Cropping Systems

Farmer-to-Farmer Participatory Training Course

Objectives

- Learn strategies of how to best utilize available farm resources by choosing the right croops and cropping systems
- Recognize that longer term cropping strategies will best meet farmers' needs for food and financial security

Cropping Systems

A critical aspect in developing an effective ecological farming system is to manage and organize crops so that they best utilize the available resources. Resources include sunlight, soil, air, water, farm labour, equipment, etc.

ACTIVITY: Get individual farmers to describe the cropping systems they use. Have the farmers answer the four questions below.

1) What are the major systems for crop rotation?

_____
_____
_____

2) Why do you do it this way?

_____
_____
_____

3) How can you improve this?

_____
_____
_____

4) What are some of the most important factors you need to consider when planning your crop rotation?

_____
_____
_____

ACTIVITY: Group Discussion

- **Does water use by crops affect crop production of the following year?**
- **If you are growing 4 different crops and 2 are high moisture users and 2 low moisture users, what sequence would you plant them?**

Year 1. Low water using crop
Year 2. High water using crop
Year 3. Low water using crop
Year 4. High water using crop

Explanation: Start your rotation off with a low water using crop to leave good residual soil moisture in the field for the next year. In the second year grow a high water using crop, as there has been adequate time for soil moisture to replenish. In the third year plant back the low moisture-using crop, as there may not be adequate soil moisture in most years to grow the high soil moisture-using crop a second year in a row. In the final year grow a high moisture-using crop. Then start the rotation again with your year 1 low water using crop.

What are the basic principles of cropping systems?

1) **Choose crops that complement each other.** This involves choosing complementary crops and systems that share resources without causing nutrient deficiencies for neighbouring or subsequent crops. Plant nitrogen demanding crops following N-fixing legume crops. Crops that respond to good soil structure should likewise follow soil-restoring crops. Crops with low fertility (i.e. flax, peas, and lentils) should be used at the end of a crop rotation when soil fertility levels are lowest.

2) **Choose crops and a cropping rotation which utilize available resources efficiently.** Examine the factors that limit crop productivity in your area (i.e. water, solar radiation, growing season, farm labour, equipment, and animal draft power) and design a rotation that emphasizes crops which best utilize available resources, yet minimize production risks (i.e. if summer heat stress is a problem include heat tolerant crops). Strategies include choosing plants with different nutrient uptake rates, different heights for even distribution of sunlight, different rooting patterns, varying plant structures, or different harvest times. For example, spring wheat and corn can be grown in strips versus solid plantings.

3) **Choose crops and a cropping system that maintain and enhance soil fertility.** This includes the maintenance of nutrients such as nitrogen and carbon (organic matter). For example:

- Crop rotations with approximately 30-50% N-fixing crops, like legumes, generally do not deplete the farming system of nitrogen. If livestock are few, the percentage should be about 50%; however, if significant amounts of livestock manure are added, the percentage can be lower. Row crops should typically not exceed 30% N-fixing crops in the rotation or it may be difficult to maintain soil organic matter levels.
- Choose crops which produce large amounts of organic matter in both above and below ground. For example, perennial forages and millet. The crop rotation should include some deep rooted crops and crops that have large roots. Incorporate residues back into the soil.

4) **Choose crops which have a diversity of growth cycles**. An ideal crop rotation would consist of early spring seeded, summer seeded, fall planted, and perennial hay and pasture crops. This however may not be possible if climatic conditions are unfavourable for crops like winter wheat, or if it is difficult to establish perennial forages because of moisture limitations.

5) **Choose a diverse species of crops**. The more diverse the rotation, and the longer the period before the soil is reseeded with the same crop, the more likely weed, pest and disease problems will be avoided. Trying to grow too many crops however may cause management problems; therefore no more than 6-7 annual crops should be planted (unless the farmer has excellent management skills). For example:

   - Typically it is a good idea to rotate between grass and broadleaf crops for disease prevention.
   - Changing the field each year between grass family plants and broadleaf plants helps reduce the carry over of pathogenic disease organisms from year to year.
   - For some disease sensitive crops, it is best not to grow the same crop on the same field for 3 years after the last planting.

