Production Practices for Annual Crops

1. Land Preparation

   It is done in accordance with the requirements of the crops, whether they grow under dryland or wetland systems. The two systems of land preparation and water management (wetland and dryland) have contrasting features in terms of its physical, biological and chemical nature of soils.

   Before seeding, the land is prepared by the process of tillage. Tillage is the manual or mechanized manipulation of the soil to provide a medium for proper crop establishment and growth. There are several purposes of tillage, the major ones are:

   1. Land Leveling – Land is leveled for several purposes.

   2. Seedbed preparation – In order for germination to occur, the seed must make good contact with the soil to be able to imbibe moisture. Seedbed preparation is done according to the seed characteristics, especially size. The fineness of the soil after tillage is called its tilth. A fine tilth is required for seeding small-sized seeds.

   3. Incorporating organic matter and soil amendments. Stubbles left after crop harvesting can be mixed in the soil to improve its physical characteristics. Fertilizers, organic and inorganic and soil amendments such as lime, may be added to the soil during the preparation prior to seeding.

   4. Weed control. Weeds compete with crop plats for growth factors and may harbor diseases and insect pests. Weeds are controlled at various stages in crop production.

   5. Improve soil physical condition. Soil texture and structure are important in crop production. Soils structure can be destroyed with time, because of a variety of reasons. Heavy traffic (vehicles, farm animals, humans) can compact the soil and create an impervious soil barrier called a hard pan. Tillage can be used to break up the hard pan for crop root growth and development.

   6. Erosion control. Tillage may be conducted in a certain way to provide a rough soil surface to impede the actions of the agents of soil erosion (conservation tillage).

   7. Shaping soil. Tillage is used to crate raised beds for planting ort to crate furrows for irrigation.

Tillage Systems

Tillage systems describe the nature and sequence of tillage operations used in preparing a seedbed for planting. Tillage systems differ in the degree of the oil stirring and nature of the finished product. The two classification of tillage are:
1. Conventional tillage. In conventional tillage the field is stirred up to a certain depth (called plow depth) using various kind of implements. The final condition depends on the purpose of tillage and the crop to be produced. Conventional tillage incorporates two basic methods: a) clean tillage (no debris or plant remains are left on the soil surface) or 2) mulch tillage (some debris are left on the soil surface).

There are three general steps in conventional tillage, namely:

a. Clearing the land to remove large pieces of debris, and trees and shrubs to facilitate the use of tillage implements.

b. Primary tillage. The mechanical manipulation of the soil that produces less than 15% of the oil covered with plant residue. The top soil is stirred up to a depth of 6 to 14 inches, and inverted, burying the vegetation and debris on the soil surface. The time of primary tillage depends on the soil type, soil moisture, climatic conditions and the time of seeding the crop. The depth of tillage also depends on the amount and nature of the plant residue on the soil, soil type and the farmer’s preference.

The primary tillage implements used are: 1) moldboard plow, disk plow, chisel plow, powered rotary tiller, sweep plow (also called stubble mulch plow), and lister/bedder (for ridges or beds).

c. Secondary tillage. The mechanical manipulation of the soil to produce a finer tilth for preparing a seedbed, usually follows primary tillage. It is done at a shallower depth from 2-6 inches. The implements pulverize the clods left by primary tillage. These farm implements include the disk harrow, harrow, and field cultivator

Conventional tillage has advantages and disadvantages that include the following:

Advantages:
1. It is the most convenient method for managing soil compaction.
2. It is easier to apply fertilizers and perform other operations when the land is clean.
3. The lack of crop residues reduce hibernating pests.

Disadvantages:
1. Erosion. The soil is exposed to agents of erosion.
2. Compaction Excessive and repeated use of farm implements predisposes the soil to compaction.

2. Conservation tillage It is a basic tillage strategy that entails practices in which some crop residue remains on the soil surface after the operation. The chief goals of conservation tillage are: 1) to reduce soil erosion and 2) conserve moisture. Conservation tillage is sometimes called crop residue management. The common types of conservation tillage include: 1) no tillage, 2) mulch tillage, 3) strip tillage, 4) minimum tillage, and 5) ridge tillage.

No tillage or zero tillage. A system of cropping whereby a crop is seeded directly into a seedbed not tilled since the harvest of the previous crop.

Mulch tillage. A system that leave crop residue to serve as mulch, as in stubble-mulch tillage that aims to conserve moisture and to protect the soil from wind and water erosion by leaving crop residues on the soil surface.

Strip tillage. It is also called strip-till or zone tillage. It entails the disturbance of narrow strips in the soil where seeding is done. The interrow zone remains undisturbed and covered with crop residue.

Minimum tillage. It involves considerable soil disturbance but to lesser extent than conventional tillage. Some crop residue is left on the soil surface. Minimum tillage is also called reduced tillage.

Ridge tillage. A small band of soil on the ridge is tilled. The soil from the top of the ridge is mixed with crop residue between ridges. The debris reduces soil erosion and increase water retention.

Conservation tillage has advantages and disadvantages that include the following:

Advantages:
1. Reduces soil erosion from wind and water.
2. Reduces soil compaction.
3. Applicable to steep slopes.
4. Soil infiltration and moisture conservation.
5. Reduces cost of tillage.
7. Increase soil organic matter.
Disadvantages:
1. Dependence in chemicals due to less stirring of the soil.
2. Cost for special planters for no till seeding.
3. Higher risks of insect pests and pathogens in early crop establishment due to soil born pathogens and soil surface insects.
4. High soil moisture increases leaching of water soluble base such as nitrate.
5. Crop residue impedes fertilizer application.
6. High level of herbicide use due to new weed problems.

Tillage Direction
The right direction in plowing, harrowing and sub-soiling should be observed to reduce the overall cost of farm operation. In flat lands, tilling following the longer side direction is done for faster operation to minimize wear and tear of machineries and to reduce fuel and oil cost.

In slightly sloping areas, plowing along the contour of the land is done to prevent soil erosion.

Jetro Tull is considered as the father of modern tillage

Characteristics of a well-prepared upland field
1. Granular, mellow yet compact enough so that seeds are in close contact with the soil for better germination;
2. Free of trash or vegetation;
3. Field is level, with minimum depressions where water may accumulate

Soil moisture as a factor for land preparation of upland fields
1. Tilling the soil when it is too dry increases power requirements and the likelihood of implement breakage;
2. Tilling soil when too wet promotes soil compaction, reduces soil granulation, lengthens land preparation;
3. The ideal soil moisture content is at a level below field capacity (the moisture content after soil has been saturated and allowed to drain for 1-3 days).

