.0	0.0	0	1,231	-	1231	10.2
4	Transplanting	M	1	2	7.4	14.9	3,820	155	18.8	746	6.2
5	Caring crop	M	1	1	14.0	14.0	270	171	11.9	212	1.8
6	Chemical application	M	1	3	1.9	5.7	542	118	35.1	202	1.7
7	Harvest-1	L	0	1	2.0	2.0	0	15	49.7	15	0.1
8	Harvest-2	M	1	1	16.7	16.7	4,973	202	6.5	971	8.1
9	Drying	C	0	0	0.0	0.0	0	865	-	865	7.2
10	Husking	C	0	0	0.0	0.0	0	288		288	2.4
11	Water management	L	0	1	23.3	23.3	0	269	-	269	2.2
			max		sum	sum	sum	sum	min	sum	sum
Work system			1	3	76.0	87.2	13,851	3,457	6.5	5,600	46.6

Where,

symbol	term	unit	Sample
TOW	Type of work: M= Machine, C= Contract, L= Manual	-	
M, Nw	No. of machine, workers	-	
WC	Work capacity	h/ha	76.0
MH	Man-hours per ha	h/ha	87.2
AFC	Annual fixed cost	$	13,851
VCa	Variable cost per ha	$/ha	3,457
ACa	Annual cost per ha	$/ha	5,600
A:	Land area	ha	10.0
CA:	Coverage of system	ha	6.5
Y:	Yield per year	t/ha	4.5
LDP:	Land productivity = Y * Crop Price =(PSa)	$/ha	12,015
LBP:	Labor productivity = (SH)=LDP/MH	$/h	
SH :	Sales per working hour of this system = (LBP)	$/h	138
Abp:	Break-even point	ha	1.6
CI-ca :	Cost per ha/ Sales per ha at system coverage	%	46.6
PRa-a:	Profit per ha of system at A (= LDP-AC-a)	$/ha	7,173
PRa-ca:	Profit per ha of system at CA (=LDP-AC-ca)	$/ha	6,415
PRa	Profit per ha of system	$/ha	6,415
PS-a	Total Sales at A (= LDP*A)	$	120,150
PS-ca	Total Sales at CA (= LDP*CA)	$	77,668
ATC-a	Total Cost at A (=AC-a*A)	$	48,420
ATC-ca	Total Cost at CA (=AC-ca*CA)	$	36,197
PR-a:	Total Profit of system at A	$	71,730
PR-ca:	Total Profit of system at CA	$	41,471
PR:	Total Profit of system	$	41,471

(i) Type of work, number of machinery and workers

Maximum number of workers is available or not?

(ii) Man-hours per ha

Saving labor hour is reasonable or not.

(iii) Labour productivity (Sales per work hour)

(iv) Land productivity (Yield or sales amount per ha)

(v) Coverage of each work and Minimum coverage

Minimum coverage of system is important limiting factor.

Also, coverage of each work should be checked out.

If annual operation area is larger than the coverage, we need to supply the additional machinery or worker, and machinery cost is added accordingly.

Assume the same kind of machine in each farm work, then the number of machinery set was adjusted and fixed cost per ha will be calculated by next equations.

M-sys = INT(Aa / CAS + 1) **Eq. 5-1**

FCa = AFC / Aa

FCa = AFCs * Msys / Aa **Eq. 5-2**

Where,

symbol	term	unit	Example
	Farm work (Harvest)		harvest-2
M-sys	Number of machinery set of work	-	4
Aa	Annual farm work area	ha	20
INT	Function of getting integer	-	-
CAS	Coverage of one set	ha	6.5
FCa	Fixed cost per ha	$/ha	995
AFC	Annual total fixed cost	$	19,894
AFCs	Annual fixed cost(of one set)	$	4,973

Table 514d. Annual total fixed cost of harvesting work

Annual farm work area	No. of set	Annual total fixed cost	Fixed cost per ha
Aa	M	AFC	FCa
(ha)	-	US$	(US$/ha)
1	1	4,973	4,973
5	1	4,973	995
10	2	9,947	995
15	3	14,920	995
20	4	19,894	995
25	4	19,894	796
30	5	24,867	829

See: harvest-2, CA = 6.5 ha

(vi) Total fixed cost of the farm work system

Total fixed cost etc. of the farm work system will be calculated by summation of each item of farm work correspond to the certain annual farm work area.

Table 514e. Total fixed cost of a farm work system: Example

CAS(minimum)=5.6ha, Sales per ha = 12,015 $/ha

Annual farm work area	No. of set (max.)	Annual total fixed cost	Fixed cost per ha	Variable cost per ha	Cost per ha
Aa	M	AFC	FCa	VCa	ATCa
(ha)	-	($)	($/ha)	($/ha)	($/ha)
1	1	13,851	13,851	3,457	17,308
5	1	13,851	2,770	3,457	6,227
10	2	18,824	1,882	3,457	5,339
15	3	24,068	1,605	3,457	5,061
20	4	35,581	1,779	3,457	5,236
25	4	35,851	1,434	3,457	4,891
30	5	40,825	1,361	3,457	4,818

See FS01R-Jm.xls : fwtotal

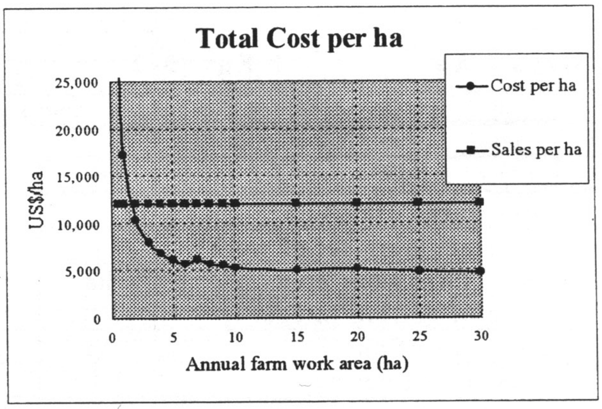


Fig. 5-2. Total cost per ha of a farm work system

(vii) Annual cost per ha at several farm scale

(viii) Break-even point

Break-even point or Cross point of rice sales and farm work cost is an important key-point for analyzing the farm work system.
If the cost of farm work system is more than the sales of rice, that is, the expense is larger than income, there is no profit by this farm work system. The break-even point of area shows the point, that there is profit by the system if the farm scale is larger than this point. The break-even point of area is calculated as follows. (Refer to 4-6. Break-even point)

$$PSa * Abp = AFC + VCa * Abp \qquad \text{Eq. 5-3}$$

or

PSa = VCa + AFC / Abp **Eq. 5-4**

Abp = AFC / (PSa - VCa) **Eq. 5-5**

where,

symbol	term	unit	Example
PSa	Sales per ha	$/ha	12,015
Abp	Break-even point of area	ha	1.62
AFC	Annual total fixed cost	$	13,851
VCa	Total variable cost per ha	$/ha	3,457

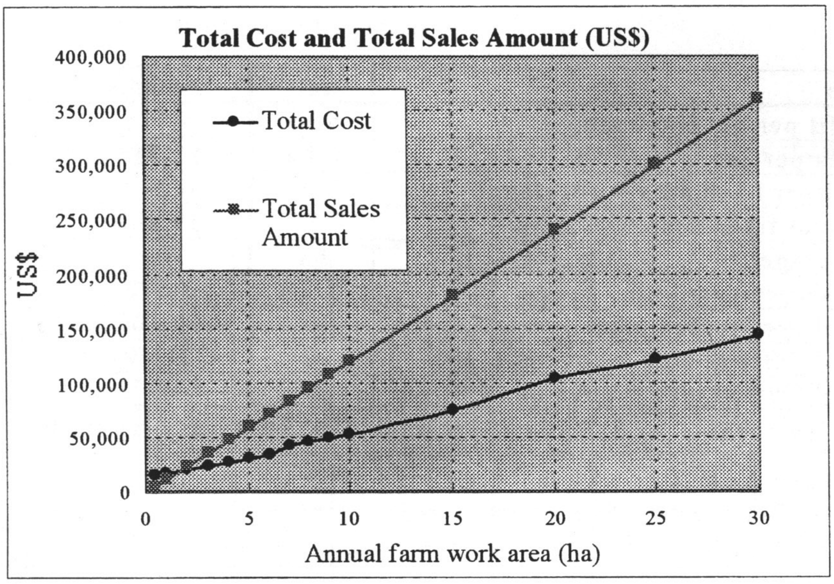


Fig. 5-3. Total cost and sales amount
See FS01R-Jm.xls :fwtotal

(ix) Cost performance (Cost index of farm work)

Cost performance is basic index for economic evaluation. Here, we calculate the ratio cost per ha to sales per ha (Cost index of farm work).

If this is over 100%, it means no profit.

(x) Profit per ha of system

PRa = PSa − ATCa **Eq. 5-6**

(xi) Maximum profit of farm work system

Maximum profit of farm work system will be normally obtained at largest scale of farm.

If the minimum coverage is less than the farm scale, then it is the limit factor of the farm scale. We can cultivate the farm within the range of the minimum coverage. Therefore, the maximum profit will be normally obtained at the farm scale that is same to the minimum coverage.

PRa-max = PSa - ATCa-ca

= PSa - [AFC/CA + VCa] **Eq. 5-7**

PR-max = PS-ca - ATC-ca

= PS-ca - [AFC + VCa * CA] **Eq. 5-8**

Where,

symbol	term	unit	Example	in FS01R-J
PRa-max	Profit per ha: maximum	$/ha	5,771	7,148
PSa	Sales per ha	$/ha	**12,015**	**12,015**
ATCa-ca	Cost per ha at area = coverage	$/ha	6,248	5,624
AFC	Annual fixed cost	$	**29,894**	**13,851**
CA	Coverage	ha	**10.4**	**6.464**
VCa	Variable cost per ha	$/ha	**3,373**	**3,482**
PR-max	Total Profit: maximum	$	60,107	41,310
PS-ca	Total Sales at area = coverage	$	124,496	77,668
ATC-ca	Total Cost at area = coverage	$	64,973	36,358

See:fwtotal-1 and FS01R-Jm.xls: 4-4.Summary-system

Exercise 5-1., 5-2., 5-3., 5-4., 5-5.

5-1-5. Comparing of farm work systems

Compare and discuss on the several farm work systems: Table 515.

(i) Work system name with crop
(ii) Type of data: Experimental, Statistical, Reference etc.
(iii) Region or country and Farm scale of the system
(iv) Maximum workers available and Total man –hours per ha
(v) Annual cost per ha at farm scale 1, 10, 20 ha and at coverage
(vi) Sales amount of product
(vii) Cost index at the farm scale (Cost performance)
(viii) Sales per working hour (Labor productivity)
(ix) Profit per ha of system
(x) Break-even point

Table 515. Comparing of several farm work systems

No.	System	Type	FS	Nw-max	TMH	AFC	VCa	CA	ACa-1ha	ACa-10ha	ACa-30ha	ACa-ca	PSa	CI-ca	SH
			ha		h/ha	$	$/ha	ha	$/ha	$/ha	$/ha	$/ha	$/ha	-	$/h
1	FS0m-J	Ref.	1	3	1683	323	18,258	1.2	18,581			18,524	12,015	154	7
2	FS0a-J	Ref.	1	3	727	335	9,661	2.0	9,995			9,829	12,015	82	17
3	FS01-J	TE	6.5	3	68	10,773	3,506	6.5	14,279	4,583	3,865	5,163	12,015	43	177
4	FS01-H	TE													
5	Rice	Stat.: 2000	1	3				1.0	0	0	0	9,925	9,895	100	
6	Rice	Stat.: 2000	10	3				10	9,925	0	0	6,463	9,895	65	
7	Wheat	Stat.: 1998	1	1				1.0	0	0	0	3,706	4,701	79	
8	Soy bean	Stat.: 1998	1	1				1.0	0	0	0	4,380	3,386	129	
9	Rice kanto	Rice-sys	10	6	196	29,894	3,373	10	33,267	6,362	4,369	6,362	12,015	53	61

Note: 1. FS0m-J: Manual farm work system in Japan by references
2. FS0a-J: Animal farm work system in Japan by references

Where,

symbol	term	unit
FS	Farm scale of system	ha
Nw-max	Number of workers available	-
TMH	Total Man-hours per ha	h/ha
AFC	Annual fixed cost	$
VCa	Variable cost per ha	$/ha
CA	Covered area	ha
ACa-*	Annual cost per ha at farm scale of *	$/ha
PSa	Sales per ha	$/ha
CI	Cost index (x100): = Cost per ha/ Sales per ha	-
SH	Sales per working hour	$/h
PRa	Profit per ha of system	$/ha
Abp	Break-even point	ha

<u>TE/TE-2002.xls</u>: Compare-system, <u>bunken/NOUKI/Ag-cost1.xls</u>

5-1-6. Coverage of the plural farm works

a) Single farm work

In case of a farm work, coverage is simply obtained as following equation.

CA = DC * AWD * (M or Nw) **Eq. 5-9**

DC = EFC * Dn **Eq. 5-10**

AWD = DWP * ADR **Eq. 5-11**

or,

CA = ANWH * EFC * M = ANWH / WC * M **Eq. 5-12**

where,

symbol	term	unit	Seed preparation
CA	Coverage	ha	67.1
DC	Daily Capacity	ha/d	2.13
M	Number of machine set	-	
Nw	Number of workers	-	**2**
EFC	Effective Field Capacity	ha/h	**0.333**
Dn	Net working hour	h/d	**6.4**
AWD	Available Work Day	d	15.7
DWP	Days of Work Period	d	**21**
ADR	Rate of Available Work Day	-	**0.75**
ANWH	Available Net Work Hour	h	100.8
WC	Work Capacity	h/ha	3.0

Example: Seed preparation in above table.
Coverage CA = 2.13 * 15.7 * 2 =67.1 ha

b) Plural farm work

(i) Plural farm work in the certain overlapped period of one operator
We need to operate more than two farm works in certain work period.

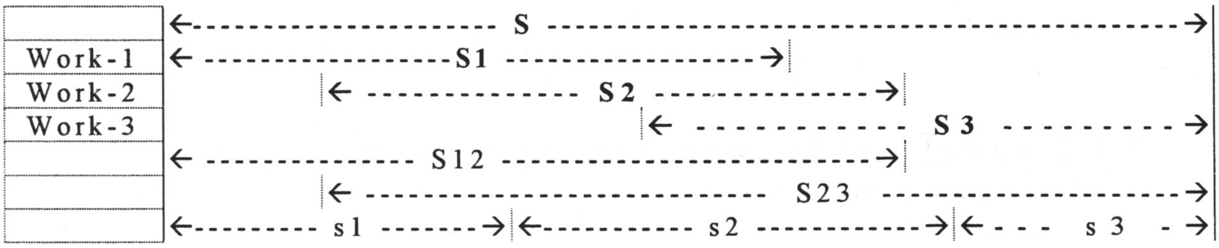
CAS = ANWH * EFCp = ANWH / WCp **Eq. 5-13**

WCp = WC1/M1 + WC2 / M2 + WC3 / M3 + **Eq. 5-14**

where, EFCp = 1 / WCp

symbol	term	unit
CAS	Coverage of one set	ha
ANWH	Available Net Work Hour	h
Mi	Number of machine set of farm work(i)	-
Nw	Number of workers	-
EFCp	Effective Field Capacity of plural works	ha/h
WCi	Work Capacity of farm work(i)	h/ha
WCp	Work Capacity of plural works	h/ha

(ii) Plural farm work in overlapped different work period by one operator



Where, S = Total available working hour
S1, S2, S3 = Available working hour for work-1, work-2, work-3 respectively
S12 = Available working hour for work-1 and 2
S23 = Available working hour for work-2 and 3

Fig. 5-4 Work period overlapped by plural works

If total working hour is available without constraint for three works, each time required to work 1,2,3 are calculated as following equations. (fw-sche.xls)

s1 = S * WC1 / WCp

s2 = S * WC2 / WCp

s3 = S * WC3 / WCp **Eq. 5-15**

where, WCp = WC1 + WC2 + WC3

(1) When S12 >= s1 + s2 and S23 >= s2 + s3,

(a) and S1 >= s1, S2 >= s2, S3 >= s3, then

CA = S / WCp = s1 / WC1 = s2 / WC2= s3 / WC3 **Eq. 5-16**

(b) When S1<= s1,

CA = S1 / WC1 **Eq. 5-17**

(c) When S2<= s2,

CA = S2 / WC2 **Eq. 5-18**

(d) When S3<= s3,

CA = S3 / WC3 **Eq. 5-19**

(2) When $S12 < s1 + s2$ or $S23 < s2 + s3$,

CA = min [S12 / (WC1 + WC2), S1 / WC1, S2 / WC2]   Eq. 5-20, or

CA = min [S23 / (WC2 + WC3), S2 / WC2, S3 / WC3]   Eq. 5-21

(3) Therefore, the coverage of plural works CA is shown as next equation.

