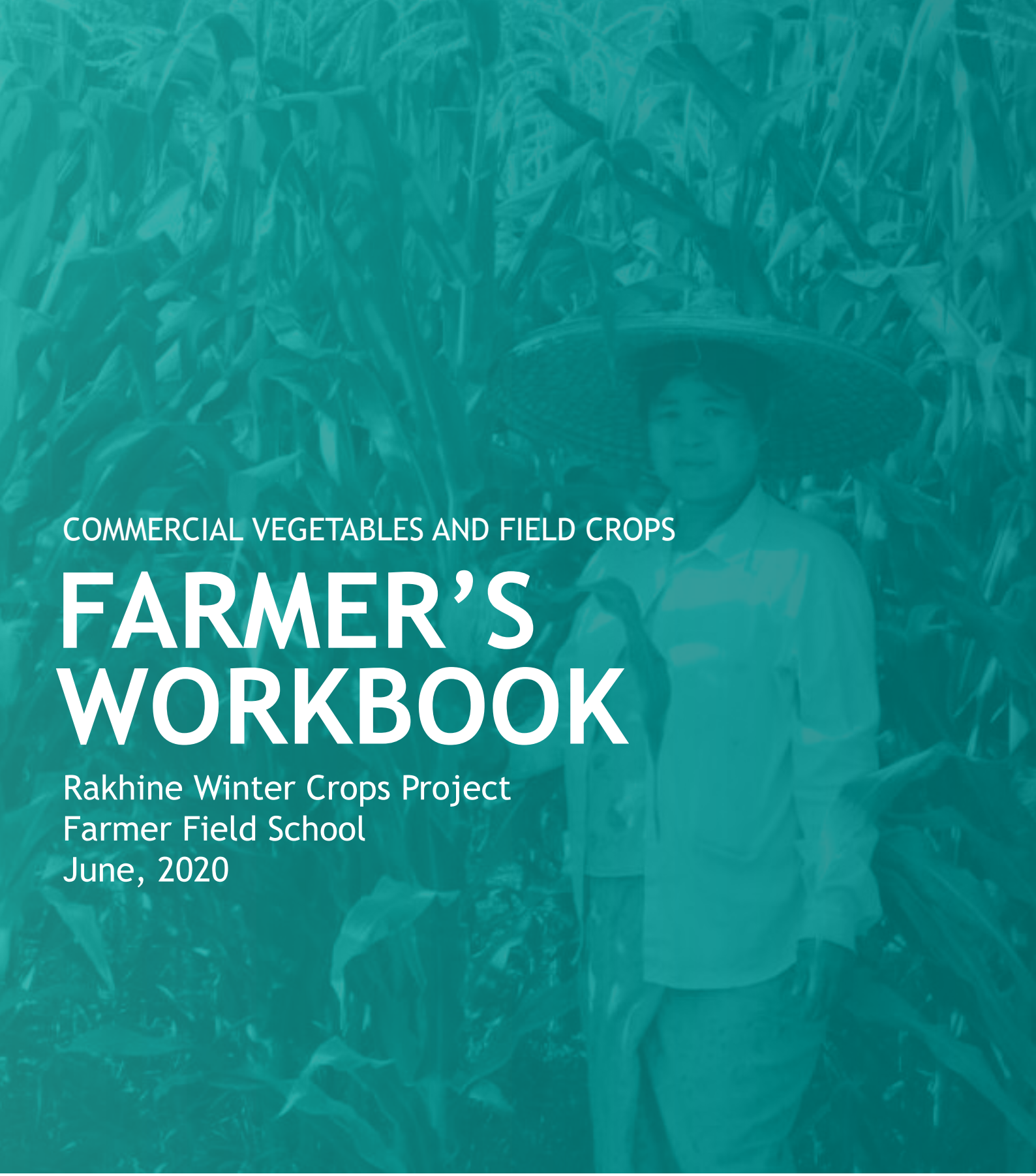

COMMERCIAL VEGETABLES AND FIELD CROPS

FARMER'S WORKBOOK

Rakhine Winter Crops Project
Farmer Field School
June, 2020

RAKHINE WINTER CROPS PROJECT

NEW ZEALAND
FOREIGN AFFAIRS & TRADE
Aid Programme

Table of contents

Introduction:

The Rakhine Winter Crops Project (RWCP) supports Good Agriculture Practice (GAP) extension activities for the implementation of Commercial Vegetable and Commercial Field Crop farming to provide fresh and healthy food to the grower, to protect the environment, and to improve income for farming families. This 'Farmer's Workbook' provides general technical advice on how to grow a wide range of crops from planting to post harvest, and is delivered through a Farmer Field School training approach.

While participants in the training need to be basically literate and numerate, they do not need to have had any significant formal education. Participants will be encouraged to form subgroups of 3-5 people, with each subgroup having someone who is literate, numerate and a fast writer. In this way, exercises can be completed and notes written within each subgroup, where the main learning experience occurs through listening and discussion. Those within the sub group who have not kept pace with the numeric and written exercises, can catch up with assistance from subgroup leaders after the training sessions, in their own time. Participants should write their notes in spare lines in this book, so all ideas about farming are in one place for easy reference.

Leader Farmers are encouraged to tell other farmers what they have learned. They can do this by explaining the notes in this book to others, as well as helping them practice these improved farming techniques in the field. In this way you can spread the benefits of your training to many other farmers, improving their lives as well as your own. The project wishes you well with your training and field results.

Session 1: Introduction to the Commercial FFS and Crop Selection Criteria

Exercise 1.1: Farmer's Expected Results After Attending the FFS Sessions

Expectations:	Circle: 1 Low: 5 Medium: 10 High
1.....	1; 2; 3; 4; 5; 6; 7; 8; 9; 10
2.....	1; 2; 3; 4; 5; 6; 7; 8; 9; 10
3.....	1; 2; 3; 4; 5; 6; 7; 8; 9; 10
4.....	1; 2; 3; 4; 5; 6; 7; 8; 9; 10
5.....	1; 2; 3; 4; 5; 6; 7; 8; 9; 10
6.....	1; 2; 3; 4; 5; 6; 7; 8; 9; 10

Exercise 1.2: Crop Net Income Results Before and After RWCP

Crop Type before RWCP	Area (acres)	Yield (A) (Consumed/ donated/ sold/crop left in the field)	Crop Harvest Units	Average Price (B)	Total Estimated Income (A x B)	Total Estimated Expense (C) (Seed, Fertilizer, Other)	Estimated Outside Labor (D)	Net Income (A x B) - (C + D)
Crop Type in this last season after RWCP								

Exercise 1.3: The project's CV/CFC Expected Results

1. Improved agronomic theory and field practice for those who want to become commercial farmers with access to land and sufficient water resources
2. Focus on winter production of vegetables and commercial field crops for consumption and sale
3. Increased net income
4. Greater diversity of crops to reduce disease and market risk and to improve nutritional intake
5. Motivation for farmers to extend GAP to other farmers

Exercise 1.4: Explanation of GAP

1. As shown under the umbrella below, when a farmer is protected by GAP practices, the food is safe to eat, the practices are safe for farmers and farm workers, they protect the environment, and their farms are more profitable. If farmers do not follow GAP (outside the protection of the GAP umbrella), their produce may be unsafe to eat, farm workers may get sick, the environment might be destroyed and farmers may get low profits

Exercise 1.5: Myanmar GAP protocols

MYANMAR GAP PROTOCOLS

1. Site Selection
   - The selected site and the surrounding area must be free from chemicals and biological hazards. Site plan and Crop Type Record should be kept.
2. Water
   - Water for agricultural use should be analyzed. Water from animal farms, hospitals, industrial and municipal wastes are harmful to the environment soshould not be used. (If using recycled water, follow WHO guidelines.)
3. Seed/ Seedlings
   - Seeds free from pests and diseases and well adapted to the current location should be selected.
   - The source, the amount, the date of receipt of the seedlings and propagated plants, should all be recorded.
4. Fertilizer and Soil Additives
   - Fertilizer and soil additives used for a specific crop should be free from chemical and biological contamination.
   - Use only well decomposed organic fertilizers.
   - Mixing, storing of fertilizers and composting the organic fertilizers should not be done on land near a water source, to prevent contamination.
   - The purchased fertilizers and soil additives should be from Government Approved Lists and Records should be kept on what fertilizer was used, how much and when.
5. Agricultural Chemicals and Other Chemicals
   - Follow Integrated Pest Management (IPM) to reduce the use of chemicals.
   - For health and environmental safety, pay full attention to Pesticide and Fertilizer Law and Regulations.
   - Only when necessary, use only the approved chemicals.
   - Strictly follow the Pre-Harvest Interval (PHI), according to the chemical used.
   - Know how to handle and use pesticides.
   - Purchase, storage, use and disposal of chemicals should be done according to regulations, and records should be kept.
   - Fuel, lubricants and non-agrichemicals should be used, handled, stored and disposed of properly to prevent product contamination.
6. Crop Care
   - Crop care should be done according to the specific needs of each crop.
7. Agricultural Tools and Materials
   - Agricultural tools and materials should not contaminate produce.
   - The tools and materials which were used in storing chemicals should be well labeled.
   - Do not use the above-mentioned tools and materials when storing other materials or products.
8. Harvesting and Post- Harvest Process
   - Harvest the crop at the right time with the right means.
   - Do not put produce directly on the ground, on the floor of packaging facility, or on the floor of the warehouse.
   - Water used in cleaning produce should be clean.
   - Grade and pack produce according to market specifications.

9. Storage and Transportation
    - Keep, store and transport produce away from chemicals, biological and physical damage.
    - Do not keep or store produce with fuels, pesticides, fertilizers and farm tools and materials.
    - Before transporting produce, ensure the vehicle is free from chemical spill, pests and diseases.
10. Construction
    - To minimize damage to produce, ensure that packaging, handling and storing facilities have been constructed to specifications and are in an approved place.
    - The facilities should be well maintained.
11. Control of Farm Animal and Pets
    - Domesticated and farm animals should not be in contact with harvest, packaging, and storage areas.
12. Evidence and Records
    - The producer should keep GAP records for at least two years.
    - Daily activities and practices should be noted down on the relevant forms.
13. Traceability
    - Significant marking and registration should be kept with the produce for traceability purposes.
    - Keep a separate record for the destination and delivery date of each produce.
14. Training
    - Both the producer and the worker should attend GAP training to attain good skills and knowledge in their respective fields.
15. Evaluation
    - The producer should conduct an annual evaluation on GAP protocols.
    - The producer should settle complaints and keep a complaints record.
16. Personal Hygiene and Welfare of Workers
    - Advice on personal hygiene, in bold letters, should be put in a common place, so every worker can see it, (or) distribute the advice to every worker.
    - Sanitary water and waste water should be carefully disposed of.
    - Pay full attention to the health and well-being of workers.

Exercise 1.6: Commercialization of Farming

Definition:

Commercialization means growing agriculture crops to sell for a profit, not just for family consumption. the practices protect the environment, and they are profitable.

Exercise 1.7. Review your family situation regarding farming

Why are you a farmer?

1. Is it just to produce food for yourself and your family? Circle: Yes/No
2. Is it just to earn more cash? Circle: Yes/No
3. Or is it for both food production and for money? Circle: Yes/No
4. Is earning money more important to you than just producing food? Circle: Yes/No

What do you use the money for?

1 .....
2 .....
3 .....
4 .....
5 .....
6 .....
7 .....
8 .....

Exercise 1.8: RWCP Crop Selection Criteria:

Selection of vegetables to grow:

1. What season can the crops grow – Cropping calendar
2. Diversity of crops to lower risk and to protect the environment
3. Crop rotation requirements for soil improvement and disease control
4. Price and timing of planting and harvest to get the best price
5. Market – What do the buyers want
6. Suitable site - free from flooding, contamination etc.
7. Soil type preferences or tolerances e.g. acid, neutral, alkaline
8. Labor requirements
9. Water requirements and availability
10. Profitability
11. Impact on males and females – if too negative, don't do it!
12. Impact on the environment – if harmful, don't do it!
13. Know how to grow the crop
14. Availability of quality inputs and reasonably priced inputs
15. Acceptable risk (of loss) from flooding, drought, pest and disease etc.

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Exercise 1.9: Calendar of Crops for the Different Seasons

Crops	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Group - 1												
1. Yard-long Bean												
2. Okra												
3. Onion												
4. Carrot												
Group – 2												
5. Chili												
6. Tomato												
7. Egg-plant												
8. White Egg-plant												
9. Coriander												
Group – 3												
10. Cabbage												
11. Cauliflower												
12. Broccoli												
13. Radish												
14. Water spinach												
15. Sweet Corn												
16. Mustard												
Group – 4												
17. Bottle Gourd												
18. Snake Gourd												
19. Ridge Gourd												
20. Bitter Gourd												
21. Cucumber												
22. Water Melon												
23. Pumpkin												
Field Crops												
1. Goundnut												
2. Chili												
3. Corn												
4. Watermelon												
5. Onion												

Remark:

Good growing period

Difficult growing period

Exercise 1.10: Why should you choose a range of crops, not just one crop?

It is risky to have just one crop because:

1. Disease might destroy your whole crop. It is better to spread the risk of diseases among a diversity of crops so you do not lose all your crop from the one disease at the one time.
2. The price might go down so you get a low price from all of your land. It is better to have different crops to spread the price fluctuation risk.
3. The maturity date is the same so you get your income all at one time. For your family cash flow it is better to spread your income so the produce from one crop can pay for the inputs for the next one.
4. If everybody grew the same high value crop the supply in the market would be too much and the price would go down. Better to have many crops to smooth out the supply/demand price fluctuation effects.

5. .....

6. .....

7. .....

Exercise 1.11: Definition and Benefits of Crop Rotation

Definition of crop rotation:

Moving similar family crop groups from one location to a new location each year

Benefits of Crop Rotation:

1. Disease Prevention: Disease organisms can build up over time, resulting in eventual crop failure. Rotating crops reduces the same disease buildup.
2. Insect Control: Crop rotation also helps reduce insect infestations.
3. Nutrient Balance: Different families of plants require different nutrients. By rotating your crops, you keep the soil from being depleted of the same nutrient every time.
4. Nutrient Enhancement: Some plants actually improve the soil (like groundnut or beans), so rotating them around the vegetable plots can produce organic soil conditioning for free (without additional cost).
5. Reduce risk: If one crop dies you have other crops from which you can still get income

The Principals of Crop Rotation

Optimizing nutrient requirements:

1. Legumes (groundnut and green gram or beans) can be grown to replenish the nitrogen in the soil.
2. Leafy plants have a high demand for nutrients, particularly nitrogen, and should follow the planting of nitrogen producing legumes.
3. Fruiting plants such as tomato, eggplant, chili, okra and pumpkin should follow the planting of leafy plants because fruiting plants have a high demand for phosphorous and too much nitrogen stops them from fruiting properly.
4. The root crops e.g. onion and shallot, should follow the leafy or fruiting crops because they do not need as much phosphorous or nitrogen.

Reducing the buildup of pests and diseases

1. Plants that are related to each other suffer from the same problems with pests, weeds and diseases
2. It is important not to grow plants from the same family in a plot year after year, to prevent the buildup of pests and diseases.
3. Tomato and plants related to tomato (chili, eggplant) are very susceptible to the same pests and diseases
4. Cabbage and cauliflower are related to each other. Onions and shallots are related to each other.
5. A gap of three growing seasons should be left between growing these crops.
6. For short term crops e.g. salad and spring onions, you can grow them time after time in the same year and then leave a 3 to 4 year gap.
7. When the soil is left bare, nutrients can easily be washed out, especially during heavy rains in the wet season. If no crop is growing during this period, it is well worth sowing a short-term cover crop such as velvet bean (Mucuna) as this prevents large amounts of fertility being lost from the soil.

Flexibility.

Don't be too rigid with your rotation plan. If plants are showing signs of pest or disease damage you may need to change the plan or remove the crop. Or if a field in a rotation has a long standing weed problem, it may be necessary to change the plan to avoid growing weed susceptible crops there.

Exercise 1.12: Example of a 4 season crop rotation on a plot of land

Group - 1	Group - 2
1. Yard-long Bean	1. Chili
2. Okra	2. Tomato
3. Onion	3. Egg-plant
4. Carrot	4. White Egg-plant
	5. Coriander
Group - 3	**Group - 4**
1. Cabbage	1. Bottle Gourd
2. Cauliflower	2. Snake Gourd
3. Broccoli	3. Ridge Gourd
4. Radish	4. Bitter Gourd
5. Water spinach	5. Cucumber
6. Sweet Corn	6. Water Melon
7. Mustard	7. Pumpkin

Exercise 1.13: Average monthly price per unit

Crops	Unit	10	11	12	1	2	3	4	5	6	7	8	9	Duration
Group - 1														
1. Yard-long Bean	Bunch	100	80	80	80	100	120	150	150	100	120	100	10	50-60 days (Akari 111)
2. Okra	Bunch	60	80	80	80	100	120	100	120	120	120	120	120	50-60 days Kirti
3. Onion	Viss	2000	2000	3000	3500	2000	1200	1200	1200	1500	1500	1500	1800	90-150 days
4. Carrot	Viss	3500	2800	2800	200	2500	3000	3000	3500	3500	3500	3500	3500	90 days Chike
Group – 2														
5. Chili	Tin	250	200	200	150	150	200	200	200	250	300	300	250	85-90 days Demon and Tongla692
6. Tomato	Viss	1300	1300	1000	600	500	1000	1200	1200	1200	1200	1200	1300	75-90 days Nirvana 044
7. Egg-plant	Bunch	300	300	250	250	300	400	400	400	500	400	400	300	80-90 days Runako
8. White Egg-plant	Fruit	20	20	20	20	20	20	20	20	20	20	20	20	70-80 days White Color
9. Coriander														30-60 days
Group – 3														
10. Cabbage	Head	1500	1000	800	500	400	400	800	1000	1500	1500	1500	1500	85-90 days Nuzaka
11. Cauliflower	Flower	1500	1000	800	500	400	400	800	1000	1500	1500	1500	1500	85-95 days Poornima 088 (winter) 75 days Atria153 (Hot)
12. Broccoli	Flower	900	900	800	600	500	700	900	900	1000	1000	1000	1000	
13. Radish	Bunch	250	250	250	200	100	50	80	100	100	150	200	200	45 days Ural
14. Water spinach	Bunch	30	30	30	30	30	30	30	30	30	30	30	30	45-55 days Liao, Yangtze
15. Corn	Ear	150	150	200	200	120	120	150	200	200	200	200	150	70-90 days
16. Mustard														40-45 days
Group – 4														
17. Bottle Gourd	Fruit	1500	800	500	400	400	800	800	1000	1500	1500	1500	1500	65 days Anmol
18. Snake Gourd	Fruit	100	200	200	100	100	100	200	250	250	250	100	100	65 days
19. Ridge Gourd	Fruit	100	150	300	300	100	100	300	300	300	250	100	100	65 days
20. Bitter Gourd	Bunch	150	150	150	120	150	150	150	200	200	150	150	150	65 days
21. Cucumber	Fruit	150	150	100	80	80	100	150	150	150	100	100	150	60-70 days Shweyati 777

22. Water Melon	Fruit	2500	2000	2000	2500	2000	1000	2000	2500	2500	2000	2500	2500	90-100 days Padamya 824
23. Pumpkin	Fruit	1000	1200	1200	1500	1500	1200	1000	1000	800	1000	1000	1000	85-90 days Arjuna
24.														
25.														

*(*Source: East West Seed)*

Exercise 1.14: How do you know what crops buyers want?

Some ideas:

1. Visit buyers and ask them
2. Ring them
3. Invite them to come and talk with your group. They may not come to see one individual, but might come if they can talk to a whole group.
4. Analyze prices – high price at high demand, low supply periods

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Exercise 1.15: Definition of an agreement

Agreements are formal written contracts or informal verbal agreements made between individuals or groups for products and services.

Exercise 1.16: Questions about Agreements

What are the benefits of having a written sales agreement with a product buyer?

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What are the benefits of having a verbal sales agreement?