Practical indicators are: 1) soil should slide freely from the moldboard 2) soil is friable and breaks easily, 3) a fresh cut surface should not glisten with moisture.

Tillage equipment for upland operations
1. Carabao or bullock drawn
   a. moldboard plow cuts a depth of 9.8-15.2cm
   b. native spike tooth harrow (kalmot) – made of bamboo or steel bars
2. hand tractor drawn equipment (moldboard or disc plow and rotavator)
3. tractor-mounted implements (four-wheeled)
   a. moldboard plow – cuts, inverts and breaks furrow slices and turns under surface weeds, crop residues, and trash; cut ranges from 15-30 cm
   b. disc plow – cuts the soil without inversion of furrow slice; cut ranges from 15-20 cm
c. disc harrows – the disc cuts the soil and crop residues while the trailing edge can raise soil and push it to one side
d. rotavators – with a set of cutting knives which rotates vertically at high speed that initially cut the soil and crop residues
e. mower – for grass cutter for cutting into small pieces standing stubbles
f. subsoiler – used to break hard pans to improve internal drainage of the soil with a penetration of 51-91 cm
g. furrower or ridger – it resembles a double mounted moldboard, joint together at the middle used for setting furrows where seeding or planting of seeds/seedpieces is done manually

Sources of power for upland tillage
1. ox or bullock is preferable in upland conditions than the carabao because it can withstand heat better
2. hand tractors
3. four-wheeled tractors

Land Preparation Under Submerged Conditions

This requires at least one plowing and two harrowing ands leveling operation, all done in a muddy or puddle condition. The series of activities include:

1. fixing dikes to improve water impounding
2. soaking paddies with water 2-3 days before plowing/rotavating
3. harrow the area 7-10 days after plowing with a combed tooth harrow
4. 7-10 days after harrowing, level the field with a planer or leveling board, then marking using a planting board

Harrowing and leveling at 7-10 days should be done until the weeds are decomposed ad if rotavator is used, there is no need to plow the field.

Tillage Operation for upland (dryland) condition:
A. Plowing to cut the soil into furrow slices, to pulverize the soil and to incorporation weeds and stubble underneath the soil using a carabao drawn moldboard plow or a tractor drawn implement.

B. Harrowing to pulverize the clods left after plowing, to level the field, to compact soil to a certain degree and to destroy weeds as they start to grow. Harrowing is done 2-3 times using a native spike tooth harrow or a tractor drawn farm implement.

The number of plowing and harrowing depend on the soil type, weed density and moisture content of the soil.
A well prepared upland field is granular, mellow yet compact enough so that the seeds are in close contact with the soil for better germination, free of trash or vegetation and the field is leveled.

B. Planting Material, Selection and Preparation

Definition of Terms:
- Planting materials: seeds, setts, seedpieces, propagules
- Seeding rate: number of seeds to be planted in a given hill or linear meter
- Population density: the amount of seeds planted in a given area
- Furrows: an opening in the soil where the seeds are planted
- Basal fertilizers: fertilizer materials before the seeds are placed

Planting materials for row planting
1. Seeds: all grain crops (legume and cereals), forage grasses and legumes; fiber crops (jute, ramie, cotton)
2. Vegetative materials:
   - Stem cuttings: sugarcane, sweet potato, cassava, forage grasses
   - Tubers: Irish potato, yams
   - Bulbs: multiplier onions, garlic
   - Corms: taro (gabi)
   - Rhizomes: ramie, ginger

Characteristics of planting materials:
1. adaptability to the area where it will be planted
2. high yielding ability
3. purity
4. quality of products for market
5. disease and insect resistance

For good seeds, it must have the following qualities:
1. strong germination
2. proper size and development
3. uniformity
4. freedom from seed-borne diseases
5. freedom from noxious and other weeds
6. high purity
7. freedom from mechanical injury

Pre-germination treatments

1. Use of fungicides as protectant against fungal diseases of crops at seedling stage
   - Vegetables and legume seeds – Captan, Arasan
   - Corn seeds – Metalaxyl (Apron 35 SD) against downy mildew as a very effective method of chemical control discovered by Dr. Efelio Exconde
2. Vernalization or cold treatment to enhance germination. e.g. gladioli, the corm is vegetative and dormant – dormancy of freshly harvested gladioli corm at 35oF at high RH is required to prolong its dormancy to 12-18 months; a period of storage of 4-6 months at below 40oF.

GA3 can be used as a substitute for vernalization by soaking the corms in a solution at 500-2,500ppm for 12 hours.

To induce cabbage, onions, and radish to flower for seed production purposes, vernalization or subjecting seeds to refrigeration temperatures before planting will help.

3. Seed inoculation – Soybeans, peanuts, and mungo seeds are treated with rhizobia wherein seeds are coated with the inoculants by wetting the powder and mixing the seeds thoroughly but inoculated seeds should not be exposed to sunlight.

4. Preparation of vegetative planting material

Cassava – use mature stems; 7 months old; 20-25 cm long; viable for 5 months if properly stored

    Sugarcane – top portion of stem with 3 nodes
    Sweet potato and kangkong – 25-30 cm long, tip cuttings preferred
    White potato – tuber cut into seedpieces, with a bud in each portion and treated with methoxyethyl mercury chloride (MEMC)

Recommended varieties of crops

In the Philippines, there are a number of public institutions and private seed companies that undertake research and development relating to varietal improvement of major crops. To rationalize the release of varieties emanating from different sources, a system of coordinated ecological trials has been in operation since 1955 under the aegis of the Philippine Seed Board (PSB) now renamed as the national Seed Industry Council (NSIC).

The recommended varieties of crops are only those that have been grown widely in the country which include the following:

1. Rice : breeding institutions are IRRI, UPLB, DA-BPI and DA-Philrice
   a. lowland varieties – C4-63, BPI-76, IR 36, IR 42, IR 64, IR 66 (with salinity tolerance), PSB RC 2, PSB RC 4, PSB RC-6, IPS RC 8, PSB RC 10, PSB RC 12, PSB RC 14.; F-1 hybrids: PSB RC 26H, PSB RC 72H released by PhilRice
   b. lowland glutinous varieties: IR 29, UPL Ri-1, UPL Ri 3, IR 65
   c. rainfed lowland: IR 46, IR 52, UPL Ri 2
   d. upland varieties: C-22, IR 45, UPL Ri 5 (with acid sulfate tolerance), UPL Ri 7, PSB RC 1, PSB RC 16 (Ennano)

2. Maize – The institutions involved in varietal improvement are IPB-UPLB, DA, and USM. The major private companies are: Pioneer Overseas Corp-Phil; Cargill Phil, Inc, Ayala Agricultural Development Corporation, BM Domingo and Co., Inc. or Corn World Breeding System Corp, and Asian hybrid Corporation.
   a. open-pollinated varieties – yields 5-6 tons per hectare
a.1 Yellow corn – IPB Var 1 (Ginintuan), IPB Var 5, IPB Var 7, BPI LG Comp 1, USM Var 3, USM Var 5, USM Var 7; IES Cn 3
a.2 white flint types – IPB Var 2 (Tanco White), IPB Var 4, USM Var 10, USM Var 12, IES Cn 6; CMU Var 2
b. F-I hybrids – Pioneer 3228, SMC 305, SMC 301, IPB 911 (single cross), IPB 947 (3 way cross), etc.