CA = min [S / WCp, S1 / WC1, S2 / WC2, S3 / WC3, S12 / (WC1 + WC2), S23 / (WC2 + WC3)]   Eq. 5-22

(4) Calculation of CA by Linear Programming: See A-5-1-6 in appendix

5-1-7. Analysis of farming management of multi-crop system

Generally farming system is not single crop system, but multi-crop system as followings:

(i) Rice + Wheat
(ii) Rice + Vegetable or Fruit
(iii) Rice + Animal husbandry
(iv) Rice + Rice

Cost analysis will be done annual base, that is, the cost and sales amount should be calculated as total cost of all crop system and as total sales of all crop system within one year, in order to compare the economical benefit of each system.

5-2. Planning of new farm work system

Planning of farm work system newly, the following procedure for each crop system will be useful.

5-2-1. Pre-conditions

(i) Region and farm scale
(ii) Management system
(iii) Crops

5-2-2. Planning table of work system

(i) Sequence of farm work
(ii) Cultivation standard: Period
(iii) Operation standard

At first, select the basic machinery like as tractor, combine and drying system.
The second, select each machine width or capacity. (See 5-2-3.)
The third, the Rate of work will be calculated by using the empirical data or the official data as followings.
1) Effective Field Capacity(EFC) is calculated by Operation width(W), Operation speed(V) (Table A-215b.) and Field efficiency(EF) (Table A-216.).
2) Coverage(CA) of each work is calculated by a) Working hour per day(Dt), b) Daily net working rate(NWR), c) Days of work period(DWP), d) Rate of available work days(ADR) (Table 33a.).

5-2-3. Selection of machinery in planning stage

a) Selection of machine

Economic selection finds that capacity which produces the lowest net cost. The increased ownership cost of high capacity machines are balanced against the increased operation costs and timeliness costs of low capacity machines.
(See ASAE P496)
Size selection of machinery is based on a combination of expected performance and expected costs. Both capacity and capital costs increase with size. At the same time performance improves, particularly with critical operations such as planting and harvesting. Delays in planting can reduce yields. Delays in harvest can reduce both quantity and quality of production.
See [Selection of tractor size] in reference 5)

b) Machinery capacity

Simple capacity selection is made by estimating the number of days in the time span within which the operation should be accomplished, and by determining the probability of a working day in this time span. The required capacity of machinery or farm work for an area is

EFC = A / (AWD * Dn) **Eq. 5-23**

or C = A / (D * H * pwd)

Where:

symbol	term	unit	example
EFC	Effective Field Capacity	ha/h	0.139
C	Required machine capacity or farm work	ha/h	
A	Area	ha	10
AWD	Available work days	d	12
D	Number of days within the time span within which the operation should be accomplished	d	
pwd	Probability of a working day	in decimal	
Dn	Net work hours per day	h/d	6
H	Expected time available for field work each day	h/d	

The width of machinery will be shown by next equation.

Wt = 10 * EFC / (Vt * ef) **Eq. 5-24**

Where: example is rotary tillage.

symbol	term	unit	example
Wt	Theoretical operation width	m	0.93
EFC	Effective Field Capacity	ha/h	0.14
Vt	Theoretical operation speed	km/h	2.0
ef	Field efficiency	in decimal	0.75

c) Low cost machinery by using cost data base

Select minimum cost correspond to the planning farm scale, using the data of annual operation area vs. cost per ha.

See Table A-523. in Appendix

d) How many set of tractor and implement is necessary in plural work

Implements are mounted on tractor and the capacities of them are not same, therefore it is not necessary to prepare the same number of these kind of implement. Required number of tractors and implement is obtained by next equation.

M >= A / CAS **Eq. 5-25**

Where:

symbol	term	unit	example
M	Number of machine set	-	3
A	Area	ha	27
CAS	Coverage of one set	ha	9.1

Table 523. Required number of implement: Example

(Area: A = 27 ha and Available net working hour: ANWH=157.5 h)

Farm work with tractor	Implement	Work capacity: WC	Number of operation : N	Required number of implement
		h/ha	times	
Tillage	Rotary	4.3	1	2
Harrow	Rotary	3.7	2	
Leveling	Tooth harrow	0.6	2	1
Seeding	Grain drill	2.9	1	1
Pressing	Roller	1.5	1	1

Work capacity of these five farm work is required as followings:

$WCp = \Sigma WCi * Ni = 4.3 + 3.7*2 + 0.6*2 + 2.9 + 1.5 = 17.3$ h/ha

Coverage and number of tractor are shown as following from equation 5-12 and the above equation.

CAS = ANWH / WCp = 157.5 /17.3 = 9.1 ha

Required number of tractor: M = 3 >= A/CAS =27/9.1 = 2.97

Required number of each implement or work is obtained by next equation.

Mi >= A / CASi = A * WCi * Ni / ANWH **Eq. 5-26**

M1 >= 27*4.3/157.5 = 0.74

M2 >= 27*3.7*2/157.5 =1.27

M3 >= 27*0.6*2/157.5 =0.21

M4 >= 27*2.9/157.5 = 0.50

M5 >= 27*1.5/157.5 =0.26

Work-1 and 2 are operated by same implement, therefore number of rotary is M1+M2 >= 2.01. Required numbers of implement are shown in above table.

Exercise 5-10., 5-11., 5-12.

5-3. Optimization of Farm System

5-3-1. Economical optimization of farm work system

a) Optimization by system analysis method

Seek optimal investment by simulation

Select maximum d Profit / d capital

See Steepest gradient method: SGM-001.doc

b) Modifying several factor

(i) Cropping system or varieties

(ii) Farm work period

(iii) Farm scale

(iv) Machinery

c) Improvement by replacing machinery

(i) By replacing machine which shows excessive capacity

Machinery cost is decreased by replacing machine, which shows excessive capacity to lower capacity machine.

1. Select maximum CA of farm work operated by machinery:
Example = 21-Baler = 51.5 ha
2. Replace baler to smaller one in sheet step-02 from machinery table step-03:
Example 1.4m ->0.73m
3. Change EFC in sheet 1.field-capacity, and FRh in 2.Variable-cost
4. Calculate new CA, total cost per ha etc. in sheet fwtotal

See Table A-531-i. Improvement by replacing machinery in Appendix.

(ii) Improvement the system coverage by increasing machine which shows the lowest capacity

See Table A-531-ii. Improvement coverage of system in Appendix.

Exercise 5-8., 5-9.

5-3-2. Energetic or environmental evaluation

a) Energetic evaluation

Energy consumption will show the important index of energetic evaluation of farm work systems.

LCA (Life Cycle Assessment) is acceptable method of calculating energy

consumption in industry or daily life.
Calculation of energy consumption of farm machinery or facilities by using input-output analysis of inter-industry (SANGYOU RENKANBUNSEKI) is also effective method for energetic evaluation.(ECU in the following table)
Total annual energy consumed for manufacturing will be obtained as following equations. (ECU in next table)

AEG = AFC * Yrate* ECU/1000 **Eq. 5-27**

where,

symbol	term	unit
AEG	Total annual energy consumed	MJ
AFC	Annual fixed cost ($): Total	$
Yrate	Yen exchange rate	Yen/$
ECU	Energy conversion unit	kJ / Yen

Variable energy per ha(MJ/ha) will be calculated by using conversion factor of next table.

Table 532a. Conversion factor

Output energy of per ha = Yield * RCF =4500(kg/ha) * 14.9(MJ/kg) = 67 GJ/ha

symbol	Conversion factor		unit
ECU	Energy conversion unit for manufacturing the machinery by using input-output table of inter-industry	48.1	kJ / Yen
RCF	Rice grain Conversion factor	14.9	MJ/ kg
GCF	Gasoline Conversion factor	35.2	MJ/ L
KCF	Kerosene Conversion factor	37.3	MJ/ L
DCF	Diesel light oil Conversion factor	38.5	MJ/ L
ECF	Electric power Conversion factor	9.4	MJ / kWh

by handbook of energy save: 1996 and food handbook: 1 kWh = 3.6 MJ

Example See Rice-erg.xls: Step-C1, fwtotal-erg

b) Environmental evaluation

Method of environmental evaluation is not yet completed now, but CO2 exhaust amount will show some index of environmental situation.

Table 532b. CO2 gas generation ratio

CO2 gas generation ratio		unit
Gasoline	2.3587	kg / L
Kerosene	2.5284	kg / L
Diesel light oil	2.6444	kg / L
Electric power	0.42	kg / kWh

c) Total evaluation See Fmech-10.doc, fm-12.xls

5-4. Machinery Management

5-4-1. Investment to machinery

a) Investment, Revenue and Profit

Profit will be calculated simply as next equation.

$$B = NI - I \qquad \text{Eq. 5-28}$$

where,

symbol	term	unit
B	Profit	$
NI	Net income	$
I	Investment	$

Example

If we invest to the combine shown in the following table, then the profit of n year will be obtained as follows.(Assume interest rate = 0)

term	Investment: Price	Economic Life	Operating Cost	Custom Charge	Effective Field Capacity	Net work hour	Daily Capacity	Available work days	Coverage
symbol	I	L	OC	CC	EFC	Dn	DC	AWD	CA
unit	$	year	$/ha	$/ha	ha/h	h/d	ha/d	d	ha/year
data	130,000	8	300	1,800	0.2	5.0	1.0	30	30.0

Net income of the year: NIi = (CC-OC)*CA

n	year	1	2	3	4	5	6	7	8
NIi	Net income	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
NI: ($)	Total Net income	45,000	90,000	135,000	180,000	225,000	270,000	315,000	360,000
B=NI-I: ($)	Profit	-85,000	-40,000	5,000	50,000	95,000	140,000	185,000	230,000

See fm-541.xls: Ex-9

This table shows that the profit will be obtained after 3 years and total profit of 8 years later is $230,000, and rate of profit (B / I) is 1.77.

b) Recover period

Recovery period will be obtained by next equation.

$$n = I / N1 \qquad \text{Eq. 5-29}$$

where,

symbol	term	unit	Example
n	Recovery period	year	2.9
N1	Net income of one year	$	45,000
I	Investment	$	130,000

This means we will get profit after 3 years use of the combine.

5-4-2. Machine renewal (or replacement)

a) Replacement

Machine employed in production may need to be replaced for one or more reasons.

1. A machine suffers accidental damage such that the cost of renewal is so great that a new machine is more economical.

2. The capacity of the existing machine is inadequate because of increased scale of production.

3. The machine is obsolete (see ASAE S495)

4. The machine is not expected to operate reliably. (Suffers considerable unanticipated downtime from random part failures.)

5. The cost of making an anticipated repair would increase the average unit accumulated cost above the expected minimum. Only capital costs and actual repair and maintenance costs need be accumulated.

For example, a $3000 machine is used 100 ha annually. It experiences the following end-of-year depreciation, interest (8% simple interest on average investment), and actual repair and maintenance costs in next table. Year 9 has the lowest unit cost and indicates the machine should be replaced with a similar machine at the end of year 9 if not before for other reasons. Inflation effects must be considered in making replacement decisions. Annual depreciation charges may be quite low or even negative in times of rapid inflation producing a premature minimum unit accumulated cost. In such instances replacement is better indicated by comparing the unit accumulated cost of the present machine with the projected costs for a potential successor machine. Optimum replacement time may be delayed beyond that time determined under more stable economic conditions. (See ASAE-P496)

Table 542. Average unit accumulated costs

year	R&M costs	Depr.	Int.	Tot. acc. Costs	Acc. Use, ha	Unit acc. Costs
	$	$	$	$	ha	$/ha
1	10	1000	200	1210	100	12.10
2	50	600	136	1996	200	9.98
3	70	400	96	2562	300	8.54
4	100	300	68	3030	400	7.58
5	200	200	48	3478	500	6.96
6	300	150	34	3962	600	6.60
7	350	125	23	4460	700	6.37
8	450	100	14	5024	800	6.28
9	550	25	9	5608	900	6.23
10	600	25	7	6240	1000	6.24

b) Annual payment of worth

Total cost of several years for machinery is calculated as next equation , and machinery should be replaced at the year so that annual payment is minimum, which is called as economical life of devices.

AP(n) = { P + Σ [(Rj + Qj) / (1+i)^j] - [Sn / (1+i)^n]} * {[i * (1+i)^n] / {(1+i)^n - 1} **Eq. 5-30**

Where:

symbol	term	unit
AP(n)	Adjusted annual payments of worth after n year usage	$ / year
P	Purchase price	$
Rj	Repairing cost in j year	$
Qj	Timely cost etc. in j year	$
Sn	Remaining value after n years	$
i	Annual interest	in decimal

Equation above 5-30 is induced from next equation.

AP(n) = P(n) + R(n) + Q(n) - S(n) **Eq. 5-31**

E = P * [(1+i)^n] **Eq. 5-32**

symbol	term	unit
P(n)	Annual present worth after n year	$ / year
R(n)	Annual repairing cost after n year	$ / year
Q(n)	Annual timeliness cost after n year	$ / year
S(n)	Annual remaining value after n year	$ / year
E	Final worth after n years	$
P	Present worth	$
(1+i)^n	Final worth factor or compound amount factor	-
1 / [(1+i)^n]	Present worth factor	-

Table 542. Annual payment: Example: Combine(P=5 M Yen, i =0.05)

Year	P(n)	Rn	R(n)	Remaining ratio	Sn	AP(n)*	AP(n)**
n	k Yen	k Yen	k Yen	%	k Yen	k Yen	k Yen
1	5,250	50	50	65	3,250	2,050	2,100
2	2,689	100	74	40	2,000	1,788	1,862
3	1,836	150	98	25	1,250	1,538	**1,636**
4	1,410	1,850	505	15	800	1,729	2,234
5	1,155	800	558	10	500	1,623	2,181
6	9,85	650	572	4	200	**1,527**	2,099
7	8,64	2,300	784	2	100	1,636	2,420

*: Assume Q(n) =0 **: Assume Q(n) = R(n)

In case of above table, it is recommendable to replace combine after 6 years or 3 years depending on evaluation of timeliness cost.

c) By decision making method

(i) AHP (Analytic Hierarchy Process)

See Table A-542c. AHP: Example in replacement of tractor in Appendix.

5-5. Exercise

Exercise 5-1. Obtain Maximum number of workers, Total Man-hours per ha, Minimum coverage, Annual cost per ha at farm scale of 10 ha, and Farm work cost index at farm scale 10, 30ha in next table.

Assume, Sales per ha = 12,015 $/ha

No.	Work	M	Nw	MH	AFC	VCa	CA	AC-10ha	AC-30ha	AC-CA	CI-10ha	CI-30ha	CI-CA
		-	-	h/ha	$	$/ha	ha	$/ha	$/ha	$/ha			-
1	Tillage	1	1	3.5	0	79	93	79	79	79	0.7	0.7	0.7
2	Puddling	1	1	3.3	1,350	74	42		119	282			2.3
	Nursery				0	1,230	-						
3	Transplanting	1	2	9.5	4,050	100	29						
4	Caring crop	1	1	12.5	324	153	13	185	164	203	1.5	1.4	1.7
5	Chemical application	1	3	5.7	549	118	87	173	137	203	1.4	1.1	1.7
6	Harvest	1	2	33.3	4,500	330	6.5	780	480	1026	6.5	4.0	8.5
7	Drying	0	0	0.0	0	865	-	865	865	865	7.2	7.2	7.2
8	Husking	0	0	0.0	0	288	-	288	288	288	2.4	2.4	2.4
9	Water manage	0	1	0.0	0	269	-	269	269	269	2.2	2.2	2.2
		max		sum	sum	sum	min	sum	sum	sum	sum	sum	sum
Work system		1			10,773	3,506			3,865	5,172			43

Where,

symbol	term	unit
TOW	Type of work: M= Machine, C= Contract, L= Manual	-
M, Nw	No. of machine, workers	-
WC	Work capacity	h/ha
MH	Man-hours per ha	h/ha
AFC	Annual fixed cost	$
VCa	Variable cost per ha	$/ha
CA	Covered area	ha
AC-*	Annual cost per ha at farm scale of *	$/ha
CI	Cost index (x100): = Cost per ha/ Sales per ha	-

Exercise 5-2. Obtain the maximum total profit and the maximum profit per ha of a farm work system give in next table.(Assume the original machinery set only available)

symbol	term	unit	Example
PRa-max	Maximum Profit per ha:	$/ha	
PSa	Sales per ha	$/ha	12,015
ATCa-ca	Cost per ha at area = coverage	$/ha	
AFC	Annual fixed cost	$	10,773
CA	Coverage	ha	10.1
VCa	Effective Field Capacity	$/ha	3,438
PR-max	Maximum Total Profit	$	
PS-ca	Total Sales at area = coverage	$	
ATC-ca	Total Cost at area = coverage	$	

PRa-max = PSa - ATCa-ca = PSa - [AFC/CA + VCa]

PR-max = PS-ca - ATC-ca = PS-ca - [AFC + VCa * CA]

Exercise 5-3. When annual operation area is larger than the coverage, we need to supply the additional machinery or worker, and machinery cost is calculated accordingly.