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Would a written agreement be better than a verbal agreement? Why?

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What are the negative aspects of having a sales agreement?

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Exercise 1.17: Factors to look for in a Sales Agreement

1. What products do you want to buy? Describe your product clearly.
2. How much product can you buy? For example, 5 baskets per farmer, or 100 baskets from the whole group.
3. What is the time period when the buyer wants to buy the produce?
4. What quality standards are required? For example: size, color, moisture content and grade.
5. What GAP cultivation practices are required to market produce as 'GAP produce'?: This refers to how the crop was produced, for example: (i) Safe for the consumer – sold after chemical withholding periods; (ii) used less chemicals, more organic; (iii) used government approved chemicals only; (iv)

not harmful to the environment; (v) not harmful to the farmer and the workers; (vi) used quality seed from pure varieties; and (vii) harvested, stored and transported properly so there is a long shelf life. Remind participants of the other government GAP requirements outlined in the GAP definition in their workbooks.

6. How and where should the products be delivered? For example, specific locations, time, mode of transport, packaging, who pays for transport. Perishable products like fruit and vegetables may need special packaging, ripeness, storage and transport requirements.
7. What price will be paid and under what conditions? For example, price based on quality and price based on quantity. Ask about individual farmer price and group price for a larger volume of sales and better prices.
8. What payment procedures?: How and when will the farmer be paid by the buyer; for example cash on delivery, payment after some days or months, paid by cheque?
   Does the buyer offer technical support: Examples might be a leaflet or a personal visit to advise on quality standards.
9. Other incentives: These are extra benefits the seller or buyer can offer. For example, if you sell me more than 10,000 baskets of products, I can give you credit for inputs (pre financing), or a free motorbike or other promotions. This especially applies to group buying/selling of large volumes.
10. If there is disagreement between buyers and sellers, how can these problems be solved?
11. How is the product insured against risks like fire, flood, drought, damage in transport? Who is responsible for organizing and paying for this?
12. Are there any penalties if either party breaks the agreement?

Exercise 1.18: Example of Ground rules:

1. Be on time.
2. Participate actively.
3. Listen to what other people have to say without interrupting them.
4. Raise your hand to ask a question or to say something – wait for your turn.
5. Be willing to share experiences and learn new things from others.

6. ……

7. ……

8. ……

Session 2: Buyer Led Workshop

Exercise 2.1: Factors to look for in a Sales Agreement

1. What products do you want to buy? Describe your product clearly.
2. How much product can you buy? For example, 5 baskets per farmer, or 100 baskets from the whole group.
3. What is the time period when the buyer wants to buy the produce?
4. What quality standards are required? For example: size, color, moisture content and grade.
5. What GAP cultivation practices are required to market the produce as 'GAP produce'?: This refers to how the crop was produced, for example: (i) Safe for the consumer – sold after chemical withholding periods; (ii) used less chemicals, more organic; (iii) used government approved chemicals only; (iv) not harmful to the environment; (v) not harmful to the farmer and the workers; (vi) used quality seed from pure varieties; and (vii) harvested, stored and transported properly so there is a long shelf life. Remind them of the other government GAP requirements outlined in Exercise 1.3 in their workbooks.
6. How and where should the products be delivered? For example, specific locations, time, mode of transport, packaging, who pays for transport. Perishable products like fruit and vegetables may need special packaging, ripeness, storage and transport requirements.
7. What price will be paid and under what conditions? For example, price based on quality and price based on quantity. Ask about individual farmer price and group price for a larger volume of sales and better prices.
8. What payment procedures?: How and when will the farmer be paid by the buyer; for example cash on delivery, payment after some days or months, paid by cheque?
   Does the buyer offer technical support: Examples might be a leaflet or a personal visit to advise on quality standards.
9. Other incentives: These are extra benefits the seller or buyer can offer. For example, if you sell me more than 10,000 baskets of products, I can give you credit for inputs (pre financing), or a free motorbike or other promotions. This especially applies to group buying/selling of large volumes.
10. If there is disagreement between buyers and sellers, how can these problems be solved?
11. How is the product insured against risks like fire, flood, drought, damage in transport? Who is responsible for organizing and paying for this?
12. Are there any penalties if either party breaks the agreement?

Session 3: Crop Selection (continued)

Exercise 3.1: Farmers site selection evaluation:

Criteria	Your Site Evaluation (Tick for 'yes', or cross for 'no')
1. Not far from home to enable regular visits	
2. Free from flooding	
3. Near a sufficient contaminate free water source	
4. Free of pests or disease from their field and neighboring fields	
5. Soils are suitable for vegetables or field crops	
6. Soils free from contamination by poisonous heavy metals like chromium and arsenic.	
6. Previous history of suitable land use	
7. Have some shade trees but not too many	
8. Have good access to market links e.g. collectors and buyers	
9.	
10.	
11.	
12.	

Exercise 3.2: Soil components

Question 1: What are the main components of soil?

- Big and small particles of mineral substances (45%),
- Organic matter, micro-organisms (5%),
- Air (25%)
- Water (25%)

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Question 2: What does a good soil for growing vegetables look like?

- Black, brown or red top soil
- Good smell
- Crumbly texture but not too fine
- Moist but not too wet
- Rich in organic matter which is the home for nutrients and micro organisms

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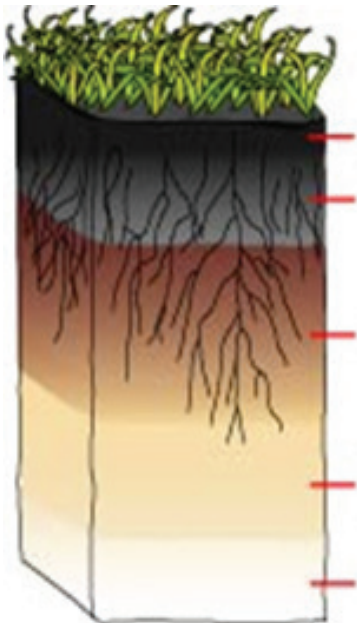

Exercise 3.3: What to look at while analyzing the soil

1. Soil structure and texture determines what sort of plants we can grow. Important properties are:
   - Clay – binds nutrients and water
   - Humus – helps aeration and root growth
   - Sand – increase porosity (porosity is defined as being full of tiny holes so that air or water can pass through)
2. Soil structure is defined by the way individual particles of sand, silt and clay, are assembled to form larger particles. Sand is the biggest particle, clay is smaller and silt is even smaller.
3. Soil Texture is how the soil feels in the hand and behaves when it is cultivated. The relative percentages of sand, silt and clay are what give soil its texture.
   - Sandy soils feel gritty, are easily cultivated, and are free draining, but don't hold water in the dry season.

- Silt soils are very fine and hold moisture but compact with cultivation
- A clay soil feels sticky, does not drain well and gets hard when dry

4. Soil color is determined by the amount of minerals and organic matter in it. Soils high in iron are deep orange-brown to yellowish-brown. Soils that are high in organic matter are dark brown or black. Color can also tell us how a soil "behaves" – a soil that drains well is brightly colored and one that is often wet and soggy will have a mottled pattern of greys, reds, and yellows.
5. Other soil characteristics.
   - Plant and animal life in the soil like earthworms and other biota
   - Roots.
6. Identifying your soil type. Wet a handful of soil and rub the soil between your fingers. The soil can be classified on how it feels.
   - Clay: sticks to fingers, is cohesive (particles stick together), has a high plasticity (can be shaped or formed easily) and has a shiny surface after squeezing between fingers.
   - Silt: is non-sticky, only weakly formable, has a rough surface after squeezing between fingers and feels like flour
   - Sand: cannot be formed, does not stick to fingers and feels very grainy.

Exercise 3.4: Horizon of the farmer's own soil

1. Draw a horizon profile of your most popular vegetable soil

2. Describe the feel of the soil in the growing zone

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   .....

3. Describe the color of the soil in the growing zone

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   .....

4. Describe other characteristics of the growing zone

   .....

   .....

Exercise 3.5: Matching crops to preferred soil type

Crops	Soil type	Tick or Cross Suitability
Group - 1		
1. Yard-long Bean	Best in friable (easy to crumble), well drained soils such as silts	
2. Okra	Will grow in silts but like high organic matter	
3. Onion	Will tolerate a wide range of soils including silt loam	
4. Carrot	Will grow in silt loam but can tolerate heavy clays	
Group – 2		
5. Chili	Best in friable well drained soils such as silt loam but tolerant of a range of soils	
6. Tomato	Best in friable well drained soils such as silt loam but tolerant of a range of soils	
7. Egg-plant	Best in friable well drained soils such as silt loam but tolerant of a range of soils	
8. White Egg-plant	Best in friable well drained soils such as silt loam but tolerant of a range of soils	
9. Sweet corn	Best in friable well drained soils such as silt loam but tolerant of a range of soils	
Group – 3		
10. Cabbage	Will grow in silt loam but can tolerate heavy clays	
11. Cauliflower	Will grow in silt loam but can tolerate heavy clays	
12. Broccoli	Will grow in silt loam but can tolerate heavy clays	
13. Radish	Will grow in silt loam but can tolerate heavy clays	
14. Water spinach	Will grow in silt loam but can tolerate heavy clays	
Group – 4		
15. Bottle Gourd	Will grow in silt loam but likes high organic matter	
16. Snake Gourd	Will grow in silt loam but likes high organic matter	
17. Ridge Gourd	Will grow in silt loam but likes high organic matter	
18. Bitter Gourd	Will grow in silt loam but likes high organic matter	
19. Cucumber	Will grow in silt loam but likes high organic matter	
20. Water Melon	Will grow in silt loam but likes high organic matter	
21. Pumpkin	Can tolerate heavy clays with some organic enrichment	

Exercise 3.6: Soil Degradation Causes and Solutions

Soil Degradation Causes	Solutions
1. Mono-cropping drains all nutrients specific to that crop	Use a rotation with different crops
2. Burning surface cover damages organic matter	Dig in green (wet) and dry materials to decompose and make the soil fertile
3. Only using chemical fertilizer results in lower fertility and yield in the long term	Use organic matter or a mixture of chemical and organic matter
4. Water erosion causes loss of soil and nutrients	Select flood free sites, have free draining soils, have raised beds and drainage channels
5. Direct sunlight on the soil causes high temperature, erosion, evaporation of soil nutrients and water	Cover the soil with straw, plastic, or a cover crop and have filtered shelter
6. Strong wind causes soil erosion and water evaporation	Have filtered shelter to reduce wind speed. Some air flow is good.
7. Compacting the soil breaks down soil structure and makes it become hard	Use low impact cultivation and plant care techniques
8.	
9.	
10.	

Exercise 3.7: Labor participation planning

A labor participation plan helps to:

1. Calculate total labor requirements
2. Assess family labor availability and preferred tasks. For example, males do some heavy jobs like cultivation while females specialize in lighter work like weeding. Other tasks are shared between men and women.
3. Hired labor from outside may be needed if there is not enough family labor.
4. Cost of labor - Family labor is usually for free (but share in the profit), while outside labor has to be paid for and should be included in the budget costs.

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Exercise 3.8: Crop water requirements

Crops	Water Requirements (L/ square yard)	Ranking 1 for the least water requirement, 2 for second least water requirement etc.
Group - 1		
1. Yard-long Bean	319	
2. Okra	425	
3. Onion	637	
4. Carrot	319	
Group – 2		
5. Chili	637	
6. Tomato	531	
7. Egg-plant	743	
8. White Egg-plant	743	
9. Coriander	334	
Group – 3		
10. Sweet corn	743	
11. Cabbage	637	
12. Cauliflower	637	
13. Broccoli	531	
14. Radish	212	
15. Water spinach	319	
Group – 4		
15. Bottle Gourd	212	
16. Snake Gourd	212	
17. Ridge Gourd	212	
18. Bitter Gourd	212	
19. Cucumber	531	
20. Water Melon	425	
21. Pumpkin	637	

Exercise 3.9: Definitions of a budget and breakeven analysis

A budget plan is a method of measuring the Profit or Loss of an enterprise before you start.
It records **INCOME** minus **EXPENDITURE = PROFIT OR LOSS**.
It is important to estimate if you will get a Profit or Loss BEFORE you grow your crop. There is no point in growing something that is likely to make a loss. Better to save your money and NOT grow that crop, and instead find another crop that is likely to be profitable.
Breakeven analysis shows us at what price the farmer will break even - that is, no profit and no loss. If you think the price will go below this amount then you will make a loss. You should therefore NOT GROW this crop at this time.
Break even calculation: **TOTAL EXPENDITURE** divided by the **YIELD/UNIT** to give the **BREAKEVEN PRICE**

PER UNIT. For example, it costs 55,000 kyat to produce 500 viss of tomatoes. Divide Cost (55,000) by total viss (500) to get the breakeven price (110 kyats/viss).

Note 1: Profit, loss and breakeven estimates at crop selection time are your best estimates (calculated guesses) of the financial outcome. You can never be sure if you will get the yield you want or if the price will go up or down, because you do not know the future for sure. You can however try hard to carry out the activities that you have put in the budget so that you will have a good chance of getting the result you planned. Aim for a high yield and good price to get the income, by using the listed inputs along with the correct application timing, amount and costs, to achieve your target expenditure. Costs should include the cost of production like seeds and fertilizer, and also hired labor, harvesting and marketing costs. Do not cost family labor because the family can share in the profit.

Note 2: In farming budgets, do not include personal costs like school fees, house repairs, etc. These can be recorded in a separate family budget if you want.

Exercise 3.10: What is the order of profitability of the different crops using the recommended GAP?

Crops	Profit per 0.06 acres	Profitability Ranking Rank 1 for the most profitable, 2 for second most profitable etc.
Group - 1		
1. Yard-long Bean	93800	4
2. Okra	89500	3
3. Onion	162552	2
4. Carrot	114800	1
Group – 2		
5. Chili	139200	3
6. Tomato	198800	1
7. Egg-plant	110200	4
8. White Egg-plant	91600	5
9. Coriander	168000	2
Group – 3		
10. Cabbage	130550	2
11. Cauliflower	125075	4
12. Broccoli	149075	3
13. Radish	86225	5
14. Water spinach	139700	1
15. Corn	95900	6
16. Mustard	63400	7
Group – 4		
17. Bottle Gourd	146075	2
18. Snake Gourd	110375	4
19. Ridge Gourd	117075	3
20. Bitter Gourd	82425	7

21. Cucumber	181820	1
22. Water Melon	96125	6
23. Pumpkin	145750	5
Field Crop	1 Acre	
24. Corn	887520	4
25. Chili	1950800	1
26. Groundnut	304087	5
27. Water Melon	1963900	3
28. Onion	1911830	2

Exercise 3.11: Impact on Men and Women of CV/CFC with Irrigation:

Male		Female	
Practical needs: (Support food, shelter, income and other family basic needs)	**Less: Same: More**	**Practical needs: (Support food, shelter, income and other family basic needs)**	**Less: Same: More**
Access to food		Access to food	
Access to income		Access to income	
Work load		Work load	
Empowerment needs: (Strengthen the individual person's status and feelings about themselves)		**Empowerment needs: (Strengthen the individual person's status and feelings about themselves)**	
Control of decision making		Control of decision making	
Learning opportunities		Learning opportunities	
Leadership opportunities		Leadership opportunities	
Status/Self worth		Status/Self worth	
Other Effects		**Other Effects**	

Exercise 3.12: Environmental problems and mitigation measures

Environmental Problems	Effects	Solutions
High disease	High chemical use, low yield.	Use disease resistant varieties, crop diversity, rotations, good air flow lowers moisture around crops and reduces disease.
High chemical use	Destroys soil, high cost, harmful to farmers and consumer health.	Use less chemical and more organic approaches.

Inefficient water use	Wastes water causing crop losses and high irrigation costs. Can cause leeching and erosion.	Use water more carefully using water saving technologies like a shower rose, or drip instead of flood irrigation.
Low organic matter in the soil	Poor soil structure and nutrient uptake.	Use more organic matter.
Imbalanced soil nutrition – taking more out of the soil than putting in.	Gradual reduction in yield and soil breakdown until you have to stop farming.	Apply GAP levels or chemical and organic fertilizer according to each crop and yield requirements.

Exercise: 3.13: Definition of Risk

Definition of Risk

Risk is the probability of a harmful activity happening. Example: High probability of floods in the monsoon.

Exercise 3.14: Risk Assessment

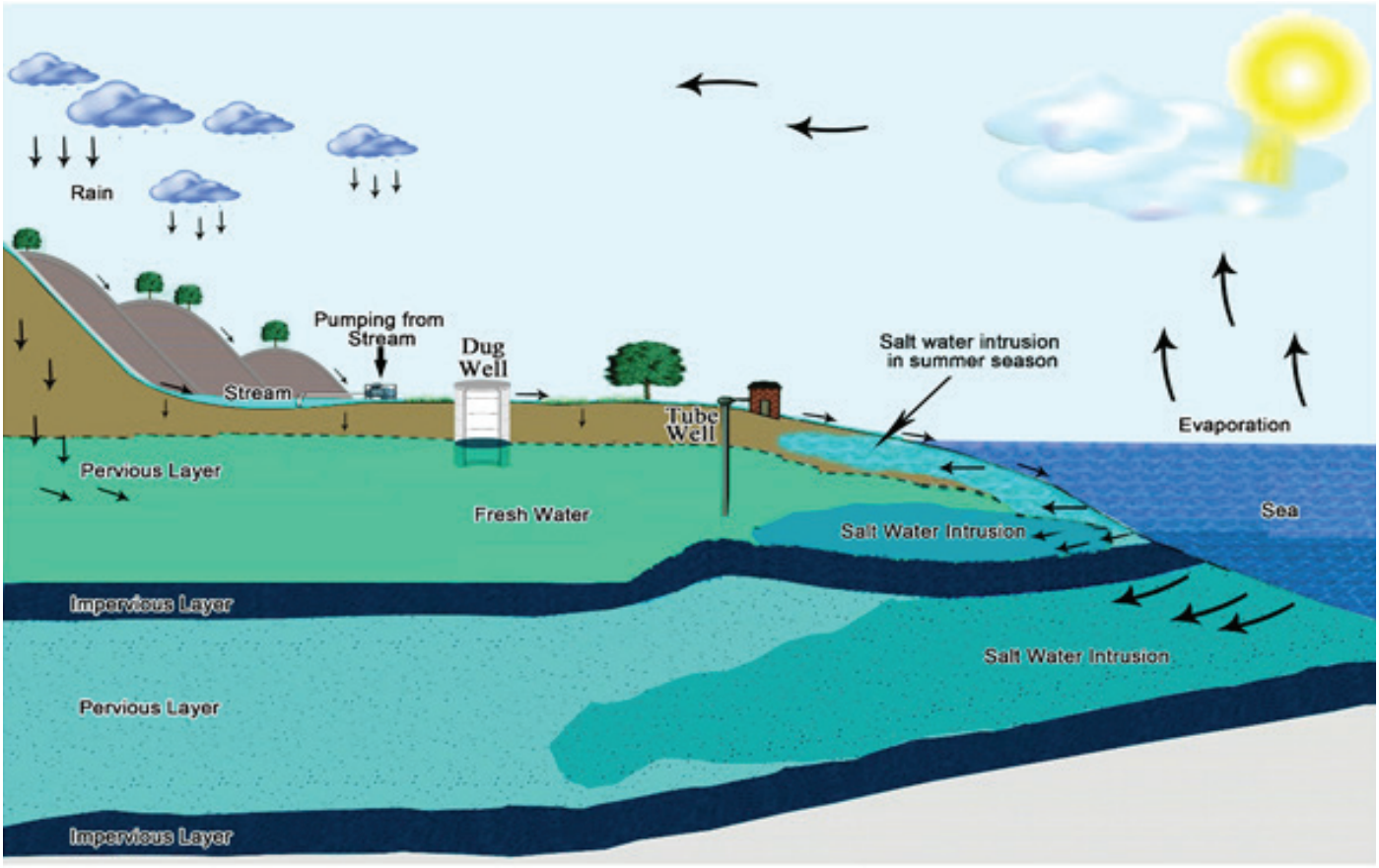
Environmental Problems	Effects	Solutions
Not enough water (drought)		Have irrigation with enough water. Use water efficient application methods
Salty water		Find ways to stop the flow of salty water Grow in salt free soil
Hot weather		Grow in cool periods Grow heat tolerant crops
Pest outbreak		Crop rotation Crop diversity Check crops regularly and take control steps early Use organic prevention and controls where possible to protect friendly insects Only use chemicals when absolutely necessary
Disease		As immediately above Keep crop surfaces dry to reduce fungal disease
Flood		Grow in flood free periods Grow on high flood free ground Use raised beds above flood levels
Storm		Grow in storm free periods Provide crop shelter
Low market price		Grow what the market wants Grow in high price periods Diversify crops to spread risk Develop marketing networks in different regions Develop purchase agreements