6) **Keep the soil covered.** Efforts should be made to grow sequences of crops that maximize solar radiation capture and minimize risks of soil erosion. For example, winter cereals can be seeded following peas, or alfalfa can be established by undersowing in flax.

7) **Strategically plan and modify your cropping system as needed**. The optimal crop rotation for your farm will evolve only through effective planning and many years of experimentation and observation. Diversified cropping systems will need more management, and possibly specialised equipment. You need to consider your entire farm planning goals, including: household food security, income generation needs, livestock feed requirements, labour and management skills, and animal draft and farm equipment availability. You may also need to make adjustments for the prevailing weather and market conditions as the cropping year progresses.

8) **Monitor your progress!** Make a plan and keep records. Learning from your mistakes will result in more efficient crop production.

What are some types of cropping systems?

Cropping systems are designed to mimic nature and bring diversity into our farming systems. Cropping systems include:

1) *Crop rotation:* Crops are changed in the field from year to year according to a planned sequence rather than the same crop being grown in the same field. The crop rotation can include both annual and perennial crops which are seeded for several years.

2) *Multiple Cropping:* Two or more crops grown in the same field within a given year. Annual and perennial plants can be organized in fields together. Another example might be planting rows of fruit trees with cereal grains or vegetables in between and windbreaks planted around the field perimeter.

3) *Mixed Cropping:* Two or more crops are mixed together in the same field at the same time without a definite row arrangement. Complimentary crops include oats and peas or mixtures of forage grasses and legumes.

4) *Strip-Intercropping:* Two or more crops are planted in the same field in alternate rows. The two crops generally have their main production period at different times of the year. This system more evenly uses water throughout the growing season, and ensures some level of productivity during the dry season by the more drought tolerant crops. For example, wheat or peas can be spring sown in one-meter strips with an adjacent fallow one-meter strip area. Later this area can be planted with two rows of corn.

5) *Planting for Genetic Diversity:* Using several varieties of seeds in the same field can be a good strategy to increase crop diversity and reduce vulnerability to disease and insect outbreaks.

ACTIVITY: As a group, discuss the types of cropping systems locally used.

What are the benefits of cropping systems?

1) **Maintain and enhance soil fertility.** Some crops are soil exhausting while others help restore soil fertility. However, a diversity of crops will maintain soil fertility and keep production levels high.

2) **Enhanced crop growth.** Crops may provide mutual benefits to each other. For example, reducing lodging, improving winter survival, or even acting as windbreaks to improve growth.

3) **Minimize spread of disease.** The more diverse the species of plants and the longer the period before the soil is reseeded with the same crop, the more likely disease problems will be avoided.

4) **Control weeds.** Crops planted at different times of the year have different weed species associated with them. Rotating crops helps prevent build up of any one serious weed species. The more different growth cycles the crops have in your rotation, the fewer weeds will be able to adapt to the field conditions.

5) **Inhibit pest and insect growth.** Changing crops each year to unrelated species can dramatically reduce the population of pests and insects. Crop rotation frequently eliminates their food source and changes the habitat available to them.

6) **Increase soil cover.** Growing a diversity of crops helps keep field sizes smaller, which increases soil cover, improves solar radiation capture and reduces erosion.

7) **Use resources more efficiently.** Having a diverse group of crops helps to more efficiently use the available resources. Natural resources, such as nutrients, sunlight and water in the soil, are evenly shared by plants over the growing period, mimimizing the risk for nutrient deficiencies and drought. Other resources, such as labour, animal draft power, and machinery, are also utilised more efficiently as the time and effort spent planting and harvesting crops is more spread out over the harvesting period.

8) **Reduce Risk for Crop Failure.** Having a diverse group of crops helps prevent total crop failures, as climate weather in one part of the season may not affect all crops equally. It also reduces food security concerns, as well as the amount of money required to finance production.

9) **Improved Food and Financial Security.** Choosing an appropriate and diverse number of crops will lead to a more regular food production throughout the year. With a lower risk for crop failure, there is a greater reliability on food production and income generation.

ACTIVITY: As a group, discuss the following questions and fill in the table below.

1) **What crops do you grow?**
2) **How would you rank them in their overall soil fertility demands?**
3) **Nitrogen demand?**
4) **Phosphorus demand?**
5) **Water demand?**

What crops do you grown and how do they rank?