Msys = INT(Aa / CAS + 1)

FCa = AFCs * Msys / Aa

Where,

symbol	term	unit	Example
Msys	Number of machinery set of system	-	
Aa	Annual farm work area	ha	
INT	Function of getting integer	-	-
CAS	Coverage of one set	ha	10.1
FCa	Fixed cost per ha	$/ha	
AFCs	Annual fixed cost of one set	$	4,500

Fill the blank columns of next table.

Annual farm work area	No. of set	Annual total fixed cost	Fixed cost per ha
Aa	Msys	AFC	FCa
(ha)	-	US$	($/ha)
1	1	4,500	4,500
5			
10			
15			
20			
30			

Exercise 5-4. Obtain Annual Total fixed cost(AFC) of the farm work system from next table of each farm work. Examine cost per ha(ATCa) of them.

Variable cost per ha(VCa)=3,439$/ha

	Annual fixed cost of each farm work(AFC)									No. of set				
Aa	1	2	3	4	5	6	7	8	9		AFC	FCa	VCa	ATCa
ha	$										$	$/ha	$/ha	$/ha
1	0	1,350	4,050	324	549	4,500	0	0	0	1	10,773	10,773	3,439	14,212
5	0	1,350	4,050	324	549	4,500	0	0	0	1	10,773	2,155	3,439	5,593
10	0	1,350	4,050	324	549	4,500	0	0	0	1			3,439	
15	0	1,350	4,050	648	549	9,000	0	0	0	2			3,439	
20	0	1,350	4,050	648	549	9,000	0	0	0	2			3,439	
25	0	1,350	4,050	648	549	13,500	0	0	0	3			3,439	
30	0	1,350	8,100	972	549	13,500	0	0	0	3	24,471	816	3,439	4,254

Exercise 5-5. Obtain the break-even point of area, using next table.

symbol	term	unit	Example
PSa	Sales per ha	$/ha	12,015
Abp	Break-even point of area	ha	
AFC	Annual total fixed cost	$	10,773
VCa	Total variable cost per ha	$/ha	3,439

Abp = AFC / (PSa - VCa)

Exercise 5-6. When the farm work period schedule is given as following table, obtain the coverage of these farm work.

	←---------------------- S ----------------------→
Work-1	← -----------------S1 -----------------→
Work-2	← -------------- S2 --------------→
Work-3	← ----------- S3 ---------→
	← -------------- S12 -------------------------→
	← --------------------------- S23 --------------------→
	←--------- s1 -------→←----------- s2 ------------→←--- s3 -→

Where,

Symbol	term		Work Capacity: WC
		h	h/ha
S	Total available working hour	200	
S1	Available working hour for work-1	140	WC1 = 8.0
S2	Available working hour for work-2	70	WC2 = 1.0
S3	Available working hour for work-3	56	WC3 = 1.0
S12	Available working hour for work-1 and 2	175	
S23	Available working hour for work-2 and 3	91	

$WCp = WC1 + WC2 + WC3$

$si = S * WCi / WCp$

$CA = \min [S / WCp, S1 / WC1, S2 / WC2, S3 / WC3, S12 / (WC1 + WC2), S23 / (WC2 + WC3)]$

Exercise 5-7. Obtain Annual cost at farm scale 1, 10, 20 ha and at coverage, Sales amount of product, Cost index at the farm scale, no. 2,3,4 in next table.

No.	System	Type	Country	AFC	VCa	CA	AC-01ha	AC-10ha	AC-30ha	AC-CA	PSa
				$	$/ha	ha	$/ha	$/ha	$/ha	$/ha	$/ha
1	FS01-J	TE	J	10,773	3,506	6.5	14,279	4,583	3,865	5,163	12,015
2	FS01-X	TE	J	10,000	3,000	10					12,000
3	FS01-Y	TE	J	12,000	2,500	20					12,000
4	FS01-Z	TE	J	15,000	2,000	30					12,000

Where,

symbol	term	unit	1	2	3	4
FS	Farm scale of system	ha	6.5	10	20	30
Nw-max	Number of workers available	-	3	3	3	3
TMH	Total Man-hours per ha	h/ha	68	50	40	30
AFC	Annual fixed cost	$				
VCa	Variable cost per ha	$/ha				
CA	Covered area	ha				
AC-*	Annual cost per ha at farm scale of *	$/ha	-	-	-	-
PSa	Sales per ha	$/ha				
PRa	Profit per ha	$/ha	6,852			
Abp	Break-even point	ha	1.27	1.11	1.26	1.50
CI	Cost index (x100): = Cost / Sales	-	43			

Exercise 5-8. We have farm work system data of our theme experiment as following table. What and how farm work should be improved for more coverage.

Exercise 5-9. Discuss the idea and plan for more economical farm work system in case of 10ha farm scale.

	Farm work	Daily Capacity	No. of machine set	Working days	Rate of available day	Available work days	Coverage of one set
		DC	M	DWP	ADR	AWD	CAS
No.	Name	ha/d	-	d	%	d	ha
1	Tillage	1.83	1	70	73	51.1	93.5
2	Puddling	1.92	1	30	73	21.9	42.0
3	Transplanting	1.34	1	30	73	21.9	29.4
4	Caring crop	0.44	1	47	65	30.6	13.5
5	Chemical application	2.92	1	47	65	30.6	89.5
6	Harvest	0.33	1	47	65	30.6	10.1
7	Drying		1	47	65	30.6	1000.0

Exercise 5-10. Obtain the required capacity of machinery and the width of machine (Wt), when data are given in next table.

symbol	term	unit	rotary tillage
EFC	Effective Field Capacity	ha/h	
A	Area	ha	15
AWD	Available work days	d	12
Dn	Net work hours per day	h/d	6
Wt	Theoretical operation width	m	
Vt	Theoretical operation speed	km/h	2.0
ef	Field efficiency	in decimal	0.75

EFC = A / (AWD * Dn)

Wt = 10 * EFC / (Vt * ef)

Exercise 5-11. How many machinery sets are necessary to next farm.

symbol	term	unit	example
M	Number of machine set	-	
A	Area	ha	50
CAS	Coverage of one set	ha	13

Exercise 5-12. : How many tractors and implements are required for the following farm work by 35PS tractor (Area: A = 50 ha and Available net working hour: ANWH=250 h)

Farm work	Implement	Work capacity: WC	Number of operation: N	Required number of implement
		h/ha	times	
Tillage	Rotary	5	1	
Harrow	Rotary	4	2	
Leveling	Tooth harrow	1	2	
Seeding	Grain drill	3	1	
Pressing	Roller	2	1	

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APPENDIX

FOR FARM MECHANIZATION PLANNING

Table A-1. Production Cost of Agricultural Products in Japan, 1998

Unit : yen per 0.1ha

Classification	Paddy field rice · Brown base		Wheat ·husked		Soybeans	
Term	House-hold	%	House-hold	%	House-hold	%
Seed and seeding	3,570	2.6	2,898	5.8	2,207	3.9
Fertilizer and manures	8,297	6.0	6,682	13.4	3,860	6.8
Agricultural chemicals	7,680	5.6	3,659	7.3	4,562	8.0
Light, heat and power	2,973	2.2	1,135	2.3	1,292	2.3
Miscellaneous materials	2,184	1.6	258	0.5	149	0.3
Land improvement, water utilization	7,913	5.7	702	1.4	2,119	3.7
Rent and charge	12,321	8.9	12,446	24.9	5,845	10.2
Tax	2,579	1.9	1,308	2.6	824	1.4
Buildings	4,558	3.3	1,163	2.3	852	1.5
Agricultural implements	28,754	20.8	8,957	17.9	7,367	12.9
Depreciation	21,227	15.4	6,584	13.2	5,588	9.8
Management	235	0.2	214	0.4	123	0.2
Labour	56,986	41.3	10,479	21.0	27,889	48.9
Self-supplied (family members')	55,135	39.9	10,313	20.7	26,836	47.0
Total cost	138,050	100.0	49,901	100.0	57,089	100

	Paddy field rice Brown base		Wheat husked		Soybeans
	Individual	Co-operative	Individual	Co-operative	
Total cost	138,050	104,656	49,901	41,275	57,089
Purchased	56,502	54,660	31,482	24,249	23,098
Self--supplied	55,914	37,098	10,783	11,988	27,639
Depreciation	25,634	12,898	7,636	5,038	6,352
Value of by-products	3,373	2,713	1,724	1,080	155
Production Cost*	134,677	101,943	48,177	40,195	56,934
Interest	839	1,286	778	421	404
Land rent	4,316	9,536	2,404	2,117	3,916
Production Cost**	139,832	112,765	51,359	42,733	61,254
Self capital interest	8,430	3,486	2,013	1,245	2,310
Owner land rent	21,765	15,953	8,525	6,788	8,986
Production Cost***	170,027	132,204	61,897	50,766	72,550
Gross income per 10 a	141,339	142,826	61,115	47,458	44,012
Income per 10 a	53,269	60,673	18,345	12,883	9,439
Income per day	5,303	17,659	10,462	7,760	—

Source: "Survey of Production Cost" by the Ministry of Agriculture, Forestry &Fisheries.

from fm-01.xls

Table A-211. Standard value of work rate: part 1

Kind of work	Implement: Name	Implement: Dimension	Implement: Width	Tractor horse power	Work rate & others: Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	Fuel Consumption	
Symbol			Wt		W	V	EF	EFC	WC	Nw			
Unit	-	-	m	PS	m	km/h	%	ha/h	h/ha	-	-	L/h	L/ha
Manure Spreader	Manure loader	bucket 0.1m3	75kg	11-24				0.18	5.6	1	L	3.5	19.5
		0.35m3	270kg	25-				0.79	1.3	1	L	4.5	5.7
	Manure loader (self P.)	0.14m3	100kg	14				0.24	4.2	1	G	4.0	16.7
		0.31m3	240kg	30				0.57	1.8	1	G	8.0	14.0
	Manure Spreader	horizontal beater	1t	20-30	1.8	4.0	60	0.43	2.3	1	L	2.5	5.8
			2t	30-40	2.2	5.0	60	0.66	1.5	1	L	3.0	4.5
			3t	40-50	2.4	5.0	60	0.72	1.4	1	L	3.5	4.9
			5t	50-	3.0	6.0	60	1.08	0.9	1	L	4.0	3.7
		vertical beater	1t	30-40	8.0	4.0	60	1.92	0.5	1	L	3.5	1.8
			3t	50	10.0	4.0	60	2.40	0.4	1	L	4.0	1.7
Ferilizer, etc.	slurry injector	subsoiler: 1200L		35-45	1.2	1.2	3.0	0.180	0.18	5.6	L	8.0	44.4
		2000L		60-	2.4	3.0	50	0.36	2.8	1	L	11.0	30.6
		30001		70-	2.4	4.0	50	0.48	2.1	1	L	12.5	26.0
		rotary: 1100L		40-	2.4	2.4	2.5	0.300	0.30	3.3	L	8.0	26.7
	vacuum car	500L		-20	2.1	4.0	60	0.50	2.0	1	L	3.5	6.9
		1200L		30-40	2.4	4.0	60	0.58	1.7	1	L	12.5	21.7
	Slurry spreader	2000L		50-	2.6	6.0	60	0.94	1.1	1	L	10.0	10.7
		3000L		70	2.7	6.0	60	0.97	1.0	1	L	12.5	12.9
	for tiller	pull: 0.3m3		5-	1.2	1.2	4.0	0.240	0.24	4.2	G	1.5	6.3
	Lime sower	0.3m3		15-20	1.4	5.5	50	0.39	2.6	2	L	2.0	5.2
		0.4m3		20-30	1.8	5.5	50	0.50	2.0	2	L	2.5	5.1
		0.5m3		30-40	2.4	5.5	50	0.66	1.5	2	L	3.0	4.5
		0.6m3		50-	2.7	5.5	50	0.74	1.3	2	L	3.5	4.7
	Broadcaster	Centrifugal	100L	15-20	5.0	4.0	55	1.10	0.9	2	L	1.5	1.4
			200L	20-30	6.0	5.0	55	1.65	0.6	2	L	2.0	1.2
			300L	30-	6.0	6.0	55	1.98	0.5	2	L	2.5	1.3
		Reciprocating	200L	25-	8.0	4.0	55	1.76	0.6	2	L	2.0	1.1
			400L	40-	10.0	6.0	55	3.30	0.3	2	L	3.0	0.9
		Pulling	10000L	30-	8.0	4.0	55	1.76	0.6	2	L	2.5	1.4
Pan-breaker, trencher	Subsoiler	depth 40cm	1row	30-40	3.0	2.5	80	0.60	1.7	1	L	6.5	10.8
					1.5	2.5	80	0.30	3.3	1	L	6.5	21.7
		30cm	2row	40-50	4.0	2.5	80	0.80	1.3	1	L	8.0	10.0
					3.0	2.5	80	0.60	1.7	1	L	8.0	13.3
		50cm	2row	60-	4.0	3.0	80	0.96	1.0	1	L	11.0	11.5
					3.0	3.0	80	0.72	1.4	1	L	11.0	15.3
	Oscillating subsoiler	30-40cm	1row	15-20	3.0	0.8	80	0.19	5.2	1	L	3.0	15.6
					1.5	0.8	80	0.10	10.4	1	L	3.0	31.3
		30-40cm	2row	35-	4.0	0.8	80	0.26	3.9	1	L	6.5	25.4
					3.0	0.8	80	0.19	5.2	1	L	6.5	33.9
	Chain trencher (self p.)	Depth 100cm	10cm	5-	1.0	0.2	85	0.02	58.8	1	G	2.0	117.6
			15cm	10-	1.0	0.4	85	0.03	29.4	1	L	4.0	117.6
			18cm	15-	1.0	0.5	85	0.04	23.5	1	L	5.0	117.6
	Chain trencher	Depth 120cm	1row	20-40	1.0	0.3	85	0.02	47.1	1	L	4.5	211.8
			2row	40-60	2.0	0.3	85	0.04	23.5	1	L	5.0	117.6
	Rotary trencher	Depth 30cm	40cm	25-	5.0	1.0	80	0.40	2.5	1	L	4.5	11.3
Tillage	Japanese plow for tractor	10 x 2	0.50	15-20	0.5	5.0	75	0.19	5.3	1	L	3.0	16.0
		10 x 3	0.75	20-30	0.8	5.0	75	0.28	3.6	1	L	3.5	12.4
		10 x 4	1.00	30-50	1.0	5.0	75	0.38	2.7	1	L	5.0	13.3

