In agriculture, cultivation is the process of growing plants (specifically crops) on arable land. It is usually associated with large-scale agriculture, as opposed to small-scale gardening. Crop cultivation requires fertile soil, water (from irrigation or precipitation), and seeds. Cultivation involves the sowing of the seeds in the appropriate season. In the process of cultivation a farmer is often required to also initially till the land, weed control, and ultimately harvest the crops. In the modern age, this practice has been developed into the professional art of agronomy, and may be analyzed by specialized agronomists to maximize efficiency. Soil cultivation refers specifically to the tilling of the soil, such as by ploughing, to prepare the soil for planting and to control weeds.

2.1 CROP PRODUCTIONS AS A SCIENCE

Crop production involves applying theories from various scientific disciplines, chiefly agronomy. The term agronomy is derived from the Greek words ἀγρός ("field") and νόμος ("to manage"). Agronomy can be defined as the branch of agriculture concerned with the principles and practices of crop production and field management. It became a distinct and recognized branch of agricultural science in about 1900. As a branch of agriculture, it combines soil and crop science. Agronomists have a strong foundation in basic science disciplines, such as chemistry, botany, and physics, applying the principles of these disciplines to the production of crops. The ultimate goal of crop production is the yield of an economic plant product. This is accomplished through the management of plant morphological and physiological responses within a given production environment. Plant breeders utilize genetic principles to develop new and improved cultivars that are high-yielding, environmentally responsive, disease-resistant, and adapted to environmental stresses. They manipulate plant morphology to make them more physiologically responsive to the growing environment. The yield (quantity and quality) of economic products is enhanced.

Modern producers use science and technology to reduce the adverse impact of the vagaries of the weather in crop production. For example, farmers have access to weather
forecast information, providing guidance for the best time to plant crops in the field. Soils
scientists conduct research to determine plants' nutritional needs for optimal yield. Fer-
tilizer research provides guidance for optimal rates of application of plant soil nutrients.
Soil analysis is used to determine the precise needs of crops to meet yield goals. The use
of new crop varieties that are adapted to new production areas has expanded crop pro-
"Suction worldwide.

Scientists develop chemical products such as growth hormones, pesticides, and fer-
tilizers that enhance crop productivity. They also develop cropping systems, which are
the production packages comprised of crop or pasture communities and sets of manage-
ment practices of farming systems (pertaining to particular farms). Agricultural engineers
develop machinery and equipment to facilitate production operations. These include
equipment for land preparation, seeding, cultivating, fertilizing, irrigating, spraying to
protect against pests, and harvesting.

2.2 CROP PRODUCTIONS AS A BUSINESS
Crop production and productivity (production efficiency) entails managing production
inputs to produce outputs. The crop producer is a decision maker.

The crop producer as a decision maker

A crop production operation requires careful planning. The producer should be
able to make the right choices in terms of selecting and managing the appropriate
production inputs. The goal of crop production is high productivity for profitability. Even
in farming systems where production is primarily for domestic use (selling only when
there is surplus), the producer still aims for high productivity. The crop producer is faced
with critical decisions throughout the enterprise.

There are three categories of factors that the producer has to be concerned with in
planning and producing a crop. Some factors are within the producer's total control, others
can be manipulated for better results, while yet others are totally outside his or her
control (Figure 1.4)
Factors Within Total Control

The crop producer is responsible for selecting the site for the enterprise. This requires knowledge of the requirements of the crop plant of interest, in terms of adaptation, suitability of the soil type, and other growth requirements. The soil type needed for tuber and root crop production is different from that for cereal grains. The producer has to select the best crop that can grow on the soil and find the best cultivar suited to the region. The cultivar should be high-yielding, regarding the plant product of interest to the producer, and should be adapted to the cultural method to be used. The producer has control over the acreage to produce. This will be based in part on the anticipated market demand. The producer also decides on the best cultural practice to adopt for high productivity. This includes time of planting, planting density, type and amounts of production inputs, pest control, time of harvesting, and others.

Factors That Can Be Manipulated

Some factors in the production operation can be modified for best results. Sometimes, the best site cannot be found for a crop plant. Certain soil amendments may be required to improve soil physical and chemical conditions. This includes drainage,
leveling, terracing, and liming. Even if the soil conditions are adequate to start with, the producer may want to increase crop productivity by providing supplemental nutrition and other factors that promote growth and development (e.g., fertilizers and irrigation). Sometimes, temperature can be manipulated within certain limits for early planting. This could be done by simply using raised beds. Producers also use various devices to protect plants against frost (e.g., row covers, heat caps, and wind machines). Production under a controlled environment (greenhouse) allows temperature, light, and humidity to be more effectively controlled for optimal production environment for high productivity.

Factors outside the Producer's Control

The weather factor is considered as the chance element in crop production. Shall we then blame it on the weather when we have a crop failure? The producer may select the best site and cultivar and adopt the best cultural practices and still be unsuccessful if the weather does not cooperate. Mild fluctuations in the weather are usually not difficult to overcome or plan against (e.g., a brief drought period or a mild unexpected cold spell). Supplemental irrigation or using drought-resistant cultivars can rectify a mild drought. However, a severe and protracted drought may make irrigation impractical, leading to heavy or total crop failure. Acts of nature such as strong winds, hail, and floods are usually devastating to a crop production enterprise. Too much rain during the crop harvesting time may lead to significant field and even storage losses. The producer does not have control over the incidence of pests. Certain pests are endemic in some regions, whereas others are associated with certain weather systems. For example, a grower does not have control over a locust invasion.