Exercise 3.15: Crop Selection for the coming season – under all headings in the columns, tick for alright, or cross for not so good

Crops	1. YLB	2. Okra	3. Carrot	4.	5.	6.								
Can grow in the season														
Diversity														
Rotation														
Price														
Market Buyer Recommendation														
Site														
Soil														
Labor														
Water														
Profit														
Males & Females Agree														
Not harmful to the environment														
Have technique														
Have access to inputs														
Risk														

Session 4: Irrigation Construction and Equipment Requirements

Exercise 4.1: Irrigation water hydrology and salt water intrusion



Exercise 4.2: Structures & Equipment needed to access irrigation water

Structure or Equipment	Cost MMK per structure (June 2020)	Advantages	Dis-advantages
Pumping from streams	Zero cost. No structure.	No construction cost Plenty of water most of the time Sub surface and surface pumping	Sometimes end of season water dries up High lift, high pumping cost Could be a long way from their field
Shallow 3' diameter dug wells (18' deep)	720,000	Long lasting (20yrs+) Small construction site Low maintenance High refilling rate so can irrigate 2-3 sites at one time Can do manual or machine water lifting Sub surface and surface pumping Operation and Maintenance by local expertise Can increase the depth if water dries up	Only access water maximum 20-25 feet Risk of things falling into the well Could damage by flood without cover Not so pure water especially for drinking

Shallow 4" tube wells (50' deep	520,000	Very small construction site Can access water at greater depths Cost is low compared with other structures Access to pure water Easier to protect from flooding and impurities	Silting up after around 5 years Higher operation and maintenance to flush silt by outside skilled technicians Only access by surface pumping Can have problems pumping from greater depth

Exercise 4.3: Types of pumps to access irrigation water

Types of Pumps	Cost MMK per structure (June 2020)	Advantages	Dis-advantages
5.5 HP petrol water lifting pumps	200,000	Small so can carry Available anywhere Easy to operate High discharge High water lifting capacity in short time	Fuel cost 1-2 litres/day Easy to maintain when not old Costly to maintain when older Not more than 25' suction height Environmental damage
Small diesel water lifting pumps	260,000	Fuel consumption lower than petrol High water lifting capacity in short time Easy to operate Spare parts available locally	Higher purchase cost Fuel costs Heavy to move Repair and maintenance difficult and costly Need mechanic to maintain Not more than 25' suction height Environmental damage
DC solar submersible pumps **Solar panel (200- 300watts)**	380,000 120,0000	No fuel cost No noise Easy to operate Easy to move No repairs and maintenance Becoming more easily available Environmentally friendly	Must replace pump when broken Not more than 25' suction height Small area watering capacity
Solar surface water lifting pump **Solar Panel (200 -300 watts)**	45,000 120,000	Low cost No fuel cost No noise Easy to operate Easy to move No repairs and maintenance Becoming more easily available Environmentally friendly	Must replace pump when broken Not more than 25' suction height Small area watering capacity

Solar deep well pumps **Solar panel 100 watts** **Battery 70 Ah**	200,000 70,000 80,000	Can pump 100' or more depth No fuel cost No noise Easy to operate Easy to move No repairs and maintenance Becoming more easily available Environmentally friendly	Initial cost high Must replace pump when broken More than 25', Up to 65' suction height and above on pump capacity Small area watering capacity
Bilge horizontal watering pump **Solar panel 100watt**	26,000 70,000	Low cost No fuel cost No noise Easy to operate Easy to move No repairs and maintenance Becoming more easily available Environmentally friendly	Low pressure horizontal flat land pumping only Must replace when broken Not more than 14' Total head Suction from ground level Small area watering capacity (up to 1.0 acre in stages)

Exercise 4.4: Irrigation methods

Advantages	Dis-advantages
Furrow irrigation	
• Low operational costs • Easy distribution in soils with high water holding capacity	• Need level field to get even water distribution • High set up costs to level fields • Uses a lot of water • Encourages weed growth • Erodes sides of beds • Can result in build-up of salts by evaporation
Sprinkler Irrigation	
• Low operational costs for wide coverage • Can be used for frequent short term application on soils with low water holding capacity • Price varies with quality of material • Movable increases flexibility and reduces cost	• High set up costs • Requires high pump pressures • High losses from evaporation • Leaching of nutrients from plants and soil • Increases risk of disease because water is on the leaves • More weeds
Drip irrigation	
• Very efficient use of water • Equal distribution of water to all plants • Reduced weed growth • Can be used on uneven fields • Price varies with quality of material • Movable increases flexibility and reduces cost • Saves labor • Can apply fertilizer by fertigation (through drip irrigation)	• High set up costs • Tubes can become blocked • Difficult to change layout for different planting layouts • Tubes deteriorate in the sun unless under mulch

Shower rose in 8” x 4” furrow between rows on top of beds	
• Low cost fitting on end of hose • Can use with varying water pressures • Can direct water to the furrow where it can gradually seep into the bed rather than run off, reducing water waste and weed growth. • The rose lowers pressure & reduces erosion • Takes little time per bed if reasonable pressure	• Need level beds for even distribution of water
Watering can	
• Low set-up costs • Reasonably low use of water if directed at base of plants and not all over the land. • Can regulate spread and application point • Can be used on uneven fields in plant holes • Reduced weed growth if directed only at root zone and not all over the field.	• More labor intensive than other methods • Difficult to apply enough water

Furrow irrigation

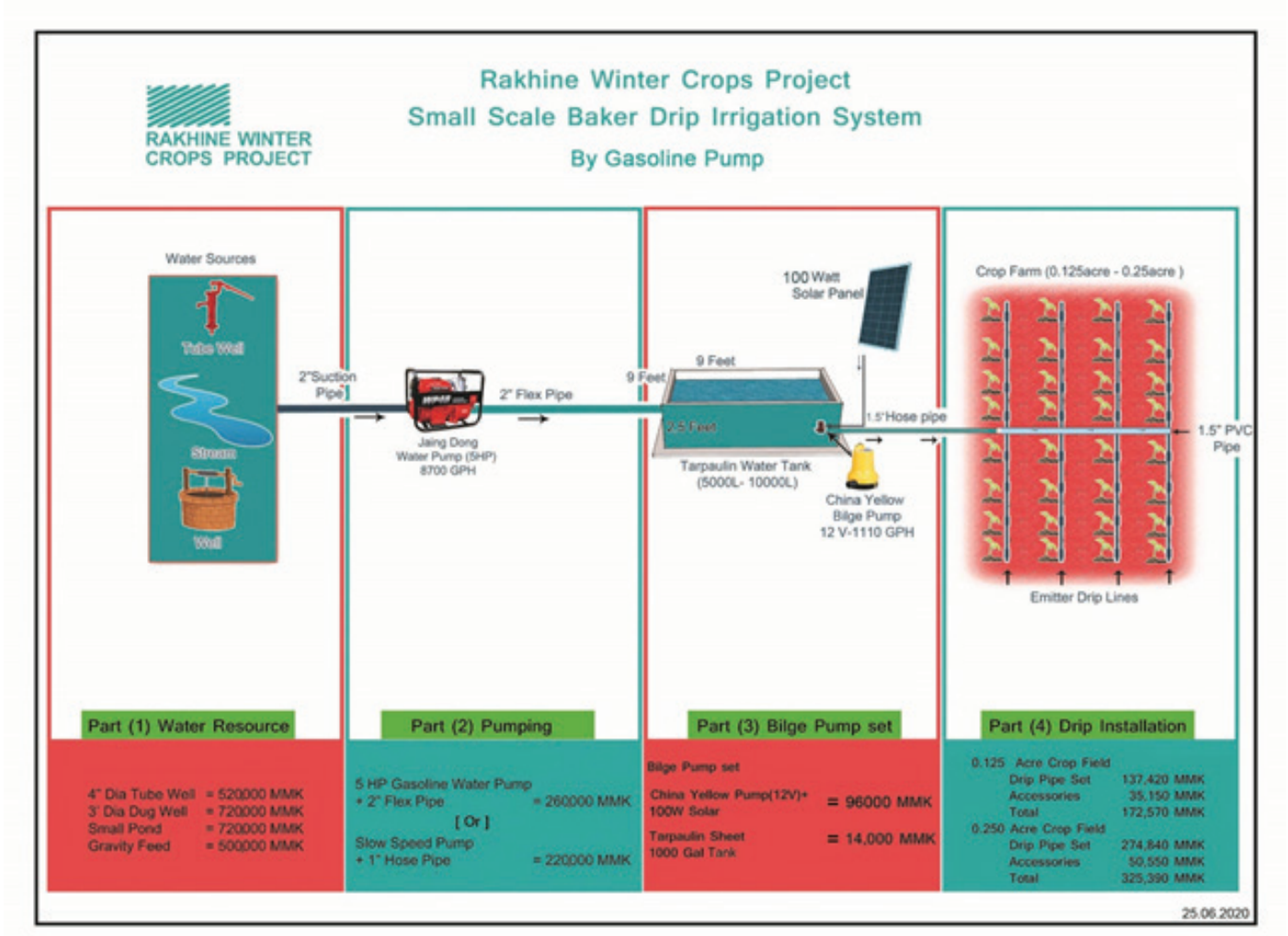
Sprinkler irrigation

Drip Irrigation

Hand Watering

Shower Rose Inter Row on top of Bed

Exercise 4.5: Baker Drip System (BDS) layout



Exercise 4.6. Cost of the Baker Drip System

Total Cost for 0.125 Acre Drip Set — June 2020

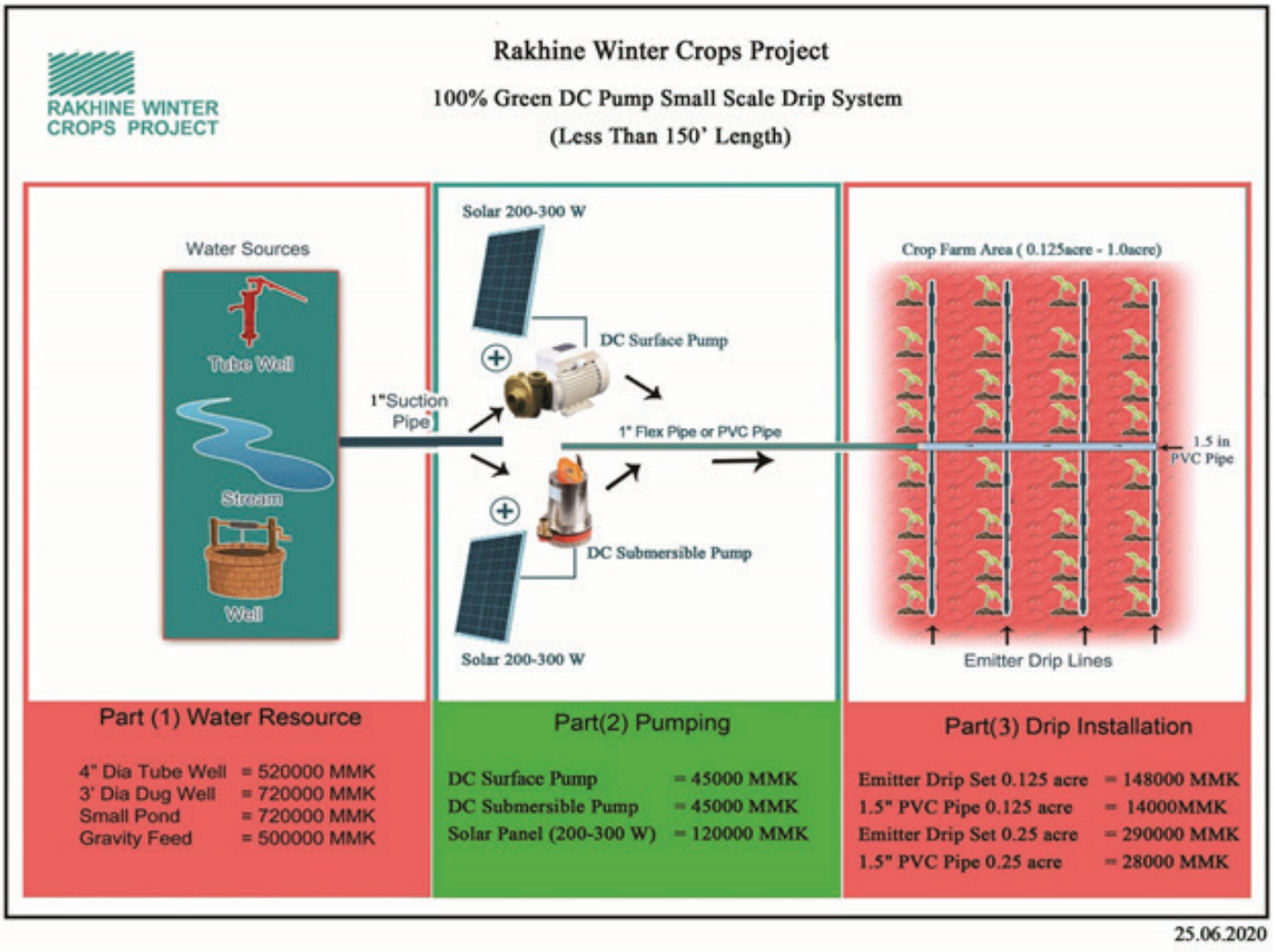
Item No	Particular	Rate	Per unit	Qty	Amount MMK
1	1.5" PVC Pipe	4800	pipe	3	14400
2	1.5" to 0.75" Reduced Socket	450	socket	1	450
3	1.5" Bell End Adaptor	450	adaptor	1	450
4	1.5" Valve PVC	1950	valve	2	3900
5	1.5" Socket PVC	500	socket	3	1500
6	PVC Glue	1550	Tin	1	1550
7	Water Tape	200	coil	2	400
8	Bilge Pump (Yellow China Bilge Pump) 12V, 1110 GPH	26000	pump	1	26000
9	Solar 100 watts	70000	panel	1	70000
10	Pond Liner (Tarpaulin Sheet 15'X15')	14000	sheet	1	14000
11	Take off Tap	565	tap	44	24860
12	Rubber Grommet	140	grommet	44	6160
13	0.75" Hose Pipe (30m)	25000	coil	0.5	12500
14	Emitter Drip Pipe (Irritec Co; ltd, Italy)	133	meter	800	106400
	Total				**282570**

Rakhine Winter Crops Project
Total Cost for 0.25 Acre Drip Set — June 2020

Item No	Particular	Rate	Per unit	Qty	Amount MMK
1	1.5" PVC Pipe	4800	pipe	5	24000
2	1.5" to 0.75" Reduced Socket	450	socket	2	900
3	1.5" Bell End Adaptor	450	adaptor	2	900
4	1.5" Valve PVC	1950	valve	4	7800
5	1.5" Socket PVC	500	socket	5	2500
6	PVC Glue	1550	Tin	1	1550
7	Water Tape	200	Coil	2	400
8	Bilge Pump (Yellow China Bilge Pump) 12V, 1110 GPH	26000	pump	1	26000
9	Solar Panel 100 watts	70000	panel	1	70000
10	Pond Liner(Tarpaulin Sheet)	14000	Sheet	2	28000
11	Take off Tap	565	tap	88	49720
12	Rubber Grommet	140	grommet	88	12320
13	0.75" Hose Pipe (30m)	25000	Coil	0.5	12500
14	Emitter Drip Pipe (Irritec Co; ltd, Italy)	133	Meter	1600	217000
	Total				**453590**

Exercise 4.7 Solar Pumping Directly to the Drip System

Farmers can pump directly to the field using solar as long as the field plots are not longer than 150 feet away from the water source.



Exercise 4.8: Taking care of the Baker Pump and drip system

The Baker pump system is made from three components

- The Solar panel
- The Bilge pump
- The Drip irrigation tubing

100 Watt Solar Panel

1. Keep the panel clean of dust by wiping with a clean dry rag once per week.
2. Move panel to catch the most sun. Between 9am and 3 pm this will generally mean laying the panel flat and facing the sun
3. Small amounts of shade will reduce the effectiveness of the panel.

The Bilge Pump

1. Carry the pump in a bag. Do not carry by the wire cord as it may lose the connection.

2. Take care to pump clean water or try to filter unclean water
3. Ensure that the pump sits above any mud by placing it on top of a few small rocks or on a small frame
4. Enclosing the pump in mesh like a mosquito net or a rice or fertilizer bag can act as a filter.

The drip system

Installation

Ensure that all of the drip lines are installed so that the lines are straight and the emitters are facing up:

Every day checking

Five minutes after turning on the drip system, farmers should check to see that the drip system has even firm pressure within the lines. Squeeze the lines at the closest and furthest point from the pump to check that the pressure is consistent. If pressure is weak or uneven then check that the pump is working properly, that there are not too many lines open at the same time, and that the system is not leaking from disconnected lines or major leaks.

Walk next to the lines and check for leaks. Fix any leaks with a 4 inch sleeve of drip tape.

Regular checking

If water quality is good, check every 2 weeks. If dirty water, check more regularly.

Checking is achieved by opening the ends of the drip lines (one line at a time) and running the water for about one minute or until the water flows clear.

End of Season Storage

1. At the end of each season ensure that the tape is retrieved by rolling it back onto a reel. Join the ends of drip lines with a piece of sticky tape.
2. Make sure that the drip lines are not folded or twirled when rolling up.
3. Store undercover for next season

Exercise 4.9: Check list for FOs and farmers

Before we start…

- Is the mini dam at the highest point in the field?
- Can the Solar panel access full sun?
- Has the farmer placed his compost and fertilizer in the soil beneath the drip irrigation tape?
- Is the farmer using sufficient mulch?
- Has the farmer access to good quality seed and seedlings?

If yes then we can proceed!

The following checks are routine when visiting the farmer or are a good trouble shooting guide for any problems that may occur with the Baker Irrigation system

District	**Village**	**Date**	Farmer
RWCP Staff member name			
Check list	**Yes/no**	**Corrective action/Comment**	

1. Is Solar panel clean	Y/N	
2. Solar panel maximizing light reception	Y to the south/N	Keep in full sun at 22 degrees
3. Mini dam clean and clear of debris	Y/N	Minimize the amount of dirt pumped by enclosing pump in rice bag and perching on rocks
4. Check Pump performance If flow rate is lower than at installation	Impeller is clean? Y/N Impeller broken? Y/N Leak from hose? Y/N Wires connected? Y/N Solar panel clean? Y/N	
5. Pipe length and diameter	Is pipe diameter at least 1” Y/N	
6. Check lines Look for puddles	Y/N	If puddles then locate leak and repair
7. Are the drippers all facing up?	Y/N	Check for twisted lines or lines that are upside down. Drippers must face up. Walk up and down every three rows and check each line
8. Are the ends of the drip lines secured with small sleeves?	Y/N	If leaking then line ends may need to be folded an extra fold
9. Are the ends of the lines tied off to stakes?	Y/N	
10. Flush lines with farmer	Is water clear ?Y/N	If water is not clear then farmer needs to flush all lines. Establish a weekly, fortnightly or monthly flushing schedule depending on water cleanliness. Explain why he must flush the lines regularly (i.e. to stop emitters blocking)
11. Are there any leaks that need fixing?	Y/N	
12. Inspect crop	Crop is healthy or stressed?	Check at lunchtime. If crop is stressing then crops need more water. Do not forget that crop water use increases with crop leaf area
13. If the water is collecting in the furrows	Y/N	If yes then farmer is watering too much. Apply less water
14. Are drippers all facing up	Y/N Yes…. no problem	Are any lines twisted? Make sure that all lines are facing up
15. Check line pressure	Firm/not firm to touch?	
16. Is the line pressure strong and consistent throughout the crop?	Y/N Too many lines open?	Can check with water cups under 4-5 drippers randomly though the crop
17. Variation in crop size	Y/N	If variation is present is it due to irrigation or some other cause? Seedlings? Crop nutrition?
18. Farmers thoughts?		Is the farmer comfortable with managing the drip system or is he/she having problems? What further training is required?

