TKP3501
AGRICULTURAL MECHANIZATION & IRRIGATION

UPM-PJJPROGRAM
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RESEARCH INTEREST: Agricultural Mechanization, Precision Agriculture, Sensors in Agriculture, Proximal Soil Sensing

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Majalah Teknologi dan Mekanisasi Pertanian
https://www.facebook.com/MajalahAgriMTech/
Outlines

General overview
Power source in agricultural production
Machinery needs in crop production
Field efficiency
Cost analysis
Summary
GENERAL OVERVIEW
WHAT IS THE ROLE OF AGRICULTURAL MECHANIZATION & IRRIGATION?
Agricultural Mechanization & Irrigation

What?
Role
Why?
Economy
How?
Technology
Hunting & gathering

Self sufficient

Modern agriculture

Population increase
Demand for food
Increase production rate
Efficiency

1400 - In Egypt, used a reaper for wheat harvesting
1660 - The use of steel was introduced - plow
1800 - Horse and machinery was intensively utilized to grain production
1916 - Crop copper, harvester, thresher were design and attached to the horses

UNTIL the introduction of the STEAM engine
Introduction

Why we need machineries?
Type of machine available
Traditional vs modern

Introduction to a tractor
Type of tractor
Specification

Tractors' components & Systems
Main components
Systems;
- Fuel & Intake
- Combustion
- Cooling
- Electric & instruments
- Lubrication
- Hydraulic

Others
- Bearing & seal
- Shaft
- Belt & pulley
- Chain & sprocket
- Gear
- Lubrication (grease, oil)

Power tiller
Other small equipment
Compact equipment

Filters, oil, lubrication, parts
Maintenance

Theoretical Field Capacity
Effective Field Capacity
Field Efficiency**

How to choose the tractor and implement size**
Tractor & power unit
Type of power available

Future

Crop Production

Seedling & Planting
Crop type
Planter**

Land preparation
Crop type
- Oil palm
- Rice
- Vegetable

Fertilization & Irrigation**
Spreader
Pump
Sprinkler

Harvesting
Yield, Baller
Transportation

Livestock
Feeding system
Milking
Aquaculture

Forestry
Optimization

Horticulture

Emerging Technologies
Sensor
Tracking
GPS, GNSS
GIS, Mapping

Cost analysis**

Implementation
Primary tillage
Secondary tillage

Filters, oil, lubrication, parts
Maintenance
Learning Outcomes

BE ABLE TO;

• Know and to understand the principle of agricultural machineries
• Choose the type of machines, size and the number needed
• Distinguish the different type of machineries available in the market
• Coordinate and to operate the machines in the field
POWER SOURCE IN THE FARM
Power source in the farm

- Mechanization and Human Power
- Mechanization and Animal Power
- Mechanical-electrical Power
1) Mechanization and Human Power

- Hand tool technology - basic and simple
- Time consuming
- Conventional tools without improvement - used throughout the ages and from country to country.
- Most of the tools is a single purpose

- 1 human power = 0.25 - 0.27 hp
- 1 animal power (horse) 1 Hp = 745.7 Watt

- Calculate the human power in Watt?
2) Mechanization and Animal Power

- More advanced than sole manual.
- Extra power is needed to increase the work rate and ease out the load.
- More area can be covered compared with man with single tool.
3) Mechanical-electrical Power

- When human + animal = Unsatisfactory, limited time and energy
- Introduction of mechanical power - more easy and faster.
- Engine in combination with wheels (2 or 4) can be used to pull various implements in various combination.
- Like automobile modern tractors have its own beginning. There are many tractor shapes that are configured to suit its main purpose.
Diesel Engine

- In-line fuel injection pump
- Valves
- Cylinders
- Piston
- Crankshaft
- Fuel Injector
- Connecting rods
- Counter weights
- Main bearings
- Oil tank
## Range of tractor types