3. Tropical wheat: Trigo 1, Trigo 2 and Trigo 3 (yields 1.6-1.8 tons/ha as grown in Northern Luzon)

4. Sorghum – UPL Sg 5 (Cosor 5), PSB Sg 93-01 (USMARC 104), PSB Sg 02 (IES Sor 1), PSB Sg 94-02 (IES Sg 2)

5. Sugarcane – The agencies involved in the breeding work are the Sugarcane Regulatory Administration (SRA) and the Victorias Milling Corporation (VMC).

Recommended varieties: Phil 66-14, Phil 56-226, Phil 72-70, SRA 80-13, SRA 85-83, VMC 71-39, VMC 711-238, VMC 73-229

6. Rootcrops (with VisCa, IPB-UPLB)
   a. Cassava – UPL Cv 3 (Sultan 1), UPL Cv 4 (Vassourinha), UPL Cv 5 (Sultan 2), UPL Cv 1 (Datu 1), UPL Cv 2 (Lakan 1); Lakan 2, lakan 3, Lakan 4, PSB Cv 9, PSB Cv 10
   b. Sweet potato – UPL Sp 1 (Kinabakab), UPL Sp 3 (Tinipay), UPL Sp 5, UPL Sp 2, UPL Sp 4 (Cambel), UPL Sp 6, PSB Sp 16 (VisCa), PSB Sp 17 (VisCa)
   c. Taro (Gabi) – PSB Vg 2, PSB Vg 3
   d. Yam (Ubi) – PSB Vt 2, PSB Vt 3

7. Grain legumes
   a. Mungbean – MG 50-10A, Mg 1 (Pag-asa), UPL Mg 3 (Pag-asa 3), UPL Mg 5 (Pag-asa 5), UPL Mg 7 (Pag-asa 7), etc.
   b. Peanut – UPL Pn 2 (Mekong), UPL Pn 4 (Biyaya 4, UPL Pn 8 (Biyaya 8), etc.
   c. Soybeans – UPL Sy 4 (Tiwala 4), UPL Sy 6 or PSB Sy 2 (Tiwala 6), BPI Sy 4, PSB Sy 3 (La Granja)

8. Cotton – UPL Ct 1 (Batac 1), UPL Ct 2 (Batac 2), CRDI-1, PSB Ct 6

9. Kenaf – UPL K-1

10. Vegetables. The breeding institutions are: IPB-UPLB, DA, East-West-Phil, Kaneko Seeds-Phil.
    a. Pole sitao – UPL PS 1 (Sandigan), UPL PS-2 (Ana), CSL 15, BPI PS 3
    b. Bush sitao – UPL BS 3 (Sumilang), PSB B2-2
    c. Cowpea – UPL Cp 1 (Sagana), UPL Cp 3, UPL Cp 5 (Magbunyi), UPL Cp 9 (Juliet), BPI Cp 4, BPI Cp 3
    d. White potato – T-204 (Banahaw), Arka, Siro, Kennebec, Up-to-date, Conchita, Cosima
    e. Cabbage – F-1 KK Cross, F-1 KY Cross (heat tolerant), Marion market, F-1 Princess #39, F1 Stone Head, YR Summer 50
f. Tomato – UPL Tm-1 (Marikit), UPL Tm 2 (Marilag), UPL Tm 6 (Maligaya), Improved Pope  
g. Eggplant – UPL Eg 11, Dumaguete Long Purple, Dingras Multiple Purple #1, EG Long Purple  
h. Onion - Red Globe, Excel, Yellow Granex  
i. Cauliflower – Early Patna  
j. Chinese Cabbage – Esperanza, Corazon, Reyna Elena  
k. Cucumber – UPL Cu-1 (Pilipinas), UPL Cu 6 (Pilmaria), UPL Cu-2 (Pinagpala), Explorer, Panorama  
l. Garlic – Ilocos Purple Shank, Ilocos White Shank, Batangas Strain  
m. Lima Bean – Kentucky Wonder, Habas, Sugar Mammotj  
n. Honey Dew Melon – Tan Dew, Honey Dew  
o. Pechay – Black Behi  
p. Watermelon – Sugar Baby

PLANTING PRACTICES

Crop productivity begins with good crop establishment, which is a factor of seed quality and favorable environment. In addition to seed quality, seeding should be conducted such that land use is optimized and this is accomplished by adopting appropriate plant distribution or spacing in the field. Appropriate seeding enables plants to develop optimally without adverse competition for high productivity.

1. Seed Analysis. A good crop starts with a good quality seed and a good crop stand and establishment depends on the quality of seed planted and the conditions under which the seed was planted.

   Seed testing is a procedure for gathering pertinent information about a seed, its capacity for establishing a stand of seedlings. There are several methods of seed viability testing, namely:

A. Standard Germination Test

   1. Rug doll method or rolled-towel test. Seeds are arranged in rows and rolled up. The rolled material is placed in a germinator at 90% RH at 26°C for 16 hours, then another 8 hours at 30°C for one to several weeks.

   2. Seedbox method. Seeds are sown in previously sterilized soil.

   3. Petri dish method. Seeds are placed in absorbent material in the dish.
Scoring is done by grouping seedlings into categories as normal, hard seed (no imbibition), abnormal (malformed) and dead or decaying seed.

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\text{% Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100
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B. Tetrazolium Test.

It is a colometric test in which the biochemical reaction causes the test solution to change color under certain conditions. Certain enzymes become active when viable seed (living tissue) imbibe water (hydration) and start respiration. Hydrogen ions are released when the dehydrogenases act on the substrate (seed tissue such as cotyledon). T-Z test (2,3,5 triphenyltetrazolium chloride) solution is colorless but changes into a red insoluble compound called a formazan upon being reduced by hydrogen ions. Respiring and viable seeds will change color to red; dead or non-respiring seeds remain colorless. T-Z test is quick and reliable. Seeds are first soaked in water for 24 hour, dissected longitudinally through the embryo, ten the halves are soaked in 0.1% TZ chloride for one hour. However, the test is difficult to score and interpret correctly.