Exercise 4.10: Directions for Drip Tape Collection and Storage at End of Season

1. After the end of the season we need to collect and store the drip irrigation tape for long term use year by year without damage. Please follow the guidelines below:
2. Wash the dust and earth off on the inside and outside of the drip lines
3. Dry the lines in the sun after washing
4. Roll the tape onto the original roll or on a big diameter piece of bamboo
5. Join pieces together by stapler or plastic tape or sleeve of drip tape to fix leaks
6. Store in the shade as sunlight destroys the tape over the longer term
7. Store off the ground
8. Protect from destruction by rats and dogs
9. Write a list of all the irrigation materials stored so you can refer to the list next year

Exercise 4.11: Irrigation input order form format

Water Source	**Input Description**	**Number of Units**	Cost per Unit	Total Cost

Session 5: Calculating Agro Inputs and Making Nursery Seedling Mix

Exercise 5.1: Site layout

Some guidelines:

1. Consider crop history. You should not grow the same crops in the same place each season.
2. Select small plots for the other seasonal vegetables on a crop rotation basis.
3. Make sure there is room for an entry path, and about 0.5m between the plots so you can walk around to take care of the crops.
4. Leave room for a trench around the outside of the field to drain surplus water or store water for later use.

Example of Site Layout

Example of crop rotation of yard long bean, chili, cabbage and cucumber.

Exercise 5.2: Types of seeds

1. Open pollinated seeds

Open pollinated (OP) seeds are produced by traditional and native plants crossing with each other by self, wind or insect pollination.

In this uncontrolled environment the characteristics of the plant are randomly crossed and the new plants may not look like the parents. Therefore, the high yield or disease resistance characteristics of the parents may not be the same in the new plants.

2. Hybrid seeds

Hybrid seeds are produced in controlled laboratory or seed production farm conditions where the new plant carries the beneficial characteristics like high yield and disease resistance of the selected parent plants.

Seeds shouldn't be replanted next year from hybrid plants. They will either be sterile or the plants of the next generation will probably not have high yield or disease resistant characteristics, because you do not know with which other plant from your field or someone else's field they have pollinated.

F1 or F2 show the hybrid category. F1 is first generation, and F2 is second generation, therefore F1 is closer to the parents' characteristics.

Summary of Open Pollinated seed compared to Hybrid seed

	Advantages	Disadvantages
Open Pollinated Seeds	1. High resistance to local diseases 2. Farmer can produce own seeds 3. Low cost 4. Local market sometimes prefers local varieties	1. Low resistance to new diseases 2. Low yield, low quality 3. Low germination
Hybrid Seeds	1. High yield and high quality 2. High germination	1. Expensive compared to local seeds 2. Farmer can't produce own seeds 3. Local market sometimes does not prefer new varieties

Exercise 5.3: Seed Quality

Look at seed quality by:

1. Looking at the category of seed, for example F1 or F2 Hybrid or open pollinated to judge the quality. F1 & F2 should be of higher quality.
2. Checking for the purity of seeds by size, shape, color. This can be expressed as a percentage.
3. Reading the germination test and date of testing on the seed packet or report from the seed seller, or by doing a germination test yourself.
4. Reading the expiry date of the strength of seeds.
5. Noting if the seeds have chemical treatment.
6. Looking for pests and seed-borne diseases by visual examination with the naked eye, or magnifying lenses 15 times strength.
7. Spreading the seeds on contrasting colored paper. Gray or white coloration on the seed surface indicates fungal contamination.
8. Looking for shriveled, small, irregular shaped and other colored seeds might correspond to specific mutations.

Exercise 5.3: GAP seed storage techniques

Storage of seeds

1. Note that sealed packets of seed store the best as they prevent moisture, pests and disease infection.
2. Dry non-sealed packs or newly harvested seeds before storing. If the seed contains moisture, it can lead to damage.
3. Store seeds in a cool, dark, dry place such as a clay pot or basket with a lid.

Storage Type	Dark	Light	Humidity	Heat
Unsealed seeds	Good germination	Reduces germination	High reduction in germination	Reduces germination
Sealed Seeds	Very good germination	Transparent pack reduces germination	No effect on germination	Reduces germination

Exercise 5.5: Germination

Question: Why is knowing germination rate important?
Answers:

- To know the quality of the seed.
- To know how many seeds you have to buy to get enough seeds to fill your field – Example: if the germination is 66%, then you need around 50% more seeds to add up to 100% of seed requirements.

Question: How do you test germination?
Answer:
Get a cloth or tissue and mark it with a grid pattern of 20 squares

1. Put the cloth or tissues on a tray and wet it so it is just moist but not too wet
2. Put 1 seed in each square (or just spread some seeds randomly on the tray)
3. Cover with another wet cloth or tissues
4. Put in a warm dark place
5. Check daily to keep the seeds moist
6. Count the number of seeds that have germinated after a reasonable time
7. Multiply by 5 the number of germinated seeds to get the percentage of the 20 seeds that are being tested or divide the number of germinated seeds by the total number of seeds to get the percentage germination. Example 80 seeds out of 100 seeds = 80%).

Summary of germination

1. Read the seed packet or test germination before buying seed
2. Buy enough seed to allow for the seed that does not germinate
3. Plant seed in a firm, fine, moist seed bed
4. Plant the seed at the right depth – 2 times the diameter of the seed.
5. Planting too deep or too shallow means the seed may not germinate. Then blame the farmer, not the seed!
6. Report bad germination to the seed seller so the seller can report back to the supply company.

Exercise 5.6: Farmers need to fill up Crop types and Area

Farmer Name.....	Village.....
Crop Name	Area
1.	
2.	
3.	
4.	
5.	
6.	

Exercise 5.7: Type of Inputs required for GAP

Input Name From CMT Budgets	Available From		Quality (Insert Low; Medium: High)
	Own Farm	Outside (State where from?)	
Seed			
EM (for Bokashi)			
Molasses			
Rice Bran			
Trichoderma			
Compound fertilizer (15:15:15)			
Urea (for Basal)			

Exercise 5.8: To compare quality and price

A story:

Saw Hla Htwe is a farmer who always wants to save money. The seed he buys is low quality, has low yield potential, and is less resistant to pests and disease. He therefore gets lower yields, poorer quality crops with lower prices, and spends more money and time on pest and disease control. He also finds that the other inputs like cheap fertilizer do not work so well, and cheap machinery does not last so long, so he has to repair and replace it more quickly.

Question: What can Saw Hla Htwe do to improve his input purchasing strategy? Write your ideas in the space below.

.....

.....

.....

.....

.....

Exercise 5.9: Factors to know for input buying agreement

1. Product names: "Describe what inputs you sell?"
2. Product amounts: (i) "How much product do you keep in stock in your shop and how much do you order from outside? (ii) Can the agro/irrigation dealer supply required amounts for small orders and large amounts for group orders?
3. Timing: (i) "Can the agro-dealer supply inputs on time?" (ii) "How long between ordering the product and pickup time for small orders and for large group orders?"
4. Quality standards: (i) "What is the quality of the products you sell?" (ii) "Do you have test results to show their quality?" E.g. seed germination, size, color, moisture content and grade.
5. Product delivery arrangements: "Where, when, who and how will the inputs be delivered? E.g. specific locations, time, mode of transport, packaging, who pays for transport. Note that perishable inputs like rhizobium may need special packaging, storage and transport requirements.
6. Pricing arrangements: "What price will be paid for the different inputs and under what conditions?" For example, price based on quality and price based on quantity. Are there discounts for large group purchases?
7. Payment procedures: "How and when should the agro/irrigation dealer be paid?"E.g. cash on delivery, payment after some days or months, etc. Does the agro/irrigation dealer offer products on credit for payment after harvest (e.g. pre-financing)?
8. Technical support: "Does the agro/irrigation dealer offer technical support?" Examples: Advisory services like pamphlets or a personal visit to show how to apply fertilizer or pesticide correctly, or are there mechanics available who can fix machinery or other technical problems.

9. Other incentives: “Does the agro/irrigation dealer offer other incentives?” These are extra benefits the seller can offer. For example, a free motorbike if you buy more than 100 ton of fertilizer, or special promotions like free samples of products.
10. Return of products: “Can the farmer return products if not satisfied with them?”
11. Disputes: “Is there anywhere that the farmer and agro/irrigation dealer can go to settle disputes?”

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Exercise 5.10: Making seedling mix

Material needed in equal portions

1. Well decomposed cow-dung - 1 portion
2. Rice husk charcoal - 1 portion
3. Top soil - 1 portion

Making Process

1. Mix together equal portions of well decomposed cow-dung manure, rice husk charcoal and top soil.
2. Put the mixture in a sealed plastic bag (black color) and heat up for fermentation in the sun light for 3-4 hours. The heat in the plastic bag can also kill some soil diseases.

Session 6: Agro Dealer and Irrigation Dealer Led Workshop

No exercises

Session 7: Rodent Control

Exercise 7.1: Definition of a Rodent

Rodent Species in Myanmar

All rodents have one pair of upper and one pair of lower incisors, which continue to grow throughout their life. To keep the incisors short, they spend a lot of time gnawing hard objects to wear their teeth down, including cutting of rice plants and other harder objects.
Rodents make up 42% of all mammals in the world with more than 2,270 species worldwide. There are 17 species of rodent in Myanmar that belong to the following families:

1. Rats and mice
2. Bamboo rats
3. Squirrels
4. Porcupines

Exercise 7.2: Common rodent species in villages and fields

Insert only the common rodent species photo and details. Include the control methods underneath type.

E.g.
(1.7) Short -tailed -rice -field mouse (Mus cervicolor)

Litter Size	Nothing known
Breeding Season	Nothing known
Habitat Use and Damage to crop	It can be found in rice field.
Behaviour	Group
Control methods:	1. Synchronous planting 2. Sanitation (in and around field) 3. Reduce bund size (<1 feet)

Exercise 7.3: Problems caused by rodents and timing of damage

Crop	Problems caused	How much damage do they cause (%)	Timing of damage occurring

Exercise 7.4: Implementation steps for each type of control method.

1. Synchronous planting

- All farmers planting within two weeks to limit breeding periods around harvest.
- Breeding of rodents is strongly linked with food availability. Spread out planting can extend the food supply for rodents and that leads to higher rodent populations.

2. Sanitation (in and around field)

- Vegetation can provide both shelter and alternative food sources for rodents.
- Cleaning vegetation (weeds, bushes, grasses) in and around field prior to the reproductive stage of crop limits rodent nesting and alternative food opportunities.

3. Reduce bund size (<1 feet)

- Larger bunds can provide the shelter for rodents (especially for the Bandicota sp.).
- Smaller bund size can restrict rodent's ability to make their burrows.

Session 8. Record book training and composting

Exercise 8.1: Why have a record book?

Question: How can I know the exact details of my crop practices, production and profit?
Answer: .....

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Exercise 8.2: What is a farm record book?

Definition: A record book is written proof (evidence) of what has happened on your farm.

Question: What kind of records are kept in farm record books?

1. Site layout records for crop rotation mapping
2. Crop growth information records
3. Labor participation records
4. Production records
5. Expenses records
6. Income
7. Profit/Loss records

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Exercise 8.3: GAP crop growth information records

1. Planting date
2. Seed source and germination rate
3. Plant emergence (days)
4. Infills (spaces left by dead seedlings or non-germinated seeds) required (%)
5. Organic and chemical pesticide applications dates
6. Pests and diseases, and control methods for each of these

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Exercise 8.4: Free Family Labor Record

Question: "Why have a free family labor record?

Answers:

1. To know how much time males and female family member spend growing the crop
2. To compare with last season and with other farmers as a guideline
3. To compare the time and effort spent against the profit earned to see if it is worthwhile being a farmer compared with other outside work by calculating the return (profit) per labor day.

Example: 1,500,000 MMK combined profit for all crops for the season divided by 100 free family labor days equals 15,000 MMK/day. This is double the salary compared to working in construction in Myanmar (7,000 MMK/day).

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"What should you note for a labor record? For example:

Date	Activity	Male Labor (Hours)	Female Labor (Hours)	Total Hours
12.11.17	Weeding	1	4	5

Exercise 8.5: Production Record

Question: "Why have a production record?

1. To know when you produced the crop
2. To know how much crop you produced including what you consumed and what you sold
3. To know the production per area to compare with last season and with other farmers

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"What should you measure for a production record? Example:

Date	Crop	Unit	Quality/Grade	Area	Total Yield	Yield/Area
12.04.17	Carrot	Bunch	A	0.06	300	4800 bunches/acre

Exercise 8.6: Expense Record

Question: "Why have an expense record?

1. To know when you had the expenses
2. To know how much you spend
3. To know the cost of each item purchased
4. To know the quality of the inputs and services which you spent your money on, so you can consider if growing that crop was worthwhile or not

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"What should you measure for an expense record? Example:

Date	Activity	Unit	Source and Quality/grade	Quantity	Cost/Unit spent	Cost/Unit spent
12.04.17	15:15:15	50kg Bag	U Kyaw Moe A grade	3	30,000	90,000

Exercise 8.7: Income Record

Question: "Why should you have an income record?

Answers:

1. To know when you sold your crop
2. To know how much you got for your produce and compare prices at different dates
3. To know the total income for the crop to compare total income/area with other crops
4. To know the quality of the crop sold and compare this with the price of each quality crop

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"What should you measure for an income record? Example:

Date	Crop	Unit	Where sold Quality/grade	No. of Units	Price/Unit earned	Total Income earned
12.04.17	Carrot	Bunch	Daw Myint Win A	300	300	90,000

Exercise 8.8: Profit/Loss Record for each crop

Question: "Why have a profit and loss record?

Answers:

1. To know which year you made the profit or loss to compare year by year results
2. To know how much profit you made on each crop
3. To know the profit or loss per area to compare with last season and with other farmers
4. To know the total profit adding the profit for all crops together

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"What should you note for a labor record? For example:

Date	Area	Total Income	Total Expenditure	Profit/Loss per Area	Comments why low or high profit/loss

Exercise 8.9: What is composting and why use it?

Definition of compost:

Compost is a mixture of dry and wet organic materials that have fermented and decomposed at high temperature over a period of time to form a fertile nutrient and micro-organism rich substance to add to the soil.

Question: Why use compost?

(i) Adds fertility and essential micro organisms
(ii) Creates a good structure for air and water to be retained in the soil to promote good plant growth
(iii) Improves drainage, reducing excess water and damage to crops
(iv) Helps to reduce disease in the soil and the plants

Question: What types of compost are there?

Two main types are:

(i) Effective Micro-organism (EM) bokashi compost – takes 3 weeks to be ready to use
(ii) Organic waste compost – takes 3-6 months to be ready to use

Other types include:

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Exercise 8.10: How to make EM Bokashi compost

Steps in making EM Bokashi for 1/16th acre (0.06ac)

Materials needed

Rice Husk	-	2 bags
Cow Manure	-	2 bags
Rice Bran	-	1 bag
Instant EM	-	1 Liter
Molasses	-	1 Liter
Water	-	40% moisture

Procedure:

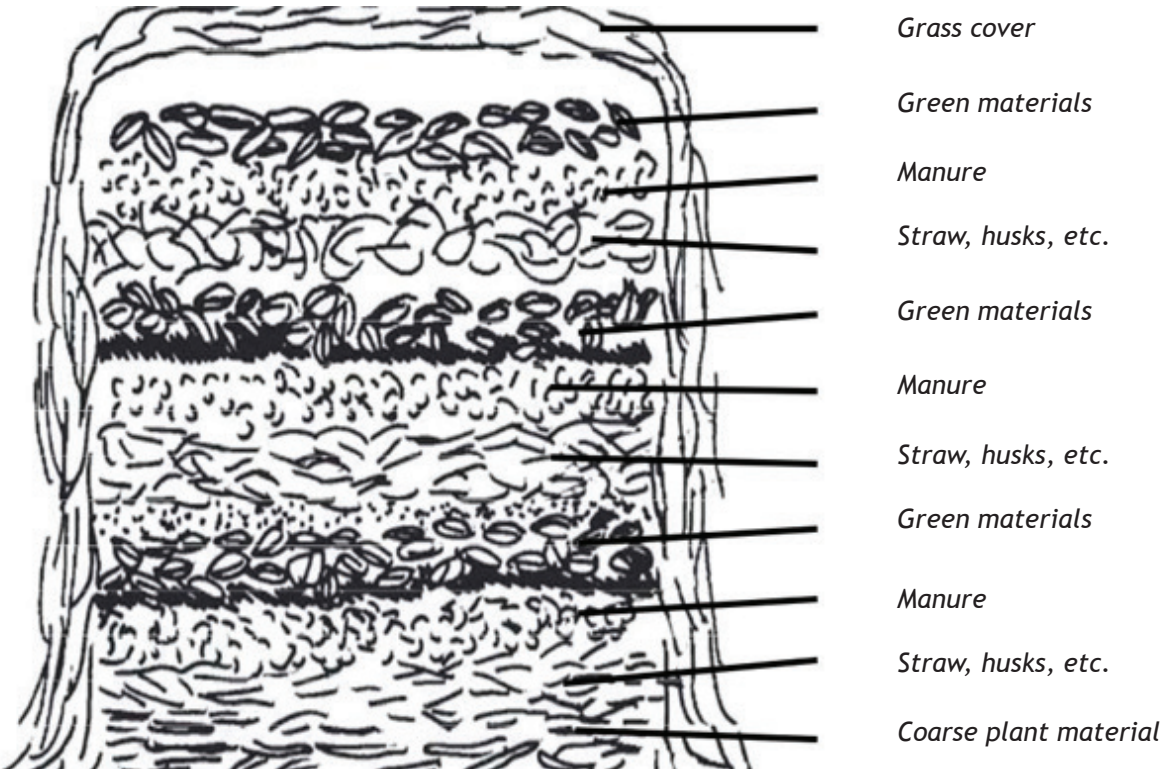
1. Find a shady flood-free site big enough for your bokashi making. You need to use at least 600 viss of compost for 1 acre.
2. Water the ground thoroughly before making the compost. Dry soil can suck the moisture out of the compost and it will not be successful.
3. Sprinkle the rice husk on the ground, then mix in the cow manure and bran.
4. Mix the EM and molasses together, pour it over the dry material and mix well.
5. Add enough water to make a ball to bring the moisture up to 40%.
6. Cover with black plastic or dark colored tarpaulin to prevent light from reaching the mixture. The micro-organisms do not like the light.
7. Bury the edges of the black plastic or tarpaulin to prevent air getting into the mixture because the micro-organisms work better without air.
8. Add some water every 10 days if the mixture is getting dry.
9. After preparation, when it has a sweet-sour fermented smell and forms white fungi filaments on the surface, it is ready to use.
10. The bokashi should be ready after 3 weeks.
11. If you do not use the bokashi immediately, you can store it in bags in a dry cool place for up to 6 months.

Exercise 8.11: How to make compost with organic waste materials

For a good result, include a mixture of old and tough materials (“brown materials”) with young and juicy materials (“green materials”). There needs to be about half “browns” and half “greens” by volume. You can adjust this ratio depending on the quantity and quality of the materials you have at hand.
Making the heap. Make a base (6 (foot) x 6(foot)) of sticks about 1 foot deep on top of soil. This will ensure good air circulation and drainage.