The acreage devoted to production is related to anticipate demand for the crop plant product for which the operation is initiated. The producer is not in control of the total acreage of the crop produced in other regions or nations of the world. As such, there could be overproduction at the end of the production season and consequently a loss of potential revenue to falling prices. Agricultural production is a high-risk activity. Failure to make the right decision in a timely fashion can lead to significant losses. You might think about ways by which decision making in crop production can be improved.
Crop production is not immune to politics. The government may implement legislation that discourages crop producers from allocating adequate resources to a production activity. Farmers allocate resources based on anticipated profitability of the crop to be produced. Political influences on crop production may come in the form of trade agreements, application of tariffs, taxes, subsidies, and financial assistance. Administrations implement policies according to a certain political agenda. Since political administrations usually have a limited term in office, there is always the potential for a drastic policy change in the short term. Agricultural production is not as resilient as many manufacturing industries. Agricultural production adapts slowly to significant changes in demand and price, and it often suffers adverse consequences as a result. This is largely because agricultural production is slow and tedious, often requiring a full year to complete the lifecycle of most field crops. Agriculture is not able to compete for land with other high-return manufacturing enterprises.

Since a government often cannot directly create the supply of a particular commodity, it has to stimulate production by implementing incentives to producers. Field production is subject to the vagaries of the weather. Returns to field crop production are unstable. Farmers prefer to grow crops for which the price is predictable and stable. To encourage the production of specific field crops, the government may introduce price stabilization measures. The government may also implement policies to assist selected agricultural industries by direct subsidy or price support. The government may also enter into trade agreements such as the General Agreement on Tariffs and Trade (GATT) to stabilize world trade with respect to certain agricultural commodities.

What is the driving force behind decision making in crop production? Farmers make production decisions based on expected profitability. If the outlook and world price are poor for a crop, producers will divert resources into alternative and more viable enterprises. Agriculture is generally a risky enterprise. Certain crops are high-risk and have large variations in yield and market price. These are less attractive to producers, especially those with limited resources. Crops such as cotton are capital-intensive and require high-technology input. This limits the type of producers who are able to undertake cotton production.

Producers must first identify markets for their produce. Access to markets may be local or even international. When the crop production center is located far from the pro-
cessing center, a good and efficient transportation network is required to encourage distant farmers to produce the crop.

2.3 EVOLUTION OF MODERN AGRICULTURE

Crop production has not always been what it is today. How has it changed over the years? Modern agriculture benefits from research and technological advancement. As economics permits, producers are able to implement new techniques and technologies to facilitate agricultural production. World agriculture has experienced changes that can be categorized into four fairly distinct eras, based on how production resources were utilized and managed.

(i) Era of resource exploitation (before 1900)

Modern agriculture started with the identification and exploitation of production resources. First, prime lands were identified and cleared for farming. The land was tilled and prepared for planting and crop establishment. The basic rationale of this era was that soil productivity was a resource to be exploited for crop productivity. The soil nutrients were repeatedly removed without replacement. This is the mining approach to crop production. This led to the progressive depletion of organic and inorganic soil factors and consequently reduced crop productivity. When the soil was deemed unproductive (just like an old mine), it was abandoned for a new fertile site. This was a non-sustainable production approach, requiring new lands to be exploited on a regular basis.

Some exploitative activities continued even to the twenty-first century. A major production activity of this kind is the continued mining of groundwater of the Great Plains for crop irrigation. The consequence of this exploitation is the decline in water levels of the Ogallala aquifer, as discussed later in this book. Furthermore, the implementation of the fiber subsidies encouraged overgrazing of the land in sheep and goat production regions.

(ii) Era of resource conservation and regeneration (early 1900s)

In the early 1900s, producers began adopting production techniques that were less exploitative of the soil. Abandoned farmlands were eventually restored to health, though only after many years in fallow. Crop rotation provided a strategy for a more efficient use of soil moisture that the previous continuous cropping system did not offer. Legumes, through
symbiosis, contributed to regeneration of the soil by nitrogen fixation. Organic manure from green manuring (growing a crop for the purpose of plowing under while still green) and deliberate use of barnyard or livestock manure replenished soil fertility.

(iii) Era of resource substitution (mid-1900s)

The activities of this era made the industrialization of agriculture possible. The period started roughly in the mid-1900s (a little before 1950). This period saw the exploitation of mechanization that has continued to this day. Machines replaced farm draft animals. Supplemental moisture was supplied through crop irrigation. Chemical fertilizers were used more commonly than the bulky organic fertilizers. Pesticides were used more frequently to control weeds and other crop pests. Plant breeders developed more improved cultivars for farmers. Technological advances in this era enabled producers to cultivate large tracts of land. The late 1900s saw the introduction of biotechnology and other revolutionary technologies, such as precision farming, into crop production.

(iv) Era of information

Technology will continue to advance. New resources will be discovered. The future of agricultural production will probably be shaped by the ability of the producer, as a manager, to translate information and knowledge into value. The use of the Internet and other regional and national information networks will continue to make crop production information more readily accessible to producers.