II. Seed Purity Test

Seed Purity is the percentage pure seed (only the seed of the desired kind without contaminants) in the sample tested. Contaminants include the following:

1. seed of other crops (seeds other than the desired crop seed for planting)
1. weed seeds
2. inert matter (foreign matter such as small stones, pieces of wood and other plant materials)

III. Field Seeding/Planting

Types of Planting Materials

1. Seeds – all grain crops, vegetable crops, forage grasses and legumes, and fiber crops
2. Vegetative materials
Stem cuttings (sugarcane, sweet potato, cassava, forages grasses)  
Tubers (white potato, yam)  
Bulbs (multiplier onion, garlic)  
Corms (taro, yautia)  
Rhizomes (ramie, ginger)

Preparation of Vegetative Plant Materials

Many field crops are direct seeded (cereal grains, grain legumes, forage crops, oil crops and fiber crops). The seeds are placed where they will grow and develop until maturity. This is opposed to transplanting where the seedlings are raised in nurseries and then transferred to permanent locations in the field. Tree crops and many vegetables are transplanted. However, some vegetables may be direct-seeded.

After selecting the appropriate cultivar and preparing the seedbed, the producer has to determine the depth of seed placement, plant density, plant arrangement, time of planting and method of planting.

A. Depth of Seed Placement. It is influenced by several factors such as: seed size, type of seedling emergence, soil type and depth of soil moisture available.

A.1. Seed size. Small seeds are planted at shallow depths.

A.2 Type of seedling emergence. Species with epigeal germination need to emerge above the soil to commence seedling establishment hence should not be planted too deeply for seeds may rot in the process.

A.3 Soil type. Seed placement in heavy soils (clay) should be shallow. For light soils (sandy), shallow planting is necessary because it is prone to drying.

A.4 Depth of soil moisture available. It is related to soil type and seeds placement should be dependent on the type of soil to be planted.

B. Estimation of Required Plant Population Density

Plant density is determined by the seeding rate of a crop or the number of established plants per unit land area.

Plant population density is computed as follows:

1. Hill Method
NP = area (square meter) or 
S2

No of plants/ha = 10,000 square meters X no. of plants per hill 
DBR X DBH

2. Drill Method

Plants/ha = area X no. of plants per linear meter 
(1m)(DBR)

C. Plant Arrangement. It is influenced by some of the factors that influence plant density. Seeds may be distributed in the field according to predetermined, constant and uniform spacing pattern, or randomly distributed. Distribution pattern depends on seed size and production system.

There are two common categories of plant distributions:

a. random distribution is called broadcasting. Small-size seeds are distributed without pre-determined interplant spacing (wheat, oats, rice, forage grasses and forage legumes).

a. Structured/patterned distribution

b.1 Seed drilling is the planting of seeds with a mechanical seed drill (drum seeder for rice)

b.2 Row planting entails more accurate spacing between seeds in a row and between rows

   b.2.1 drill planting – seeds are placed individually at predetermined spacing between adjacent seeds in a row common to row crops.

b.2.2 hill drop – two or more seeds are placed in a group in one planting hole or spot called hill.

Preparation and Selection of Rice Seeds

There are four classes of rice seeds available, namely:
1. breeder seeds – purest seeds and controlled by plant institutions or plant breeders. It is planted to produced foundation seeds. It has a white tag.

2. foundation seeds – multiplied from breeder seeds and is planted to produce registered seeds. It has a red tag.

3. registered seeds – are progeny of the breeder or foundation seeds and the source of the certified seeds with a green tag.

4. certified seeds – available in large quantities and are sold commercially to farmers, has a blue tag.

Good seeds – seeds produced from certified seeds which are widely available at village levels

Methods of Raising Rice Seedlings

1. wetbed method – seeds are sown raised beds with continuous irrigation water and seedlings are ready for transplanting in 25-30 days

2. dapog method – pre-germinated seeds are sown in cemented or puddle soil covered with banana leaves or plastic sheet. Seedlings are ready for transplanting in 10-14 days.

3. dry-bed method – It is only applicable for rainfed areas wherein seedbeds are prepared followed by sowing of seeds. Seedlings are ready for transplanting in 20-40 days.

Transplanting Distances

Using a planting board to mark the distance of planting, there are three methods of planting rice seedlings:

1. square method – Two to three ordinary rice seedlings or 4-6 seedlings for dapog method shall be planted at a distance of 20cm x 20cm or 25cm x 25 cm.

2. wide rows, closer hills – Rice seedlings are spaced at a distance of 40cm x 5 cm with 1 seedling per hill or 30cm x 30 cm with 2 seedlings per hill

3. double row method – alternation of 20cm and 40 cm row spacing with hills 10cm apart and 2 seedlings per hill
Direct Seeding on Puddled Field

Seeds are pre-emerged and the seed requirement is 100-125 kg per hectare.

There are several methods of seeding rice in a puddle field, namely:

a. broadcast (with herbicide application)

b. drill – Pre-germinated seeds are sown in rows with spacing at 25-30cm using a rice drum seeder at the rate of 50-100 kg per hectare

c. dibbling – Pre-germinated seeds are dibbled in straight rows and in hills at 15cm x 15cm to 25cm with 5-8 seeds per hill.

Dryland Seeding of Lowland Rice

Non germinated seeds are sown in unpuddled soil by broadcast method followed by a single pass of a spike toothed harrow along the furrows to cover the seeds. An “inverted T-seeder” may be used to drill the seeds in straight rows.

Water Requirements of Crops

Water Requirements of Crops – refers to the total amount of water that is required to bring a Crop to complete its growth cycle, from germination to full maturity.

  e.g. to produce 1 kg of rice, 5000 L of water
  1 kg of corn, 1,400 L of water is required

To determine irrigation requirement of a crop, an estimate of the “consumptive use” of water by crops or the amount that is lost through evaporation and transpiration should be obtained.