<table>
<thead>
<tr>
<th>Main type</th>
<th>Power group</th>
<th>Approx. power range (hp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market garden</td>
<td>Motor hoe</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td>Two wheel general purpose</td>
<td>3-15</td>
</tr>
<tr>
<td></td>
<td>Self propelled tool basis</td>
<td>15-70</td>
</tr>
<tr>
<td>Wheeled, rear-wheel drive</td>
<td>Small</td>
<td>15-30</td>
</tr>
<tr>
<td></td>
<td>Small-medium</td>
<td>31-45</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>46-60</td>
</tr>
<tr>
<td></td>
<td>Medium-large</td>
<td>61-80</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>81-100</td>
</tr>
<tr>
<td></td>
<td>Very large</td>
<td>Over 100</td>
</tr>
<tr>
<td></td>
<td>Small and medium</td>
<td>15-60</td>
</tr>
<tr>
<td>Wheeled, four-wheel-drive</td>
<td>Large-medium</td>
<td>61-100</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>101-150</td>
</tr>
<tr>
<td></td>
<td>Very large</td>
<td>Over 150</td>
</tr>
<tr>
<td>Tracklayers</td>
<td>Small</td>
<td>Under 50</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>51-100</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>Over 100</td>
</tr>
</tbody>
</table>

1 hp = 0.75 kW

**Q: What is the best estimator for the market price of the 1 hp tractor?**
Agricultural Tractors: 2 wheeled drive

Agricultural Tractors: 4 wheeled drive

Tracked tractor
- Bulldozer for land leveling and dozing
Agricultural Tractors: articulated type

- 2 WD Tractor
- Hp ranging from 5 – 15, for paddy the Hp is 10 – 12.
- Used for vegetable farm and also short term (annual) crops.
- May pull trailer, mostly diesel engine
3 wheeled tractor

Self Propelled Machines

- E.g, Combine harvester
- Transplanter
- Transporter
Fig. 1-7—A high-clearance row-crop tractor for special crops.
Fig. 1-8—Different wheel spacings available.
3 types of power output from tractor:

- pulled,
- lift and
- rotation

1) 3 Point Hitch
2) Power Take Off (PTO)
3) Drawbar
Review

1. Why do we still need a human touch despite a present of the machine in the farm?
2. In what situation animal power is still practical to be used?
Review

1. What is the type of connection required to a tractor, if using;
   A. Moldboard plough –
   B. Disk plough –
   C. Boom sprayer –
   D. Corn planter –
Group Activity

• Name the machine suitable based on the engine type (2 or 4 stroke engine) for each operation below;

<table>
<thead>
<tr>
<th>Operation</th>
<th>Engine type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass trimming and cutting</td>
<td>2 stroke engine (light) or 4 stroke (heavy)</td>
</tr>
<tr>
<td>Pruning</td>
<td></td>
</tr>
<tr>
<td>Plowing</td>
<td></td>
</tr>
<tr>
<td>Transporting the goods</td>
<td></td>
</tr>
<tr>
<td>Water pump for irrigation</td>
<td></td>
</tr>
<tr>
<td>Planting</td>
<td></td>
</tr>
<tr>
<td>Spraying</td>
<td></td>
</tr>
</tbody>
</table>
Small & Compact Tractor
Attachment with trailer
Rotovator
Seedling-corn / soy bean
Water pump
Harvesting
Transplanting
FIELD EFFICIENCY
Sawah Sempadan, Kuala Selangor

More than 10,000 ha area

How can we properly manage the machine effectively?

How many tractors required to complete a single task in short time?

Why we need to know about the field efficiency?
Theoretical Field Capacity (TFC)

• TFC = \( \frac{V \times W}{10} \)

Where
• \( V = \) Speed of implement in kilometer/hr
• \( W = \) width of implement in meter

![Graph showing theoretical field capacity (TFC) depending on speed and swath width. The graph has a grid with lines indicating different speeds such as 2km/hr, 4km/hr, 6km/hr, etc. Each speed has a corresponding theoretical field capacity. For example, at 2km/hr, the theoretical field capacity is 0.024 ha/hr at a swath width of 20m.](image-url)
Effective Field Capacity (EFC)

• The EFC of a machine or implement may be calculated as follows;

\[
\text{EFC} = \frac{V \times W \times F.E}{10}
\]

Where
- \( V \) = Speed of implement in kilometer/hr
- \( W \) = width of implement in meter
- \( F.E \) = Field efficiency in percent, Refer Table 1
Table 1: Average Field Efficiency (F.E.) of common implements used in agriculture production