2.4: CROP PRODUCTION SYSTEM

Cropping systems vary among farms depending on the available resources and constraints; geography and climate of the farm; government policy; economic, social and political pressures; and the philosophy and culture of the farmer. Shifting cultivation (or slash and burn) is a system in which forests are burnt, releasing nutrients to support cultivation of annual and then perennial crops for a period of several years. Then the plot is left fallow to regrow forest, and the farmer moves to a new plot,
returning after many more years (10-20). This fallow period is shortened if population density grows, requiring the input of nutrients (fertilizer or manure) and some manual pest control. Annual cultivation is the next phase of intensity in which there is no fallow period. This requires even greater nutrient and pest control inputs. Further industrialization lead to the use of monocultures, when one cultivar is planted on a large acreage. Due to the low biodiversity, nutrient use is uniform, and pests tend to build up, necessitating the greater use of pesticides and fertilizers. Multiple cropping, in which several crops are grown sequentially in one year, and intercropping, when several crops are grown at the same time are other kinds of annual cropping systems known as polycultures.

In subtropical and arid environments, the timing and extent of agriculture may be limited by rainfall, either not allowing multiple annual crops in a year, or requiring irrigation. In all of these environments perennial crops are grown (coffee, chocolate) and systems are practiced such as agroforestry. In temperate environments, where ecosystems were predominantly grassland or prairie, highly productive annual cropping is the dominant farming system.

The last century has seen the intensification, concentration and specialization of agriculture, relying upon new technologies of agricultural chemicals (fertilizers and pesticides), mechanization, and plant breeding (hybrids and GMO's). In the past few decades, a move towards sustainability in agriculture has also developed, integrating ideas of socio-economic justice and conservation of resources and the environment within a farming system. This has led to the development of many responses to the conventional agriculture approach, including organic agriculture, urban agriculture, community supported agriculture, ecological or biological agriculture, integrated farming, and holistic management.

2.5 PRODUCTION PRACTICES

Tillage is the practice of plowing soil to prepare for planting or for nutrient incorporation or for pest control. Tillage varies in intensity from conventional to no-till. It may improve productivity by warming the soil, incorporating fertilizer and controlling weeds, but also
renders soil more prone to erosion, triggers the decomposition of organic matter releasing CO₂, and reduces the abundance and diversity of soil organisms.

**Pest control** includes the management of weeds, insects/mites, and diseases. Chemical (pesticides), biological (biocontrol), mechanical (tillage), and cultural practices are used. Cultural practices include crop rotation, culling, cover crops, intercropping, composting, avoidance, and resistance. Integrated pest management attempts to use all of these methods to keep pest populations below the number which would cause economic loss, and recommends pesticides as a last resort.

**Nutrient management** includes both the source of nutrient inputs for crop and livestock production, and the method of utilization of manure produced by livestock. Nutrient inputs can be chemical inorganic fertilizers, manure, green manure, compost and mined minerals. Crop nutrient use may also be managed using cultural techniques such as crop rotation or a fallow period. Manure is used either by holding livestock where the feed crop is growing, such as in managed intensive rotational grazing, or by spreading either dry or liquid formulations of manure on cropland or pastures.

**Water management** is where rainfall is insufficient or variable, which occurs to some degree in most regions of the world. Some farmers use irrigation to supplement rainfall. In other areas such as the Great Plains in the U.S. and Canada, farmers use a fallow year to conserve soil moisture to use for growing a crop in the following year. Agriculture represents 70% of freshwater use worldwide.

### 2.6 CULTIVATION PRACTICES

(i). Land Preparation

**Summer Ploughing**

- Summer ploughing improves soil structure due to alternate drying and cooling. Soil permeability is increased by breaking the compacted layers. Tillage improves soil aeration which helps in multiplication of micro
organisms. Organic matter decomposition is hastened resulting in higher nutrient availability.

- Increased aeration also helps in degradation of herbicide and pesticide residues and harmful allelopathic chemicals exuded by roots of previous crop or weed. It also helps in reducing the soil dwelling insect pests. In view of several benefits summer ploughing could be taken up at optimum moisture level.
- Frequent harrowing has to be avoided as it results in destruction of soil structure. Tillage at improper moisture level is to be discouraged as it also damages soil structure and leads to development of hard pans.

**Shallow Ploughing**

- It is generally followed by the most of the farmers repeatedly at the same depth (12-15 Cm). As a result of this hard pans are created, which inhibits the penetration of roots in deep rooted crops.
- Eg: Cotton roots grow to a depth of 2 Mts. in deep alluvial soils without any pans, when hard pans are present they grow only up to hard pan (5 - 20 cm). But shallow ploughing is practiced to open the soil crust to increase the receptivity of rainfall.

**Puddling**

"Making soil impermeable by manipulating and compacting it in standing water, which reduces its apparent specific volume, thus facilitates transplanting."

As a result of puddling, an impervious layer is formed below the surface which reduces deep percolation losses of water.

**Leveling**

Leveling is the tillage operation in which the soil is moved to a establish a desired soil elevation stage. Due to leveling the use of water and fertilizer efficiency increases effectively.
Harrowing

Harrowing is a secondary tillage operation which pulverizes, smoothens and packs the soil in seed-bed preparation and control weeds.