  Evaporation - loss of soil water
  Transpiration – loss of water in leaves
  Seepage and percolation – loss of water during irrigation
  Seepage – lateral subsurface water movements
  Percolation – vertical subsurface water movement

Seepage and percolation are affected by:

1. soil texture and structure
2. soil permeability
3. depth of hardpan and impervious layer
4. extent of soil puddling

Rate of evapo-transpiration in the Philippines - 2-5mm/day for wet season and 4-9mm/day for dry season

Water requirements of plants of different stages:

1. seedling – adequate moisture for germination and early seedling establishment

2. vegetative period – adequate amount of moisture during the succeeding 3-4 weeks of rapid vegetative growth

3. reproductive stage – at flowering is the most critical period and moisture should be in adequate amounts (e.g. rice)

4. seed filling stage – critical in seed development; lack of moisture in the soil will result in reduced seed yields

5. ripening stage – 2-3 weeks prior to harvesting when irrigation is no longer needed

Methods of water application for lowland rice:

1. continuous submergence – from 2 weeks up to about 2 weeks before harvesting
2. intermittent – paddy fields are alternately flooded and drained; soil surface is allowed to dry before the next water application is made

Sources of water for lowland rice fields:

1. rainfall – for rainfed lowland rice fields, bunding paddies to impound water
2. surface water from streams and rivers
3. river diversion system – e.g Magat Dam (Region II), Pantabangan and Angat Dams (Region III)
4. small farm reservoirs - reservoir is found in elevated portion to irrigate the field
5. ground water - use of tube wells and shallow tube wells
Pump Irrigation

Pump systems - is used to lift water from surface sources such as canals, rivers and streams or from water table and underground sources.

Types of mechanical devices for transferring water:

1. hydraulic ram – gravity operated device that can be used to raise part of a large amount of water available at some elevation to a higher elevation, e.g. 20 feet. It is gravity operated, hence no fuel or electricity is necessary.

2. axial flow pump or propeller pumps – the propeller is submerged in the water source and provides a lifting action of the water to as high as 4 meters. The propeller is coupled to an engine or belt-driven by a power tiller. The “sipa pump” is a pump designed for low-lift application of 1 to 3 meters which uses an improved boat-type propeller.

3. Shallow-well centrifugal pumps or “suction lift” pumps – the pump is located above the well and takes water from the source by suction lift. Pumps operate within the limit of 7m of water depth.

The types of shallow-well pumps are:

a. watt-miser electric pumps – are small self-priming electric pumps that can provide supplemental irrigation for 1-3 ha of rice using a matching single phase electric motor from 0.5 to 1.5 hp. The pumps are connected to an electric power source of 115/230 v.

b. centrifugal pump – is run by an engine to operate a shallow tube-well at depths of 6-7 m of aquifer. Shallow tube-wells do not require the installation of the casing.

4. Deep well or “submergence” pumps – these are installed within the well casing (of 4” diameter) and with the pump inlet submerged below the pumping level through a shaft. The motor or engine is located at ground and drives the submersible pump through the shaft. The water is raised through a tube enclosed within the well casing. It operates beyond the limit of suction lift pumps and at depths beyond 100ft.

Five general ways of applying Irrigation water:

1. flooding – wetting all land surfaces
2. by furrows – wetting part of the ground surface
3. by sprinkle – same way as rain
4. sub-irrigation – surface is wetted a little
5. localized – water is applied at each plant at daily rate
Choice of irrigation – depends on the slope of the land, crops to be irrigated, source of water supply, permeability of the soil and its water holding capacity

Methods of irrigation in the Philippines (and other countries):

1. Border strip irrigation – the fields are divided into strips that are bounded by low levees or dikes. The slope down the length of a strip should not exceed 3% (3 feet drop per 100 feet) and the slope across the strip should not exceed 1%. Strip dimension are 5-15 m in width and 75-100m in length. The water is spread over the strip but it is not allowed to accumulate for long. This system of irrigation is period and is used for pasture and upland grain crops (upland rice for export).

2. Basin or paddy irrigation – Water is applied to level plots surrounded by dikes or levees and leveled following the topography of the land.

3. Furrow Irrigation (dryland areas) – For areas planted to potatoes, vegetables and corn wherein water runs down the furrows between row of plants

4. Irrigation of dryland crops after lowland rice – For vegetables/spices like onions, garlic, tomatoes, cotton, soybeans, peanuts, maize, tobacco, and watermelon usually using irrigation structures plus temporary farm ditches to convey water to areas planted to crops.

5. Aerial irrigation – Sprinkler irrigation used on most crops and over a wider range of topography, flat or rolling to a slope of 12%. These are used in irrigating corn, sugarcane, and banana, particularly the hand-moved portable lateral system or the center-pivot sprinkler.

6. Trickle irrigation – This was developed in Israel and the most commonly used type is the “drip” irrigation where water is slowly applied directly and only to the soil immediately surrounding each plant. It has been used in growing vegetables, and flowering plants in greenhouses and fruit trees.

Soil Fertility Management

Crop Nutrition – very important contributing factor to increase production nutrient should be present in proportionately balanced condition, and if any one elements is lacking, it should be made available in the soil. Plants absorb significant amounts of macro-nutrients (N, P, K, Ca, Mg, S) and trace elements (Fe, Mn, B, Cu, Zn, Mo, and Cl) from the soil during their growth period. These nutrients should be present in a proportionately balanced condition and if any one element is lacking, it should be made available to the soil.
Manipulative ways to maintain soil fertility:
1. adoption of agronomic practices that would return crop residues to the soil
2. use of animal and green manure and chemical fertilizers
3. Correction of soil acidity
4. Enhance cation exchange capacity of soils
5. Correct methods and timing of fertilizer application to prevent leaching

Fertilizer Application Methods

1. broadcast – application of fertilizer be done at final harrowing, done either by hand or with the use of a “cyclone spreader”
2. band application - fertilizer is applied in a strip 2-3 cm beneath and to the side of the location of the seed during seeding.
3. sidedressing and topdressing
   sidedressing – placement of fertilizer along the rows near the base of the plant
   topdressing – N fertilizers are applied to juvenile crops wherein fertilizer is broadcast over the growing plants
4. localized placement – placement of fertilizer-centered mudballs in flooded soils wherein one mudball (urea) is plunged 10-12 cm deep for every four rice placed spaced at 20 x 30cm which are applied immediately after transplanting
5. foliar application – involves dissolving the fertilizer material in water and applying it as a spray to plants which is effecting in correcting trace element deficiency at critical stages of the crop.

Other sources of nutrients:
1. organic fertilizers (compost) 1-7%N, 2-13%P2O5 and 1-10% K2O from plant and animal sources

   Trichoderma harzianum – speed up decomposition of compost materials (1 ton of compost material needs 10 kg of Trichoderma inoculum)

2. green manure – biomass produced by a N-fixing legume crop, plowed under at ear flowering time to serve as source pf nutrient to the succeeding crop

3. azolla (Anabaena azolla) – water fern that grows symbiotically with blue-green algae; can produce 30T/ha in one growing season equivalent to 150 kg of N/ha
Liming – application of lime to correct soil acidity; Ideal pH range is from 6.0 - 6.5

Calcic limestone is the main liming material in the Philippines. It should be done at least one month before planting the crop. Lime materials be mixed with the plow layer (15-30cm deep) by plowing and harrowing.