	Nitrogen Demand		**Phosphorus Demand**		**Water Demand**
Highest:		Highest:		Highest:	
Lowest:		Lowest:		Lowest:	

Examples of Crop Rotations:

1) MULTIPLE CROP ROTATION FOR FARMS WITHOUT LIVESTOCK (COG, Organic Field Crop Handbook)

Year/Field #	**CROP Spring**		**Fall**
1	Winter Wheat		Oilradish
2	Barley*	underseeded with	Red Clover
3	Soybeans		Winter Rye
4	Rye		Buckwheat
5	Oats and Peas	underseeded with	Red Clover
6	Red Clover harvested for seed		Winter Wheat.

* Flax could replace barley.

Features of this rotation:

a) Field #6 has all the soil-building advantages of growing perennial forage, without the large carbon loss that would occur from selling hay off the farm.
b) The rotation allows the ground to be covered throughout the winter every year.
c) There is never more than one year without a legume (soybeans, red clover, and peas) eliminating the need for manure.
d) The rotation contains nine plant species.

2) MULTIPLE CROP ROTATION FOR DAIRY/BEEF and CASH CROP FARM

Year/Field #	**CROP**	
	Spring	**Fall**
1	Winter Wheat or Spelt	Oilradish
2	Oats underseeded with	Red Clover
3	Barley	Winter Rye
4	Rye	Oilradish
5	Vegetable Crop underseeded with (Red Clover-Timothy-Brome)	Triple Mix 60-20-20
6	Forage	
7	Forage	
8	Forage	
9	Forage plowed	Winter Wheat

Features of this rotation:

a) Reduced use of row crops and increased reliance on high quality forages and winter cereals.
b) Typically a hay mixture is undersown into spring barley and kept for 3 or 4 years.
c) Sod is plowed 4-6 weeks before seeding of winter cereal to allow adequate decomposition of organic material.
d) Winter cereal is followed by oilradish in mid August so that living material is present on the soil surface at the beginning of winter to reduce erosion, and minimize nutrient losses as well as weed reproduction.
e) One quarter of the rotation is sold as cash crops. Despite the large amount of biomass removed, fertility levels are kept constant through the maintenance of long-term hay and pasture, as well as the use of oilradish to bring up nutrients from deep levels.
f) Liquid manure or Fish and Seaweed emulsions are applied on growing oilradish.
g) Tillage includes chisel plowing the undersown red clover in the fall and mouldboard plowing hay or pasture. A chisel plow is also used on the oil radish in the spring.

3) MULTIPLE CROP/MARKET GARDEN ROTATION WITH STRAWBERRIES
(Koepf, Pettersson & Schaumann, *Biodynamic Agriculture*)

Year	Plot1	Plot2	Plot3	Plot4	Plot5
1	Roots	Leaf	Potatoes	Fruit Veg.	Strawberries
2	Fruit Veg.	Roots	Leaf	Potatoes	Strawberries
3	Potatoes	Fruit Veg.	Roots	Leaf	Strawberries
4	Leaf	Potatoes	Fruit Veg.	Root	Strawberries
5	Root	Fruit Veg.	Potatoes	Strawberries	Leaf
6	Fruit Veg.	Potatoes	Leaf	Strawberries	Root
7	Potatoes	Leaf	Root	Strawberries	Fruit Veg.
8	Leaf	Root	Fruit Veg.	Strawberries	Potatoes

Features of this rotation:

a) Each plot produces different "organs" of the plant and should be grouped by botanical classifications, thereby not growing the same or related crop in successive years and combining crops with similar cultural requirements.
b) Diversification of each plot makes them more resistant to disease and insects.
c) If flowers are desired, plant them in the potato plot.
d) Strawberries do best after root crops.
e) Carrots can be planted and harvested prior to strawberries, or winter rye-vetch can be planted in the preceding fall.
f) Brassicas (cole crops) should be grown in 'leaf' plots since we eat the "flower".
g) Grow corn in 'fruit-veg' plots.
h) Add compost in fall after the 'roots' and before the heavy feeders (i.e. potatoes, corn, etc.).
i) Incorporate living mulches (i.e. white clover-annual rye) in 'fruit-veg' plots after crops are well established (4-6 weeks).
j) To increase yield divide each plot into 4' wide beds (North-South for heat; East-West on dry soil).
k) Peas, oats and barley increase scab on potatoes. Soybean decreases scab.