<table>
<thead>
<tr>
<th>Operation</th>
<th>FE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most tillage operations (plowing, disking, cultivating)</td>
<td>75-90%</td>
</tr>
<tr>
<td>Seeding or fertilizing row crops or grain</td>
<td>60-80</td>
</tr>
<tr>
<td>Seeding AND fertilizing row crops or grain</td>
<td>45-65</td>
</tr>
<tr>
<td>Combine harvesting</td>
<td>65-80</td>
</tr>
<tr>
<td>Field chopping of grass for animal feed</td>
<td>50-75</td>
</tr>
<tr>
<td>Spraying</td>
<td>55-65</td>
</tr>
</tbody>
</table>
Field Machinery Index (FMI)

Increase in the FMI index as in reduction of the turning time

![Graph showing the relationship between FMI and turning time]

Figure 6. Relationship of field machine index with turning time of citrus canopy shaker (Oxbo 3220).

Exercise #1

Calculate theoretical field capacity, effective field capacity and field efficiency of a 4.5 m grain combine operating at a forward speed of 5.0 km/hr.

The average width of cut is 3.5 m and time required for emptying the grain tank is averaged to 9.0 minutes per hectare. Turning, adjusting and other miscellaneous time requirement is amounted to 15% of the effective operating time.
Solution Exercise #1

Theoretical field capacity = \( \frac{\text{Speed (km/hr)} \times \text{Width of implement (m)}}{10} \)

\[ = \frac{4.5 \times 5}{10} = 2.25 \text{ ha/hr} \]

Time required for emptying tank = \( 9 \times 2.25 = 20 \text{ min} \)

\( \therefore \) Effective operating time = \( 60 + 20 = 80 \text{ min} \)

Time for turning, adjustment and other miscellaneous
\[ = 0.15 \times 80 = 12 \text{ min} \]

\( \therefore \) Total operating time = \( 80 + 12 = 92 \text{ min} \)

Effective field capacity = \( \frac{\text{Speed (km/hr)} \times \text{Effective Width (m)}}{10} \times \text{Total operating time} \)

\[ = \frac{5 \times 3.5 \times 60}{10 \times 92} = 1.41 \text{ ha/hr} \]

Field efficiency = \( \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100 \)

\[ = \frac{1.41}{2.25} \times 100 = 63 \% \]
MACHINERY IN CROP PRODUCTION
Machinery requirement according to the crop production timeline

- Land preparation
- Crop type
  - Oil palm
  - Rice
  - Vegetable

- Seedling & Planting
  - Crop type
  - Planter**

- Fertilization & Irrigation**
  - Spreader
  - Pump
  - Sprinkler

- Farm maintenance
  - Grass, road, drainage

- Harvesting
  - Yield, Baller
  - Transportation
A. Land Preparation

- A **plow** is an implement used to cut, lift, and turn over soil. It is commonly used to prepare the soil for planting. There are various types of plows and the one most commonly used in many countries is the moldboard plow.

- A **harrow** is an implement with spikes or disks that is used to cultivate the soil by pulverizing and smoothing it.

- A **cultivator** is an implement used to loosen the soil and control weeds between rows of growing crops.
• Tillage tool – an individual soil engaging element
• Tillage implement – an assembly of tillage tools and associated framework, wheels, or control elements
• Primary tillage – initial soil manipulation after a period of crop or fallow (not cropped or cultivated in any production mode)
Harrow
Rotovator
Seedbed preparation

Tractor mounted raised bed planter
Seed bed preparation
Type of implements

1. Primary tillage
2. Secondary tillage
3. No-till operation
1. Primary tillage

- Mainly for the cutting and loosening of soil 15-90 cm depth.
- Moldboard plow is the most commonly used as primary tillage-capacity to break up many types of soil. Which soil is the most difficult to break?
- Moldboard plow is able to turn over and cover sod, crop residues and weeds.
- Other example of primary plow: disk plow,
- Used singly or in groups from two to a large number of shares, the width of each plowshare between 25-45cm or more.
Disk harrow (*Bajak piring*)

- Direct drawbar or three point pitch
- Wheel - for depth control and transport if using drawbar

ATV disk harrow – light weight

Stubble disk
Subsoiler

- Similar principle with chisel, but more heavily build and rigid for operation of 40-90 cm to loose deep soil later, promote water movement and root growth
- Due to heavy task, tractor of 40-60 kW power is needed to pull one subsoiler shank at a depth of 45 cm in heavy soil
- While track-laying tractor is required to operate three winged subsoilers operating at 90 cm depth.
Method of mounting behind the tractor – semi mounted.
2. Secondary tillage