Pest Management

Causes of crop losses or reduction in yield:
1. damaged caused by weeds
2. insect
3. pests and diseases.

In pest management, indiscriminate and careless use of farm chemicals should be avoided, and if possible, biological and sound management practices should be an integral part of the overall control strategy (integrated pest management).

A. Weed Control Management

Weeds cause 34% reduction in transplanted rice; 45% in direct seeded rainfed rice and 67% in upland rice.

Classes of weeds:
- a. grasses (Graminae) – e.g. cogon (Imperata cylindrica)
- b. sedges (Cyperaceae) – e.g. Purple nutsedge (Cyperus rotundus)
- c. broadleaves (Angiospermae) – e.g. Hagonoy (Chromolaena odorata)

Common weeds of lowland and upland fields
1. Associated with lowland rice
   Annuals:
   - Sedges – Cyperus difformis, C. iria
   - Grasses – Echinochloa glabrescens; E. crusgalli (barnyard grass)
   - Broadleaves – Monochoria vaginalis, Ludwigia octovalvis, Schenoclea zeylanica

   Perennials:
   - Grasses – Cynodon dactylon, Paspalum conjugatum
   - Sedges - Scirpus maritimus
2. Common weeds in upland crops

Grasses – Gramineae family
a. Dactyloctenium aegyptium (Krus-krusan)
b. Eleusine indica
c. Pasplaidium flavidum
d. Rottboellia exaltata (Auingay or itchgrass)
e. Imperata cylindrical (cogon)

Sedges – Cyperaceae family
a. Cyperus rotundus (Mutha)
b. Cyperus iria

Broadleaved weeds
a. Ageratum conyzoides (bulak manok)
b. Celosia argentina (kadayohan)
c. Cleome rutidosperma (silisilihan)
d. Euphorbia hirta (Gatas-gatas)
e. Heliotropium indicum (Buntot-leon)
f. Ipomoea triloba (Kamotikamotihan)
g. Mimosa pudica (Makahiya)
h. Portulaca oleraceae (Ulasiman)
i. Amaranthus spinosus (Uray or Kulitis)

Methods of weed control in rice fields:
1. thorough land preparation
2. continuous flooding
3. handweeding and use of rotary weeders
4. use of herbicides

Methods of weed control for upland fields:
1. thorough land preparation
2. combination of “offbarring” and “hiling-up”
3. interrow cultivation (for wider spacing, 50-75cm using animal drawn “lithao”)
4. handweeding and hoeing
5. mulching – cut grasses or crop residues, black plastic film
6. use of herbicides

Methods of weed control:
a. handweeding – the minimum time of weeding for some crops are:
1. Transplanted rice (with continuous submergence) – 1 handweeding at 35-42 DAT plus 1 rotary weeding at 60-65 DAT
2. Direct seeded (drilled), pre-germinated, irrigated rice – 1 handweeding at 20-21 DAS plus one rotary weeding at 42-43DAS
3. Dry-seeded (drilled) lowland rice – 1 handweeding at 21-25 DAS, 1 rotary weeding at 42-43 DAS and another rotary weeding at 63-64 DAS
4. Upland rice – 1 handweeding/hoeing at 21-22 DAS, another handweeding at 42-43 DAS or interrow cultivation and another handweeding at 63-64 DAS

b. Intertillage operations

b.1. Offbarring – plow is plowed along the side of the row, throwing soil slice away from plants
b.2. Hilling up – soil slice is thrown towards the base of the plants
   - Corn – offbarring – 14-18 DAS; hillling-up – 26-34 DAS
   - Sugarcane – offbarring – 30DAT; hillling-up 40 DAT

c. Chemical weed control – use of herbicides; should be used with great caution; are applied directly to the soil or to leaves of plants

Herbicide Applications:
1. Pre-plant – applied before the crop is planted and incorporated with the soil at 15-20 cm depth to prevent volatilization or UV degradation
   - e.g. Trifuralin
2. Pre-emergence – applied shortly after the crop has been planted but prior to crop emergence; applied 2 cm of the soil surface but soil must be wet
   - e.g. Atrazine
3. Post-emergence – is selective or non-selective and applied after the weeds and crop have emerged from the soil

B. Insect Control Management

Integrated Pest Management (IPM) – a strategy in combating pest using integration of many components: varietal resistance, good cultural and sanitation practices; use of biocon, synchronous planting, and cropping patterns, crop rotation, use of trap crops, attractants, repellants and insecticides.

1. Varietal resistance – crops have been bred for resistance to pests
   - e.g. 15 rice varieties have increased level of resistant to borers; 9 varieties are resistant to BPH
2. Sound cultural practices: sanitation or removal of weeds, synchronous planting and crop rotation

3. Biocon – use of natural parasites, predators and parasites against pests
   e.g. Trichogramma evanescens – parasitizes eggs of corn borer
   T. chilonis – against cotton bollworm
   T. japonicum – against rice stem borers
   Bacillus thuringiensis – against corn borers, rice stem borer and DBM of cabbage
   Diadegma semiclausum – against DBM in cabbage
   Epidinocarsis manihoti – controls cassava mealy bugs

   *detasseling of corn (leaving 2 rows intact for every 4 rows) before pollen shedding to control corn borers

4. use of trap crops and intercropping – e.g. cabbage and tomato; white potato and corn

5. use of light traps, attractants (female sex pheromones) against adult moths and potato weevil

6. use of vertebrate biological agents – ducks against GAS and weeds

7. Use of insecticides

   Kinds of insecticides:
   a. contact insecticides – penetrates exoskeletons of insects; pose dangers to non-target and beneficial organisms (spiders)
   b. systemic insecticides – be applied on plants or to the soil in the presence of water in the soil

Classification of insecticides based on structure:

1. Organochlorines or chlorinated hydrocarbons – DDT, dieldrin, endrin, endosulfan, heptachlor, chlordane and lindane

   DDT – most widely used insecticide ever manufactured; discovered by Paul Mueller of Geigy Chemical Company in Switzerland. It was banned in 1972 in the USA and other countries.
2. Organophosphates – These are esters of phosphoric or phosphorochloic acid which are nerve poisons – e.g. phosdrin, dimethoate, malathion, parathion. These chemicals are non-persistent in the environment and do not bioaccumulate.