from fm-211.xls

Table A-211. Standard value of work rate: part 2

Kind of work	Implement			Tractor horse power	Work rate & others								
	Name	Dimension	Width		Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	Fuel Consumption	
Symbol			Wt		W	V	EF	EFC	WC	Nw			
Unit	-	-	m	PS	m	km/h	%	ha/h	h/ha	-	-	L/h	L/ha
Tillage	Bottom plow	14 x 1	0.35	20-30	0.4	5.0	70	0.12	8.2	1	L	3.5	28.6
		16 x 1	0.40	30-40	0.4	5.0	70	0.14	7.1	1	L	5.0	35.7
		18 x 1	0.45	40-50	0.5	5.0	70	0.16	6.3	1	L	6.5	41.3
		20 x 1	0.50	50-60	0.5	5.0	70	0.18	5.7	1	L	7.5	42.9
		22 x 1	0.55	60-	0.6	5.0	70	0.19	5.2	1	L	9.0	46.8
		14 x 2	0.70	30-40	0.7	5.0	70	0.25	4.1	1	L	5.0	20.4
		16 x 2	0.80	40-50	0.8	5.0	70	0.28	3.6	1	L	6.5	23.2
		18 x 2	0.90	60-	0.9	5.0	70	0.32	3.2	1	L	9.0	28.6
		14 x 3	1.05	50-60	1.1	5.0	70	0.37	2.7	1	L	7.5	20.4
		16 x 3	1.20	60-80	1.2	5.0	70	0.42	2.4	1	L	10.0	23.8
		16 x 5	2.00	90-	2.0	5.0	70	0.70	1.4	1	L	12.0	17.1
	Drive disk	One way	5row	20-30	1.3	3.0	70	0.27	3.7	1	L	1.5	5.5
			7row	30-40	1.6	3.0	70	0.34	3.0	1	L	2.0	6.0
			8row	40-	2.0	3.0	70	0.42	2.4	1	L	2.5	6.0
		Two way	4row	20-25	1.4	1.8	80	0.20	5.0	1	L	3.0	14.9
			6row	25-30	1.9	1.8	80	0.27	3.7	1	L	4.0	14.6
			8row	30-40	2.3	1.8	80	0.33	3.0	1	L	4.5	13.6
Harrow, leveller	Disk harrow	18x24		25-30	1.7	5.0	80	0.68	1.5	1	L	3.5	5.1
		18x20		30-40	1.8	5.0	80	0.72	1.4	1	L	5.0	6.9
		18x24		50-60	2.1	5.0	80	0.84	1.2	1	L	7.5	8.9
		20x26		60-	2.3	5.0	80	0.92	1.1	1	L	9.0	9.8
	Tooth harrow	30x2		15-25	2.3	6.0	70	0.97	1.0	1	L	3.0	3.1
		30x3		30-40	3.4	6.0	70	1.43	0.7	1	L	5.0	3.5
		30x4		40-	4.5	6.0	70	1.89	0.5	1	L	6.5	3.4
	Culti-packer	1.8m		20-30	1.8	4.0	70	0.50	2.0	1	L	2.0	4.0
		2.4m		40-50	2.4	4.0	70	0.67	1.5	1	L	3.0	4.5
		2.7m		60-	2.7	4.0	70	0.76	1.3	1	L	4.0	5.3
Rotary tillage	Rotary harrow			15-20	1.0	3.0	80	0.24	4.2	1	L	3.0	12.5
				25-30	1.4	3.0	80	0.34	3.0	1	L	4.0	11.9
				40-50	1.8	3.0	80	0.43	2.3	1	L	6.5	15.0
				50-60	2.0	3.0	80	0.48	2.1	1	L	7.5	15.6
				60-	2.4	3.0	80	0.58	1.7	1	L	9.0	15.6
	Rotary tiller			-8	0.5	1.4	85	0.05	18.7	1	G	1.5	28.0
				8-12	0.6	1.4	85	0.07	14.0	1	L	3.0	42.0
	Rotary (upland)		0.8m	-15	0.8	2.5	80	0.16	6.3	1	L	3.0	18.8
			1m	15-20	1.0	2.5	80	0.20	5.0	1	L	3.5	17.5
			1.2m	20-25	1.2	2.5	80	0.24	4.2	1	L	4.0	16.7
			1.4m	25-30	1.4	2.5	80	0.28	3.6	1	L	4.5	16.1
			1.6m	30-40	1.6	2.5	80	0.32	3.1	1	L	6.5	20.3
			1.8m	40-50	1.8	2.5	80	0.36	2.8	1	L	8.0	22.2
			2m	50-60	2.0	2.5	80	0.40	2.5	1	L	10.0	25.0
			2.3m	70-	2.3	2.5	80	0.46	2.2	1	L	12.5	27.2

Table A-211. Standard value of work rate: part 3

Kind of work	Implement: Name	Implement: Dimension	Implement: Width	Tractor horse power	Work rate & others: Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	Fuel Consumption	
Symbol			Wt		W	V	EF	EFC	WC	Nw			
Unit	-	-	m	PS	m	km/h	%	ha/h	h/ha	-	-	L/h	L/ha
Rotary tillage	Rotary (paddy field)		0.8m	-15	0.8	1.4	75	0.08	11.9	1	L	3.5	41.7
			1m	15-20	1.0	1.4	75	0.11	9.5	1	L	4.0	38.1
			1.2m	20-25	1.2	1.4	75	0.13	7.9	1	L	4.5	35.7
			1.4m	25-30	1.4	1.4	75	0.15	6.8	1	L	5.0	34.0
			1.6m	30-40	1.6	1.9	70	0.21	4.7	1	L	6.5	30.5
			1.8m	40-50	1.8	1.9	70	0.24	4.2	1	L	8.0	33.4
			2m	50-60	2.0	2.0	70	0.28	3.6	1	L	10.0	35.7
			2.4m	60-	2.4	2.0	70	0.34	3.0	1	L	11.0	32.7
	Rotary deep type	Depth 40cm		40-50	1.5	0.5	80	0.06	16.7	1	L	8.0	133.3
		60cm		70-100	1.6	0.5	80	0.06	15.6	1	L	14.5	226.6
Fertilizer, seeder	Fertilizer, seeder by tiller			3-6	0.6	1.5	75	0.068	14.81	1	G	1.0	14.8
				8-12	1.2	1.5	65	0.117	8.55	1	L	2.0	17.1
	Drill seeder	Mount type	7row	20-30	1.4	3.5	55	0.270	3.71	2	L	2.5	9.3
			13row	30-40	2.0	3.5	55	0.385	2.60	2	L	3.5	9.1
			17row	50-	2.6	3.5	55	0.501	2.00	2	L	4.5	9.0
		Drawing type	18row	40-	2.7	4.0	60	0.648	1.54	2	L	4.5	6.9
			24row	60-	3.6	4.0	60	0.864	1.16	2	L	6.9	8.0
	Rotary seeder	Mount type	6row	40-	1.8	2.3	60	0.248	4.03	2	L	6.5	26.2
			10row	60-	2.4	2.3	60	0.331	3.02	2	L	9.8	29.6
	Pneumatic seeder	2row		30-40	1.2	5.4	55	0.356	2.81	2	L	5.0	14.0
		4row		40-	2.4	5.4	55	0.713	1.40	2	L	6.5	9.1
	Corn planter	Mount type	2row	20-30	1.2	2.0	55	0.132	7.58	2	L	3.0	22.7
			2row	20-30	1.4	2.0	55	0.154	6.49	2	L	3.0	19.5
			3row	30-	1.8	2.0	55	0.198	5.05	2	L	4.0	20.2
			3row	30-	2.1	2.0	55	0.231	4.33	2	L	4.0	17.3
			4row	40-	2.4	2.0	55	0.264	3.79	2	L	5.5	20.8
			4row	40-	2.8	2.0	55	0.308	3.25	2	L	5.5	17.9
Transplanter	Transplanter	by tiller	1row	6-8	0.6	0.5	80	0.022	46.30	2	G	1.0	46.3
	Transplanter		2row	30-	1.2	1.2	60	0.086	11.57	3	L	2.5	28.9
			4row	50-	2.4	1.2	60	0.173	5.79	5	L	3.5	20.3
Cultivating	Ridger	2row		20-30	1.2	3.5	70	0.294	3.40	1	L	3.0	10.2
		3row		30-	1.8	3.5	70	0.441	2.27	1	L	4.0	9.1
	Cultivator	2row		15-25	1.2	3.5	75	0.315	3.17	1	L	2.5	7.9
		3row		25-	1.8	3.5	75	0.473	2.12	1	L	3.0	6.3
		4row		30	2.4	3.5	75	0.630	1.59	1	L	4.0	6.3
	Rotary cultivator	2row		20-	1.2	3.5	75	0.315	3.17	1	L	3.0	9.5
		3row		25-	1.8	3.5	75	0.473	2.12	1	L	3.5	7.4
		4row		35-	2.4	3.5	75	0.630	1.59	1	L	5.0	7.9
Puddling	Paddy Harrow	1.8m		13-20	1.8	3.2	85	0.490	2.04	1	L	3.0	6.1
		2m		20-25	2.0	3.2	85	0.544	1.84	1	L	3.5	6.4
		2.4m		25-30	2.4	3.2	85	0.653	1.53	1	L	4.0	6.1
		2.8m		25035	2.8	3.2	85	0.762	1.31	1	L	5.0	6.6
		3.3m		40-	3.3	3.2	85	0.898	1.11	1	L	6.5	7.2
		3.3m		40-	3.3	4.0	85	1.122	0.89	1	L	6.5	5.8
	Rotary +Plank	2.4m	1m	5-6	1.0	2.9	80	0.232	4.31	1	G	3.0	12.9
		3.5m	1.2m	8-12	1.2	3.0	80	0.288	3.47	1	L	3.0	10.4

Table A-211. Standard value of work rate: part 4

Kind of work	Implement: Name	Implement: Dimension	Implement: Width	Tractor horse power	Work rate & others: Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	Fuel Consumption	
Symbol			Wt		W	V	EF	EFC	WC	Nw			
Unit	-	-	m	PS	m	km/h	%	ha/h	h/ha	-	-	L/h	L/ha
Rice-transplant	Rice transplanter	Walking type	2row	2.2	0.6	1.5	65	0.059	17.09	2	G	1.0	17.1
			3row	2.7	0.9	1.5	65	0.088	11.40	2	G	1.0	11.4
			4row	3.0	1.2	1.5	65	0.117	8.55	2	G	1.2	10.3
			6row	3.1	1.8	1.5	65	0.176	5.70	2	G	1.2	6.8
		Riding type	4row	3.7	1.2	2.0	60	0.144	6.94	2	G	1.5	10.4
			5row	4.5	1.5	2.0	60	0.180	5.56	2	G	1.8	10.0
			6row	5.0	1.8	2.0	60	0.216	4.63	2	G	2.0	9.3
		high speed type	4row	5.8	1.2	2.5	60	0.180	5.56	2	G	2.5	13.9
			5row	5.8	1.5	2.5	60	0.225	4.44	2	G	2.5	11.1
			6row	7.7	1.8	2.5	60	0.270	3.70	2	G	3.1	11.5
			8row	7.7	2.4	2.5	60	0.360	2.78	2	G	3.3	9.2
Chemical application	Knap-sack power sprayer	Duster			6.0	1.2	65	0.468	2.14	1	M	0.8	1.7
		Granular			10.0	1.2	65	0.780	1.28	1	M	0.8	1.0
		Mist			6.0	1.2	65	0.468	2.14	1	M	0.8	1.7
		Long hose duster			30.0	1.2	45	1.620	0.62	2	M	0.8	0.5
					40.0	1.2	45	2.160	0.46	2	M	0.8	0.4
	Boom sprayer	200L		15-25	4.5	2.5	65	0.731	1.37	2	L	2.0	2.7
		300L		25-35	6.5	2.5	65	1.056	0.95	2	L	3.0	2.8
		400L		40-	8.0	2.5	65	1.300	0.77	2	L	3.5	2.7
					8.0	3.5	65	1.820	0.55	2	L	3.5	1.9
	Mount type sprayer	Long hose duster		40-	100.0	3.0	65	19.500	0.05	2	L	4.0	0.2
		Levy sprayer		30-40	10.0	3.0	65	1.950	0.51	2	L	2.5	1.3
				40-	30.0	3.0	65	5.850	0.17	2	L	3.0	0.5
					30.0	3.5	65	6.825	0.15	2	L	3.0	0.4
	Sprayer	20L/min			3.0	2.0	65	0.390	2.56	2	G	1.0	2.6
Harvest	Binder	1row		1.8	0.3	2.0	75	0.045	22.22	1	G	0.8	17.8
		2row		3.0	0.6	2.0	75	0.090	11.11	1	G	1.5	16.7
	Self-feeding Combine (for wheat x 2)	bag type	2row	6-10	0.6	1.3	70	0.055	18.32	2	L	1.8	33.0
			2row	12-14	0.6	2.2	70	0.092	10.82	2	L	2.5	27.1
			3row	18-22	0.9	2.6	70	0.164	6.11	2	L	3.5	21.4
			4row	29-32	1.2	3.0	70	0.252	3.97	2	L	5.0	19.8
			5row	46	1.5	3.0	70	0.315	3.17	2	L	6.5	20.6
		tank type	5row	46	1.5	3.0	65	0.293	3.42	1	L	6.5	22.2
	Combine (for wheat x 2)	tank type	2m	60-	2.0	3.0	65	0.390	2.56	2	L	10.0	25.6
			2m	60-	2.0	3.6	65	0.468	2.14	2	L	10.0	21.4
			3m	107-	3.0	3.0	65	0.585	1.71	2	L	19.0	32.5
	Bean harvester	Walking type	1row	1.8	0.7	3.2	65	0.146	6.87	1	G	1.0	6.9
	Soybean harvester		2row	15	1.4	2.5	65	0.228	4.40	2	L	3.5	15.4
	Thresher			6				0.200	5.00	2	L	2.0	10.0
	Soybean sheller			5				0.190	5.26	3	G	3.0	15.8
	Husker	Roll width	6.4 cm					0.100	10.00	2	E	1.5kW	
			7.6 cm					0.200	5.00	2	E	1.9kW	
			10.2cm					0.250	4.00	2	E	1.9kW	
			12.7cm					0.333	3.00	2	E	3.7kW	

Table A-212. Standard value of work rate (for Vegetable and Fruit)

Vegetable

Kind of work	Implement			Tractor horse power	Work rate & others								
	Name	Dimension	Width		Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	Fuel Consumption	
Symbol			Wt		W	V	EF	EFC	WC	Nw			
Unit	-	-	m	PS	m	km/h	%	ha/h	h/ha	-	-	L/h	L/ha
Ridging	Ridge	Walking type	1row	4-6	0.6	3	75	0.135	7.41	1	G	1.0	7.4
			2row	8-12	1.2	3	75	0.270	3.70	1	G	1.5	5.6
Mulch	Mulcher	Walking type		6-8	0.6	1.4	75	0.063	15.87	1	L	1.0	15.9
				6-8	0.9	1.4	75	0.095	10.58	1	L	1.0	10.6
				15-	0.9	1.6	75	0.108	9.26	1	L	2.0	18.5
				15-	1.35	1.6	75	0.162	6.17	1	L	2.5	15.4
				20-	1.8	1.6	75	0.216	4.63	1	L	2.5	11.6
Trans-plant	Transplanter	1 row disk		6-8	0.6	0.45	80	0.022	46.30	2	G	1.5	69.4
		2 row disk		30-	1.2	1.2	60	0.086	11.57	3	L	3.5	40.5
		4 row disk		30-	2.4	1.2	60	0.173	5.79	3	L	4.0	23.1
	Potato planter	Semi-auto		25-	1.2	2	60	0.144	6.94	3	L	3.0	20.8
		Full-auto		25-	1.2	2.5	60	0.180	5.56	2	L	3.5	19.4
Soil disinfection	Soil disinfector	1 row			0.3	3.5	70	0.074	13.61	1	G	1.0	13.6
		2 row		4-6	0.6	3.5	75	0.158	6.35	1	G	1.0	6.3
		4 row		15-	1.2	3.5	75	0.315	3.17	2	L	2.5	7.9
		6 row		20-	1.8	3.5	75	0.473	2.12	2	L	3.0	6.3
Cultivation	Ridge	1row		4-6	0.6	2.5	75	0.113	8.89	1	G	1.0	8.9
		1row		8-12	0.6	3.5	75	0.158	6.35	1	G	1.5	9.5
	Cultivator	1row		4-6	0.6	2.5	75	0.113	8.89	1	G	1.0	8.9
	Rotary culti	1row		4-6	0.6	1	75	0.045	22.22	1	G	1.0	22.2
				4-6	0.9	1.2	75	0.081	12.35	1	G	1.0	12.3
	Rotary plow			8-12	0.9	1.3	75	0.088	11.40	1	G	1.5	17.1

Fruit

Kind of work	Name	Dimension	Width	Tractor horse power	Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	L/h	L/ha
Protection	Speed sprayer	50L/min		18	10	2.0	75	1.500	0.67	1	L	5.0	3.3
		90L/min		35	14	2.7	75	2.835	0.35	1	L	6.0	2.1
		160L/min		53	16	3.2	75	3.840	0.26	1	L	10.0	2.6
Cultivation	Mower	Shoulder		1.2-1.5	2.2	0.3	80	0.044	22.73	1	M	0.5	11.4
	Rotary mower			5-6	0.6	3.0	80	0.144	6.94	1	G	2.0	13.9
				6-7	0.75	3.0	80	0.180	5.56	1	G	2.0	11.1

Table A-213. Standard value of work rate (for Forage crop)