Conservation Tillage

- The main objective is to conserve soil and moisture. Conservation tillage is an operation that is designed to maintain roughness of a field surface and leave most of the previous crop residues on the surface while providing a suitable seed-bed and weed control for the next crop.
- This roughness reduces water run off and soil erosion.

Ridges and Furrows

- A long, row ridge of earth with gently sloping sides and a shallow channel along the upper side, to control erosion by diverting surface run-off across the slope instead of permitting it to flow uninterrupted down to slope. EG: Sugarcane, Sunflower, Vegetable crops.

Bunding

- It is the process of forming an artificial earthen embankment made across slopping agricultural land to cut short lengthy soil slopes and reduces run-off and erosion.
- These bunds are also formed along the contours across the slope of land in the low rainfall regions to conserve soil moisture.

(ii) Sowing

Methods of Sowing

Broad Casting

- Seeds are spread uniformly over well prepared land and are covered by ploughing or planking. It is most primitive method of sowing crops. The broadcasting has several disadvantages.
- Seeds fall at different depths when broadcasted resulting in uneven stand.
1. It requires more seed rate.
2. Seeds fallen deep in the soil may not germinate.
3. Due to broadcasting excess competition at certain areas and no competition at all in other areas takes place in the field. So, yield returns will be decreased.
4. Water use efficiency and fertilizer efficiency will be decreased.
5. There is no possibility of controlling weeds by inter cultivation.

Drilling

To overcome the problems of broadcasting drilling the seeds in lines has come into practice. Weeds can be controlled economically by inter cultivation in line sown crops. In addition, drilling or line sowing facilitates uniform depth of sowing resulting in uniform crop stand. Seed rate can be considerably reduced drilling.

Planting

When individual seeds or seed material is placed in the soil by manual labour, it is called planting. Generally crops with bigger sized seeds and those needing wider spacing are sown by this method. Eg: Cotton, Maize, Potato, Sugarcane, etc.

Transplanting

It is the process of planting seedlings in prepared main field. Small seeded crops like Tobacco, Chillies, Tomato, etc. are to be sown shallow and frequently irrigated for proper germination. Taking care of the germinating seed or seedlings which are spread over large area is a problem with regard to application of water, weed control, pest control etc. Therefore, seeds are sown in a small area called nursery and all the care is taken to raise the seedlings. The advantages of transplanting saving in irrigation water, good stand establishment and increase in intensity of cropping. In respect to paddy the nursery is raised in small puddled plots and later transplanted in the main field at required spacing.
Seed Rate

The quality of seed required for sowing in a unit area of land. It is usually expressed in kg/ha.

Spacing

The distance between crop row (inter-row spacing) and between plants within the row (intra-row spacing) is referred as spacing. It is expressed in cms.

Plant Population

Number of plants maintained in an unit area of land is known as plant population/density. Establishment of optimum plant population is essential to get maximum yield. When sown densely competition among plants is more for growth factors resulting in reduction of yield. Yield per plant decreases gradually as plant population per unit area is increased. The plant population density varies with the type of soil and crop. Optimum plant population density has to be maintained for securing maximum yield.

(iii) Nursery Raising

When more than one crop is to be grown in an year on the same piece of land, the time occupied by each crop has to be reduced. The seedling growth in the early stages is very slow. Seedlings need extra care for establishing in the field because of their tenderness. Small seeded crops are to be sown shallow and frequently irrigated for proper germination. Taking care of the germinating seed or seedlings which are spread over large area is a problem with regard to application of water, weed control, pest control etc. Therefore, seeds are sown in a small area called nursery and all the care is taken to raise the seedlings.
Transplanting Method

Transplanting is usually done manually. In case of rice it is also done mechanically with transplantor provided the nursery is raised through dapog method.

Time

For achieving good results from transplanting, the seedlings are to be transplanted at optimum age and at proper depth. The age of seedlings for transplanting depends on crop and seasonal conditions.

Equipment for Sowing

Country plough (Akkadi), Seed drill, Ferti-cum-seed drill, and Mechanical seed drill is generally used.

Inter Cultivation

It is an operation of soil cultivation performed in standing crop. It is also called as inter culturing. It facilitates good aeration, and better development of root system.

Weeding

Weeding is the process of eliminating competition of unwanted plants to the regular crop in respect to nutrition and moisture. So that crops can be grown profitably. It also facilitates other operations like irrigation and fertilizer application. The advantages of weeding are Conservation of soil moisture. Reduced competition for nutrients and water. Purity of seed can be maintained.

Earthing Up

It is the process of putting the earth or soil just near the base for certain crops like Sugar cane, Cassava, Papaya, Potato, etc. to give support to the plants.
Sugarcane, Papaya, Banana - To avoid lodging Cassava, Potato - To provide more soil volume for the growth of tubers. Vegetables - To facilitate irrigation.

Other Operations

Certain other operations like gap filling, thinning and propping are required as part of inter cultivation operations. In crops like Cotton, Paddy, the gap filling is done in missing areas of the planted main field to maintain optimum population. Like wise thinning is also practiced in direct sown crops like Jowar, Chillies, to avoid over crowding and to maintain uniform plant stand. In crops like Sugarcane, betelwine, Grapes propping is necessary to support the main crop establishment.