1. The heap should be built on a raised soil bed to prevent flooding.
2. Make a heap of organic materials in a series of layers - each layer is about 6 inches- 10 inches thick.
3. The first layer should be with coarse and woody materials such as thin sticks or twigs. This will ensure good air circulation and drainage.
4. Add a layer of harder, more difficult to compost, materials (“browns”), such as rice straw, rice husks or leaves and stems of maize

5. Add the animal manure (wet) to cover the plant material
6. Add the “green” material that is easily composted, such as fresh grass, leaves, vegetables and fruit residues
7. Ash and cow or chicken manure can then be lightly sprinkled onto these layers, to accelerate the process of decomposition.
8. Repeat all these layers except the first layer of coarse material, until the heap reaches a height of 3 feet - 3.5 feet. The last layer is again green material.



The layers of a compost heap

Session 9: Preparation Before Planting

Exercise 9.1: Cultivation methods – Advantages and Disadvantages

Advantages	Disadvantages
By hand: Inexpensive tools; can study the soil closely as you are working.	**By hand:** Needs a lot of labor; hard work; takes a long time; perhaps cannot go deep enough.
By cow: Some families have cows and implements for ploughing. Cow dung (manure) can also be used for natural fertilizer.	**By cow:** Hard work controlling the animals while ploughing; a lot of work feeding the animals all year round when you only need them for a short time; cows close to the house can cause family health problems by attracting flies and providing contamination from dung and urine.
By hand tractor: Not too expensive for a commercial farmer to own a hand tractor for cultivation and transport; quick; efficient; can have joint ownership to reduce costs; can hire a contractor at reasonable cost.	**By hand tractor:** Too expensive to buy for some farmers; need money for fuel and repairs. Sometimes contractors hard to get on time
Furrow plough Able to deep plough. Can break hard ground to improve drainage.	**Furrow plough** Heavy weight of tractor can destroy soil structure Turns the surface organic matter to the bottom and lifts less fertile subsoil to the top.
Tractor disc plough: Can easily cut already broken ground into smaller pieces Can also cut new ground but to a shallower depth than furrow plough Keeps fertile top organic layer close to the surface root zone.	**Tractor disc plough:** Heavy weight of tractor can destroy soil structure, May not go deep enough to improve drainage.
Tractor rotary hoe: Breaks up tough soil structures and produces a fine seed bed, Assists in incorporating organic matter. Reduces number of in soil-borne insect pests.	**Tractor rotary hoe:** Slow moving so takes a long time and high cost Soils with poor structure become more compact, Fine structure can become hard and crusty when it gets wet. Not as deep as a furrow plough.
Harrows: **Breaks up the soil into finer pieces** **Improves drainage and aeration** **Easy to pull with cow or tractor**	**This is an extra task which cost more money to do**
Levelling: **Important for even water distribution and plant growth** **On a small scale can be done easily by dragging a log or steel bar behind other equipment like harrows so not an extra task**	**Levelling:** **On a large scale moving large amounts of soil from one part of the field to another is difficult and expensive.**
Rolling: **Useful for breaking up larger lumps of earth and making a firm seed bed** **Can be pulled behind other equipment like harrows to reduce cost as an extra task**	**Rolling:** **Can be expensive to buy if not home made.**
Direct seeding: Maintains soil structure and water holding capacity. Reduces weed problem as it does not expose new weed seeds.	**Direct seeding:** Crop residues slow breakdown and may carry diseases, Hard top soils make it difficult for root penetration.

Tractor disc plow

Mynamar cow plow

Myanmar 2 wheels' tractor disc plow

Tractor rotary hoe

Simple direct seeder

Large scale direct seeder

Exercise 9.2: GAP steps for land preparation

Tips	Reasons
1. Clean tools very well before use.	This helps to prevent contaminants such as diseases being transferred from one place to another.
2. Clear the land of weeds and keep dry for 1 week.	After one week the dry soil will break up more easily during cultivation.
3. If there is a good layer of top soil rich in organic matter you can plant directly without ploughing.	This technique keeps the top soil from mixing with the less rich lower soil and enables more nutrients to be available for the crops.
4. Normally roughly plough only 6-8 inches deep and leave the soil for 7-14 days exposed to the sunlight.	The upper layer of the soil is rich in micro-organisms and nutrients, so do not mix it with the lower layer which has few organisms and nutrients. Exposure to sunlight can kill pests and diseases in the soil.

Exercise 9.3: Why is fencing important?

GAP reasons why fencing is important

1. To prevent damage by animals
2. To prevent contamination by animals
3. To protect chemically sprayed areas from children and others entering the field and becoming contaminated
4. To safeguard worker health and protect the environment - Make a small child proof enclosure for rubbish (old plastic bags, empty pesticide bottles etc.) and dispose of the rubbish regularly and safely.
5. .....
6. .....
7. .....
8. .....
9. .....
10. .....

Exercise 9.4: Methods of fencing and their advantages and disadvantages

Fencing Materials	Advantages	Disadvantages
Old fishing net	Small mesh provides good protection; Easy to erect	A little hard to get; a little expensive
Bamboo	Can mostly find in the forest or around the home	Hard work to cut and make the fence; Expensive in some areas
Live fencing	Provides fruits, leaves for consumption and compost, fire wood source	Requires maintenance, shady and takes nutrients from the soil
Other ideas:		
Community policy and taking action against wandering livestock		
Lobby for a national rule for no wandering of livestock as in Vietnam		

Bamboo fence

Fencing with Gliricidia Plants

Note : Farmers should think about growing Gliricidia plants which grow fast and provide nitrogen for the soil. Leaves can be used as natural fertilizer, flowers for food, and sticks for fire wood.

Exercise 9.5: GAP controls for soil borne diseases

Natural control:

1. Plough 14 days before planting to let the sun shine on the soil and kill the pests and diseases
2. Spread black plastic over the soil for 2 weeks in summer to raise the temperature and to kill some harmful pests and diseases
3. Add Trichoderma fungi to control harmful diseases in the soil

Integrated Disease Management

1. Do not go from disease areas to clean areas without washing your boots and tools first.
2. Keep the crop free of weeds. Some weeds are hosts for crop pests and diseases
3. Only use compost that has been made using high temperatures that kill pests and diseases
4. Using mulch provides a protective barrier between the soil and foliage by preventing water from splashing on the foliage
5. Improve the drainage by using raised beds
6. If possible, use drip irrigation so plants are not too wet, as dampness attracts disease
7. Use seeds that are resistant to disease. Hybrid seeds are more resistant to most diseases.
8. Changing acid soils to more alkaline may make conditions difficult for some diseases to develop. For example, club root disease in cabbages and some types of wilt in tomatoes.
9. Too much or too little fertilizer can also increase disease problems in plants.

Chemical control:

1. Seed treatment with a fungicide helps control the development of damping off in seedlings but does not protect the plant as it gets bigger
2. Soil treatment with a fungicide drench helps control root rots and crown rots but needs to be done frequently
3. Some chemicals can evaporate when they are applied to the soil. These are used to control nematodes but are often very toxic so their use is not encouraged.

Other ideas:

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Exercise 9.6: Reasons for changing from direct seeding to seedlings in a nursery for transplanting

1. Use of less seed means you can afford to buy expensive high quality seed
2. Use less water in nursery than in the field, so can save water costs and effort
3. Easier to protect young plants from extreme weather by using 30% shade
4. Can more easily control pests in nursery plants because in a small area you can take more care
5. Higher success in germination and young plant growth
6. Can start 3 weeks early during the rainy season under cover so you can catch a high early season prices at harvest time
7. Can transplant only healthy plants giving greater success in the field

Exercise 9.7: Plants preferred planting method

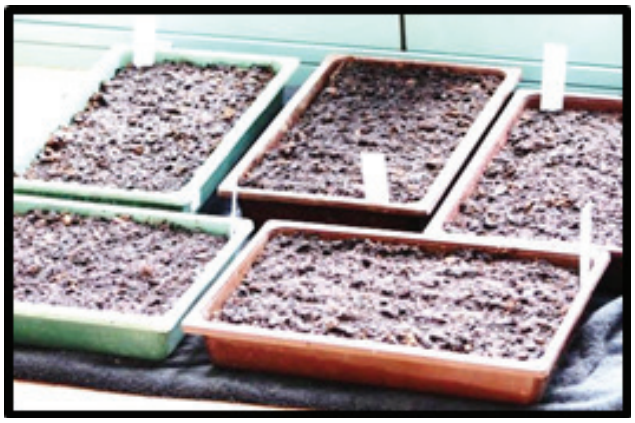
Plant Name	Transplanted: Direct Seeded: Both
Group – 1	
1. Yard Long Bean	Direct seeded
2. Okra	Direct seeded
3. Onion	Direct seeded / Transplanted
4. Carrot	Direct seeded
Group – 2	
5. Chili	Transplanted
6. Tomato	Transplanted
7. Egg-plant	Transplanted
8. White egg-plant	Transplanted
9. Coriander	Direct seeded
Group – 3	
10. Cabbage	Transplanted
11. Cauliflower	Transplanted
12. Broccoli	Transplanted
13. Radish	Direct seeded
14. Water spinach	Direct seeded
15. Mustard	Direct seeded / Transplanted
16. Corn	Direct seeded
Group – 4	
1. Bottle Gourd	Direct seeded / Transplanted
2. Snake Gourd	Direct seeded / Transplanted
3. Ridge Gourd	Direct seeded / Transplanted
4. Bitter Gourd	Direct seeded / Transplanted
5. Cucumber	Direct seeded / Transplanted
6. Watermelon	Direct seeded / Transplanted
7. Pumpkin	Direct seeded / Transplanted
Commercial Field Crops	
8. Groundnut	Direct seeded
9. Chili	Transplanted
10. Corn	Direct seeded
11. Onion	Direct seeded / Transplanted
12. Water Melon	Direct seeded / Transplanted

Exercise 9.8: How to Establish and Maintain a Nursery

TIPS	REASONS
1. Select a raised or slightly sloping, secure site close to water.	Water can run off to prevent flooding. Fencing protects plants from damage. Water is essential for plant growth.
2. Do not put your nursery close to guava or banana plants.	These plants harbor pest and disease.
3. Build a nursery table from local materials to save cost.	
4. Put shade cloth or palm leaves on top of the seedling table for 30% shade and plastic for protection from rain. 	Direct sunlight dries the soil quickly and high temperature stresses the young seedlings. The rain can wash out the seedlings. Too much shade makes long stemmed weak seedlings, while too much light stresses young plants and they do not grow well. Airflow from the sides reduces moisture and disease.  *Too much shade produces elongated seedlings*
5. Put a ring of an ash and oil mixture around the nursery seedbed to prevent ant invasion.	Ants can destroy the seedlings
6. Grow seedlings in separate small pots with water drainage holes like a plastic seed tray, bamboo joint, newspaper, or other small homemade containers with holes in the bottom.	This method reduces competition for light, nutrients and root development between plants. Plants can also be easily taken out of the pot and transplanted without disturbing fine roots and the plant next to it in the nursery.

7. Seedling Mix and seed planting: i. Put together equal portions of well decomposed cow-dung manure, rice husk charcoal and top soil. ii. Put the mixture in a sealed plastic bag (black color) and heat up for fermentation in the sun light for 3-4 hours. iii. Gently sprinkle the mixture into a seed tray or other container. Don't press the soil mixture, but shake the container 3-4 times after putting the mixture to help it settle. Fill up the mixture to the top of the container. iv. When the seedling mix is ready, poke a hole about twice the seed diameter below the surface with a sharp stick, then plant and cover the seed. v. Water the soil by using a gentle sprayer until very wet. vi. Transfer the seed containers to the nursery house and cover the trays with nipa palm leave or tarpaulin or newspaper sheet until germination. Then remove the cover with part (30%) shade for the young seedlings.	Special seedling mix helps germination and healthy seedlings to grow. Seed depth is important – too deep or too shallow and the seed will not grow well. A wet, warm, dark place is ideal for stimulating seed germination. 
	
8. To get weekly income from seasonal vegetables, stagger your sowing time in the nursery so that seasonal vegetables will not be competing in the market. Selling over a long period evens out fluctuations in income, rather than selling all at one time for one price.	This method grows just enough to eat each week over a number of weeks. Not have every plant ready for harvesting at the same time.
9. Keep the nursery seedlings moist by lightly watering 2-3 times per day. Make sure the seedlings are not too wet or too dry, just moist. Check for, and control for pests and disease by picking up and destroying them manually.	Plants need water for growth but too much water rots the roots and base of the stems and attracts disease.
10. Seedlings are ready to transplant when there are 3 fully open leaves (do not count the first round leaves)	If seedlings are planted too early they are weak with small root development, while old seedlings can develop tangled roots which restricts growth.
11. 2 days before transplanting, reduce watering to 1 x per day and increase the light exposure.	Helps adjust the seedling to life outside the nursery.

Note: When transplanting from seed trays, the plants grow fast because the roots are not damaged.



Seedling tray

Seed Trays with cells

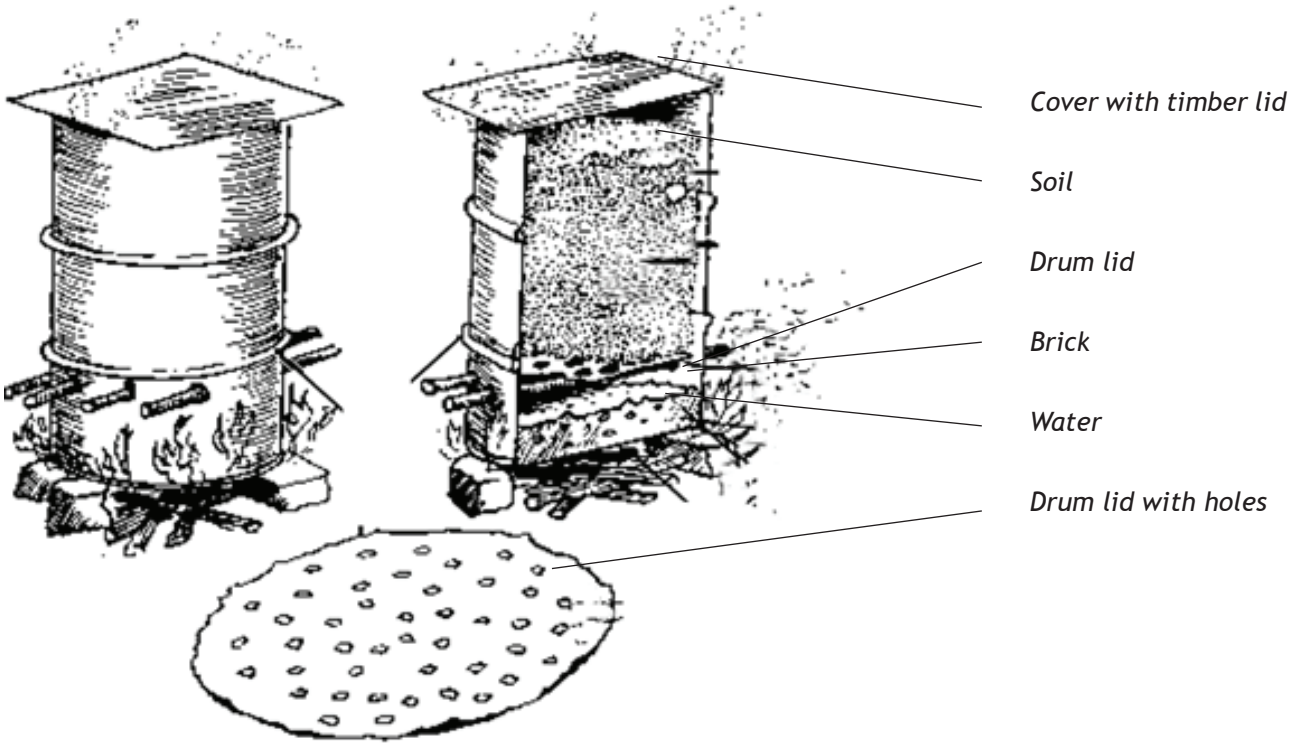
Open Ground

Exercise 9.9: Sterilizing soil for nurseries

Well-made compost should be sterilized but if you mix the compost with ordinary soil it should be partially sterilized to kill harmful organisms and weed seeds. Soil to be sterilized can either be placed on a corrugated iron sheet over a heated grill or in a container made from a metal drum (see diagram below). Put some holes in the lid of the drum and lay it on 3 bricks placed inside and on the bottom of the drum. Fill the drum with water until it reaches the top of the bricks. Add the soil on top of the lid inside the drum, and place a new timber lid on the top of the drum. Light a fire under the drum and heat the water for one hour. The steam will go through the soil and sterilize it.

The soil to be heat-treated should be relatively dry and fine in texture. Heat will take longer to penetrate any lumps and may leave pockets of unsterilized soil.

A cassava root can be placed in the soil to test the time required for heating. When the cassava root is cooked then the soil will be sterilized.



Session 10: Making raised beds and plant nutrition

Exercise 10.1: Why is it recommended to have raised beds?

It is recommended that farmers have raised beds because:

1. Soil is loosened while making raised beds. This creates more spaces between the soil particles for air, so the roots can breathe more effectively.
2. Excess water can initially drain away from the plant reducing the chance of disease and water logging stress, and excess water does not block air spaces.
3. The excess water that drains into the furrows can slowly soak into the bottom of the bed and then move up towards the plant roots. Therefore, the excess water is not lost.
4. Roots can grow quickly toward the water in the bed. Long roots improve the feeding and production of the plant.

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Forming raised beds for tomato

Black plastic cover on raised beds

Exercise 10.2: Raised bed designs

Note that these are optimum sizes for different plants. Farmers will need to consider the method of irrigation (furrow), drip or hand watering and the labor involved in making each bed.

a) Method 1 - for climbing plants requiring trellises like cucumber, gourds, and yard long beans, beds should have a flat surface not wider than 10 inches, but with enough space for placement of the seed and the drip line. The base of the bed should be 3 feet and the height 1 foot.
b) Method 2 - two rows per bed, suitable for crops like corn, cabbage, cauliflower, chili okra. The top should be about 2 to 2.5 feet in width, 10 inches in height with a bed base of 3 feet. If using drip irrigation then one drip line is used per bed placed between the two planted rows for clay loam soil, and 2 drip lines for sandy loam.
c) Method 3 - three rows per bed, suitable for salad vegetables. The shape of the bed is similar to Method 2: a bed base of 3 feet, top of 2-2.5 feet, and height of 10 inches. If using drip irrigation use two drip lines per bed.
d) Method 4 - four rows per bed, suitable for small vegetable crops like onions and shallots.

Exercise 10.3: GAP plant spacing tips

TIPS	REASONS
1. Plant at suitable spacing (according to grower instructions on seed packets)	Reduces the need for thinning, saves seed
2. When planting small seeds, mix them with fine sand and then plant them.	Reduces the seed rate and thinning requirement
3. Transplant healthy seedlings at suitable spacing	This results in fewer gaps and no or infilling requirements
4. Calculate your plant spacing to maximize your yield per land area. Fill in gaps with reserve seedlings or direct seeding	This maximizes your plant population and increases your profit per land area
5. Space the plants according to the size of produce that the market wants. See onion example in the photos below	The market may pay a high price for a certain sized product. Grow to market requirements
6. Space the plants evenly so you get an even sized crop. For example, to get large onion bulbs the plants should be about 3-4 inches apart. Smaller bulbs can be obtained from a closer plant spacing of 1.5 – 2 inches apart (see photos below)	Buyers want even sized produce according to market requirements. Buyers may pay a low price if the sizes are all mixed up
7. Plants must be spaced so they can access the water	This gives the plants a chance to grow. E.g. Do not plant in areas where sprinkler irrigation does not reach

Even plant spacing

Even spacing = even size bulbs

Uneven spacing = uneven mixed size bulbs

Exercise 10.4: The major nutrient requirements of plants

There are six major nutrients that plants require. Plants get the first three—carbon, hydrogen and oxygen—from air and water. The other three are nitrogen, phosphorus and potassium from the ground.