3. Carbamates – similar to the organophosphates and are widely used in agriculture, forestry, health, veterinary practice and in the homes.– e.g. carbofuran (Furadan), aldicarb, carbaryl and pirimicarb

4. Pyrethroids – has a synthetic structure resembling natural pyrethrins derived from pyrethrum flowers which are relatively safe to the spray operators – eg. Permethrin, cypermethrin and bioremethrin

5. Insect growth regulators – juvenile hormones which was first elucidated in 1967 which kills insects by inhibiting the molting process or interfering with chitin synthesis. – e.g. methoprene, fenoxycarb, benzoylphenyureas, diflubenzuron and chlorfluazuron

6. new classes of chemicals – for control of arthropods – eevernectins, chloronicotinyls, pyrroles, phenyrazoles and spinosyns.

7. Botanical insecticides – naturally existing compounds in plants which have insecticidal properties. Commercial products are extracted from plant sources.

Pyrethrum - from Chrysanthemum cinerariaefolium flower heads
Rotenone - from Derris elliptica or tubli
Nicotine - from Nicotiana tabacum
Azadirachtin – extracted from Azadirachta indica or neem tree

B. Disease Management

Plant diseases constitute one of the natural hazards in crop production. Disease are caused by bacteria, fungi, viruses, viroids and nematodes.

Components of disease control:
1. varietal resistance
2. sound practices such as timely planting (as in the case of downy mildew of corn), proper nutrition, sanitation, crop rotation, use of disease free planting materials
3. soil sterilization in seedbeds
4. biological control agents:

Paecilomyces lilacinus (fungus) – control against nematodes of white potatoes, bananas and citrus; commercial product is Biocon
Bacillus (China) – a bacterial fungicide; used to enhance yield of wheat, rice, corn, cabbage, turnip, rapeseed

5. Use of fungicides

Kinds of fungicides:

1. protective fungicides– as foliage and fruit sprays or dusts to keep disease-causing fungi from penetrating plants
   e.g. Zineb

2. eradicant fungicides– kills or inhibits fungi after they have penetrated the plants
   e.g. mercury chloride

3. protective and eradicant fungicides – controls foliage and druit diseases; as seed treatment.
   e.g. captan

    4. systemic and curative fungicides – absorbed by roots and distributed within the plants to control certain diseases; applied to seeds or soil
       e.g. Benlate, Apron 35

Harvesting and Post harvest Operations

Harvesting – separation of the economic yield (whether the whole plant biomass or the portion of the whole plant biomass when crops have reached highest or optimum level of productivity (physiological maturity onwards)

Primary processing – postharvest handling that will market the product suitable for consumers or to prepare it for further processing

Secondary Processing – Postharvest handling that results in a product that cannot be subjected for another change – include food processing in food crops and industrial processing in non-food crops

Classification of harvested products:

1. perishables – include root and tuber crops which have large unit sizes, high to very high respiration rate, soft and with short shelf-life
2. durables – include cereal and grain legumes; smaller unit sizes, low moisture content, low respiration rate, hard and with longer shelf-life
Harvesting – refers to cutting or collecting of crops from the field which can either be done by hand, harvesting tools machines, etc depending on the technical and economic factors.

Postharvest handling – refers to the movement of farm products or operations through which the commodities undergo from harvest to possession by the final consumer.

Harvesting → packing house (sorting/grading, cleaning, or primary processing, packaging, etc) → transport → storage → marketing → consumer

Factors to consider in harvesting:
1. labor cost and its availability
2. timeliness of operation
3. farm size and layout
4. soil properties
5. available capital

Indices of maturity of cereals:
*appearance of black layer at the seed stalk (corn)
*grains are clear and firm (rice)
*change in color of stalk, leaf, panicle
*expected maturity date
*moisture content of seeds

Methods of harvesting:
1. traditional – using sickle or scythe (rice, sorghum, soybean); yatab (rice)
2. modern – use of windrower and cutter binder (rice), combine harvester

Methods of threshing rice:
1. manual (foot-threshing)
2. mechanical

Drying – It is the heat transfer by converting the water in the grain into vapor transferring it to the atmosphere; prevents growth of molds and respiration; reduce MC from 20-25% to 14% or lower; prevents development of Aspergillus flavus which produces aflatoxin.
12-14% of grains results to high milling recovery; if MC is less than 12%, rice grains become too brittle

Methods of drying rice grains:

1. sundrying – 2-3 days to bring the MC to 14%
2. mechanical drying – heated air drying
3. continuous flow grain drying – for large volume (artificial drying)

Type of storage:

1. farm house storage
2. granary
3. warehouse storage
4. bulk storage (silos)

Rice milling – removal of outer covering, husk, hull which involves a dehulling or dehusking process; the removal of the pericarp and testa and the aleurone layer or bran involving the polishing process

Milling recovery – is expressed as the ratio of milled/clean rice over raw rice (palay); should be 62% - 68% or more

Types of milling machines:

1. kiskisan – one pass mill (Engelberg mill)
2. improved village type – 2 passes
3. cono rice mill – multi pass rice milling machine
4. modern rice mill – with separate dehuller and involves 4 stages of the whitening process
5. micromill – household model

Maturity Indices of Annual and Field Crops

1. Growth duration – days from germination to flowering or maturity
2. Change in the color – grains, pods, fruits
3. Appearance of senescing foliage
4. Other physical conditions associated with maturity

Grain Crops
Harvesting Based on maturity indices Manual, mechanical (reapers)
Threshing Separation of grains from straw, cob, pods Manual, mechanical (stripper/combine)
Drying Reduction of seed or MC from 20-30% at harvesting/threshing to 12-14% for the following purposes:
• Prevention of micro organism growth such as Aspergillus flavus (mold)
• Reduction of seed respiration (spoilage)
• Lengthening of pre-milling storage life
• High milling recovery • Sundrying (2-3 days)
• Heated air-drying by convection principle (batch dryer, continuous flow grain dryer)

Storage Grain changes its MC to equilibrate with surrounding air temperature and relative humidity
• Grain MC of 13-14% is maintained in storage at 70%RH
• A good storage structure to isolate grains from ambient temperature, with good ventilation and RH <70% • Farm house storage in sacks or baskets
• Granary for bulk storage in sacks and bags
• Bulk storage using steel bins and silos

Milling • Removal of outer covering (husk or hull) – dehulling or dehusking
• Removal of pericarp & testa and aleurone or bran & germ – whitening/polishing process
• Milling recovery – 62 to .68 (rice) • Rice mills (dehulling– grading)
• Corn mills (dry-wet process)

Other Field Crops
Fiber crops Harvesting based on maturity indices Fiber –concentrated in bark layer and extracted by retting
Retting:
• Submergence in water for 9-20 days. Process (with action of anaerobic microorganisms) is complete when bark can be separated (peeled) from wooden portion
• Stripped fibers are washed, dried for 3-4 days and finally cleaned of remaining bark tissues
Decortications by machine:
• Direct separation of the fiber and the bark
• Stripped fibers are dried and finally cleaned