Kind of work	Implement: Name	Implement: Dimension	Implement: Width	Tractor or horse power	Work rate & others: Operation width	Speed of Travel	Field Efficiency	Effective Field Capacity	Work capacity	Worker	Fuel	Fuel Consumption	
Symbol			Wt		W	V	EF	EFC	WC	Nw			
Unit	-	-	m	PS	m	km/h	%	ha/h	h/ha	-	-	L/h	L/ha
Processing	Trencher	Chain type		6-10	1.0	0.1	70	0.01	119.0	1	G	1.5	178.6
	Mower	Walking type	Rotary	3-6	0.7	3.0	60	0.13	7.9	1	G	1.0	7.9
			Recipro.	3-6	0.9	3.0	60	0.16	6.2	1	G	1.0	6.2
		Riding type	Recipro.	25-	1.5	6.5	65	0.63	1.6	1	L	3.5	5.5
				40-	1.8	6.5	65	0.76	1.3	1	L	6.5	8.5
				40-	2.1	6.5	65	0.89	1.1	1	L	6.5	7.3
			Disk x 4	40-	1.6	8.0	70	0.90	1.1	1	L	8.0	8.9
			Disk x 6	50-	2.4	8.0	70	1.34	0.7	1	L	10.0	7.4
			Drum x 2	40-	1.6	8.0	70	0.90	1.1	1	L	8.0	8.9
		Self p.		15-	1.5	5.0	70	0.53	1.9	1	G	2.0	3.8
				35-	2.0	5.0	70	0.70	1.4	1	G	3.0	4.3
	Conditioner	Pull type		50-	2.1	6.5	60	0.82	1.2	1	L	10.0	12.2
	Forage harvestor	Flail type		25-	1.0	3.0	75	0.23	4.4	1	L	4.5	20.0
				40-60	1.5	4.5	75	0.51	2.0	1	L	10.0	19.8
		Cutter head		50-	1.8	4.5	75	0.61	1.6	1	L	10.0	16.5
				50-	3.0	3.5	75	0.79	1.3	1	L	10.0	12.7
		Low crop	1row	50-	0.8	4.5	75	0.25	4.0	1	L	10.0	39.5
		Low crop	2row	80-	1.5	4.0	75	0.45	2.2	1	L	14.5	32.2
	Corn harvester	Fly-wheel cylinder	1row	40-	0.8	4.0	70	0.21	4.8	1	L	8.0	38.1
			2row	80-	1.5	4.0	75	0.45	2.2	1	L	14.5	32.2
	Hay tedder	Vertical	1-2	20-	1.8	7.0	80	1.01	1.0	1	L	2.5	2.5
			4-6shaft	25-	3.6	7.0	80	2.02	0.5	1	L	3.5	1.7
		Drum		25-	2.4	5.5	80	1.06	0.9	1	L	3.5	3.3
			straight	25-	2.4	5.5	80	1.06	0.9	1	L	3.5	3.3
	Hay rake	Chain belt		25-	1.8	5.5	80	0.79	1.3	1	L	3.5	4.4
		Revolution wheel		20-	2.1	6.5	80	1.09	0.9	1	L	3.0	2.7
				30-	2.5	6.5	80	1.30	0.8	1	L	3.5	2.7
		Drum		25-	2.4	6.0	80	1.15	0.9	1	L	3.5	3.0
		Chain		25-	1.8	5.5	80	0.79	1.3	1	L	3.5	4.4
	Hay baler	Tight	1.2m	35-	3.0	4.0	60	0.72	1.4	1	L	5.0	6.9
			1.5m	40-	3.0	4.5	60	0.81	1.2	1	L	6.5	8.0
		Roll	straw	3.5-6	1.5	1.8	50	0.14	7.4	1	L	1.5	11.1
	Roll baler	Mount	0.45x0.85	15-	1.5	3.6	75	0.41	2.5	1	L	3.0	7.4
		Pull type	0.9x1	25-	3.0	4.0	75	0.90	1.1	1	L	6.5	7.2
			1.2x1.2	40-	3.0	6.0	75	1.35	0.7	1	L	8.0	5.9
	Load wagon	1 t	1.4m	25-	2.4	3.0	65	0.47	2.1	1	L	3.0	6.4
		2 t	1.6m	35-	2.4	3.5	65	0.55	1.8	1	L	5.0	9.2
		3 t	1.8m	50-	2.4	4.0	65	0.62	1.6	1	L	6.5	10.4

Source: Zennoh, Kikaika-keikaku-no-tebiki, 1990

Table A-214. Standard value of work rate of Dryer

Type	Crop	Grain tank Capacity	Inlet-outlet time	Moisture reduction rate		Power required	Combustion rate per hour (Kerosene)
Symbol				min	max		
Unit		t	h	%/h		kW	L/h
Circulate type	Rice and wheat	1.0	0.8	0.9		0.7	1.6
		1.5	0.9	0.8		1.5	1.8
		2.0	0.9	0.8		1.5	2.8
		2.5	1.0	0.7		1.9	3.0
		3.0	1.2	0.7		1.9	3.6
		4.0	1.3	0.7		3.0	4.9
		5.0	1.6	0.7		3.2	6.1
		15.0	1.5	0.7		-	-
		20.0	2.5	0.7		-	-
		30.0	3.0	0.7		-	-
General type (Flat bed)	Rice and wheat	0.7	0.7	0.5	0.7	0.4	1.8
	Soy bean	0.7	0.7	0.4		0.4	1.8
	Rice and wheat	2.0	0.9	0.3	0.6	1.5	1.8
	Soy bean	2.0	0.9	0.4		1.5	1.8
General type	Bean	5.0	1.1	0.4		4.0	6.5
	Bean	7.0	1.5	0.4		4.8	9.4

Grain tank capacity in case of wheat is 1.1 - 1.5 times of in case of rice

Source: Zennoh, Kikaika-keikaku-no-tebiki, 1990

Table A-215b. Operation speed

Name of operation	Equipment	Operation speed (km/hr)			Remarks
		Low	Standard	High	
Tillage	"Suki" Japanese plow	3.8	4.3	4.7	hand tractor
		3.5	4.5	5.5	
	Bottom plow	3.5	4.5	5.5	
	Rotary	1.2	1.4	1.6	0.45-0.6m width
		1.3	1.6	1.9	15 PS (0.9-1.2m width)
		1.6	2.0	2.3	30 PS <(1.6-1.8m width)
Plowing with harrowing	Harrow - plow	2.7	3.7	4.7	High - cut plow etc
Pan breaking	Sub-soiler	1.8	2.0	2.2	
Harrowing	Rotary	1.2	1.4	1.6	(0.45-0.6 m width)
		1.7	2.0	2.3	15 PS (0.9-1.2m width)
		1.8	1.8	2.5	30 PS <(1.6-1.8m width)
	Desk harrow	4.4	5.2	6.0	
Leveling	Tooth harrow	4.0	5.2	6.3	15 PS (2-3 m width)
		4.6	5.9	7.1	30 PS< (3-4 m width)
Pressing	Landroller	3.6	4.5	5.0	
	Culti - packer	3.6	4.5	5.0	
Puddling	Puddling rake	2.2	2.9	3.6	power tiller
	Paddy harrow	3.6	4.0	4.4	Riding type tractor
	Rotary and leveling plate	3.8	4.0	4.2	Riding type tractor
Transplanting	for mat-type rice seedling	1.1	1.6	2.1	Power driven 2 row type
		1.1	1.4	1.8	Power driven 4 row type
Fertilizer application	Manure spreader	4.5	5.8	7.0	
	Lime Sower	4.0	4.7	5.7	
	Broad - Caster	3.6	4.5	6.2	For fertilizer application
	knapsack power duster	0.6	1.0	1.4	For fertilizer application (boom type blow head)
Sowing and Fertilizing	Grain - drill (Drill-seeder)	2.2	2.6	3.0	Pull - type (walking type)
		1.5	1.9	2.3	Power driven (walking type)
		1.6	2.7	3.7	7 row type (15 PS <)
		2.8	3.3	3.9	11-13 row type (30 PS <)
Sowing and Fertilizing	knapsack power duster	0.8	1.2	1.6	Use granule blow head
Pest and disease control	knapsack power applicator	0.8	1.2	1.6	Duster (boom type blow head)
		1.0	1.2	1.4	Duster (Single blow head)
		1.1	1.4	1.6	Granule blow head
		0.7	0.9	1.1	Mist blower
	Power sprayer	2.0	2.7	3.4	Horizontal type nozzle
		1.5	2.1	2.6	Swath nozzle
	Power duster	1.1	1.6	2.0	Manual type (boom type)
		1.8	2.2	2.5	Pulling-type (boom type)
		1.6	2.0	2.3	Mount type (boom type)
	Granule applicator	1.8	2.3	2.9	Manual type
Harvesting by reaping & binding	Binder	2.0	2.6	3.3	one row type
		1.8	2.2	2.7	two row type
Harvesting & Threshing	Head-feeding type Combine	1.2	1.6	2.1	0.5-0.7 m cutting width
		1.0	1.4	1.8	0.9-1.3 m cutting width
	Standard Combine harvester	0.7	1.2	1.6	1.5-2.4 m cutting width
		0.7	1.3	2.0	3.0 m cutting width
		1.0	1.5	2.5	4.7 m cutting width

Source: Reference 18.

For upland work, see ASAE-D497

Table A-216. Field efficiency

Name of works	Equipment	Field efficiency (%)			Remarks
		Low	Standard	High	
Tillage	Suki for hand tractor	75	84	94	power tiller
	Bottom plow	50	62	73	Including Suki
	Rotary tiller	82	89	96	power tiller
		64	75	86	15PS< tractor
Plowing & Pulverizer	Plow with pulverizer	50	62	73	High-cut plow, plow-rotary etc
Pan-break	Sub-soiler	30	35	40	
Pulverizer ,harrowing	Rotary & tiller	82	89	96	power tiller
		70	82	94	Above 15 PS tractor
	Disk-harrow	65	70	75	
Leveling	Tooth-harrow	70	80	90	
Pressing	Roller	60	65	70	Including culti-packer
Pudding	Paddy harrow	70	82	94	Rotary and leveling plate
Trans-planting	Rice transplanter with young seedling	33	54	74	Manual operated one row type
		37	55	74	Power driven two row type
	with large rice seedling	39	56	73	Power driven two row type
Fertilizer application	Manure spreader	20	30	40	Including the feeding manure and transporting
	Lime sower	40	50	60	
	Broad - castor	45	55	66	
Sowing & fertilizing	Grain drill (Drill seeder)	54	65	76	Power driven(walking type)
		30	45	60	Direct mounted type
		38	52	66	Traction type
Pest and disease control	Knapsack type power duster	35	50	65	Dusting
	Power sprayer	35	50	65	Used horizontal nozzle
		24	35	46	Swath - nozzle
	Power duster	35	50	65	
	Manual hand sprayer	37	54	71	
Reaping & binding	Reaper binder	47	65	83	
Threshing	Self-propelled power thresher	47	65	83	
Harvesting & threshing	Head-feeding type Combine	34	50	66	Including harvesting by hand in corner
		51	65	79	Not including by hand harvest
	Standard type Combine	43	55	66	

Table A-216. shows Field efficiency, which contains the statistically arranged results, based on examination. This field efficiency is the standard value, which comes from the average value of the test results (tested in the experimental station in Japan), regardless of the shape, size of field and method of works. The column of "low" is the number, which the standard deviation was deduced from the value.
(for upland work see ASAE-D497)

Source: Reference 18.

Table A-23b. Effect of field size and shape etc.

Machinery	Operating method	Analytical equations		
plow	returned + followed	T = (x*y)/(v*w) + tb + tc + td + te	tb = η0*[(y-2*n*w)/v1]+2*(x-L)/v1 + 4*t0 + [(x-2*n*w)/w - 1] + 4*η*t2	
harrow	spiral	T = [x * (y-2*H)]/(v*w) + (x/w - 1)*t1+ tc + td + te	ta = [x * (y-2*H)]/(v*w) + (x/w - 1)*t1	
rotary	returned + followed	T = (x*y)/(v*w) + tb + tc + td + te	tb = [(x-2*n*w)/w - 1] * t1+ 4*n*t2	
mount type drill seeder	returned + followed	T = (x*y)/(v*w) + tb + tc + td + te + tf	tb = [(x-2*n*w)/w - 1] * t1+ 4*n*t2	tf = (qf*x*y*t4f)/Qf + (qs*x*y*t4s)/Qs
trail type drill seeder	returned + headland	T = (x*y)/(v*w) + tb + tc + td + te + tf	tb = [x/w - 2] * t1+ 2*(n-1)*t20 + 2*t21	tf = (qf*x*y*t4f)/Qf + (qs*x*y*t4s)/Qs
mount type boom sprayer	returned + headland	T = (x*y)/(v*w) + tb + tc + td + te + tf	tb = [x/w - 1] * t1+ y/v1	tf + tg = (t4 + t5)*(q*x*y)/Q
	returned + followed	T = (x*y)/(v*w) + tb + tc + td + te + tf + tg	tb = [(x-2*n*w)/w - 1] * t1+ 4*t2	tf + tg = (t4 + t5)*(q*x*y)/Q
levee nozzle sprayer	both side returned	T = (x*y)/(v*w) + tb + tc + td + te + tf + tg	tb = 2*x/v2 + t6	tf + tg = (t4 + t5)*(q*x*y)/Q
	both side one-way	T = (x*y)/(v*w) + tb + tc + td + te + tf	tb = (x*y)/(v1*w) + 2*x/v2 + t6	tf + tg = (t4 + t5)*(q*x*y)/Q
	both side returned	T = (x*y)/(v*w) + tb + tc + td + te + tf	tb = 2*x/v2	tf + tg = (t4 + t5)*(q*x*y)/Q
	both side one-way	T = (x*y)/(v*w) + tb + tc + td + te + tf	tb = (x*y)/(v1*w) + x/v2	tf + tg = (t4 + t5)*(q*x*y)/Q
bag unloading combine	followed round + returned	T = (x*y)/(v*w) + tb + tc + td + te + th	tb = [(x-2*n*w)/w - 1] * t1+ (4*n-4)*t2 + 4*t20	

where,

T	total operating time	h, s
x	width of field	m
y	length of field	m
w	effective operating width	m
v	effective operating speed	m/s
ta	actual operating time	h, s
tb	total turning time	h, s
tc	moving time in field	h, s
td	regulating time	h, s
te	rest time	h, s
tf	total loading or unloading time	h, s
tg	total transporting time	h, s
th	waiting time	h, s
n0	number of opening process	times
n	number of process at head land	times
v1	operating speed at opening	m/s
v2	idling speed at spraying with levee nozzle	
L	machinery length	m
H	length of head land	m
t0	turning time at opening	s
t1	u type turning time	s
t2	Δ type turning time	s
qf	spreading quantity of fertilizer per unit area	kg/m2
qs	spreading quantity of seed per unit area	kg/m2
Qf	fertilizer hopper capacity	kg
Qs	seed hopper capacity	kg
t20	corner dealing time	s
t12	round turning time	s
t4f	fertilizer loading time	s
t4s	seed loading time	s
t4	loading or unloading time	s
t5	transporting time	s
t6	transporting time	s

Source: Reference 8.

Example (a): Plow

In case of plow, total time will be shown as followings:

T = (x*y)/(v*w) +n0*[(y-2*n*w)/v1]+2*(x-L)/v1 + 4*t0 + [(x-2*n*w)/w - 1] + 4*n*t2+ tc + td + te

where,

x	36	m
y	54	m
w	0.84	m
v	1.3	m/s
tc	65	h, s
td	66	h, s
te	0	h, s
n0	2	times
n	9	times
v1	1.2	m/s
L	machinery length	m
H	5.6	m
t0	26	s
t11	18	s
t2	22	s
lc	5.6	m

and m = y / x and A = x * y / 10**4, then,

$$T = 0.915*xy + 0.297*x**2 + 0.09*x + 1.67*y + 1014$$

$$\fallingdotseq 2.56*A + 0.833*A/m - 0.046 * (\sqrt{m} * A) + 0.28 \qquad \text{(h)}$$

$$C = 1 / [2.56 + 0.83/m - 0.046* (\sqrt{m} / A) + 0.28 / A \qquad \text{(ha/h)}$$

Fig. A-23 shows how the actual field efficiency is varied with size and shape of field. For example, the field efficiency with same plow increases as 47%, 63% and 71% in the area of 20 x 50(10 are), 25m x 80m(20 are) and 30m x 100m(30 are) respectively.