1. Nitrogen (N) helps plants make new leaves, stems and roots, and helps to develop the proteins they need to produce new tissues. Nitrogen is often in short supply so plants take up as much as they can. If too much nitrogen is available, the plant may grow too many leaves and not produce flowers or fruit.
2. Phosphorus (P) stimulates root growth, helps the plant set buds and flowers, improves vitality and increases seed size. To absorb phosphorus, most plants require a soil pH of 6.5 to 6.8. Organic matter and the activity of soil organisms also increases the availability of phosphorus.
3. Potassium (K) improves overall vigor (health) of the plant. It also helps the plants make sugars and provides disease resistance.

Secondary important nutrients:

4. Calcium is used by plants at their growing points.
5. Magnesium is needed to make the green color in the leaves and stems and plants use it to absorb sunlight.
6. Sulfur is needed to build strong plants (e.g. Onion need large amount of sulfur)

Micro nutrients are very important but are needed only in very small amounts so generally do not require supplementation.

Exercise 10.5: Different types of fertilizer

1. Single element fertilizers: These can be used when there is a deficiency of just one nutrient and can be used as side dressings. For example, urea contains 46% nitrogen. Muriate of potash contains around 50% potassium. Bitter salt contains 50% magnesium. It is important that these fertilizers are used in small amounts only and should not be placed in direct contact with the plant stem or roots. It is best if they are applied mixed with water.

2. Compound fertilizer (N:P:K): This compound fertilizer is commonly used as a basal dressing and contains all three major nutrients in different amounts. For example, a 20: 15: 10 fertilizer will contain 20% nitrogen: 15% phosphorous: 10% potassium. Compound fertilizers are strong and will not easily mix with water. It is best if they are applied and mixed in with the soil before seeds are sown or transplanting takes place.

3. Liquid fertilizers (foliar): These can be sprayed on the leaves or poured directly onto root systems. Because they are water soluble, they can be immediately absorbed into the plant's root system to give a quick boost to the plant. If sprayed on leaves liquid fertilizers need to be watered down to avoid burning. Liquid fertilizers are used as supplements to solid fertilizers.

Exercise 10.6: Fertilizer types, their strengths, weaknesses, and GAP application recommendations:

Fertilizer Type - Strengths	Weaknesses	GAP Recommendations
Chemical Fertilizer:		
Usually there are many different chemical supplements available to buy.	Some markets do not supply the full range of quality fertilizers.	Form linkages with quality suppliers so you can get the fertilizers you need.
Farmers do not have to spend time making the fertilizer. They can buy it.	The cost is usually quite high.	Use the minimum amount of fertilizer specific to the crop and soil needs, so you do not waste money on too much fertilizer.
Very effective if applied at the right time in the right amount	Farmers do not know how or when to apply the fertilizer.	Use multi-nutrient or single nutrient fertilizer at the right planting time to stimulate root, leaf and fruit growth.
Rakhine soils are acid (less than 5.5 pH) and require lime to be added	Have to buy the lime	3-5lbs per 25 square yards to raise pH by 0.5 pH unit
Chemical fertilizer feeds the plant, not the soil.	Chemical fertilizer does not encourage improvements in soil structure, or make a home for beneficial micro and macro organisms, nor does it develop long term natural nutrient growth.	Combine chemical fertilizer with organic matter to promote natural soil health and combined fertilizer effectiveness.
Most chemical fertilizers are natural products like phosphates, lime and potassium and are not directly harmful to the soil in limited amounts.	Some fertilizers are artificially made like Urea from the underground gas refining process. This fertilizer is harmful to the organic matter in the soil in the long term. Fertilizers can be washed into streams creating problems for fish and other aquatic animals.	Do not use artificially made fertilizers whenever possible.
Organic fertilizer:		
Organic fertilizer feeds the soil so the soil can produce its own nutrients for a long time.	It is difficult to make the large amounts of organic fertilizer required to meet all of the plant needs.	Make as much organic fertilizer as possible and supplement it by chemical fertilizer if required.
The solid form (compost) can be made for free in a pit filled with chopped up natural plants, mixed with animal manures, water and air.	Takes a lot of work and time (3-6 months) to make.	Follow the GAPs for making organic fertilizer efficiently (sweet smell with a crumbly dry texture). Do not apply raw manure directly to the crop as it has harmful bacteria and can make you sick. Do not use human waste as this can be very dangerous for your health.
The liquid form is a mix of the above but is put in a large container fermented for a specific period. It can be applied as a foliar fertilizer.	Takes time to make and the farmer has to buy a sealed container.	Follow the GAPs for making organic fertilizer efficiently. Only apply organic fertilizer when it is fully composted.

Solid and liquid organic fertilizer can cause contamination.	Organic material is toxic during the early part of its decomposition process. Sometimes the toxic water can drain into the garden or waterways.	Keep the compost pit way from the garden. Do not use human waste. Keep children and animals away from the compost pit. Do not let toxic waste water from the process drain into waterways of touch the vegetables.
Effective Micro-organisms (EM):		
Farmers can buy this liquid product as a concentrated mix of beneficial micro-organisms made from the fermenting of special bacteria, lactic acid and yeast.	Can be difficult to buy it locally. It costs around 3,000MMK per litre which is expensive for some farmers.	Improve linkages with the supplier so that it is easy to get. Buy in bulk so it is cheaper.
The concentrate can be diluted up to 1:1000 and still be effective	If dilute it too much it loses its effectiveness	Follow the recommended dilution guidelines according to the use of EM.
EM can be added to rice husks and molasses to make good super nutrient compost which is fermented under cover from sunlight for only 2-3 weeks.	Farmers often do not follow the guidelines properly so it is not so effective	Follow the EM guidelines
A mixture of EM and FPJ (Fermented Plant Juice) can be applied to control pests.	Some farmers do not prepare it properly and then it is not so effective	Follow the guide lines of EM preparation
Crop rotations		
Crops should be rotated every 1-2 years so the soil is not stripped of the same nutrients every year and disease cannot be transferred between the same crops.	Farmers do not take care to record the crops and areas where they have been grown so don't clearly remember.	Follow GAP and record where and when you have grown your crops and rotate them every 1-2 years
Grow crops that improve the soil structure and nutrients like legumes (groundnut, mung bean, soy bean) which put nitrogen into the soil	It takes time and money to grow these crops.	GAP recommends the growth of legumes such as beans and groundnut from which you can make a profit and improve the soil at the same time.
Cover crops can be grown to conserve soil water and control temperature, and before they are mature you can dig them into the soil to form compost over the next few months.	It takes time and cost money to grow and dig back in cover crops with no apparent immediate return.	Understand that cover crops are good for the long term benefit of the soil and crop yields, even though in the short term the benefits cannot be seem.
Keep records	Farmers usually do not keep records	Keep records of chemical and organic fertilizer application and crop rotations so you know what has gone into your soil and what crops you have grown. People who eat the products also know how your crop was grown.

Exercise 10.7: Factors that affect nutrient availability for plants are:

	pH	GAP Recommendations	Soil Moisture	Temperature	Saltiness
Not good for Plants	Acid or alkaline	High in Silt	Uneven	Over 35ºC	Very salty
Good for Plants	Neutral	Sandy to Loamy	Constant	Under 30ºC	Low salt

Exercise 10.8: How to improve nutrient uptake by plants

1. Reduce acidity by adding lime.
2. Improve soil texture by adding compost.
3. Improve soil moisture by regular watering. Not too much, not too little.
4. Reduce soil temperature by mulching.
5. Reduce salinity by selecting low salt soils & not salty water.

Exercise 10.9: Symptoms of nutrient deficiencies in plants

Deficiency Symptoms of Nitrogen

2. Leaves become pale green and then turn yellow
3. There is poor growth and development of leaves, stalks and branches, resulting in stunting
4. Roots, shoots and fruits are smaller

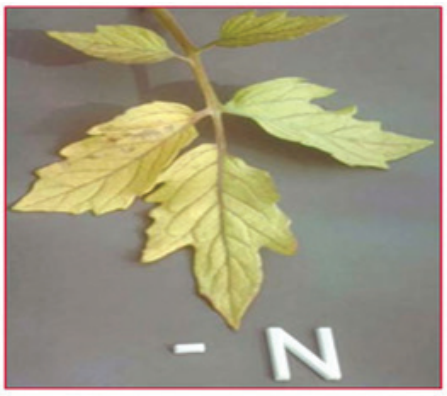
Deficiency Symptoms of Phosphorus

5. Growth of shoots and roots is stunted
6. There is poor formation of lateral shoots and buds
7. Flowering is reduced and bud and leaf formation is delayed
8. A bluish-green color is visible on the leaf surface

Deficiency Symptoms of Potassium

9. Leaves curl and the upper surface of leaves become wrinkled
10. Slight browning (scorching) occurs starting with the older leaves
11. Growth is reduced and stunted, with short internodes and bending of main stem toward the ground
12. The fruit often ripens unevenly

Look at the following photographs and see the signs of nutrient deficiency.



Tomato: Nitrogen deficiency

Tomato: Nitrogen deficiency

Tomato: phosphate deficiency

Tomato: phosphate deficiency

Cabbage: potassium deficiency

Cabbage: nitrogen deficiency

Corn: nitrogen deficiency.

Corn: phosphate deficiency

Corn: Potassium deficiency

Cucumber: nitrogen deficiency

Cucumbers: potassium deficiency

Exercise 10.10: Remedies for nutrient deficiencies

1. Nitrogen: Is easily washed from the soil so needs to be continually added. Compound fertilizers provide a slow release. A short-term boost can be provided by liquid fertilizers. Organic mulches help to reduce the loss of nitrogen from the soil.
2. Potassium: Shortages are more likely on light sandy soils. Apply muriate of potash. Do not use sulfate of potash as it will make the soil more acid.
3. Phosphate: Is not very soluble (doesn't dissolve well in water) so it is best to apply superphosphate (which is more soluble) before planting
4. Magnesium: Mix a solution of bitter salt using a table spoon per pint and water plants

Exercise 10.11: How farmers apply their fertilizer and at what stage of crop growth

Fertilizer	Method of Application	When is fertilizer applied? (At what stage of the crop cycle)

Exercise 10.12: Applying fertilizer

1. **Basal dressing**
   Basal fertilizer is applied in a 10' wide furrow, 4 inches below the surface line where you want to plant. If lime is applied to increase pH, and superphosphate for general nutrition, these fertilizers should be applied 2 weeks to 1 month before planting. All fertilizers including compound fertilizer (N:P:K) and simple fertilizer (muriate of potash) should be covered by the soil to prevent chemicals being lost by evaporation from the heat of the sun. It is also important that the soil is kept moist. Fertilizer does not release nutrients if the soil is too dry or too wet. The fertilizer can be broadcast over the land or placed in bands. Fertilizer will burn the roots if it comes in direct contact with them.
2. **Side dressing**
   This is used in sandy soils which do not hold nutrients well and when plants require additional nutrients for growth e.g. when flowering. Side dressings can be made either in a narrow furrow 6 inches from the row of plants and 2 inches deep, or applied in a furrow mid-way between more mature plants and 6 – 8 inches away from younger plants. Side dressings should also be covered by the soil to prevent evaporation of nutrients. An N:P:K 5:5:5 is a good general purpose choice for fruiting crops. Use 1 or 2 tablespoons / plant or 1 – 2 lbs for every 25 feet of row. For leafy greens use a fertilizer with more nitrogen eg N:P:K 20:5:10 .
3. **Important tips:**
   1. Too much fertilizer can be more harmful than too little. Excess fertilizer accumulates in the soil in the form of salts and damages plant roots.
   2. Don't add fertilizer during a dry period of weather if you can't irrigate your field, because without adequate soil moisture, roots can't take up nutrients.

Exercise 10.13: Timing of fertilizer applications

1. **Nitrogen:** Apply higher concentrations of nitrogen in the early growth stage as it provides for leaf and root growth. High levels of nitrogen result in a lush, green plant. However nitrogen can also burn your plants so avoid direct contact to leaves and vines. Too much nitrogen also can reduce or delay the emergence and number of flowers and fruit and can cause wilting (due to burning) of your plants.
2. **Phosphorous:** Apply just before the start of flowering. Phosphorous is important for flowering and root growth, does not burn your plants and it is difficult to damage your plants from applying too much.
3. **Potassium:** Apply as fruiting starts. Like Phosphorous, it will not burn your plants but too much may reduce the ability of your plants to take up other nutrients.

Session 11: Mulching, Transplanting and Direct Seeding

Exercise 11.1: Mulching

Definition of mulching:
Mulching is the covering of soil to prevent stress to the plant.

Question: Why should farmers use mulching?

1. To prevent the soil temperature rising and causing stress to the plant, and prevent the reduction of nutrient uptake
2. To prevent water loss through evaporation
3. To protect the soil from wind and water erosion
4. To prevent weed growth that competes with the crop for nutrients and light
5. To prevent soil disease from splashing up to the plant
6. .....
7. .....

Warning: Keep mulch away from the plant stem because the moisture in the mulch can attract disease. If mulch has contact with the stem it can pass on the disease to the plant.

Rice Straw Mulching

Mulching with Sugar Cane Leaf

Mulching with Plastic

Mulching with Newspaper

Exercise 11.2: Advantages and disadvantages of direct seeding and transplanting

Activity	Transplanting	Direct Seeding
1. Cost	High cost	Very low cost
2. Water application	Use less amount	Use more amount
3. Weather/pests impact	Easy to control in smaller nursery, low impact	Difficult to control, high impact
4. Productivity	High productivity, good uniformity in quality	Uneven productivity in plants; lower quality
5. Crop season in field	Shorter	Longer

Exercise 11.3: Steps for transplanting seedlings into the field

Transplanting

1. Two days before transplanting, wet beds until saturation and add Trichoderma.
2. Prepare the Trichoderma solution mixing 7g of tricoderma in 10 liters of water. Slowly add 40 mls of trichoderma solution to each cell and don't let the solution drain out of cell.
3. To each hole, add N:P:K, compost and trichoderma according to crop management tips.
4. Transport the seedlings carefully to the field. Select only healthy and stout seedlings for transplanting.
5. Make a hole in the soil where you are going to transplant, according to the crop management tips. If you plant too close, you will get thin weak plants and if you plant too far apart, weeds can grow fast, stealing plant nutrients and light.
6. Take the seedling from the pot by the crown (around the head) of the plant without bending or pressing too hard and lift it completely out of the seed bed tray. Drop the seedling into the hole at ground level and cover the seedling roots with soil; Gently firm the soil around the plant pressing up and down ('puddling in') so the air and water will reach the young roots.
7. As soon as transplanting is finished, water the row.

Tips:

1. Transplant seedlings level with the soil surface, not below the surface which could cause water to gather and flood the plant, reducing oxygen and causing stem disease.
2. Onions, tomatoes, eggplant and chili can be planted deeper to encourage root growth.
3. The soil around the roots should be pressed firmly to prevent the roots from drying. Try to transplant seedlings after 3:30 pm to avoid dehydration.

Exercise 11.4: Direct Seeding guidelines:

1. Mark straight lines using string or another technique
2. Make a shallow trench in the soil about 10 inches wide and 4 inches deep, along the line of the crops, add N:P:K, compost and trichoderma according to the Crop Management Tips. Cover with soil.
3. Make a small furrow in the top soil, generally at a depth of 2 times the diameter of the seed.
4. Place seeds at the spacing recommended by the Crop Management Tips.
5. Gently cover the seeds with soil and press firmly. As soon as seeding is finished, water the row.

6. .....

7. .....

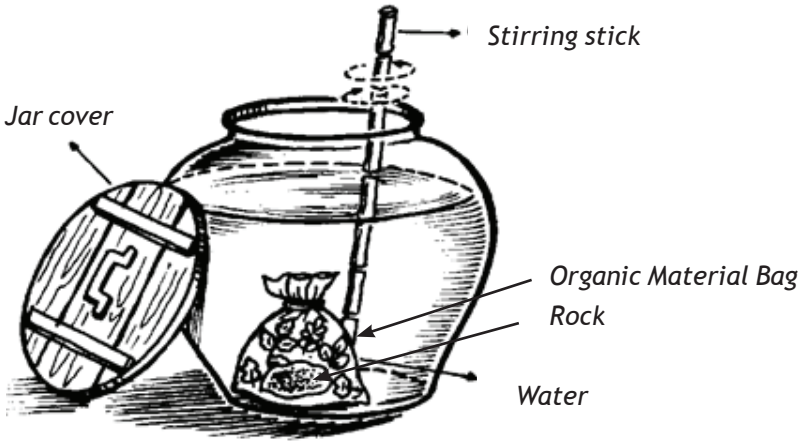
8. .....

Direct Planting Corn Seeds

Exercise 11.5: How to make organic pesticide

Option – 1 Garden waste repellent (takes 2 months to mature)

- Put 10 pounds of organic materials (kitchen waste, cow dung, chopped up strong smelling plant material) and a heavy piece of rock in an open weave bag and put that bag at the bottom of a jar
- Pour 20 liters (or 5 gallons) of water into the jar.
- Cover the jar with a wooden lid to avoid eggs from houseflies, and bad smells
- Stir the mixture in the jar twice a day for 2 months until it does not smell so bad
- After 2 months, apply the pest disease control mixture every 4-5 days during the crop cycle. Dilute with water 1:20 for young plants and 2:20 for older plants



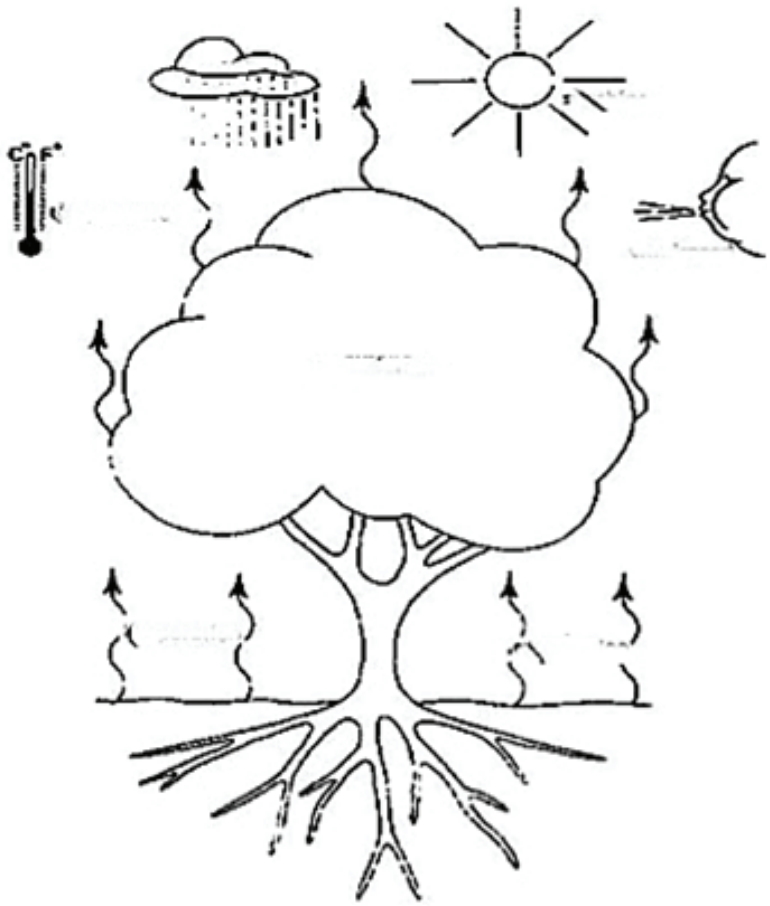
Option 2: EM-5 Repellent (takes 2 weeks to mature)

1. Concentrate Alcohol - 100 Cc
2. Vinegar - 100 Cc
3. Molasses - 100 Cc
4. Concentrated EM - 100 Cc
5. Water - 600 Cc

- Put all materials in the above order in a 1 Liter bottle and seal tightly from air.
- Keep it in dark, dry, cool place.
- Start to use as repellent after 2 weeks.
- Apply at a rate of 1:500-1:1000 (EM-5: Water).
- Note: This is not pesticide, only repellent.
- It can be used for up to 3 months.