Rootcrops Cassava
• Harvesting based on maturity index; should be utilized or processed 46 hours after harvest
• Recommended storage:
a. Piling roots on a bed of straw in a well-drained ground covered with more straw and soil
b. Packing of roots in boxes covered with moist sawdust

Sweet Potato
Harvesting based on maturity index
Can be stored for months if properly cured
Curing – allowing bruised or peeled areas to self heal by exposure to 27-30°C and RH of 85-90% for 7-14 days

Sugarcane

- Harvesting based on maturity index
- Pre/over mature harvesting reduces tonnage/sucrose yield
- Water shoots, young/damaged stalks reduce sugar yield
- Canes should be milled within 24 hours – delayed milling induces sucrose yield reduction through inversion

Tobacco
- Tobacco leaves mature in 60-65 days after transplanting
- Lower leaves are first to mature – pale green with yellowing in the edges
- Weekly harvesting of 2-3 leaves – 25-27 leaves harvested
- Leaves are classified, poled and cured
- Curing is done to preserve desirable physical and chemical changes (e.g. retention of sugar to nicotine ratio)
- Curing methods (yellowing – color fixing-drying):
  - Air-curing – burley or air-cured type
  - Sun-curing- cigar or oriental type
  - Flue-curing – Virginia type
  - Bulk-curing – Virginia
- Cured leaves are classified and grade

Sweet corn
Exudation of milk when pierced

Maturity Indices for representative crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Maturity Period</th>
<th>Other Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days after Planting</td>
<td>Days from flowering</td>
</tr>
</tbody>
</table>
Rice 120-130 days 27-30 days Ripening of grains in 27-30 days after flowering; grains turn amber color
Corn 95-105 days 55 days Filling and ripening of grains in 55 days after silking; silking occurs 46-52 days after emergence; MC of kernels – 28-30%
Sweet sorghum 100-105 days; 114-118-up days (CMU) 18 days from silking Kernels soft & tender
Mungbean 55-65 days 30-35 days Pods turn black or tan; leaves may remain green; staggered harvesting
Soybean 80-90 days 50-60 days Complete defoliation of plants; pods straw colored and beans firm
Peanut 90-110 days 70-80 days Leaves remain green, pods full and firm
Sugar cane 10-12 months/12-14 months Uniform brix reading from base, middle and top of stalk (a refractometer is used)
Cotton 110-170 days 45 days Flowering to floozing (boll opening) takes 45 days; staggered harvesting
Cassava 8-10 months (food) 10-14 months (starch manufacture)
Sweet potato 105-120 days (DS) 135-150 days (WS)
Tobacco 60-65 DAT Leaves fully expanded & lower leaves turning pale green
Cabbage 55-60 days Head compact
Cauliflower 50-60 days Curd compact

Maturity Indices of representative crops (continuation)

Crop Maturity Period Other Indices
Days after Planting Days from flowering
Garlic 110-120 days Tops begin to dry and topple; bulbs full
Onion 75-90 days Tops begin to dry and topple; bulbs full
White potato 90-120 days Tops begin to dry and topple; tuber full
Ampalaya 80-90 days 10-14 days Change in color of fruit from deep green to light green
Eggplant 70-90 days 7-10 days Change in color of fruit to deep purple
Sweet pepper 90-120 days to first harvest 15 days Change in color of fruit from green to light green
Tomato 60-70 days to first harvest 30 days Change in color of fruit from deep green to light green
Okra 45-50 days to first harvest 3 days Full-sized fruits, tips can be snapped readily
Muskmelon 80-85 days to first harvest 30-45 days Fruit easily separates from the vine with slight twist
Watermelon 80-85 days to first harvest 30-45 days Color of lower part of the fruit turns creamy yellow; dull hollow sound when thumped

Harvesting, threshing and other operations of representative crops

<table>
<thead>
<tr>
<th>Crops</th>
<th>Operations</th>
<th>Man-hours/ha or machine capacity</th>
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<tbody>
<tr>
<td>Rice (5t/ha)</td>
<td>Manual harvesting, stacking</td>
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<tr>
<td></td>
<td>Mechanical threshing (hampasan)</td>
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<tr>
<td></td>
<td>Mechanical threshing:</td>
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<td></td>
<td>Pedal threshing &amp; bagging</td>
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<tr>
<td></td>
<td>Portable axial flow thresher (7-10hp)</td>
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<td></td>
<td>Feeding &amp; bagging</td>
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<tr>
<td></td>
<td>Harvesting with mechanical reaper</td>
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<td></td>
<td>Operation &amp; hauling</td>
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<tr>
<td></td>
<td>Harvesting with stripper-harvester with thresher-</td>
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<td></td>
<td>Cleaner</td>
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<td></td>
<td>Operation &amp; bagging</td>
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<td>“Combine-harvesting”, threshing (30 hp)</td>
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<td>Operation &amp; bagging</td>
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<td>80-160 MH</td>
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<td>83-250 MH</td>
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<td></td>
<td>500-1000 kg/hr</td>
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<td>40-80 MH</td>
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<td>2.4 ha/day (8 hrs)</td>
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<td>10 MH</td>
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<td>500 kg/hr</td>
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<td>30 MH</td>
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<td>1,350 kg/hr</td>
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<td></td>
<td>11 MH</td>
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<tr>
<td>Corn (5 t/ha)</td>
<td>Handpicking (50-60 thousand plants/ha)</td>
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<tr>
<td></td>
<td>Handpicking with husking &amp; throwing cobs along</td>
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<tr>
<td></td>
<td>Rows</td>
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<tr>
<td></td>
<td>Mechanical picker, husker</td>
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<tr>
<td></td>
<td>Shelling, hand and small tool sheller</td>
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<tr>
<td></td>
<td>Shelling, 5hp engine, 3 drums</td>
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<tr>
<td></td>
<td>Shelling, convertible rice thresher (16 hp engine)</td>
<td>50-80 MH</td>
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<td>100-120</td>
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<td>2.0– 3.5 MH</td>
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<td>400-600 MH</td>
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<td></td>
<td>2,500 kg/hr</td>
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<td></td>
<td>5,000 kg/hr</td>
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</tbody>
</table>
Grading – the process of classifying produce into groups according to a set of recognized criteria of quality and size, with each group bearing accepted name and size grouping

Grades – are the units of grading or the name of the groups to which the produce are classified. Example: Fancy Grade 1, 2, and 3

Sorting – classifying produce into groups designated by the person classifying it according to whatever criteria he may desire

Sizing – Classifying produce into different sizes (the criteria for sizing may or may not be recognized or accepted by the industry)

Size classification – is the unit of sizing. e.g. small, medium, large