4) MULTIPLE CROP/MARKET GARDEN ROTATION
(Eliot Coleman, *New Organic Grower*)

Year 1	2	3	4	5	6	7	8	9	10
Beans Cabbage	Carrot Beet Onion	Greens	Potato and/or Flowers	Corn	Peas	Broccoli Cauliflower	Squash Cukes Clover	Tomato Pepper	Corn
Compost		Compost		Compost	Compost				Compost

Features of this rotation:

1. Two corn crops (heavy feeders) are well distanced from each other.
2. Potatoes yield best after corn.
3. Tomatoes and peppers (in the same family as potatoes) are well distanced from each other.
4. Corn follows a legume (i.e. peas or beans).
5. Cabbages tend to be negative preceding crops; corn however is least likely affected by preceding crops (and it receives compost).
6. Carrots and beets are often detrimental to follow but beans are not too effected. Onions benefit the cabbage family.
7. Brassicas (cole crops) should be 3+ years apart to prevent club root disease (i.e. planted in years 1 & 7).
8. Squash is a beneficial preceding crop therefore it will aid Broccoli and Cauliflower.
9. Add compost in fall, 8-12 tons per acre. If short on compost use living mulch clover.
10. Solanaceae family (potatoes, tomatoes, peppers) prefers five-year rotations to control blight.

5) MIXED CROPPING Please read the following examples and see if they are applicable to China. The following chart shows complementary and incompatible crops which can be incorporated into a mixed cropping system:

COMPANION PLANTING CHART FOR HOME & MARKET GARDENING *(compiled from traditional literature on companion planting)*		
CROP	**COMPANIONS**	**INCOMPATIBLE**
Asparagus	Tomato, Parsley, Basil	
Beans	Most Vegetables & Herbs	
Beans, Bush	Irish Potato, Cucumber, Corn, Strawberry, Celery, Summer Savory	Onion
Beans, Pole	Corn, Summer Savory, Radish	Onion, Beets, Kohlrabi, Sunflower
Cabbage Family	Aromatic Herbs, Celery, Beets, Onion Family, Chamomile, Spinach, Chard	Dill, Strawberries, Pole Beans, Tomato

Carrots	English Pea, Lettuce, Rosemary, Onion Family, Sage, Tomato	Dill
Celery	Onion & Cabbage Families, Tomato, Bush Beans, Nasturtium	
Corn	Irish Potato, Beans, English Pea, Pumpkin, Cucumber, Squash	Tomato
Cucumber	Beans, Corn, English Pea, Sunflowers, Radish	Irish Potato, Aromatic Herbs
Eggplant	Beans, Marigold	
Lettuce	Carrot, Radish, Strawberry, Cucumber	
Onion Family	Beets, Carrot, Lettuce, Cabbage Family, Summer Savory	Beans, English Peas
Parsley	Tomato, Asparagus	
Pea, English	Carrots, Radish, Turnip, Cucumber, Corn, Beans	Onion Family, Gladiolus, Irish Potato
Potato, Irish	Beans, Corn, Cabbage Family, Marigolds, Horseradish	Pumpkin, Squash, Tomato, Cucumber, Sunflower
Pumpkins	Corn, Marigold	Irish Potato
Radish	English Pea, Nasturtium, Lettuce, Cucumber	Hyssop
Spinach	Strawberry, Faba Bean	
Squash	Nasturtium, Corn, Marigold	Irish Potato
Tomato	Onion Family, Nasturtium, Marigold, Asparagus, Carrot, Parsley, Cucumber	Irish Potato, Fennel, Cabbage Family
Turnip	English Pea	Irish Potato

http://attra.ncat.org/attra-pub/complant.html

- "Mulberry may be interplanted with several crops: Prosomillet grown under mulberry could promote the growth of both species, but foxtail millet would have a negative effect on mulberry and promote the growth of harmful insects. Sorghum was not desired because it grew to about the same height as mulberry, resulting in each shading the other from the sun. Small bean, soybean, sesame and melons, however, are very suitable for interplanting with mulberry." Another kind of tree such as elm (*Ulmus pumila*) and Chinese tallow tree (*Sapium seligerum*) could not be utilized for interplanting because of their serious shading character. This was repeatedly warned in "Chimin Yaoshu" (6th c.) as well as in succeeding literature.
  Yung Dynasty (13th-14th c.): http://www.idrc.ca/library/document/090916/chap2_e.html