• Usually perform after primary tillage operation.
• Goal- to improve the seedbed and soil structure, increase soil pulverization, soil moisture conservation, weed destruction, and chopping the crop residue
• Common tool: Harrow (Other names: Disk harrow, tandem disk harrow, spike-tooth harrow, spring-tooth or rotary cross harrow)
• Others: Ridger, Puddler, Leveller or Roller, Cultivators
• Mounting: 3-point pitch, drawbar, or PTO.
• Depth: up to 30 cm from surface
Disk Harrow
Tandem Disk Harrow
Spring-tine Harrow
Primary and secondary tillage: Rotovator
Rotary blades

Disk plow-planting bed
B. Planting

Seedling
- Row seedling, point seedling (drill), and broadcasting (e.g. rice)

Cutting
- Vine (stem) cutting, tuber

Transplanting
- Bare root, polybag, rooting media in foam tray seedling
Self propelled rice transplanter
Machine for manual planting seedlings with roots enveloped in rooting medium

Transplanter for seedlings with rooting medium
Transplanter for seedling from poly bag and the machine also places plastic mulch
Placement of plastic mulch and planting
Transplanting seedlings from ply styrene foam
### Table 1 : Planting Chart - Spacing

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Seed to sown per foot</th>
<th>Distance between plants when thinned or transplanted</th>
<th>Distance between rows</th>
<th>Planting depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>12-18</td>
<td>36-60</td>
<td>6-8</td>
<td></td>
</tr>
<tr>
<td>Bean, bush, lima</td>
<td>3-4</td>
<td>Do not thin</td>
<td>18-30</td>
<td>1-2</td>
</tr>
<tr>
<td>Bean, bush, snap</td>
<td>6</td>
<td>Do not thin</td>
<td>18-24</td>
<td>1-2</td>
</tr>
<tr>
<td>Beet</td>
<td>10</td>
<td>2-4</td>
<td>12-18</td>
<td>½ - 1</td>
</tr>
<tr>
<td>Broccoli</td>
<td>18-24</td>
<td>30-35</td>
<td>(d)</td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>9-18</td>
<td>18-30</td>
<td>(d)</td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td>1-3</td>
<td>12-18</td>
<td>¾</td>
<td></td>
</tr>
<tr>
<td>Cauliflower</td>
<td>18-24</td>
<td>24-36</td>
<td>(d)</td>
<td></td>
</tr>
<tr>
<td>Chard</td>
<td>8-10</td>
<td>4-8</td>
<td>18-24</td>
<td>¾ - 1</td>
</tr>
<tr>
<td>Corn, sweet</td>
<td>1-2 in row 4-5 per hill</td>
<td>9-12, single plants 36; hills (3 plants per hill) 24-48</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>3 in row 4-5 per hill</td>
<td>12, single plants 36; hills (3 plants per hill) 49-72</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Eggplant</td>
<td>18-24</td>
<td>30-35</td>
<td>(d)</td>
<td></td>
</tr>
<tr>
<td>Endive</td>
<td>4-5</td>
<td>9-12</td>
<td>18-24</td>
<td>¾</td>
</tr>
</tbody>
</table>

The spacing required, reflected the spacing setting on the planting machine

- **Garlic, from cloves**
  - Distance: 3
  - Planting depth: 12-18
  - Spacing: 1½

- **Kale**
  - Distance: 4-6
  - Planting depth: 8-12
  - Spacing: 18-24
  - Spacing: ½

- **Kohlrabi**
  - Distance: 6-8
  - Planting depth: 3-6
  - Spacing: 18-24
  - Spacing: ½

- **Lettuce, leaf**
  - Distance: 10
  - Planting depth: 2-4
  - Spacing: 12-18
  - Spacing: ½

- **Muskmelon**
  - Distance: 3 in row 4-5 per hill
  - Planting depth: 12, single plants 36, hills (3 plants per hill)
  - Spacing: 48-72
  - Spacing: 1

- **Mustard**
  - Distance: 20
  - Planting depth: 1-2
  - Spacing: 12-18
  - Spacing: ½

- **New Zealand spinach**
  - Distance: 4-6
  - Planting depth: 12
  - Spacing: 24-30
  - Spacing: 1

- **Okra**
  - Distance: 3
  - Planting depth: 12-15
  - Spacing: 36
  - Spacing: 1