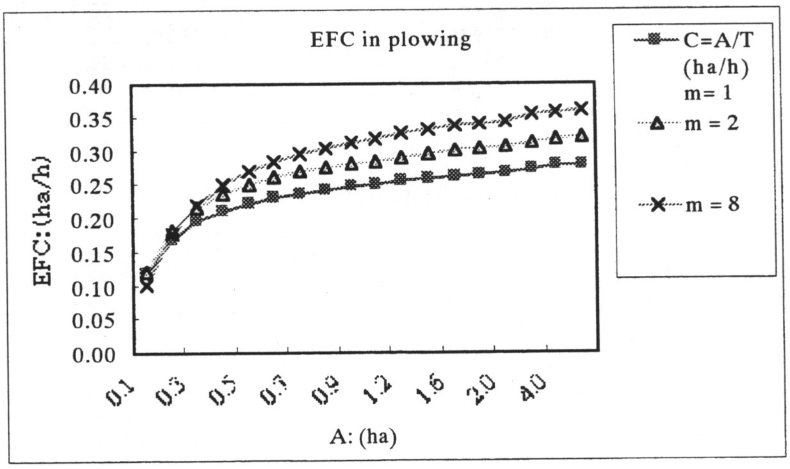

Fig. A-23 Effective Field Capacity of plowing

Table A-232. Relationships between Field Efficiency and Field Size

Shape and Size of field				A	B	C	D	E	F	G	H
				Direct Mounted Type	Direct Mounted Type	Direct Mounted Type	Feeding Needed	Feeding Needed	Feeding Needed	Feeding Needed	
width	Length	Area	Length /Width	Bottom Plow	Rotary Tiller	Tooth Harrow Type	Grain Drill Direct Mounted Type	Grain Drill Pull Type	Power Sprayer Swarth nozzle	Power Sprayer	Combine
m	m	ha		%	%	%	%	%	%	%	%
20	50	0.10	2.5	47	50	62	20	17	24	26	26
20	75	0.15	3.8	58	60	71	26	23	29	29	35
20	100	0.20	5.0	65	67	77	30	27	33	31	41
20	200	0.40	10.0	82	80	87	42	38	40	35	59
25	40	0.10	1.6	45	50	61	19	17	24	26	26
25	80	0.20	3.2	63	66	76	30	27	33	32	41
25	100	0.25	4.0	69	71	80	33	30	36	34	45
25	200	0.50	8.0	84	83	89	45	41	43	38	64
30	50	0.15	1.7	53	59	70	24	22	30	30	34
30	80	0.24	2.7	66	69	79	32	29	36	34	45
30	100	0.30	3.3	71	74	82	36	33	38	36	51
30	200	0.60	6.7	85	85	90	47	44	44	40	67
40	50	0.20	1.3	56	64	74	28	26	34	32	40
40	75	0.30	1.9	67	73	81	34	32	38	36	50
40	100	0.40	2.5	73	78	85	39	37	41	38	57
40	200	0.80	5.0	86	88	92	50	47	47	42	73
50	50	0.25	1.0	58	67	77	30	28	36	34	45
50	80	0.40	1.6	69	77	85	38	36	41	38	56
50	100	0.50	2.0	74	81	83	42	39	44	40	62
50	200	1.00	4.0	86	89	93	52	49	48	44	76
60	83	0.50	1.4	70	79	87	40	39	44	40	61
60	100	0.60	1.7	74	82	89	43	42	45	41	65
60	200	1.20	3.3	86	90	94	53	51	49	45	79
Conditions for Examination	Valid working width (m)			0.84	1.55	3	2.45	3.3	5.5	16.5	2.3
	Valid working speed (km/h)			4.7	1.4	7.9	3.2	4	2.5	2.2	0.9
	Valid working amount(ha/h)			0.39	0.21	2.38	0.76	1.31	1.39	3.56	0.21

from fm-232.xls

Table A-243b. Example of calculation for Net Work Rate

Equipment	Period of Operation (month)	Work hours per day	The Contents of working hours a day										Net work rate
			Net work	Outside of the field and others									
		Dt	Dn	Dm	Dp	Ps	Dc	Da	Dio	Dr	Db	Dw	Dn/Dt
unit		min	min	min	min	min	min	min	min	min	min	min	%
Rotary	April. B.E	606	452	12	10	5	15	10	20	42	40	–	75
Tooth harrow	May .B	648	501	12	10	5	10	5	20	45	40	–	77
Grain drill	May .B	648	416	12	5	5	10	60	20	45	40	–	64
Paddy harrow	May .M.	666	512	12	10	5	15	5	20	47	40	30	77
Rice transplanting	May .M.	666	484	20	10	–	15	15	5	47	40	–	73
Power sprayer (Swath-Nozzle)	June. M.	5	525	12	10	5	15	10	–	49	40	30	75
Knapsack type power duster	June. M.	696	546	20	10	–	10	5	–	25	80	30	78
Power binder	October . B.	528	396	20	10	–	10	15	10	37	30	–	75
Combine	October . B.	528	361	20	10	–	15	15	5	37	30	25	68

B: Beginning of month E: End of month M: Middle of month

Table A-244b. Average monthly farm operation hour per day in each area in Japan. (hours)

month / North latitude (representative place)	January	February	March	April	May	June	July	August	September	October	November	December
26.13 (Naha, Okinawa)	8.8	8.4	9.0	9.9	10.5	10.8	10.6	10.0	9.3	8.5	7.8	7.5
31.00 (Kagoshima, Miyazaki)	7.4	8.1	9.0	10.0	10.8	11.2	11.0	10.4	9.3	8.5	7.8	7.2
34.00 (Yamaguchi, Takamatsu)	7.2	8.0	9.0	10.0	10.9	11.4	11.2	10.5	9.4	8.5	7.5	7.0
35.30 (Tokyo, Tottori, Kobe, Chiba)	7.1	7.9	9.0	10.1	11.0	11.5	11.3	10.6	9.4	8.4	7.5	6.9
37.00 (Niigata, Fukushima)	6.9	7.8	9.0	10.2	11.2	11.7	11.5	10.7	9.5	8.4	7.3	6.7
40.00 (Aomori)	6.6	7.6	9.0	10.3	11.4	12.0	11.8	10.9	9.5	8.3	7.1	6.4
43.00 (Sapporo, Nemuro, Asahikawa)	6.4	7.5	9.0	10.4	11.6	12.3	12.0	11.0	9.5	8.2	6.9	6.2

Table A-423. Area Required for Garage, Housing Cost Coefficient

Model	Housing area	Housing cost coefficient
		RGC
	m^2	%
Tractor (approx. 15 PS)	6.7	0.56
Tractor (approx. 30 PS)	10.3	0.44
Tractor (approx. 40 PS)	11.7	0.46
Tractor (approx. 60 PS)	12.9	0.43
Dual purpose cultivator	3.1	0.61
Hand tractor with Suki	3.6	0.51
Tractor with Suki	2.5	1.81
Bottom plow (12 x 1)	1.7	1.61
Bottom plow (14 x 1)	1.8	1.43
Bottom plow (16 x 1)	2.4	1.14
Bottom plow (12 x 2)	2.4	1.06
Bottom plow (14 x 2)	2.9	1.07
Bottom plow (16 x 2)	3.2	0.96
Bottom plow (12 x 3)	2.3	1.06
Bottom plow (14 x 3)	4.7	1.36
Bottom plow (16 x 1)(R)	4.2	0.70
Rotary (1.2 m wide)	2.5	0.67
Rotary (1.6 m wide)	3.5	0.57
Sub-soiler	1.3	1.20
Plow with break harrow	3.5	0.85
Tooth harrow (30 x 3)	3.1	1.66
Roller	6.6	2.48
Leveling roller	2.6	0.66
Culti-packer	7.5	3.18
Manure spreader (2.2 m2)	7.9	1.15
Lime-sower	6.8	3.29
Broad-caster (200 L)	1.8	0.91
Grain drill (7 row)	4.1	0.95

Model	Housing area	Housing cost coefficient
		RGC
	m^2	%
Grain drill (13 rows)	5.3	0.68
Paddy field harrow	3.2	3.32
Rice transplanter (2 rows)	2.3	0.82
Rice transplanter (4 rows)	3.5	0.61
Portable power sprayer	0.5	0.75
Trailer type power sprayer	5.3	0.39
Loading power sprayer	2.3	0.21
duster (hand)	1.9	0.55
Running duster (trailing)	6.2	0.48
Running duster (loading)	1.8	0.17
Knapsack type power duster	0.4	0.58
Manual duster	0.3	3.04
Reaper-binder (2 rows)	2.7	0.65
Reaper-binder (3 rows)	2.0	0.69
Head feed combine (0.5 mm)	5.2	0.51
Common combine (1.6 m)	16.7	0.31
Common combine (2.1 m)	26.0	0.34
Common combine (2.4 m)	30.0	0.39
Common combine (3.0 m)	32.7	0.37
Common combine (4.2 m)	46.5	0.36
Automatic thresher (400 mm)	1.8	1.55
Huller (76 mm)	1.7	1.17
Huller (150 mm)	3.6	1.65
Flat bed forced air dryer (3.3 m2)	5.1	7.00
Vertical type force air dryer	2.4	2.03
Trailer (500 kg)	5.3	2.45
Trailer (1,000 kg)	7.7	2.30
Trailer (2,000 kg)	10.6	2.24

Table A-426. Years of Durability and Repair cost coefficient of Farm Machinery

Machinery	Name of machine	Years and hour of Durability			Repair cost coefficient		
		Economic life	Total service hour	Mean service hour per year	Total repair cost coefficient	Yearly mean repair cost coefficient	Repair cost coefficient per hour
		L			ER	RR	erh
		year	h	h/year	%	%	%
Tractor	Power tiller,Hand tractor	6	1,200	200	50	8.33	0.042
	Riding type tractor	10	5,000	500	70	7.00	0.014
Tillage & Harrow	Suki for hand tractor	6	900	150	40	6.67	0.044
	Suki for tractor	10	1,500	150	40	4.00	0.027
	Bottom plow	10	1,500	150	40	4.00	0.027
	Disk plow	10	1,500	150	40	4.00	0.027
	Rotary	8	2,000	250	50	6.25	0.025
	Plow with harrow	10	1500	150	40	4.00	0.027
	Sub-soiler	10	1000	100	20	2.00	0.020
	Teeth harrow	15	1,500	100	40	2.67	0.027
Soil preparing	Roller	15	1,500	100	10	0.67	0.007
	Culti-packer	15	1,500	100	10	0.67	0.007
	Puddling rake	6	1,200	200	10	1.67	0.008
	Puddling rotor	6	1,200	200	10	1.67	0.008
Fertilize & seeding	Manure spreader	10	1,500	150	30	3.00	0.020
	Lime sower	10	1000	100	20	2.00	0.020
	Broad-caster	10	1000	100	20	2.00	0.020
	Grain drill	10	1000	100	40	4.00	0.040
	Rice-transplanter	6	1200	200	50	8.33	0.042
Chemical applicator	Knapsack-type mist sprayer (duster)	8	800	100	32	4.00	0.040
	Power sprayer	8	800	100	32	4.00	0.040
	Power duster	8	800	100	32	4.00	0.040
	Manual type sprayer (broadcaster)	8	400	50	16	2.00	0.040
Harvesting	Binder	8	1,600	200	40	5.00	0.025
	Combine (head-feeding type and standard type)	10	2,000	200	50	5.00	0.025
	Auto-matic power thresher	8	800	100	20	2.50	0.025
	Power husker	10	500	50	15	1.50	0.030
	Grain dryer	8	3,200	400	12	1.50	0.004
Transport	Trailer (large type)	12	2,400	200	24	2.00	0.010
	Trailer (small type)	8	1,600	200	20	2.50	0.013
	Truck	5	2,000	400	25	5.00	0.013

Remarks : 1- This table shows, years of durability and hours of durability are different from table 421. This table are base on the actual data from each farm in Japan. 2- When you calculate depreciation, actually total working hours per year are less than this table's hours, it is better to use unit of year of durability, but if total working hours per year becomes more than this table's hours, it is better to use unit of actual working hours per year. 3- Total repair cost coefficient is rate of repair cost to initial cost required until the renewal of machinery. 4- This overall_ repair cost coefficient divided by years of durability is yearly mean repair cost coefficient and divided by hours of durability is repair cost per hour.

See fm-426.xls

Table A-431. Estimate Fuel Consumption

Name of machine	Type and Model	Fuel Kinds	Fuel Consumption L/h
Tractor	I. 30 ps	D	7.0
	II. 40-50. ps	D	11.0
	III. 60-80 ps	D	17.0
	IV. more than 90 ps	D	22.0
Trencher	I. Self propelled (riding) type (-20 ps)	D	3.0
	II. Tractor-attach-type	D	8.0
	III. Self-propelled (riding) type 30 (ps-)	D	4.0
Rice transplanter	I. 4-5 rows type	G	1.0
	II. more than 6 rows walking type	G	1.0
	riding type	D	2.5
Power sprayer	I. 30-55 L/min	D	7.0
	II. more than 55 L/min	D	11.0
Power duster	I. 5-8 kg/min	D	7.0
	II. more than 8 kg/min	D	11.0
Speed sprayer	I. 20-50 L/min	D	4.0
	II. 50-70 L/min	D	7.0
	III. more than 70 L/min Tractor attach pull-type	D	7.0
	Self -propelled t yp e	D	12.0
Combine	I. Head-feeding type (0.8-1.2 m)	D	4.0
	II. Head-feeding type (more than 1.2 m)	D	7.0
	III. Standard type (2.5-3.5 m)	D	19.0
	IV. Standard type (more than 3.5 m)	D	27.0
Forage harvester	I. 0.8-1.0 m	D	3.0
	II. 1.0-1.2 m	D	7.0
	III. 1.2-1.5 m	D	11.0
	IV. more than 1.5 m	D	17.0
	V. more than 2.2 m	D	56.0
Potato harvester	I. Tank capacity (less than 1,000 kg)	D	7.0
	II. Tank capacity (more than 1,000 kg)	D	11.0
	III. more than 2,000 kg	D	19.0
	more than 5,000 kg	D	39.0
Beat harvester	I. Tank capacity (less than 1,000 kg)	D	7.0
	II. Tank capacity (more than 1,000 kg)	D	11.0
	III. (more than 2,000 kg)	D	13.0
Bean harvester	I. All-purpose type	G	2.1
	Single-purpose (bean)	G	0.8
	II. Tractor attach type	D	5.6
	Self-propelled type	G	2.7

Remarks: D: Diesel (Light oil) G: Gasoline

Table A-512b. Mechanization Planning for Wheat Cultivation in Paddy Field (Example)

1. Pre-condition

Name of crop	Variety	Cultivation pattern	Yield per ha	Cultivated area	Size of field and shape	Covered area	Main farm machinery use
Wheat	Hiyoku-komugi, Asakaze-komugi	row 25 cm and drilling	estimated 5,400 kg	Kita Kanto plain area paddy field	30 a (100 x 30 m)	10 ha	46 P.S. tractor, 19 rows grain drill, 4 rows Combine

2. Table for operation

Items	Cultivation standard		Operation standard		operation standard					Fuel	
Name of operation	Period of operation	Materials use	Prime mover	Name of farm machinery	Operation accuracy & method	Field capacity	Operation hours per ha			Fuel consumption	
							Machinery	Workers	Total		
	(month & date)	(per ha)				ha/h	h/ha		h/ha		L/h
Seed preparation	11.9-11.12	Thiuram 0.5kg	Manual					1	0.50		
Manure spreader	10.20-10.28		Tractor	Manure spreader 2t	Broadcasting	0.249	4.01	1	4.01	D	2.0
Plowing	10.29-11.04		Tractor	Rotary 1.8m	13.9cm deoth	0.279	3.58	1	3.58	D	6.0
Harrowing & leveling	11.05-11.08		Tractor	Puddling harrow 2.4m		0.485	2.06	1	2.06	D	4.9
Fertilizing & seeding	11.09-11.12	Seeds 112kg, compound fertilizer (14,18,16) 533kg	Tractor	Grain drill 2.4m	row width 25cm	0.546	1.83	2	3.66	D	2.6
Herbicide application	11.13-11.06	Saturn-Bahro 7.5L	Tractor	Power sprayer 400L, 7m		0.962	1.04	1	1.04	D	3.0
Water transport(spraying assist.)	11.13-11.16	water 1,000L	Truck	Tank 500L		0.962	1.04	2	2.08	G	4.0
Pressing-1	12.18-12.27		Tractor	Roller 2m width	Pressing	0.893	1.12	1	1.12	D	2.0
Pressing-2	1.25-2.10		Tractor	Roller 3m width	Pressing	0.909	1.1	1	1.10	D	2.0
Top dressing	2.20-2.28	Compound fertilizer (17,0,16) 133kg	Manual					1	2.89		
Harvesting & threshing	6.10-6.17		Self-propelled type	Head feeding combine 4row		0.208	4.81	2	9.62	D	5.2
Harvesting & transportation	6.10-6.17		Truck	1t		0.422	2.37	2	4.74	G	4.0
Drying	6.10-6.18		Motors	Cerculated type dryer 21-koku	23.1->12.0 Moisture contents		34.14	2	5.86	K	1.8
Straw gathering	6.18-6.21		Tractor	Tedder & rake 3.6m		1.282	0.78	1	0.78	D	7.7
Straw gathering	6.18-6.21		Tractor	Basler packing 1.42m		0.559	1.79	1	1.79	D	8.4
Total							43.89		44.83		

D: Diesel ,G: Gasoline, K: Kerosene See fm-5-1b.xls

Note: Example 1-b. Wheat and Example 1-e. Soybean show two-crop system.