(iv) Harvesting

It is an operation of cutting, picking, plucking, digging or combination of these for removing the useful part or economic end product, part from the plant.

Time

Crops can be harvested at physiological maturity or at harvest maturity. Crop is considered to be at physiological maturity when the translocations of photosynthates are stopped to economic part. If the crop is harvested early, the produce contains high moisture and more immature grains. The yields will be low due to unfilled grains. Late harvesting results in shattering of grains, germination even before harvesting during rainy season and breakage during processing. Hence, harvesting at correct time is essential to get good quality of grains and higher yields.

Methods

Manual

Manual harvesting is practiced by cutting crop with sickle or knife. In some crops like Sugarcane, Millets, Paddy the crop is cut with sickles and knives. In some crops like Groundnut, tuber crops the plants are pulled and economic parts are separated. In other crops like Cotton, Chillies, and fruits the
picking is practices to remove the economic parts like kappas, pods and fruits etc.

Mechanical

The combines are used to perform several operations such as cutting the crop, separating the grain from straw, cleaning the grain from chaff and transporting grains to the storage tank. Now a days the harvesting is exclusively for harvesting crops like Paddy and threshing paddy are used. Machines are now available for separating pods from the plants and also for shelling pods (decorticators) in respect to Groundnut crop. Likewise machines are available for threshing sunflower heads, shelling of castor capsules and sowing of grain.

Drying and Processing

Drying is a process by which moisture content from grain is reduced to safe limit. Drying is done either by using solar energy or by artificial heating. Processing is the conversion of the produce into a more finished condition before it is offered for sale.

Cleaning

The removal of foreign and dissimilar material by washing, screening, hand-picking, aspiration or any other mechanical means is known as cleaning. It is required to maintain the quality of the produce.

(v) Processing green seeds

After green pods are harvested, shelling, canning, and freezing are important processing operations. Canning and freezing involve several operations including cleaning, blanching, and filling cans and polyethylene bags (Figure 17.1).

Canning

In several developing countries, canning pigeonpea for the export market is encouraged as the demand for canned pigeonpeas has increased. Canning--green pigeonpea seeds is a common, export-oriented business in some
Caribbean countries, for example, in the Dominican Republic, about 80% of the annual harvest of green pigeonpea is canned and exported. Although the quality of green seed depends mainly on its maturity and agro climatic environments, cultivars suitable for canning have been developed. Cultivars with large, uniform, bright green seeds and pods at the canning stage are preferred for canning. Green seeds with higher soluble sugars content are preferred by the consumer, but genotypes with this trait have not yet been developed.

Harvesting green seeds of similar maturity is an important step in obtaining a high quality canned product, but the nonsynchronized flowering characteristic of pigeonpea makes it difficult to harvest developing pods of similar maturity. Factors such as drained mass, volume, viscosity, and colour of brine and uniformity of colour are all dependant on maturity.

Shelling

After the developing pods are harvested in the field, they are shelled to separate the green pigeonpea from their pod walls. The ease with which pigeonpea can be shelled depends on the characteristics of the cultivar, and there are large differences in the shelling recovery of vegetable pigeonpea. Shelling recovery is very important to processors and shelling is done mechanically or by hand depending on the volume of product handled by the processor. Hand shelling not only requires a low capital investment, but also helps produce a much better-looking product. It also results in higher yields than machine shelling. Fresh pigeonpea that are sold packed in polythene bags, are invariably shelled by hand, and some frozen product packers also prefer hand shelling.

Cleaning

An appropriate cleaning procedure is followed depending on whether the shelling operation is by hand or machine. During hand-shelling for the fresh market and before freezing small quantities, the product is cleaned and inspected so that damaged seeds and foreign matter can be rejected.
Hand-shelled pigeonpea for freezing, are cleaned by placing them in containers of cold water before blanching, so as to keep the blanching water as clean as possible. Fresh market produce is not washed, and cleaning is done by the sellers themselves.

Mechanically shelled seeds are transferred to conveyors for cleaning and washing. Small pieces of pod, and damaged and small seeds are removed by air-blast. The seeds then drop onto a large-mesh screen that allows them to drop through while the screen retains pieces of pod and other extraneous material. As a part of the cleaning operation, the seeds are washed with cold running water in various combinations and types of flotation washers.
Traditional methods of dehulling pigeonpea followed in villages in various Indian states.
Blanching is an essential heat treatment operation in the canning and freezing process. According to Sammy (1971), blanching is primarily done to; fix the colour, improve the flavour, reduce the volume, and improve the texture to
permit a large mass of peas to fit into the can, remove mucous substance(s) and free starch so as to obtain a clearer brine, and to remove intercellular gases from the seeds to lessen can strain during heating. Two methods of blanching have been reported. In the most commonly used method, to obtain a clear brine, seeds are heated at 185°F (85°C) for 5 min in hot water, and then cooled immediately in cold water to about 80°F (26.7°C) (Sanchez-Nieva et al., 1961). The other method involves steam blanching, which causes less shrinkage and lower nutrient losses (Melmick et al., 1944), but is more expensive because of the energy costs involved, and hence is an unacceptable alternative in developing countries.

After blanching and cooling, seeds are inspected to remove any off-coloured ones that did not appear before blanching, and to ensure complete removal of foreign matter before canning or freezing. As shown in Figure 17.1, all the above-mentioned steps are similar for both canning and freezing processes.