- **Onion, from seeds**
  - Distance: 10-15
  - Planting depth: 2-4
  - Spacing: 12-18
  - Spacing: ½-1

- **Onion, from plants or sets**
  - Distance: 1-4
  - Planting depth: 12-18
  - Spacing: 1-4

- **Parsley**
  - Distance: 10-15
  - Planting depth: 4-6
  - Spacing: 12-18
  - Spacing: ½
How to estimate the seed population?

\[
\text{Seed per foot} = \frac{\text{Total seeds (seed per acre)}}{43,560 \text{ ft}^2 \text{ – acre}} \times \frac{\text{row spacing (inch)}}{12} \\
\text{Seed per meter} = \frac{\text{Total seeds (seed per ha)}}{10,000 \text{ m}^2 \text{– ha}} \times \text{row spacing (m)}
\]
Example

- A farmer is planning to plant a corn at 100,000 seeds per acre. The row spacing is 15 inch. How many seed per foot of row will be planted?

\[
\text{Seed per foot} = \frac{\text{Total seeds (seed per acre)}}{43,560 \text{ ft}^2 \text{ – acre}} \times \frac{\text{row spacing (inch)}}{12}
\]

\[
\text{Seed per foot} = \frac{100,000 \text{ seed per acre}}{43,560 \text{ ft}^2 \text{ – acre}} \times \frac{15 \text{(inch)}}{12}
\]

= 2.87 seeds/ft of row
= ~ 3 seeds/ft of row

Q: Why do we really care about this numbers?
Planter-Pneumatic

- Vacuum system
- Marker
- Fertilizer tank
- Seed tank
- Seed meter wheel
- Seed meter wheel gears
Operation

Figure 1 - PLANTER THAT HAS BEEN CORRECTLY LEVELED

- Planter boxes and frame are level.
- Parallel linkage arms are level in planting position to achieve maximum benefits of down pressure springs.
- Planter frame is correctly set. Consult your owner’s manual for manufacturer’s recommended frame height.
- Hitch high enough to level main toolbar.
- Seed placement is consistent.
- Sufficient down pressure closes seed trench properly.
- Coulter is above or level with the planter openers.

*On some planters using 16" coulters, coulters should be the same depth as planter openers. Consult your planter guide.
View of row continuous seeder

Continuous seeder with individual unit
C. Equipment for spraying and dusting

A sprayer is a piece of equipment that uses tanks, pumps, and nozzles to apply liquid materials.

A duster is a piece of equipment used to apply dry powder materials.

Example?

Powered by human for house or small orchard

Powered by machines for fields and orchards
<table>
<thead>
<tr>
<th><strong>Fertilizer &amp; Lime</strong></th>
<th>Fertilizer is essential elements for the plant growth. Lime application for controlling the soil pH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weed Control</strong></td>
<td>Different plant, effect; reduce the crop yield, lower product quality, increase pest control cost, interfering with harvest equipment</td>
</tr>
<tr>
<td><strong>Disease Control</strong></td>
<td>Cause the destruction of the crop. Factors: due to pathogens, seed and soil-borne, bacteria, virus, nematodes and plant pathogen</td>
</tr>
<tr>
<td><strong>Insect Control</strong></td>
<td>Most common attack to the crop such as wasps, bees and ants. Chewing the plant leave cause the plant injuries</td>
</tr>
</tbody>
</table>
High clearance sprayer
Knapsack sprayer - manually powered

Knapsack sprayer – weedicide
- insecticide
- foliar spray
Knapsack Engine Powered Sprayer

- Sprayer powered by engine, electric motor or tractor PTO.
- Types: Hydraulic sprayers
  - Hydro-pneumatic sprayers
  - Blower sprayers
  - Aerosol generators
Boom Sprayer

- Nozzles
- Pressure gauge & regulator
- Agitation system
- Control valves
- Pipe and hoses
- Support frame
- Pump
Mist sprayer spraying insecticide or fungicide. In orchards.
Spraying preemergent weedicide
Farm Pilot & Drone
Pump

- To provide sufficient pressure to the tank and to deliver desired rate of the liquid
- Pump power
  \[ Hp = \frac{Q(gpm) \times P(psi)}{1714 \times (Eff)} \]
  used eff of 50-60%