Session 12: Watering plants

Exercise 12.1: Causes of water gain or loss in your fields

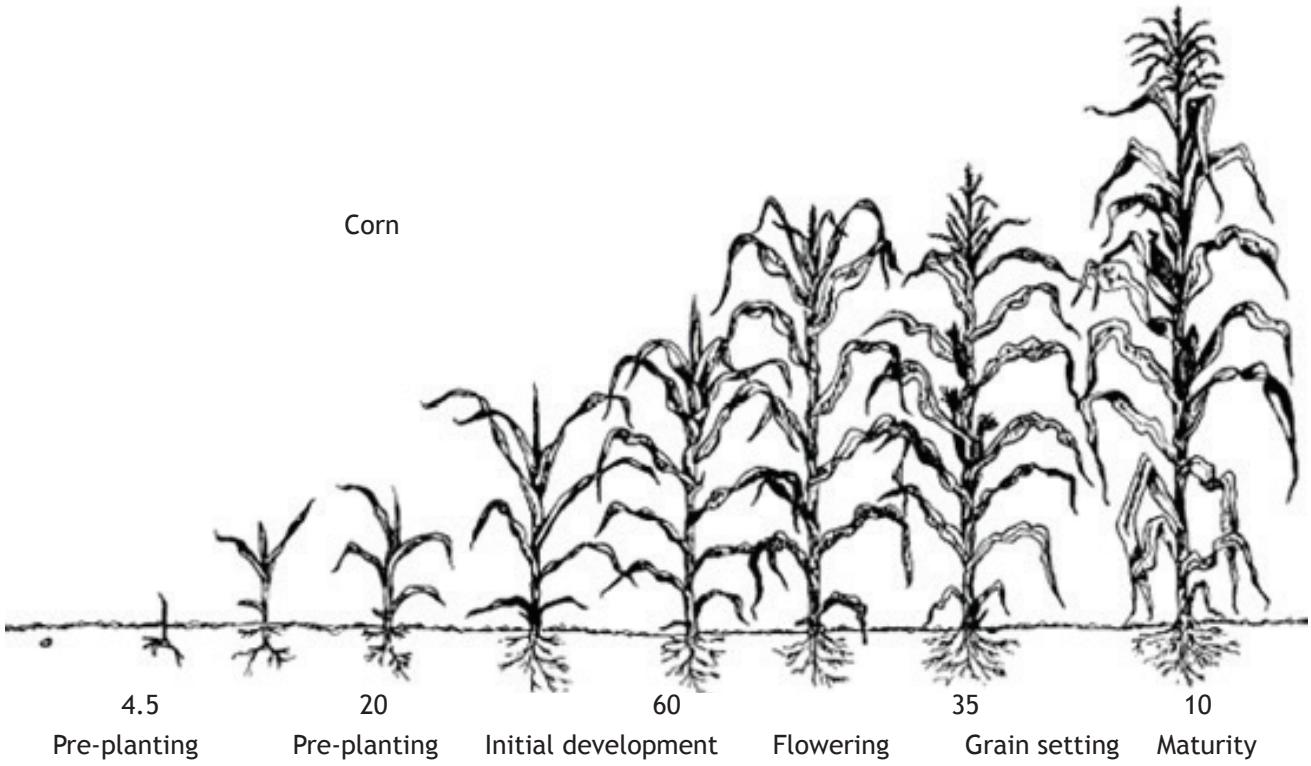


Exercise 12.2: Sources of water for irrigation

Sources of Water	Months available	Reliability - "sure" or "not sure"
1. Streams		Very low cost
2. Ponds		Use more amount
3. Dug wells		Difficult to control, high impact
4. Tube wells		Uneven productivity in plants; lower quality
5. Gravity fed springs		Longer
6.		
7.		
8.		

Notes:

Exercise 12.3: Plant water requirement through their growth stages



Water use in liters / 9 square feet/ 3 days

Exercise 12.4: Basic guidelines for plant watering

Amount of water:

The total amount of water needed to produce a crop depends on the specific requirements of the crop, the growing time and the characteristics of the soil. There are some rules to follow for water but farmers also need to learn how to read their plants and the soil conditions to best judge when and how much to water.

Guidelines for plant watering:

1. Watering is best in the early morning because water will be available to the plants as the sun gets hotter and the plants start to draw more water out of the soil
2. At regular intervals take a handful of soil 2 inches below the soil and squeeze it. Drop it from 10" above the ground. If the soil holds together it has enough water. If it crumbles it needs more water (See diagram 12.5 in their workbooks). And, as a general rule, look at the plants at mid-day, and if they look thirsty, water some more.
3. Sandy soils need more water than soils with clay
4. If direct seeding, soak the seeds over night
5. Fully wet the soil before direct seeding or transplanting
6. Puddle water around newly transplanted seedlings to push the soil close to the roots
7. After that, as a simple guideline, young plants need to be moist but not wet, watering every 4 days for 1-2 weeks, then every 3 days in week 3, every 2nd day in week 4, then water every day from week 5 onwards until harvest. Generally, the more leaf area, the more water is required. See CMTs for a guide for each crop

8. Keep the soil around the plant loose so that water is easily absorbed
9. Crops that are harvested dry should not be watered as harvest approaches
10. Too much water during fruiting may cause fruit splitting
11. Watering the leaves of some plants e.g. okra, may cause rotting
12. If using inter-row furrow irrigation on top of the beds, the beds should not be too wide as water cannot spread from the center of these beds to the plants
13. If plants are too dry the leaves will wilt but they will recover quickly when watered
14. If plants are overwatered the leaves will wilt because the roots have become rotten and they will not recover quickly. Try to avoid over watering!

Exercise 12.5: Soil moisture test

Soil Moisture test:

a. Select at random (in different rows) at least 6 points to check the soil for moisture.
b. Select a point between two plants and about 8 inches away from the line of plants.
c. Dig a hole 4 inches deep and the pick a little sample of soil between the fingers.
d. Squeeze the soil sample very hard (don't rub it).
e. Drop the sample into your other hand from about 4 inches. If the sample:

- Blows as dust, the soil needs water immediately
- Brakes in small pieces, it will need water in less than 4 hours
- Doesn't break and falls in one piece, the soil has moisture for at least 24 hours.

Exercise 12.6. Plants and water requirement

Wing bean	Uniform watering is required the whole crop life. Wing bean does not like too much water.
Broccoli	Uniform watering is required to prevent early flowering.
Cabbage	No water shortage. Irregular watering leads to splitting of cabbage head.
Cauliflower	Regular watering is required to prevent early flowering.
Chili	Gradual increase of watering is required, from planting to fruit maturing of chili.
Corn	Corn is.tolerant to drought. However water shortage during flowering time leads to decreased yield. The reason is a dry anther and early pollen production.
Cucumber	Gradually increase the amount of water from planting to flower formation, fruit setting and fruit maturity.

Egg plant	Gradually increase the amount of water from transplanting to fruit forming. Regular watering is required for good fruit formation.
Water spinach	Uniform water for the whole crop life. Water spinach is a leafy vegetable and because of a shallow root system, it requires frequent watering.
Salad vegetable	Uniform water for the whole crop life. Salad is a leafy vegetable and because of a shallow root system, requires frequent watering.
Onion and Shallot	Regular watering is required for these fibrous root crops. Provide water at bulb formation but do not water when leaves are dried.
Pumpkin	More water is needed at shoot forming, flowering and fruit development periods.
Tomato	Regular water is needed at flowering, fruit setting and fruit development periods. More water for plants with no mulch. For variety long-season-tomatoes, water requirement is low at picking time. Irregular watering at fruit development period leads to fruit cracking so water regularly during this time.
Seed germination	Frequent watering to moisten the soil. Take care of seeds washing away.
Seedlings	Keep the seedling moist. Too much moisture may lead to damping off. Do not let the seedling wilt.
Transplanted seedlings	Uniform moisture for the transplanted seedlings. Keep watering to prevent young plants from wilting. Watering is good for early root development. Prioritize watering in the first five days.

Exercise 12.7. Symptoms of plants related to water

Symptoms	Causes
1. Normal at morning. Wilt the rest of the day.	Water shortage
2. Normal at morning. Wilt the rest of the day.	If the plants do not recover in the afternoon, it may be a root rot problem.
3. Fallen flowers	Too much water or water shortage
4. Fruit crack	Too much water after water shortage.
5. Yellow leaves on the upper part of the plant	Too much water or too short of water

Exercise 12.8. Watering Methods

Advantages	Disadvantages
Furrow Irrigation	
Low cost. Use rainwater efficiently. Good water dispersing in moisture sustained soil. No runoff.	High cost in making furrow. Salt deposit due to evaporation. Large volume of water.
Sprinkler Irrigation	
Low cost to operate. Cover large area. Good for frequent irrigation in soil with low moisture holding capacity. Good materials, high price. Movable and low cost.	High cost in installation. Need high pressure. Water loss due to evaporation. Nutrient loss from both plant and soil. Water drops on leaves can cause leave diseases. Fix installation, low labor. Same operation area, high cost. High weed incident.

Drip Irrigation	
High efficiency in water usage. Low weed incident. Can use in undulating field. Good quality materials, high price. Movable and low cost.	High installation cost. Drip pipes may be blocked. Limited water dispersing area. Multi-cropping pattern, unchangeable. Without covering, pipes may be damaged due to hot Sun.
Can watering	
Low initial cost. High water usage efficiency. Can manage watering place and volume of water. Can use in undulating field. Low weed incident.	High labor cost.

Furrow irrigation

Sprinkler Irrigation

Drip Irrigation

Can watering

Exercise 12.9. Calculation of Water requirement of Tomato

Week	Estimation- water liter/plant	Water requirement in total/week (1000 plants)
4th week	2 liters/plant, 1 day interval	7000 liters
5th week	2 liters/plant, 1 day interval	7000 liters
6th week	2 liters/plant, 1 day interval	7000 liters
7th week	2 liters/plant, 1 day interval	7000 liters
8th week	3.5 liters/plant, 1 day interval	12250 liters
9th week	4 liters/plant, 1 day interval	14000 liters
10th week	4 liters/plant, 1 day interval	14000 liters
11th week	4 liters/plant, 1 day interval	14000 liters
12-15th week	3 liters/plant, 1 day interval	31500 liters
Total Water Requirement		113750 liters

Exercise 12.10. Water source registration and budget

Crop	Water requirement for one crop season(from Exercise3.8)	Availability of water (volume)	The best irrigation method and reasons	Cost per one crop per season
1				
2				
3				
4				
5				

Exercise 12.11: How to measure water flow

Water Delivery Method	How to measure the amount of water delivered
1. Inter bed furrow flood irrigation	Record the time it takes to fill a bucket of known volume. Calculate the result in litres per hour. Then estimate how many plants you can water in one hour according to plant demand. Remember you need about 50% more water for flood furrow irrigation because of evaporation, infiltration and waste.
2. Sprinkler	Record the time it takes to fill a bucket of known volume. Calculate the result in litres per hour. Then estimate how many plants you can water in one hour according to plant demand. Remember you need about 30% more water for sprinkler because of evaporation, coverage over all land including footpaths, infiltration and waste.
3. Shower rose	Record the time it takes to fill a bucket of known volume. Calculate the result in litres per hour. Then estimate how many plants you can water in one hour according to plant demand. Remember you need about 20% more water for shower rose irrigation because of evaporation, infiltration and waste.
4. Inter row (on top of beds) furrow irrigation	Record the time it takes to fill a bucket of known volume. Calculate the result in litres per hour. Then estimate how many plants you can water in one hour according to plant demand. Remember you need about 10% more water for inter row furrow irrigation because of evaporation, infiltration and waste.
4. Watering can	Take the time it takes to fill a watering can of known volume and how much time it takes to meet crop demand while walking and watering in the field for one hour. There is about 10% waste with careful use of a watering can directing water at the base of the plant.
5. Baker Drip at 0.4 bar	Put small dishes under drip emitters at the beginning, middle and end of rows. Pour these into one container and get the total volume per hour. Calculate how many plants you can water in 1 hour. There is little or no waste with drip (and mulching) so you do not have to calculate for extra water.

Session 13: Trellising, Weeding, Pest and Disease Control

Exercise 13.1: Farmers' current weeding practice

Definition of a weed:

"A weed is a plant that is in the wrong place at the wrong time". For example, a rice plant is a weed in a corn field; corn is a weed in a rice field.

Answer the questions below in the spaces provided.

1. How do you remove weeds from your crops?

.....

.....

.....

2. How often and how many hours do you (or other laborers) spend weeding on a ¼ acre plot?

.....

.....

.....

3. Which methods do you find most effective to remove weeds and why?

.....

.....

.....

Note: It is recommended not to use herbicides, but to remove weeds by hand or by using a weeding hoe. Always remove weeds before the weeds develop flowers. If removing weeds is done by hand, moisten the soil first to make it easier to pull out the weeds with its roots; and be careful not to pull or damage the crop roots.

Exercise 13.2: GAP Weeding Tips

TIPS	REASONS
1. Definition: A weed is a plant that is in the wrong place at the wrong time.	If you are selling your crop, buyers want single species products, not mixed with other products, so you have to 'weed out' the species that is in the wrong place at the wrong time.
2. Why is weeding important?	Weeds compete for light, nutrients, water and can be hosts for pests and disease.
3. Pull out weeds by hand or dig them out with a hoe or other tool. With weeds that have deep roots, take care to dig out all the underground parts.	Manual weeding loosens the soil and in this way improves aeration and plant growth. Weeding also reduces competition with the vegetables for nutrients and light.
4. Make sure the weeds are not tangled up in the seedlings.	When you pull out the weeds you may pull out the seedlings as well.
5. Leave the weeds without seed heads laying down on the surface of the soil. Take weeds with seed heads away and burn them.	This allows the sun to kill the weeds and to provide shade to the soil to prevent water loss and soil temperature increase. Over time, the weeds will break up into compost and improve the soil.
6. Keep some strong smelling weeds to chop up to make organic EM insect repellent.	Strong smelling weeds are good ingredients for this mixture.
7. Chemical control: spray weeds with a selective herbicide if other methods of control are not possible.	When it is too difficult to hand weed a large area, follow the instructions on the container about how to mix and use the chemical safely.
8. Some crops do not like their roots being disturbed so take care when weeding around them	Hand weed around the crop stems
9. Seedlings do not compete well with weeds.	It is very important to keep seedlings clear of weeds for the first 2 – 4 weeks

Chip Hoe

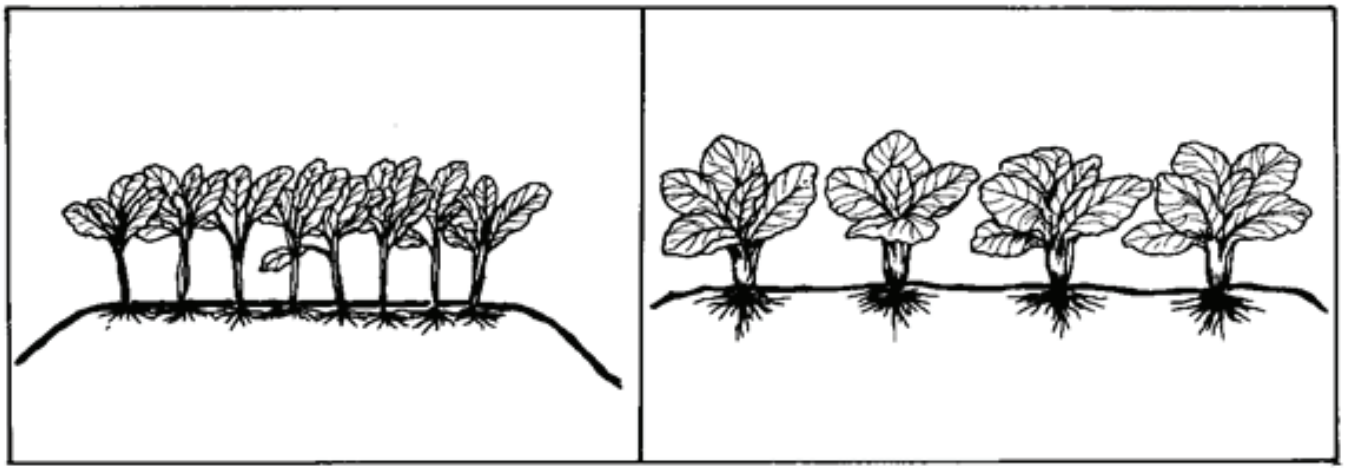
Push Hoe

Tine Hoe

Typical Rakhine weeding tool

Exercise 13.3: Methods and Purpose of Thinning

TIPS	REASONS
1. Thinning is important.	So that you can get an even product size that the market requires (better price). Thinning also maximizes yield and income per area, and reduces competition from weeds in open unused spaces.
2. Carefully pull out the plants that are not at the correct spacing. Try not to disturb the plant that is left behind too much.	Plants that are too close result in small weak plants because they compete for nutrients, light and water with each other.
3. Leave plants at a spacing that is the same as the fully-grown plant.	This provides enough room for sufficient nutrients, light and water for good plant growth
4. Fill in the gaps with new plants	This maximizes yield and maintains an even spacing



Too close making plants thin

Good spacing allows strong plants with no gaps

Exercise 13.4: Trellis Designs

Tomatoes on Bamboo Stakes

Cucumbers on Bamboo Stakes

Tomatoes on Bamboo Stakes

Cucumbers on Bamboo Stakes

Tomatoes on Bamboo Stakes

Cucumbers on Bamboo Stakes

Important Note:

1. Use preventative and organic methods of control where possible. Only use chemicals as a last resort because chemicals are dangerous for the farmer's health, can be dangerous for the consumer's health, and they are also dangerous for the environment.
2. Learn which are the good insects and which are the bad insects. Only kill the bad insects.
   Recognize pests and diseases in the crops early and how to control them. (Use the Pest and Disease Handbook if you have them to help you)

Tomatoes on Bamboo Stakes

Cucumbers on Bamboo Stakes

Tomatoes on Bamboo Stakes

Cucumbers on Bamboo Stakes

Exercise 13.5: Methods of controlling pests and diseases

Behavioral Methods

1. Use clean seed and planting materials
2. Treat the seeds by exposing them to sunlight before planting.
3. Plant when the soil is not too wet
4. Use crop rotation method

Mechanical Methods

1. Remove diseased plants
2. Remove pests with fingers
3. Use ash to prevent crawling pests
4. Plant on raised beds
5. Use insect traps
6. Use of nets to cover fruit

Biological Methods

1. Use of organic pesticides e.g. EM and Trichoderma, Neem seed extract
2. Use of biological parasites for controlling insect pests
3. Companion planting e.g marigolds and inter-planting with onions and garlic

Exercise 13.6: The principles of IPM

1. There are good insects that are natural enemies of pests so you do not have to kill every insect. The good ones can kill the bad ones.
2. It is acceptable to have a few pests and the farmer does not have to try to kill them all.
3. Preventive cultural practices: removal of diseased plants; good drainage; use of disease free seed.
4. Monitoring: Regularly observe the plants to look for an increase in insect numbers and spread of diseases.
5. Mechanical controls: Hand picking; barriers (ash); insect traps
6. Biological controls: use of parasitic insects and micro-organisms.
7. Responsible use of chemical pesticides. Avoid very toxic chemicals. Use those that are based on naturally occurring substances e.g. nicotine (from tobacco) and pyrethrum (from daisies).