Filling, Closing, and Cooling Cans

After blanching and cooling, cans of different sizes are filled with seeds and a 2% brine solution at 195°F to 200°F (90.5°C to 93.3°C). No sugar or any other additives are added. To close small cans, the brine is maintained almost at boiling point and no mechanical exhaust is required. However, for large cans, the near-boiling brine does not create a sufficient vacuum before the cans are closed, so an additional means of creating a vacuum is needed. Closed cans are thermally processed as soon as possible after closure to inhibit the growth of thermophilic bacteria that may spoil the product later if it is stored at high temperatures (Mansfield, 1981).

Freezing

Freezing is by two methods; an automatic continuous system, and a labour-intensive batch system. In the automated system, blanched and cooled seeds are transported by conveyor to a fluidized bed freezer. In this process, that operates at a temperature well below freezing (-10°F to -20°F) (-23.3°C to -28.9°C) the seeds are individually quick-frozen. Once frozen, the seeds are hand-
packed into cartons that have been especially wax-treated to prevent dehydration of the product, and are then stored at 0°F (-17.8°C).

In the batch system, blanched seeds are dropped into cooled water tanks as they come out of the hot-water blancher. After cooling, they are hand-packed into polyethylene bags, and placed in trays for freezing in a batch freezer (-10°F to -20°F) (-23.3°C to -28.9°C) for 4 to 10 h depending on the freezer design, package size, and the initial temperature of the product (Mansfield, 1981). Frozen bags are then placed in corrugated containers for storage at 0°F (-178°C).

(vi) Dehulling

In many countries of the world, grain legumes are initially processed by removing the hull and splitting the seed into its dicotyledonous components (Siegel and Fawcett, 1976). In India, dehulling pigeonpea is a primary process that converts the whole seed into dhal. The dehulling operation is usually performed in two steps; the first involves loosening the husk from the cotyledons, and the second removing the husk from the cotyledons and splitting them using a roller machine or stone chakki (quern) (Araullo, 1974; Singh and Jambunathan, 1981a).

Dehulling Methods

Dehulling pigeonpea is an age-old practice in India. In earlier days hand-pounding was common, this was later replaced by stone chakkis. Several traditional methods are used (Kurien and Parpia, 1968), that can be broadly classified into two categories: The wet method that involves water soaking, sun drying, and dehulling, and the dry method that involves oil/water application, sun drying, and dehulling. A survey of dehulling methods in India indicated that pigeonpea is traditionally dehulled in two ways depending on the magnitude of operation (Singh and Jambunathan, 1981a). One is the large-scale commercial dehulling of large quantities of pigeonpea into dhal in mechanically operated mills, and the other is the small-scale home-processing method adopted by villagers using a stone chakki.

As shown in Figure 17.2, in large-scale processing the material is first graded and then passed through a roller machine which causes a mild abrasion - the tempering
operation. This tempering causes slight scratches on the seeds and enhances their oil-and water-absorbing efficiency, leading to the loosening of the testa. The material is then treated with oil and water, and spread in the drying yard to dry under the sun. If necessary, the material is occasionally stirred. After sun drying, the material is dehusked with a roller machine (Figure 17.3). Various products i.e., dehusked split (dhal), dehusked unsplit (pearled), and undehusked material of split and unsplit seeds are obtained. These products are separated, and if required the whole operation is repeated to obtain more dhal.

For small-scale dehulling, the basic unit is a chakki comprising two grinding stones. The treatments given before dehulling in a chakki vary from region to region (Singh and Jambunathan, 1981a). For example, in the Indian states of Maharashtra, Uttar Pradesh, and Madhya Pradesh soaking pigeonpeas in water for 2-14 h is a common practice. In some other states, villagers prefer to treat the material with oil before dehulling. In some households, pigeonpea is first split using a "chakki", then treated with oil/water, and finally hand pounded to remove the seed coat. Another procedure, followed in Uttar Pradesh is heating the pigeonpea in an iron pan, with or without sand, before grinding. Figure 17.5 shows the various treatments used to dehull pigeonpea in different Indian villages.

In recent years, efforts have been made to develop improved methods and machinery to process pigeonpea more economically. Reichert and Youngs (1976) reported that attrition-type mills (plate mills) can be used for dehulling if the hull is not firmly attached to the cotyledons. If it is firmly attached, then abrasive-type mills are used; these incorporate carborundum to gradually abrade the seed coat from the cotyledon. However, this new technology has not been widely implemented.

**Equipment**

- **Harvesting:** Sickle, knife, combines, harvesters
- **Threshing:** Bullocks, Tractors, and Decorticators etc.
- **Drying:** Dryers
(vii) Post Harvest Field Management

After harvest of the crop, the remnants of the plant viz. Straw, stubbles, leaves, etc. are ploughed into soil to decompose, thereby providing source of organic matter for the next season crop. In some places the flocks of sheep are housed (penning) during night time. So that the excreta is collected on the field which is also a good source of organic nutrients. The left over stubbles, plant residues in crops like Cotton, Chillies, Maize, Sunflower etc. may be burnt as part of soil sterilization as to reduce population of harmful microbes and soil dwelling insect pests. In crops like Paddy the stubbles may be removed by ploughing after harvest to eliminate hibernating stem borer population. Field bunds may be trimmed to avoid hibernating grass hopper egg masses.