- Flowrate per nozzle
  \[ Q(GPM) = \frac{GPA \times MPH \times W}{5940} \]
  or \[ Q(L/min) = \frac{L \times V(km/hr) \times W(m)}{60,000} \]

GPA is the spray volume e.g. 15 GPA or L/ha
MPH is the speed in miles per hour or km/hr
W is the nozzle spacing in inches or meter
D. Combine harvester

Price tag: RM100K++
Combine Harvester
IRRIGATION
Methods in estimating water requirement

- Historical observations (e.g. rainfall pattern, soil data)
- Numerical models (e.g. SWAT model)
Irrigation technique

- Surface irrigation
  - Furrow
  - Contour flooding
  - Basin and check irrigation

- Subsurface irrigation

- Overhead irrigation
  - Sprinkler
  - Drip irrigation
Surface Irrigation

• Totally depends on the water source- good if abundance!
• Example – Siphon method
• Two methods;
  – Furrow and flooding
Furrow

ridge
furrow

Flooding
Subsurface Irrigation
Example of Pump Size Requirement for Fertigation

<table>
<thead>
<tr>
<th>SITE</th>
<th>CROP</th>
<th>PUMP HORSEPOWER</th>
<th>FREQUENCY OF PUMPING IN A DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turf Unit Area, Bukit Ekspo</td>
<td>Cherry Tomato</td>
<td>0.5</td>
<td>4</td>
</tr>
<tr>
<td>Glasshouse at Ladang 10</td>
<td>Rockmelon</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>AL-Mansoor Strawberry Farm</td>
<td>Strawberry</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Machinery Cost Items

- Fixed Cost: 56%
- Fuel & Lubrication: 34%
- Repair: 10%
Table 2. Average annual **fixed costs/ownership costs** (as a percentage of new cost)

<table>
<thead>
<tr>
<th>Ownership period, years</th>
<th>Tractor (percentage)</th>
<th>All Machines Other Than Tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55.44</td>
<td>64.60</td>
</tr>
<tr>
<td>2</td>
<td>35.85</td>
<td>40.04</td>
</tr>
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<td>3</td>
<td>28.89</td>
<td>31.29</td>
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<td>19.35</td>
<td>19.35</td>
</tr>
<tr>
<td>8</td>
<td>18.17</td>
<td>17.89</td>
</tr>
</tbody>
</table>
Table 3. Average Fixed and Repair Costs per Horse Power Hour

<table>
<thead>
<tr>
<th>New Cost per HP</th>
<th>Annual Tractor Use, Hours per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400</td>
</tr>
<tr>
<td>$300</td>
<td>$0.15</td>
</tr>
<tr>
<td>$350</td>
<td>$0.175</td>
</tr>
<tr>
<td>$400</td>
<td>$0.200</td>
</tr>
</tbody>
</table>

A basis for comparing leasing versus ownership cost, fixed cost plus repair cost can be combine for three levels of new tractor costs:

- $400 per horse power
- $350 per horse power
- $300 per horse power
Sample hourly cost per horse power
$35,000, 100 HP (75 kW) Tractor

<table>
<thead>
<tr>
<th>Parameter/ Hours per Year</th>
<th>400</th>
<th>600</th>
<th>800</th>
<th>1000</th>
<th>1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost to own</td>
<td>$0.150</td>
<td>$0.108</td>
<td>$0.089</td>
<td>$0.078</td>
<td>$0.073</td>
</tr>
<tr>
<td>3-year lease</td>
<td>$0.230</td>
<td>$0.166</td>
<td>$0.134</td>
<td>$0.115</td>
<td>$0.103</td>
</tr>
<tr>
<td>4-year lease</td>
<td>$0.215</td>
<td>$0.153</td>
<td>$0.124</td>
<td>$0.107</td>
<td>$0.096</td>
</tr>
<tr>
<td>5-year lease</td>
<td>$0.196</td>
<td>$0.141</td>
<td>$0.115</td>
<td>$0.101</td>
<td>$0.092</td>
</tr>
</tbody>
</table>

Leasing for longer annual use and years is less cost as compared to the short years
Example of average annual cost

$35,000, 100 HP (75 kW)