(1) Two-crops cultivation in paddy field of wheat and soybean.

(2) Total rotation of field cultivation are 10 ha, wheat for 10 ha and after wheat 5 ha for soybean, and other 5 ha for vegetable.

Table A-512c. Mechanization Planning for Corn Cultivation (Example)

1. Pre-condition

Name of crop	Variety	Cultivation pattern	Yield per ha	Cultivated area	Size of field and shape	Covered area	Main farm machinery use	Pre-plant
Corn	Kou-4	between row 75 cm between plant 25 cm	estimated 5,000 kg	East Hokkaido, Volcanic soil		ha	40-50 P.S. tractor,4 rows corn planter, corn picker	Sugar beet

2. Table for operation

Items	Cultivation standard		Operation standard							Fuel	
							Operation hours per ha (h/ha)			Fuel consumption	
Name of operation	Period of operation (month & date)	Materials use (per ha)	Prime mover	Name of farm machinery	Operation accuracy & method	Field capacity (ha/h)	Machinery op. hr/ha	Workers	Total operation hour: man-hr/ha		L/h
Tillage	11.01-11.20	kerosene: 12.4L	Tractor	Bottom plow: 14"(35cm)x2	Autumn tillage 25cm depth	0.32	3.1	1	3.1	D	
Fertilizer application		kerosene: 1.7L, Phosphorus 500kg	Tractor	Broad-caster: mount type		1.3	0.8	2	1.6	D	
Pulverise,	5.01-5.20,	kerosene: 4.8L	Tractor,	Disk harrow: 18"(45cm)x24,	1 times	1.0	1.0	1	1.0	D	
Levelling	5.01-5.20	kerosene: 4.2L	Tractor	Tooth harrow: 30x3	2 times	0.83	1.2	1	1.2	D	
Fertilizer, Sowing		kerosene: 4.0L, N 150kg, P 180kg, K 100kg, Seed 10kg	Tractor	Corn planter: 4 row	75 cm x 25 cm , 1	0.34	2.9	2	5.8	D	
Weed control	6.10-6.20	kerosene: 3.1L, Atorajin 2kg, 800L	Tractor	Sprayer: 450L: mount type		0.65	1.5	1	1.5	D	
Cultivating	6.10-6.20	kerosene: 4.0L	Tractor	Weeder	2 times	0.34	3.0	1	3.0	D	
Weeding	7.10-7.20	kerosene: 2.0L	Tractor	Cultivator: 4 row		0.65	1.5	1	1.5	D	
Pest & disease control	7.20-7.30	kerosene: 3.1L, Endorin 4,660cc	Tractor	Sprayer: 450L: mount type	Awanomeiga : 1,000L	0.43	2.3	1	2.3	D	
Harvest	10.01-11.30	kerosene: 2.15L, kerosene: 2.5L	Tractor x 2	Corn picker: 1 row, trailer tank type		0.12	8.1	2	16.2	D	
Total											

See fm-5-1c.xls

Table A-512d. Mechanization Planning for Potato Cultivation (Example)

1. Pre-condition

Name of crop	Variety	Cultivation pattern	Yield per ha	Cultivated area	Size of field and shape	Covered area	Main farm machinery use	Pre-plant
Potato	Danshaku	between row 70 cm	estimated kg	Nagano		ha	36-44 P.S. tractor	

2. Table for operation

Items	Cultivation standard		Operation standard							Fuel	
							Operation hours per ha (h/ha)			Fuel consumption	
Name of operation	Period of operation (month & date)	Materials use (per ha)	Prime mover	Name of farm machinery	Operation accuracy & method	Field capacity (ha/h)	Machinery op. hr/ha	Workers	Total operation hour: man-hr/ha		L/h
Manure	3/20-3/30	12,000kg/ha	Tractor	Manure spreader	1t	0.79	1.27	1	1.27	D	
Tillage	3/26-4/6		Tractor	Disc-plow	26"x3: 2 times	0.29	3.45	1	3.45	D	
Pulverise,	3/26-4/6		Tractor	Disc-plow	20x24: 2 times	0.40	2.50	1	2.50	D	
Levelling	3/26-4/6		Tractor	Disc-plow	30bladex3	0.63	1.59	1	1.59	D	
Fertilizer,	4/1-4/10	10-7-10:1500kg	Tractor	Drill-seeder	13x7	0.52	1.92	2	3.85	D	
Planting	4/5-4/15	2000kg	Tractor	Potato planter	2 row	0.19	5.26	2	10.53	D	
Weeding			Tractor	Weeder	40cm	1.54	0.65	1	0.65	D	
Weeding	5/10-5/20		Tractor	Cultivator: 3 row		0.71	1.41	1	1.41	D	
Weed & cultivation	5/20-5/30		Tractor	Cultivator: 3 row		0.71	1.41	1	1.41	D	
Weed & cultivation -2	6/5-6/15		Tractor	Cultivator: 3 row		0.71	1.41	1	1.41	D	
Weed control	7/5-7/15	EDPD: 4kg	Tractor	Sprayer: 400L: mount type		1.12	0.89	2	1.79	D	
Pest & disease control	6/1-6/10	Bordeaux mixture: 2000L	Tractor	Sprayer: 400L: mount type		1.12	0.89	2	1.79	D	
Pest & disease control -2	6/7-6/17		Tractor	Sprayer: 400L: mount type		1.12	0.89	2	1.79	D	
Leaf processing	7/10-7/20		Tractor	Forage harvester	1m	0.32	3.13	1	3.13	D	
Harvest	7/15-7/25		Tractor	Potato harvester 1 row		0.13	7.69	1	7.69	D	
Total											

See fm-5-1d.xls

Table A-512e. Mechanization Planning for Soybean in Paddy Field (Example)

1. Pre-condition

Name of crop	Variety	Cultivation pattern	Yield per ha	Cultivated area	Size of field and shape	Covered area	Main farm machinery use
Soy-bean	Enrei	between row 70 cm between plant 10 cm	estimated 3,500 kg	Kita Kanto plain area paddy field	15 a (56 m x 27 m)	5 ha	46 P.S. tractor,2 rows type seeder and bean harvester.

2. Table for operation

Items	Cultivation standard		Operation standard							Fuel	
Name of operation	Period of operation	Materials use	Prime mover	Name of farm machinery	Operation accuracy & method	Field capacity	Operation hours per ha (h/ha)			Fuel consumption	
	(month & date)	(per ha)				ha/h	Machinery op. Hour	Workers	Total operation hour		L/h
Fertilizer application	6.22-6.24	Lime 500 kg ,Comp.(5,15,15) 600 kg	Tractor	Lime sower	Broad casting	0.25	4	1	4	D	2
Plowing & pressing	6.25-6.30		Tractor	Rotary 1.8 m (width) Press roller 2.6 m (width)	One time operation	0.268	3.73	1	3.73	D	3.4
Sowing	6.25-6.30	Seeds 66 kg	Hand tractor	2 rows type Seeder		0.175	5.71	1	5.71	G	0.5
Herbicide application	7.1-7.3	Saturn-baharo 8.0 L	Tractor,Truck	Power sprayer 10 nozzle spray. Water transport	Spray type	0.3	3.33	2	6.66	D	3
Weeding (inter-cultivation)	7.21-7.30		Hand tractor	Rotary cultivator 45 cm width		0.125	8	1	8	G	1.8
Ridging	7.21-7.30		Hand tractor	One row type ridger		0.111	9	1	9	G	1.8
Pest & disease control											
Leaf hopper	7.28-8.1	Sumithion 1.2 L	Tractor,Truck	Power sprayer 10 nozzle spray. Water transport		0.333	3	2	6	D	3
Leaf hopper, Stink .bug, Purple seed stain	8.8-8.12	Sumithion 2.0 L Benlate 1.1 kg	Tractor,Truck	"	Mixed spraying	0.333	3	2	6	D	3
Stink bug, Pod barer, Purple seed stain	8.23-8.27	Baycid 2.0 L,Benlate 1.1 kg	Tractor,Truck	"	Mixed spraying	0.286	3.5	2	7	D	3
Stink bug, Pod borer	9.8-9.12	Baycid 2.5 L	Tractor,Truck	"		0.286	3.5	2	7	D	3
Harvest	10.7-10.14		Self propelled type	Bean harvester,0.7 m cutting width		0.089	11.24	1	11.24	G	0.8
Stack drying	10.7-10.14		Manual		Stack drying in line		0	2	19		
Threshing				Soy-bean thresher Tractor mount-type	Threshing in the field	0.279	3.58	3	10.74	D	1.9
Total							61.59		104.08		

See: fm-5-1e.xls

A-5-1-6. Coverage of the plural farm works

(i) Plural farm work in different work period by one operator

	←--------------------- S --→
Work-1	← -----------S1 -------------→
Work-2	← ------------ S2 --------------→
Work-3	← --------- S3 ---------→
	← -------------- S12 --------------------------→
	← ------------------------ S23 --------------------→
	109 | 31 | 4 | 35 | 21
	←-------- s1 -------→ ←----------- s2 ------------→ ←--- s3 -→

Fig. 1 Work period overlapped by plural works

Exercise 1. Calculate CA when farm work data are given as next table.

Symbol	term		Work Capacity	
		h	h/ha	
S	Total available working hour	200		May 26-July 5
S1	Available working hour for work-1 Tillage and Seeding	140	13	May 26 – June 20
S2	Available working hour for work-2	70	0.8	June 11 - 30
S3	Available working hour for work-3	56	0.8	June 21 – July 5
S12	Available working hour for work-1 and 2	175		
S23	Available working hour for work-2 and 3	91		

$WCp = WC1 + WC2 + WC3 = 13 + 0.8 + 0.8 = 14.6$ h/ha

$$\mathbf{s1 = S * WC1 / WCp = 200 * 13 / 14.6 = 178.1} \quad \textbf{Eq. 1}$$

$$\mathbf{s2 = S * WC2 / WCp = 200 * 0.8 / 14.6 = 11.0} \quad \textbf{Eq. 2}$$

$$\mathbf{s3 = S * WC3 / WCp = 200 * 0.8 / 14.6 = 11.0} \quad \textbf{Eq. 3}$$

(1) Therefore, the coverage of plural works CA is shown as next equation.

$S/WCp = 200/14.6 = 13.7$

<u>$S1/WC1 = 140/13 = 10.8$</u>

$S2/WC2 = 70/0.8 = 87.5$

$S3/WC3 = 56/ 0.8 = 70$

$S12/(WC1 + WC2) = 175/(13+0.8) = 12.7$

$S23/(WC2+WC3) = 56/(0.8+0.8) = 35$

$$\mathbf{CA = \min [S / WCp, S1 / WC1, S2 / WC2, S3 / WC3, S12 / (WC1 + WC2), S23 / (WC2 + WC3)] = 10.8} \quad \textbf{Eq. 4}$$

(2) Calculation of CA by Linear Programming

$$X1 <= 109 \quad \text{Eq. 5}$$

$$X2 + X3 <= 31 \quad \text{Eq. 6}$$

$$X4 <= 4 \quad \text{Eq. 7}$$

$$X5 + X6 <= 35 \quad \text{Eq. 8}$$

$$X7 <= 21 \quad \text{Eq. 9}$$

$$(X1 + X2)/WC1 - (X3 + X4 + X5)/ WC2 = 0 \quad \text{Eq. 10}$$

$$(X1 + X2)/WC1 - (X6 + X7)/ WC3 = 0 \quad \text{Eq. 11}$$

And make next objective function maximum

$$Z = (X1 + X2)/WC1 \quad \text{Eq. 12}$$

Where, X1 and X2 are hour for work-1, X3,X4,X5 are for work-2, X6 and X7 for work-3 and 1/WC1=0.0769, 1/WC2=1.25, 1/WC3=1.25.
And equations 10, 11 mean that area operated by work-1,2,3 should be equal.
Answer: Z=10.766 ha by LP-vb.xls with lpdA5ex1.xls

Table A-523. Cost per ha of harvest vs. farm scale

Yearly farm work area (ha)	Cost per ha (US$/ha)											
	83	84	85	86	87	88	89	90	91	92	93	94
	Riding 2 row	Riding 3 row	Riding 4 row	Riding 5 row	Riding 6 row	1.5m	2.4m	3.0m	3.6m	4.8m	sickle	Contract
CA(ha)	10.2	15.4	20.5	25.6	30.7	18.2	28.0	39.4	43.7	65.0	0.9	0.0
0.5	9,638	14,958	22,593	25,761	27,723	17,150	47,387	51,530	55,768	77,603	2,315	1,385
1	5,008	7,606	11,393	12,959	13,906	8,644	23,744	25,801	27,918	38,826	2,311	1,385
2	2,692	3,931	5,794	6,559	6,997	4,391	11,923	12,937	13,992	19,438	2,310	1,385
3	1,920	2,705	3,927	4,425	4,694	2,973	7,982	8,648	9,351	12,975	2,309	1,385
4	1,535	2,093	2,994	3,358	3,543	2,264	6,012	6,504	7,030	9,744	2,309	1,385
5	1,303	1,725	2,434	2,718	2,852	1,839	4,830	5,218	5,637	7,805	2,308	1,385
6	1,149	1,480	2,060	2,291	2,392	1,555	4,042	4,360	4,709	6,512	2,308	1,385
7	1,038	1,305	1,794	1,986	2,063	1,353	3,479	3,748	4,046	5,589	2,308	1,385
8	956	1,174	1,594	1,758	1,816	1,201	3,057	3,288	3,549	4,897	2,308	1,385
9	891	1,072	1,438	1,580	1,624	1,083	2,728	2,931	3,162	4,358	2,308	1,385
10	840	990	1,314	1,438	1,470	988	2,466	2,645	2,852	3,927	2,308	1,385
15	686	745	940	1,011	1,010	705	1,677	1,787	1,924	2,635	2,308	1,385
20	608	622	734	798	780	563	1,283	1,358	1,460	1,988	2,308	1,385
25	562	549	642	670	641	478	1,047	1,101	1,181	1,601	2,308	1,385
30	531	500	567	584	549	421	889	930	996	1,342	2,308	1,385