6) STRIP INTERCROPPING

Common crops used for intercropping systems include:

- Corn and Soybeans or Dry Beans. The method of alternating strips of corn and soybeans or dry beans have been used by farmers in temperate regions, as well as in Central and South America. "In the early 1950s, soybeans and corn were grown in alternating 2-row strips (91 cm row spacing) in Virginia (Alexander and Genter, 1962). In their experiments, corn in strips produced about 30 percent more than corn grown as sole crop, while soybean yields were not different. In

Maryland, Beste (1976) reported total system yields from 10 percent longer to 40 percent higher for strip cropping of sweetcorn and soybeans compared to sole culture of these two crops. Cunard (1976) found 20 to 50 percent higher yields for a system of high lysine corn and edible soybeans grown in strips compared to sole culture of the two crops."
http://www.eap.mcgill.ca/magrack/ajaa/AJAA_5.htm

- Corn-Bean-Squash. "Throughout Central America, a common intercrop of corn, beans, and squash is traditionally grown. Grown together, these three crops optimize available resources. The corn towers high over the other two crops while the beans climb up the corn stalks. The squash plants sprawl along the ground, capturing light that filters down through the canopy and shading the ground. The shading discourages weeds from growing."

- Corn-Sorghum. "Frank Cawrse, Jr. from Oregon, USA intercrops forage sorghum into his silage corn. He first plants the corn at 28,000 seed per acre, then goes back over the field with a drill with enough drop tubes closed off to plant 8 pounds of sorghum on 32 inch rows in between the corn. He also plants two different maturities of corn, a 95 day anda 75 day, to even out the silage moisture content. He harvests a mix of corn in hard dent and soft dent, and sorghum in the milk stage."

- Corn-Soybeans-Small grains. "South Dakota farmer Tod Intermill plants alternating strips of corn, soybeans, and spring wheat on his farm. The strips are six rows wide in a ridge-till system. All the crop plantings are adapted to existing equipment widths. Regular herbicide treatments can be applied using a ground sprayer of strip width. Even the wheat is drilled on ridges, using a drill with individual depth gauges on each opener. Intermill orients his rows east and west to minimize shading effects of taller crops like corn. The crops are planted in a wheat-corn-soybean pattern with soybeans on the north side of the corn. This arrangement reduces the effect of corn shading often associated with a straight corn-soybean pattern, since the wheat is mature before the corn has a chance to shade it. Corn gains the greatest benefit from the additional sunlight interception on the outside rows of the corn strip."

  http://attra.ncat.org/attra-pub/intercrop.html

ACTIVITY: Ask the farmers to individually work on the following worksheet.

Crops grown in the past: _____

_____

Others I might try: _____

_____

Total workable acres: _____

Definite requirements: (crops and number of acres of each needed to meet livestock feed *or* historic crop marketing requirements): _____

_____

_____

First possible crop rotation sequence:

_____

_____

Number of years this sequence: _____

Number acres per year: _____ (total workable acres/number of years)

To evaluate this crop rotation sequence fill in the charts on the following page.

1. Calculate total acreages of each crop per year.
2. Compare to requirements.
3. Assess for soil building capabilities, timing of planting, nitrogen use, weed control, field sizing. Do any acreages require a separate rotation?
4. Use chart on next page. Repeat with various sequences until the numbers are satisfactory.
5. Group or divide your fields into units that match the number of acres per year of rotation.

Crop Rotation Sequence Worksheet

Example Chart:

Year	Crop	Acres	Overwinter	Tillage/Manure
1	Spelt	25	Oil Radish	
2	Oats	25	Rye	
3	Rye	25	Red Clover	

Crop Rotation Planning Chart - Initially just fill in first 3 columns.

Year	Crop	Acres	Overwinter	Tillage/Manure
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Requirements for Farm - Test sample rotation for ability to meet farm needs

Acres Required	Crop	Acres from Trial Rotation