<table>
<thead>
<tr>
<th>Parameter/Hours per Year</th>
<th>800</th>
<th>1000</th>
<th>1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost to own</td>
<td>$7,120</td>
<td>$7,800</td>
<td>$8,760</td>
</tr>
<tr>
<td>3-year lease</td>
<td>$10,720</td>
<td>$11,500</td>
<td>$12,360</td>
</tr>
<tr>
<td>4-year lease</td>
<td>$9,920</td>
<td>$10,700</td>
<td>$11,520</td>
</tr>
<tr>
<td>5-year lease</td>
<td>$9,200</td>
<td>$10,100</td>
<td>$11,040</td>
</tr>
</tbody>
</table>

Leasing for longer annual use and years is less cost as compared to the short years
Ways to reduce costs

The key is to reduce the production cost

1. **Width utilization**: effective width, avoid overlap
2. **Time utilization**: adjusting and lubricating when it's not in use during “rest time” for the machine, avoid breakdown, reduce the time loss during turning, loading and unloading.
3. **Matching tractors and machines**: operates at the rated load. Small load, used wider machine.
4. **Reducing original investment**: Buy used equipment, build one
5. **Increase annual use**: to reduce the cost per unit, join ownership, increase size of enterprise, doing custom work or diversification.
Ways to reduce costs

The key is to reduce the production cost
1. Increase service life: proper maintenance, careful adjustment, avoid overload, skill operator
2. Break-even used: higher a contractor to do the work, owning machine = cost of hiring a custom operator.
3. Maintenance schedules/records
4. Buy used equipment's
Case Study

• Anas Agro Farm have been operating a 360 ha farm. He want to rent more land, including the eighty ha good farm land only 2 km down the road.

• The additional land also means additional equipment with most critical item being the need for a larger tractor. Anas recently purchased a 100-hp tractor and must make payments of $6250 year for more years.

• After carefully reviewing his cash flow, he rule out the trade for a large tractor. Their annual payments would go up to by $7500 a year and eliminate all of his remaining borrowing power. This leaves them with three alternatives;
• Alternative:
  – Option 1: Buy a used tractor with 100 hp
    • Cost $25,000, payment $6,000 a year
  
  – Option 2: Rent a 150 hp tractor for 3 months for most critical work periods
    • Cost of $1250 per month, $3750 per yr
  
  – Option 3: Lease a new 100 hp tractor with option to buy
    • Cost of $7500 per year for five years

• Why option do you think the best for the cash flow for Anas Agro Farm?
2. Alternative cost

• Calculating alternative cost is one of the techniques to decide on what size of equipment to buy.

• In this calculation, we make an accurate cost estimate for each alternative cost.

• As a shortcut of estimating cost, use fixed costs and labor costs only.

• The costs for repairs, fuel and lubrications will be fairly constants on a per-acre basis.
Case Study I: Alternative cost

• Two combines ( $64,000 and $50,000). Need to harvest a paddy of 500 acres
• Field capacity :
  Price
  – Combine 1 ($64,000) is 8 acres/hr.
  – Combine 2 ($50,000) is 5 acres/hr.
Age
  – Combine 1 ( 10 years old)
  – Combine 2 ( 8 years old)
Labor
  – Labor cost are the same : $6/hr
Refer the table for ANNUAL FIXED COST

• Average Annual Fixed Cost:

  • Combine 1:
    $64,000 \times 15.61\% = $9,990

  • Combine 2:
    $50,000 \times 17.89\% = $8,945

AVERAGE ANNUAL DEPRICIATION AND FIXED COST AS A PERCENTAGE OF ORIGINAL LIST PRICE (Source: John Deere, 1981)

<table>
<thead>
<tr>
<th>Age, years</th>
<th>All tractors</th>
<th>All other Farm Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>55.44%</td>
<td>64.60%</td>
</tr>
<tr>
<td>2</td>
<td>35.85%</td>
<td>40.04%</td>
</tr>
<tr>
<td>3</td>
<td>28.89%</td>
<td>31.29%</td>
</tr>
<tr>
<td>4</td>
<td>25.11%</td>
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</tr>
<tr>
<td>8</td>
<td>18.17%</td>
<td>17.89%</td>
</tr>
<tr>
<td>9</td>
<td>17.16%</td>
<td>16.66%</td>
</tr>
<tr>
<td>10</td>
<td>16.28%</td>
<td>15.61%</td>
</tr>
<tr>
<td>11</td>
<td>15.49%</td>
<td>14.68%</td>
</tr>
<tr>
<td>12</td>
<td>14.79%</td>
<td>13.86%</td>
</tr>
</tbody>
</table>
• ANNUAL LABOR COST:
  \[ \text{ANNUAL LABOR COST} = \frac{\text{Area}}{\text{capacity}} \times \text{labor cost per hour} \]

Combine 1 needs 62.5 hours to complete the job
(500 acres : 8 acres/hr = 62.5 hr)

Combine 2 needs 100 hours to complete the job
(500 acres : 5 acres/hr = 100 hr).