2.7 AGRICULTURAL MARKETING

Agricultural marketing can best be defined as series of services involved in moving a product from the point of production to the point of consumption. Thus agricultural marketing is a series of inter-connected activities involving: planning production, growing and harvesting, grading, packing, transport, storage, agro- and food processing, distribution and sale. Such activities cannot take place without the exchange of information and are often heavily dependent on the availability of suitable finance. Marketing systems are dynamic. They are competitive and involve continuous change and improvement. Businesses that have lower costs, are more efficient and can deliver quality products are those that prosper. Those who have high costs, do not adapt to changes in market demand and provide poorer quality are often forced out of business. Marketing has to be customer oriented and has to provide the farmer, transporter, trader, processor, etc. with a profit. This requires those involved in marketing chains to understand buyer requirements, both in terms of product and business conditions.

There are two important aspects to the marketing of agricultural products. The first has to do with the physical process that brings products from producers to consumers; the fundamental stages of this process are the collection, packaging, transport, processing, storage and lastly the retail sale of agricultural products. This first aspect shall be dealt with in detail in the fact sheet on post-harvest management. The second aspect, which is addressed here, involves the market pricing mechanism.
Emphasis will therefore be placed on the market mechanisms that contribute to the pricing of agricultural products and on the way that producers can obtain acceptable prices for their crops.

Agricultural Marketing is a process which starts with a decision to produce a saleable farm product and involves all aspects of market structure or system, both functional and institutional, based on technical and economic consideration.

The term agricultural marketing is composed of two words - agriculture and marketing. Agriculture, in the broadest sense means activities aimed at the use of natural resources for human welfare, and marketing connotes a series of activities involved in moving the goods from the point of production to the point of consumption. Specification, the subject of agricultural marketing includes marketing functions, agencies, channels, efficiency and cost, price spread and market integration, producer’s surplus etc. The agricultural marketing system is a link between the farm and the non-farm sectors.

In India Agriculture was practiced formerly on a subsistence basis; the villages were self sufficient, people exchanged their goods, and services within the village on a barter basis. With the development of means of transport and storage facilities, agriculture has become commercial in character; the farmer grows those crops that fetch a better price. Marketing of agricultural produce is considered as an integral part of agriculture, since an agriculturist is encouraged to make more investment and to increase production. Thus there is an increasing awareness that it is not enough to produce a crop or animal product; it must be marketed as well.

Agricultural marketing involves in its simplest form the buying and selling of agricultural produce. This definition of agricultural marketing may be accepted in olden days, when the village economy was more or less self-sufficient, when the marketing of agricultural produce presented no difficulty, as the farmer sold his produce directly to the consumer on a cash or barter basis. But, in modem times, marketing of agricultural produce is different from that of olden days. In modem marketing, agricultural produce has to undergo a series of transfers or exchanges from one hand to another before it finally reaches the consumer.
The National Commission on Agriculture defined agricultural marketing as a process which starts with a decision to produce a saleable farm commodity and it involves all aspects of market structure of system, both functional and institutional, based on technical and economic considerations and includes pre and post- harvest operations, assembling, grading, storage, transportation and distribution. The Indian council of Agricultural Research defined involvement of three important functions, namely (a) assembling (concentration) (b) preparation for consumption (processing) and (c) distribution.

The farmer has realized the importance of adopting new techniques of production and is making efforts for more income and higher standards of living. As a consequence, the cropping pattern is no longer dictated by what he needs for his own personal consumption but what is responsive to the market in terms of prices received by him. While the trade is very organized the farmers are not Farmer is not conversant with the complexities of the marketing system which is becoming more and more complicated. The cultivator is handicapped by several disabilities as a seller. He sells his produce at an unfavorable place, time and price.

The objectives of an efficient marketing system are:

1. To enable the primary producers to get the best possible returns,
2. To provide facilities for lifting all produce, the farmers are willing, to sell at an incentive price
3. To reduce the price difference between the primary producer and ultimate consumer
4. To make available all products of farm origin to consumers at reasonable price without impairing on the quality of the produce

Facilities needed for Agriculture marketing:

In order to have best advantage in marketing of his agricultural produce the farmer should enjoy certain basic facilities.

1. He should have proper facilities for storing his goods.
2. He should have holding capacity, in the sense, that he should be able to wait for times when he could get better prices for his produce and not dispose of his stocks immediately after the harvest when the prices are very low.

3. He should have adequate and cheap transport facilities which could enable him to take his surplus produce to the mandi rather than dispose it of in the village itself to the village money-lender-cum-merchant at low prices.

4. He should have clear information regarding the market conditions as well as about the ruling prices, otherwise may be cheated. There should be organized and regulated markets where the farmer will not be cheated by the -dalals- and -arhatiyas-.

5. The number of intermediaries should be as small as possible, so that the middleman's profits are reduced. This increases! the returns to the farmers.

Agricultural advisory services and the market

Promoting market orientation in agricultural advisory services aims to provide for the sustainable enhancement of the capabilities of the rural poor to enable them to benefit from agricultural markets and help them to adapt to factors which impact upon these. As a study by the Overseas Development Institute demonstrates, a value chain approach to advisory services indicates that the range of clients serviced should go beyond farmers to include input providers, producers, producer organizations and processors and traders.