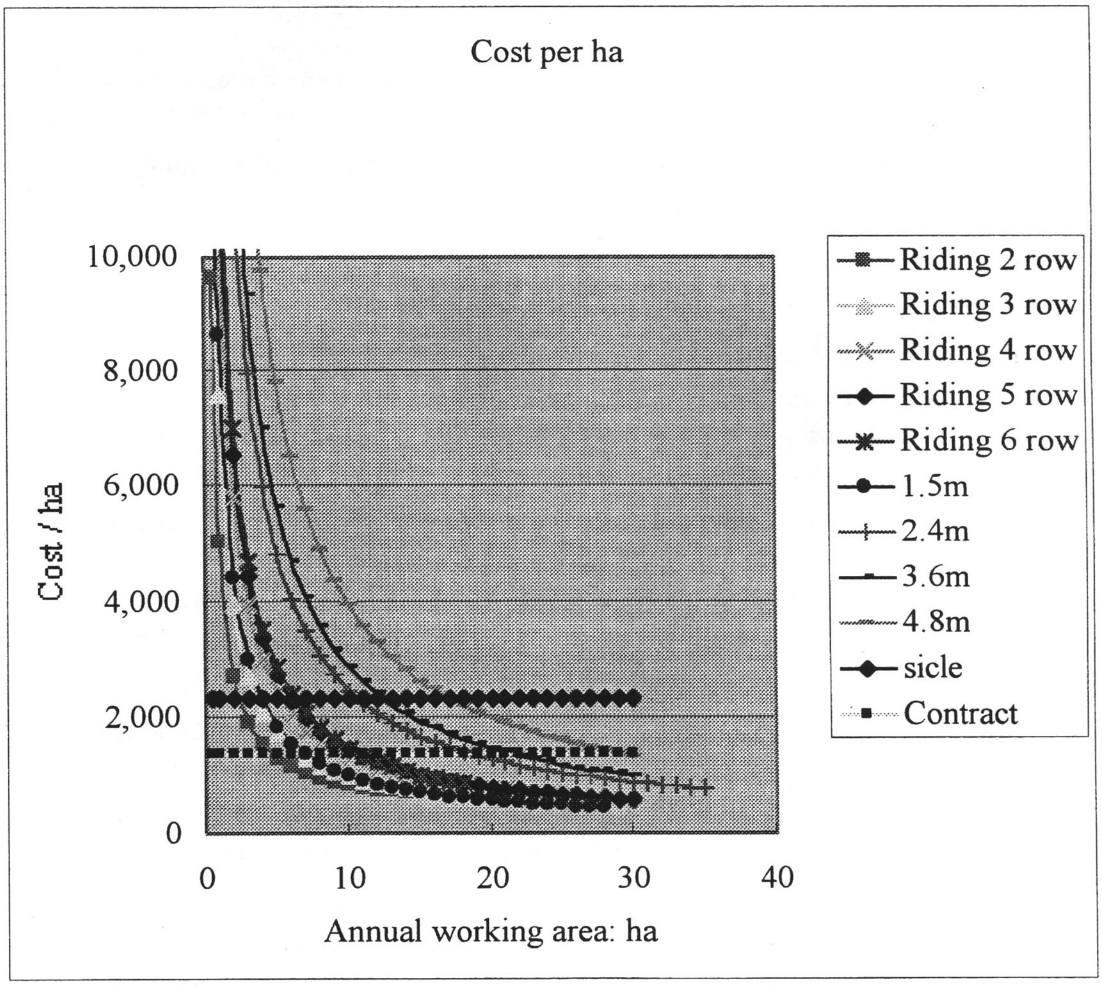

Fig. A-523. Cost per ha of harvest vs. farm scale

See DB-FW.xls: Cost harvest

Table A-531-i. Improvement by replacing machinery: Example

No.	Farm Work	Machinery	MA no.	CA (ha)	MA no.	CA (ha)	MA no.	CA (ha)	MA no.	CA (ha)	MA no.	CA (ha).
1	Preparation of seed	Manual	99	188.7		188.7		188.7		188.7		188.7
2	Nursery	Manual	99	23.9		23.9		23.9		23.9		23.9
3	Tillage	Rotary	1	20.1		20.1		20.1		20.1		20.1
4	Basal dressing	Broadcaster	2	**48.1**		**48.1**	20	32.1	20	32.1	20	32.1
5	Puddling	puddling harrow	3	**41.4**		41.4		41.4		**41.4**	203	34.5
6	Transporting seedling	1 ton truck	4	16.7		16.7		16.7		16.7		16.7
7	Transplanting	Riding type 6 row	5	13.0		13.0		13.0		13.0		13.0
8	Herbicide application	Granule spreader *	6	16.0		16.0		16.0		16.0		16.0
9	Top-dressing & spraying	Manual	99	10.4		10.4		10.4		10.4		10.4
10	Disease control	sprayer, levee	7	48.6		48.6		48.6		48.6		48.6
11	Ditto: Water	1 ton truck	4	48.6		48.6		48.6		48.6		48.6
12	Disease control Blast	sprayer, levee nozzle,	7	32.4		32.4		32.4		32.4		32.4
13	Ditto: Water	1 ton truck	4	32.4		32.4		32.4		32.4		32.4
14	Top-dressing	Manual	99	18.4		18.4		18.4		18.4		18.4
15	Water manage	(Irrigation facilities)	99	81.9		81.9		81.9		81.9		81.9
16	Harvesting & threshing	Combine harvester	8	13.6		13.6		13.6		13.6		13.6
17	Harvesting Transport	1 ton truck	4	77.4		77.4		77.4		77.4		77.4
18	Drying	Dryer	9	5.6		5.6		5.6		5.6		5.6
19	Husking	Husker	10	**44.7**		44.7		**44.7**	100	37.2	100	37.2
20	Rice straw turn over	Tedder & rake	11	**37.9**		37.9		37.9		37.9	11	**37.9**
21	Rice straw bale	Baler	12	**51.5**	120	26.5	120	26.5	120	26.5	120	26.5

FM no.	21		4		19		5	
Machine replaced	12	120	2	20	10	100	3	203
Coverage(ha)	51.5	26.5	48.1	32.1	44.7	37.2	41.4	34.5
Total Cost at 1 ha ($/ha)	33,267	31,458		31,411		31,321		30,947
Total Cost at 5 ha ($/ha)	9,352	9,029		9,029		9,028		8,962
Total Cost at 10 ha ($/ha)	6,904	6,766		6,772		6,783		6,754
Total Cost at 20 ha ($/ha)	6,534	6,490		6,498		6,515		6,496

MA No.	Name	Model	Spec.	Price: $	MA No.	Model	Spec.	Price: $
2	Broadcaster	MBC3030	300L	1,500	20	MBC2030	200L	1,308
3	Puddling harrow	HS-240	2.4m	3,031	203	HC-160	2.0m	1,754
10	Husker	MXP30	roll 76mm	2,800	100	MXP25S	roll 63mm	2,423
12	Baler	THB1050	1.4m	13,769	120	RB-510DX	0.73m	7,577

See Rice-sy1.xls:fs-improve

By replacing machine 12, 2,10, 3, all total cost per ha is improved at 1-5 ha, and normally at 10-20 ha.

Table A-531-ii. Improvement coverage of system: Example

Farm scale increase by machinery or workers, which coverage is lowest in sheet (3. Coverage), added in Rice Cultivation in Paddy Field

FM No.	Farm Work	Machinery (Case No.)	1 M	1 Nw	2 M	2 Nw	3 M	4 M	5 M	6 M
1	Preparation of seed	Manual	0	2	0	2	0	0	0	0
2	Nursery	Manual	0	2	0	2	0	0	0	0
3	Tillage		1	1	1	1	1	1	1	1
4	Basal dressing	Broadcaster	1	2	1	2	1	1	1	1
5	Puddling	puddling harrow	1	1	1	1	1	1	1	1
6	Transport seedling	1 ton truck	1	2	1	2	1	1	1	1*
7	Transplanting	Transplanter	1	2	1	2	1*	2	2	2
8	Herbicide application	Granule spreader	1	1	1	1	1	1	1*	2
9	Top-dressing	Manual	0	1*	0	2	0	0	0	0
10	Pest & Disease control	sprayer, levee nozzle,	1	6	1	6	1	1	1	1
11	Ditto: Water	1 ton truck	1	3	1	3	1	1	1	1
12	Pest & Disease control	sprayer, levee nozzle,	1	6	1	6	1	1	1	1
13	Ditto: Water	1 ton truck	1	2	1	2	1	1	1	1
14	Top-dressing	Manual	0	1	0	1	0	0	0	0
15	Water manage	(Irrigation facilities)	0	1	0	1	0	0	0	0
16	Harvesting	Combine	1	2	1	2	1	1*	2	2
17	Transporting	1 ton truck	1	2	1	2	1	1	1	1
18	Drying	Tempering type Dryer	2	0	2*	0	3	3	3	3
19	Husking	Husker	1	3	1	3	1	1	1	1
20	Rice straw turn over	Tedder & rake	1	1	1	1	1	1	1	1
21	Rice straw gathering	Tedder & rake	1	1	1	1	1	1	1	1
22	Rice straw bale	Baler	1	2	1	2	1	1	1	1

M: No. of machine set Nw: No. of workers

Case No.	1	2	3	4	5	6
Tractor	1	1	1	1	1	1
Maximum No. of workers	6	6	6	6	6	6
Coverage(ha)	10.4	11.2	13.0	13.6	16.0	16.7
* Farm work No. of minimum coverage	9	18	7	16	8	6
Total Cost at 10 ha ($/ha)	6,198	6,218	6,218	6,307	6,441	6,458
Total Cost at 20 ha ($/ha)	4,756	4,776	4,776	4,865	4,999	5,017

See Rice-sy1.xls:fscale-up

Table A-542c. AHP: Example in replacement of tractor

Replace plan	
A	Present tractor continuing use
B	Replace to new tractor same PS
C	Replace to new larger tractor
D	Contract farm work

An Ibaraki farmer 1995.

Evaluation term	
1	Breakdown or maintenance
2	Old-fashioned
3	Management scale
4	Labor shortage
5	Subsidy
6	Neighborhood

Result of AHP

Evaluation	1	2	3	4	5	6	
Weight	0.237	0.024	0.442	0.140	0.100	0.057	1.000
Scoring							Total
A	0.412	0.163	0.116	0.111	0.160	0.157	0.195
B	0.190	0.278	0.193	0.100	0.354	0.271	0.202
C	0.074	0.395	0.652	0.261	0.354	0.482	**0.415**
D	0.312	0.163	0.037	0.525	0.131	0.088	0.186

6. Technical term

Table A-600. Technical term and its abbreviation fm-term.xls

6-1. Technical term Part 1

Abb.	Term	unit	Chapter
(1+i)^n	Final worth factor or compound amount factor	-	5
1 / [(1+i)^n]	Present worth factor	-	5
A	Field area	ha	1, 2
Aa	Annual operation area	ha/year	4
Abp	Break-even point of area	ha	4
ACa	Annual cost per hectare	$/ha	4
ACh	Annual cost per hour	$/h	4
AD	Annual depreciation	$/year	4
ADR	Rate of available work days	%	3
AEG	Total annual energy consumed	MJ	5
AFC	Annual (total) fixed cost	$/year	4
AFC	Annual fixed cost	$	4
AFCa	Annual fixed cost per ha	$/ha	4
AFCh	Annual fixed cost per hour	$/h	4
AG	Annual garage cost	$/year	4
AGt	Total garage cost per year	$/year	4
AI	Annual interest	$/year	4
AIm	Yearly mean interest	$/year	4
ANWH	Available net working hour	h	3
AP	Annual insurance fee	$/year	4
AP(n)	Adjusted annual payments of worth after n year usage	$ / year	5
AR	Annual repair cost	$/year	4
AR	Annual repairing cost	$/year	4
AT	Annual taxes	$/year	4
ATC	Annual (total) cost	$/year	4
ATC-ca	Total Cost at area = coverage	$	5
ATCa-ca	Cost per ha at area = coverage	$/ha	5
AVC	Annual (total) variable cost	$/year	4
AVCa	Annual variable cost per ha	$/ha	4
AVCh	Annual variable cost per hour	%	4
AWD	Available work days	d	3
B	Benefit, Profit	$	1
Bp	Break even point	$	5
C	Cost	$	1
CA	Coverage (Covered area)	ha	3
CA	Coverage	ha	5
CAP	Capital	$	5
CAS	Coverage of one set	ha	3
CC	Custom charge	$/ha	4, 5
CC	Customary service charge	$/ha	4, 5
CI	Farm work cost index	in decimal	5
Cv	Variable cost per ha	$/ha	4

6-2. Technical term Part 2

Abb.	Term	unit	Chapter
D	Annual depreciation	$/year	4
D	Demerit, something minus	-	1
Da	Adjustment time	h: min: s	2
Db	Short brake time or time for non operation or lunch time	h: min: s	2
DC	Daily Capacity	ha/d	2,3
Dc	Time for cleaning of farm machines	h: min: s	2
DCF	Diesel light oil Conversion factor	MJ/ L	5
Df	Time for feeding	h: min: s	2
Di	Depreciation charge for i year	$	4
Dm	Moving or traveling time	h: min: s	2
Dn	Net Work hours per day	h/d	2
Dn	Net working hours	h	2
Dp	Preparation time of work	h: min: s	2
Dr	Repairing time	h: min: s	2
Ds	Time for setting	h: min: s	2
Dt	Total daily working hours	h/d	2
Dt	Working hours per day	h/d	2
DWP	Days of work period	d	3
E	Final worth after n years	$	5
ECF	Electric power Conversion factor	MJ / kWh	5
ECU	Energy conversion unit for manufacturing the machinery by using input-output table of inter-industry	kJ / Yen	5
ef	Field Efficiency in decimal	in decimal	2
EF	Field Efficiency in percentage	%	2
EFC	Effective field capacity	ha/h	3
EFCp	Effective Field Capacity of plural works	ha/h	5
er	Overall repair cost coefficient	in decimal	4
erh	repair cost coefficient per hour	/h	4
FC	Fixed cost	$	1, 4
FCa	Fixed cost per ha	$/ha	4
FCh	Fixed cost per hour	$/h	4
FRa	Fuel consumption rate per ha	L/ha	4
FRh	Fuel consumption rate per hour	L/h	4
G	Gross income, Revenue	$	5
GCF	Gasoline Conversion factor	MJ/ L	5
Ha	Annual operation hour	h/year	4
i	Annual interest	in decimal	5
I	Investment	$	5
INT	Function of getting integer	-	5
KCF	Kerosene Conversion factor	MJ/ L	5
L	Durability Year	year	4
L	Economic life	year	4
LBP	Labor productivity (SH)	$/h	5
LDP	Land productivity	$/ha	5
LR	Land rent	$/ha	5

6-3. Technical term Part 3

Abb.	Term	unit	Chapter
M	Merit, something plus	-	1
M	Number of machine set	in decimal	3
M(n)	Adjusted annual payments of worth after n year usage	$/year	5
MA No.	Machinery ID Number	-	5
MH	Man-hours	man*h	2
MHa	Man-hours per ha	man*h/ha	5
Mi	Number of machine set of farm work(i)	-	5
MRa	Material usage rate per ha	kg/ha	4
Msys	Number of machinery set of system	-	5
N	Number of operation times	-	3
NI	Net income, Return	$	5
NOA	Number of attachments	-	5
Ns	Number of machine set	-	3
Nw	Number of workers	-	3
NWR	Daily net working rate	%	2
OC	Operating Cost	$/ha	5
P	Initial price	$	4
P	Purchase price	$	4
P	Weight of production, grain etc.	t	2
P	Present worth	$	5
P(n)	Annual present worth after n year	$ / year	5
Pf	Fuel price per litter	$/L	4
Pi	Initial price	$	4
Pm	Material price per kg	$/kg	4
PR	Profit	$	5
PR-max	Total Profit: maximum	$	5
PRa-max	Profit per ha: maximum	$/ha	5
PS-ca	Total Sales at area = coverage	$	5
PSa	Sales per ha	$/ha	5
Q(n)	Annual timeliness cost after n year	$ / year	5
Qj	Timely cost etc. in j year	$	5
r	Constant depreciation rate	in decimal	4
R	Remaining value	$	4
R(n)	Annual repairing cost after n year	$ / year	5
RAF	Annual fixed cost rate	%	4
raf	Annual fixed cost rate	in decimal	4
RCF	Rice grain Conversion factor	MJ/ kg	5
RCh	Mean repair cost per hour	$/h	4
RD	Annual depreciation rate	%	4
RF	Fixed cost rate	%	4
RG	Annual garage cost rate	%	4
rgc	Garage cost rate	in decimal	4
RI	Annual interest rate	%	4
rf	Fixed cost rate	in decimal	4
Ri	Remained value of i year	$	4
ri	Yearly interest rate	in decimal	4
Rj	Repairing cost in j year	$	5
RP	Annual insurance rate	%	4
rp	Premium rate	in decimal	4
RR	Annual repairing cost rate	%	4
RT	Annual taxes rate	%	4
rtax	Tax rate (0.5%)	in decimal	4

6-4. Technical term Part 4

Abb.	Term	unit	Chapter
S	Sale amount, Gross return	$	1
S	Salvage value, Disposal value, Remaining value	$	4
S(n)	Annual remaining value after n year	$ / year	5
Sg	Garage space of machine	m**2	4
SH	Sales per working hour	$/h	5
Sn	Remaining value after n years	$	5
Sp	Share of work	%	4
St	Total garage space of house	m**2	4
T	Total time required a farm work	h	2
t1	U type turning time	s	2
t2	Δ type turning time	s	2
ta	Actual operating time	h: min: s	2
tb	Turning time	h: min: s	2
tc	Moving time in field	h: min: s	2
td	Regulating time	h: min: s	2
te	Rest time	h: min: s	2
TFC	Theoretical Field Capacity	ha/h	2
TFW	Total number of farm works	-	5
TM	Total number of kind of machine	-	5
TOW	Type of work: M= Machine, C= Contract, L= Manual, A= Animal	-	5
v, V	Operating speed	m/s	2
VC	Total variable cost of a farm work	$	1, 4
VCa	Total variable cost per ha	$/ha	4
VCF	Variable cost per hour originated from fixed cost	$/h	4
VCh	Total variable cost per hour of a farm work	$/h	4
VF	Fuel cost of a farm work	$	4
VFh	Fuel cost per hour of a farm work	$/h	4
VL	Lubricant cost of a farm work	$	4
VLh	Lubricant cost per hour of a farm work	$/h	4
VM	Material cost of a farm work	$	4
VMh	Material cost per hour of a farm work	$/h	4
VR	Repairing cost of a farm work	$	4
VRh	Repairing cost per hour of a farm work	$/h	4
Vt	Theoretical operation speed	km/h	2
VW	Labor cost of a farm work	$	4
VWh	Labor cost per hour of a farm work	$/h	4
w, W	Operating width	m	2
WC	Work Capacity	h/ha	2
WCi	Work Capacity of farm work(i)	h/ha	5
WCp	Work Capacity of plural works	h/ha	5
WP	Cultivation (operation) period	-	3
Wt	Theoretical operation width	m	2
x	Width of field	m	2
y	Length of field	m	2
Y	Yield or amount per hectare	t/ha	1, 2
Yrate	Yen exchange rate	Yen/$	5

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