• Labor cost is $6/hr
Thus, ANNUAL COST OF LABOR for Combine 1 is $375
(62.5 hr x $6.00/hr = $375)

ANNUAL COST OF LABOR for Combine 2 is RM600
(100 hr x $6.00/hr = $600)
Total Crop Value

- Total crop value can be calculated based on bushel harvested $\times$ price per bushel

- 14,730 bushels $\times$ $4.00 = $58,920 (Combine 1)
- 14,550 bushels $\times$ $4.00 = $58,200 (Combine 2)

### Corn

<table>
<thead>
<tr>
<th>1 bushel of corn</th>
<th>56 pounds</th>
<th>25.40 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bag of corn</td>
<td>60 kg</td>
<td></td>
</tr>
<tr>
<td>1 bushel/acre</td>
<td>62.77 kg/ha</td>
<td></td>
</tr>
<tr>
<td>1,00 dolar/bushel</td>
<td>2.3621 dolar/bag</td>
<td></td>
</tr>
</tbody>
</table>
Comparison combines alternatives
costs

<table>
<thead>
<tr>
<th>COMBINE COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Cost</strong></td>
</tr>
<tr>
<td>$64,000 (Combine 1)</td>
</tr>
<tr>
<td>$50,000 (Combine 2)</td>
</tr>
</tbody>
</table>

The combine I gave a reduction cost of $100 difference in net crop values -----
($48,655-48,555= $100)

The final decision would depend on manager.
However, in many cases, the reduced risk resulting from a faster harvest would make the larger combine more attractive to buy.
Question 1:
A combine harvester for rice is having 400 cm cutter bar is operated at an average speed of 10 km/hr to harvest paddy crop.

a) What is the theoretical field capacity (TFC) of the combine? – 3 mark

b) If we assumed the field efficiency (FE) of the combine is 80 percent, what is the effective field efficiency? -3 marks

c) If 10% time is lost in turning, loading and unloading, calculate the harvested area in 5 hours. – 5 mark

b) List down three factors contributed to the low efficiency during such operation. – 3 marks

c) What can be expected when the speed is reduced by half from the initial speed? – 3 mark

d) Briefly explain, how you can improve the actual field efficiency? – 3 marks
Tugasan 2 (40%)

- Mr. Anas is an agriculture entrepreneur and has leased a land of less than 1 ha for 3 years for vegetable production. This area has very minimal weeds with the soil is ready for farming. You are planning to plant a short term vegetables, such as sweet corn, water spinach, chili, tomato and other vegetables using organic and non organic growing method.

- The size of the business is small and stable, however the future market is uncertain. The company would acquire a bank loan as startup investment for the operation cost. A part of your work as the manager, you are also responsible to provide a complete plan of machinery operation and production. The proposed working rate was at 0.5 ha per hour, and the estimated cost for labor is about RM100 per hour. For the machinery usage, some operations always require a tractor/machinery involvement.
Choose the suitable crop. State the reason and the requirement if necessary e.g. the market price, potential demand, break event cost needed etc.

In your mechanization system, what is the most useful tractor/implement suitable to suite with the scale and the capital? State the reasons of tractor/machine for each of the selection?

What are the field operations that the tractor/machine of your choice can do?

Prepare a simple production schedule for the machinery application complete with the brief explanation of each of the operation.

How much do you think Mr. Anas would get the loan from the bank? What criteria used for the evaluation?

Provide the approach you would take either to purchase, rent or leasing the machinery in order to optimize the profit within 3 years period and the plan after the 3 years business and the reason of the choice. You may consider to calculate the break-even production and the potential of return on investment (ROI).

Estimate the labor cost, per ha, per season or annual operational cost of the area based on the provided information. You may extend the operation for a full season or by annual operational cost basis.
THANK YOU

Email: asuhaizi@upm.edu.my

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