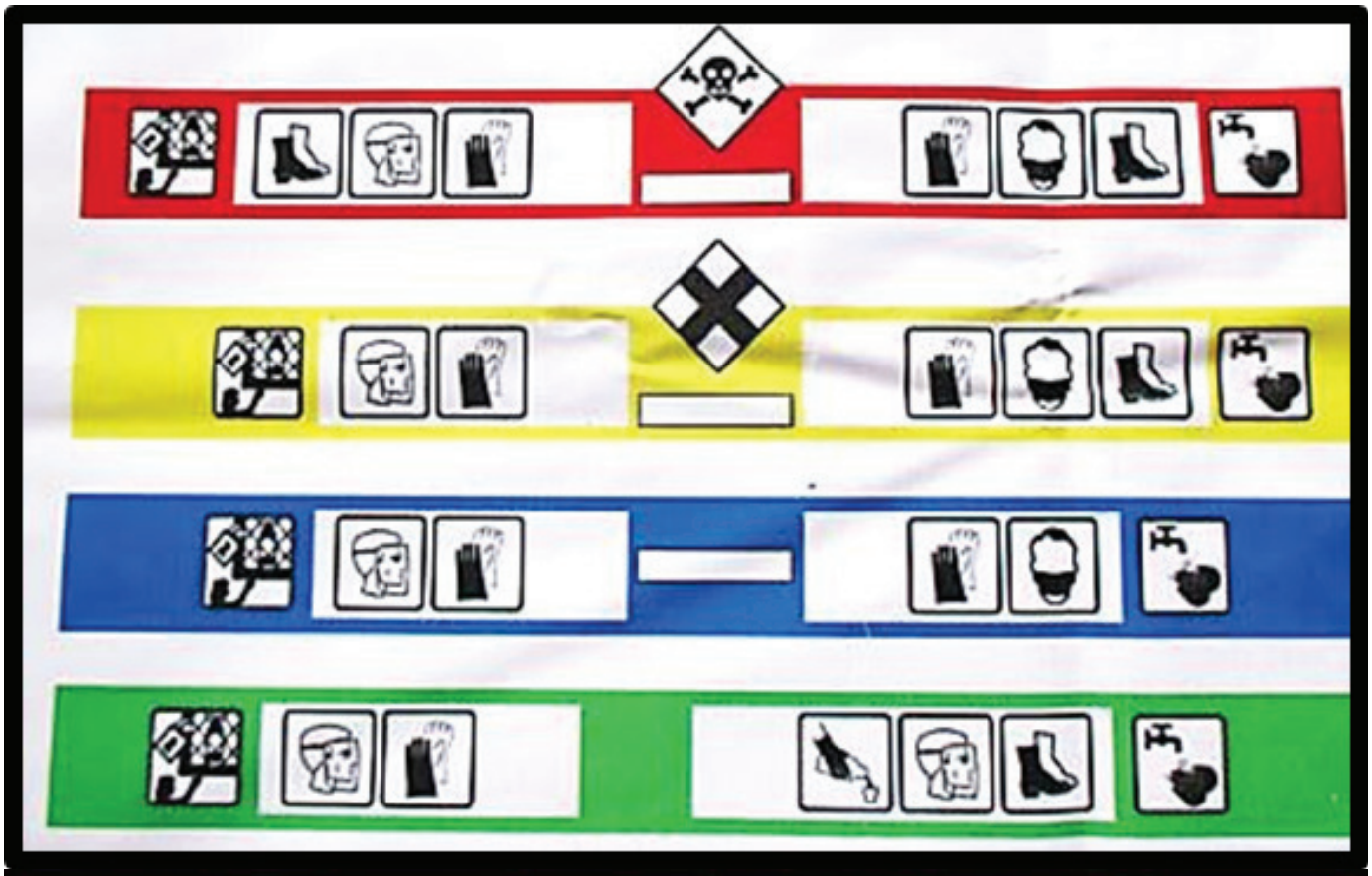
8. Explain the idea of using chemicals only when the pest/disease incidence has reached the economic threshold. That is, when the cost of spraying is less than the amount of damage. E.g. Spend 20,000 MMK to save 100,000 MMK. That is, you are 80,000 MMK better off. If there are just a few plants infected you do not have to spray the whole crop. Just deal with the individual plants. This saves money, your health and the environment.

Exercise 13.7: What are the "Do" and "Do Not" procedures for handling pesticides?

Do	Do Not
Check with your agriculture advisor for a list of banned chemicals.	Use banned chemicals. They are harmful to humans and the environment.
Store in a locked cupboard away from the home.	Harvest before the recommended Pre Harvest Interval (PHI).
Read the label carefully and follow directions for mixing.	Use your hand to mix the pesticide.
Check that the sprayer is operating correctly first and is not leaking.	Smoke or drink or eat food while you are mixing or applying pesticides.
Wear clothes that cover the whole body, gloves, and a protective mask to cover the mouth and nose at all times for mixing and applying pesticides.	Spray if it is windy or if it is a very hot day.
Mix the pesticide properly. For powdered pesticides: - pour the water into the sprayer first - mix the correct amount of powder with a little water in a separate container - pour this solution into the sprayer -	Wash the sprayer or dispose in chemical containers in ponds or rivers
Do wash yourself immediately if you spill chemicals over yourself	
Do wash yourself with soap and change into clean clothes after using chemicals	

IMPORTANT

STOP SPRAYING IF YOU FEEL ITCHY ON YOUR SKIN, DIZZY, HAVE STOMACH CRAMPS OR NAUSEA. WASH YOURSELF THOROUGHLY AND CONSULT WITH YOUR HEALTH CENTRE.




ဓါးသတ်ဆေးများကို အန္တရာယ်ကင်းစေရေး အသုံးပြုခြင်း
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Exercise 13.8: Solution for powdery mildew and downy mildew:

Ingredients:

Copper Sulphate	- 28 tickles
Lime	- 28 tickles
Water	- 10 gallons

Preparation

- Add copper sulphate (28 tickles) to water (5 gallons) and stir thoroughly in plastic bucket A.
- Add lime (28 tickles) to water (5 gallons) and stir thoroughly in plastic bucket B.
- Then mix the two solutions in a third larger bucket and stir.
- Sieve the solution in a strainer so larger particles can't pass through. Always stir thoroughly before spraying.
- This mixture can be used within 24 hours.

Note -Use a bamboo or plastic stick. Do not use iron, zinc or metal buckets because the copper will corrode them.

Exercise 13.9: Making natural pesticide to prevent sucking insects

Special Note: Must be used within a day.

Ingredients:

Green chili	-	10 Tickles
Garlic	-	10 Tickles
Ginger	-	15 Tickles
Basic Soap	-	10 Tickles
Mustard Oil	-	5 Spoons
Water	-	5 Gallons

Preparation:

1. Pound the garlic and keep it in the mustard only one night.
2. Next day add pounded ginger + green chili and mix all together.
3. Put all ingredients in the water and stir it.

Application:

Apply using a knap sack sprayer. Filter and remove particles before spraying.

Session 14: Post Harvest Handling and Quality

Exercise 14.1: Importance of post-harvest handling

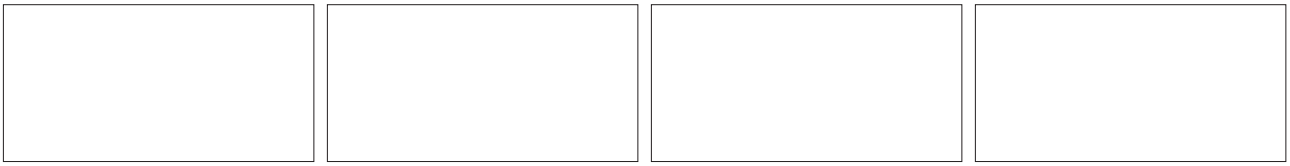
Question: Why is post-harvest handling important?

We need to meet the market requirements for:

1. Quality
2. Food Safety
3. Increase our profits by reducing our losses in harvesting, transport and storage
4. .....
5. .....
6. .....

Exercise 14.2: Losses along the supply chain

1. Map of the produce supply chain



2. How does produce get from the field to the consumer?

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3. Time taken between each stage in the chain?

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....

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4. Amount of produce destroyed or damaged in the supply chain?

....

....

....

Exercise 14.3: Market Requirements for the listed crops

Crop	Market Quality Requirements
Yard Long Bean	
Okra	
Onion	
Carrot	
Chili	
Tomato	
Egg-plant	
White egg-plant	
Coriander	
Cabbage	
Cauliflower	
Broccoli	
Radish	
Water spinach	
Mustard	
Bottle Gourd	
Snake Gourd	
Ridge Gourd	
Bitter Gourd	
Cucumber	
Water Melon	
Pumpkin	

Exercise 14.4: Market Quality Grading of Vegetables

1. Appearance
    - Check skin blemishes (spots, marks, scratches and cuts)
    - Is there surface contamination by soil, birds, insects
    - Are there broken leaves (leafy vegetables)
2. Shape
    - Is it the right shape for the variety e.g. cucumbers – straight or slightly curved
3. Color
    - Is the color similar at the same stage of development e.g. check tomato maturity and size
    - Deep glossy purple for eggplant
4. Condition
    - Leafy vegetables should not have wilting leaves
    - Okra should not have yellowing and tips should break off cleanly.

5. Size
   - Should all be of similar size
6. Texture and flavor
7. Chemical use.

Note: If you are using chemical sprays it is important to write down when the sprays were used and to show this record to the buyer to indicate that you have followed the Pre Harvest Interval (PHI) after spraying.

.....

.....

.....

4. Invite the participants to comment on the quality and possible price of the products in the photos below.

ood Grading of Bitter Gourd

Good Grading of Eggplant and Yard Long Beans

ood Grading of Bitter Gourd

Good Grading of Eggplant and Yard Long Beans

Exercise 14.5: Factors affecting vegetable quality

Factors Affecting Quality	Prevention
Mechanical damage Rough handling during harvesting and transport causes bruising (tomatoes), broken leaves (leafy vegetables) and water loss.	Mechanical damage - use a knife to harvest - pack into strong clean boxes with no sharp edges - put a layer of leaves under boxes to protect them on trucks
Temperature High temperatures cause produce to ripen too quickly and to lose water, causing leaves to wilt and resulting in weight loss.	**Temperature** - harvest early morning - pack in the shade - use wet sacks to cool and keep humidity high - cover boxes on trucks **Tip:** The temperature in the shade is usually 10-15 degrees cooler than in the direct sun.
Crop maturity If the crop is harvested too early it will not reach full maturity. If the crop is harvested too late it will deteriorate before it reaches the market.	**Time of harvest** - know the correct time to harvest
Rot and pests Rot develops after harvest causing rapid breakdown of produce. Insects may also affect produce in storage.	**Rot and pests** - dip in chemical solution to prevent rot - use mosquito netting in storage areas

Exercise 14.6: Packing materials - advantages and disadvantages

Advantages	Disadvantages
Card board boxes	
• **Readily available** • **Easy to handle and stack** • **Can be adapted to different types of products**	• Lose strength when wet • Need breathing holes • Cannot be recycled
Jute or string bags	
Low cost Can be recycled Can be moistened with water	No protection for soft products Heavy and may be roughly handled
Bamboo baskets	
Low cost Can be recycled Can get wet Strong support	Need to be lined to protect products Can be over filled Do not stack well

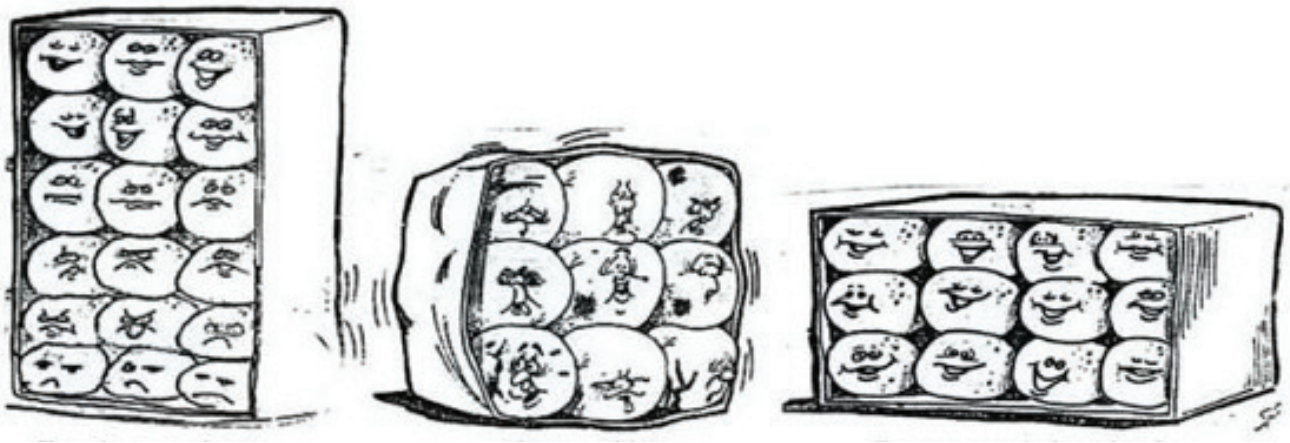
Not Good: Salad Greens Over Full Bamboo Baskets

Not Good: Tubers in Jute Bags

Good: Re-useable plastic crates

Good: Cardboard boxes in Storage

Tip 1: Cardboard boxes are very convenient however it is important not to pack them too deep or over fill the carton.



Too deep *Over filling* *Good*

Exercise 14.7: Pre and Post-Harvest GAP Handling Methods

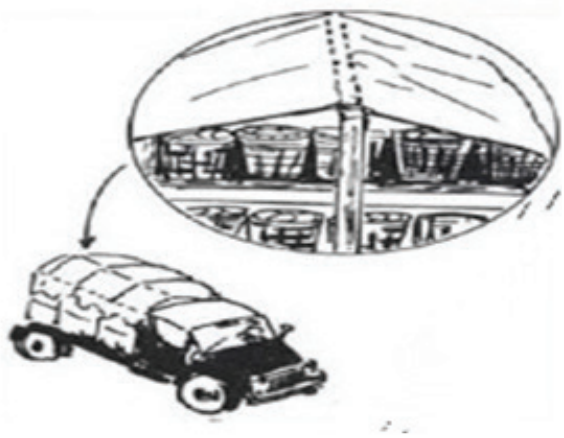
GAP Tips	Reasons Why
1. Harvesting:	
1.1 Harvest at the cooler morning part of the day.	**Produce is fresh and not dehydrated.**
1.2 Do not harvest in the afternoon.	Produce has dried out during the hot day.
1.3 If wet or humid, dry produce in a shady cool place.	Moisture can cause disease and your produce will spoil.
2. Cleaning & Sorting	
2.1 Clean and sort in a shady place	Reduces heat stress
2.2 Spread produce on a flat clean surface to help heat to dissipate (decrease) before packing.	Heat causes dehydration and a reduction in quality.
3. Packing:	
3.1 Put in well ventilated baskets or crates using liners such as banana leaves or paper to protect the produce.	Produce can be damaged in transport or storage, resulting in disease, wastage, and a lower price.
3.2 Tarpaulin and polypropylene sacks should be avoided as they restrict ventilation. Wide weave containers that let air circulate are better.	Produce heats up and spoils quickly in tight weave containers.
3.3 Do not pack containers too tightly	Packing too tightly restricts air flow and causes heating and bruising of products
4. Transporting:	
4.1 Vehicles should have a roof or cover over the produce.	Provides shade.
4.2 Vehicle should have separate shelves so that produce is not stacked on top of each other.	Stacking can cause bruising and low price.
4.3 Transporters should handle produce carefully.	To prevent bruising and other damage.
4.4 Transport quickly after harvest in the cool parts of the day or at night.	Reduces dehydration and crop spoilage.
4.5 Produce should be kept separate from contaminants like fertilizer, pesticides, animals, etc.	You don’t want to poison the produce or the consumer.
5.Storage:	
5.1 A wet cloth over a storage basket can reduce the temperature.	Prevents dehydration.

5. Look at and discuss the pictures below.

Not good: packing in the sun

Good: shade house for field packing

Not good: Uncovered produce on truck



Good: Produce covered with ventilation

Good: using ice to cool long beans

***Good: using a wet blanket to cool produce** – as the water evaporates it cools the produce*

Exercise 14.8: Harvesting at the right time

Crop	What does produce look like when it is ready to harvest?
Yard Long Bean	
Chili	
Okra	
Tomato	
Eggplant	
Coriander	
Cucumber	
Bottle Gourd	
Ridge Gourd	
Snake Gourd	
Bitter Gourd	
Pumpkin	
Watermelon	
Cabbage	
Cauliflower	
Broccoli	
Mustard	
Sweet Corn	
Carrot	
Onions	
Radish	
Water Spinach	
White Egg Plant	

Tip: Quality cannot be improved after harvest, so produce must be harvested at the right time.

Okra: mature

Okra: over mature

Cauliflower: mature

Cauliflower: Over mature

1 *2* *3* *4*

Tomato at different stages of maturity
1 = not ready for harvest. 2 = can be harvested for distant markets.
3 = can be harvested for nearby markets. 4 = for local markets only.

Produce can be dipped in solutions to prevent rots. The photos below show the difference that using dips can make. Discuss the photos.

Eggplant treated with bleach (top)
No treatment (bottom)

Cabbage no treatment (top)
Treated with lime (bottom)

Exercise 14.9: Dip in solution to prevent rotting

Bleach Dip.

1. Mix 4-8 tablespoons of bleach per 4 liters of water. This is effective for preventing rot in eggplant after harvest.
2. Baking soda. Mix 1 tablespoon of baking soda per liter of water. This is effective for preventing rot in tomatoes after harvest.
3. Lime. Mix lime (very fine) with water to make a paste. This is effective in preventing rot when it is painted on the end of the stems of cabbage and cauliflower.

Session 15: Market Buyer Led Workshop

Exercise 14.1: Importance of post-harvest handling

1. What products do you want to buy? Describe your product clearly.
2. How much product can you buy? For example, 5 baskets per farmer, or 100 baskets from the whole group.
3. What is the time period when the buyer wants to buy the produce?
4. What quality standards are required? For example: size, color, moisture content and grade.
5. What GAP cultivation practices are required to market as GAP produce?: This refers to how the crop was produced, for example: (i) Safe for the consumer – sold after chemical withholding periods; (ii) used less chemicals, more organic; (iii) used government approved chemicals only; (iv) not harmful to the environment; (v) not harmful to the farmer and the workers; (vi) used quality seed from pure varieties; and (vii) harvested, stored and transported properly so there is a long shelf life. Remind them of the other government GAP requirements outlined in Exercise 1.4 in their workbooks.
6. How and where should the products be delivered? For example, specific locations, time, mode of transport, packaging, who pays for transport. Perishable products like fruit and vegetables may need special packaging, ripeness, storage and transport requirements.
7. What price will be paid and under what conditions? For example, price based on quality and price based on quantity. Ask about individual farmer price and group price for a larger volume of sales and better prices.
8. What are the payment procedures?: How and when the farmer will be paid by the buyer; for example cash on delivery, payment after some days or months, paid by cheque?
9. Does the buyer offer technical support: Examples might be a leaflet or a personal visit to advise on quality standards.
10. Other incentives: These are extra benefits the seller or buyer can offer. For example, if you sell me more than 10,000 baskets of products, I can give you credit for inputs (pre financing), or a free motorbike or other promotions. This especially applies to group buying/selling of large volumes.
11. If there is disagreement between buyers and sellers, how can these problems be solved?
12. How is the product insured against risks like fire, flood, drought, damage in transport? Who is responsible for organizing and paying for this?
13. Are there any penalties if either party breaks an agreement?

Session 16: FFS Evaluation Session Plan

Exercise 16.1: Cropping Plan for Next Seasons.

Crops	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Group - 1												
1. Yard-long Bean												
2. Okra												
3. Onion												
4. Carrot												
Group - 2												
5. Chili												
6. Tomato												
7. Egg-plant												
8. White Egg-plant												
9. Coriander												
Group - 3												
10. Cabbage												
11. Cauliflower												
12. Broccoli												
13. Radish												
14. Water spinach												
15. Corn												
16. Mustard												
Group - 4												
17. Bottle Gourd												
18. Snake Gourd												
19. Ridge Gourd												
20. Bitter Gourd												
21. Cucumber												
22. Water Melon												
23. Pumpkin												
Field Crops												
1. Goundnut												
2. Chili												
3. Corn												
4. Watermelon												
5. Onion												

Remark:

- Good growing period
- Difficult growing period

RAKHINE WINTER
CROPS PROJECT

NEW ZEALAND
FOREIGN AFFAIRS & TRADE
Aid Programme