Market infrastructure

Efficient marketing infrastructure such as wholesale, retail and assembly markets and storage facilities is essential for cost-effective marketing, to minimize post-harvest losses and to reduce health risks. Markets play an important role in rural development, income generation, food security, developing rural-market linkages and gender issues. Planners need to be aware of how to design markets that meet a community's social and economic needs and how to choose a suitable site for a new market. In many cases sites are chosen that are inappropriate and result in under-use or even no use of the infrastructure constructed. It is also not sufficient just to build a market: attention needs to be paid to how that market will be managed, operated and maintained. In most cases,
where market improvements were only aimed at infrastructure upgrading and did not guarantee maintenance and management, most failed within a few years.

Rural assembly markets are located in production areas and primarily serve as places where farmers can meet with traders to sell their products. These may be occasional (perhaps weekly) markets, such as haat bazaars in India and Nepal, or permanent. Terminal wholesale markets are located in major metropolitan areas, where produce is finally channeled to consumers through trade between wholesalers and retailers, caterers, etc. The characteristics of wholesale markets have changed considerably as retailing changes in response to urban growth, the increasing role of supermarkets and increased consumer spending capacity. These changes require responses in the way in which traditional wholesale markets are organized and managed.

Retail marketing systems in western countries have broadly evolved from traditional street markets through to the modern hypermarket or out-of-town shopping centre. Despite the growth of supermarkets there remains considerable scope to improve agricultural marketing in developing countries by constructing new retail markets. However, there is little point in undertaking market development improvements unless they result in a positive socio-economic impact. Effective regulation of markets is essential. Inside the market, both hygiene rules and revenue collection activities have to be enforced. Of equal importance, however, is the maintenance of order outside the market. Licensed traders in a market will not be willing to cooperate in raising standards if they face competition from unlicensed operators outside who do not pay any of the costs involved in providing a proper service.

Market information

Efficient market information can be shown to have positive benefits for farmers and traders. Up-to-date information on prices and other market factors enables farmers to negotiate with traders and also facilitates spatial distribution of products from rural areas to towns and between markets. Most governments in developing countries have tried to provide market information services to farmers, but these have tended to experience problems of sustainability. Moreover, even when they function, the service provided is often insufficient to allow commercial decisions to be made because of time lags between
data collection and dissemination. Modern communications technologies open up the possibility for market information services to improve information delivery through SMS on cell phones and the rapid growth of FM radio stations in many developing countries offers the possibility of more localized information services. In the longer run, the internet may become an effective way of delivering information to farmers. However, problems associated with the cost and accuracy of data collection still remain to be addressed. Even when they have access to market information, farmers often require assistance in interpreting that information. For example, the market price quoted on the radio may refer to a wholesale selling price and farmers may have difficulty in translating this into a realistic price at their local assembly market. Various attempts have been made in developing countries to introduce commercial market information services but these have largely been targeted at traders, commercial farmers or exporters. It is not easy to see how small, poor farmers can generate sufficient income for a commercial service to be profitable although in India a new service introduced by Thompson Reuters was reportedly used by over 100,000 farmers in its first year of operation. Esoko in West Africa attempts to subsidize the cost of such services to farmers by charging access to a more advanced feature set of mobile-based tools to businesses.

Marketing training

Farmers frequently consider marketing as being their major problem. However, while they are able to identify such problems as poor prices, lack of transport and high post-harvest losses, they are often poorly equipped to identify potential solutions. Successful marketing requires learning new skills, new techniques and new ways of obtaining information. Extension officers working with ministries of agriculture or NGOs are often well-trained in horticultural production techniques but usually lack knowledge of marketing or post-harvest handling. Ways of helping them develop their knowledge of these areas, in order to be better able to advise farmers about market-oriented horticulture, need to be explored. While there is a range of generic guides and other training materials available from FAO and others, these should ideally be tailored to national circumstances to have maximum effect.
Enabling Environments

Agricultural marketing needs to be conducted within a supportive policy, legal, institutional, macro-economic, infrastructural and bureaucratic environment. Traders and others cannot make investments in a climate of arbitrary government policy changes, such as those that restrict imports and exports or internal produce movement. Those in business cannot function if their trading activities are hampered by excessive bureaucracy and form filling. Inappropriate law can distort and reduce the efficiency of the market, increase the costs of doing business and retard the development of a competitive private sector. Poor support institutions, such as agricultural extension services, municipalities that operate markets inefficiently and export promotion bodies, can be particularly damaging. Poor roads increase the cost of doing business, reduce payments to farmers and increase prices to consumers. Finally, the ever-present problem of corruption can seriously impact on agricultural marketing efficiency in many countries.

Recent developments

New marketing linkages between agribusiness, large retailers and farmers are gradually being developed, e.g. through contract farming, group marketing and other forms of collective action. Donors and NGOs are paying increasing attention to ways of promoting direct linkages between farmers and buyers. The growth of supermarkets, particularly in Latin America and East and South East Asia, is having a significant impact on marketing channels for horticultural, dairy and livestock products. Nevertheless, “spot” markets will continue to be important for many years, necessitating attention to infrastructure improvement such as for retail and wholesale markets.