Principles of Field Crops

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Brief History in Crops Cultivation

Primitive human lived on wild game, leaves, roots, seeds and fruits. As the population increased, the food supply was not always sufficiently stable or plentiful to supply his needs. Crop production began when domestication of plants became essential to supplement natural supplies. The art of crop production is older than civilization, and its essential features have remained almost unchanged since the dawn of history. These features include:

1. Gathering and preserving the seed of the desired crop plants.

2. Destroying other kinds of vegetation growing on the land (weeds).

3. Stirring the soil to form a seedbed.

4. Planting the seed when the season and weather are right as shown by past experience.

5. Protecting the crop from natural enemies.

6. Gathering, processing and storing the products.

7. Removing by hand the destructive insects in the fields.

Agronomy is defined as a branch of agriculture that deals with the principles and practices of crop production and field management. The term was derived from two Greek words, **agros** (field) and **nomos** (to manage). Prior to the early years of the present century, crop experimenters usually were trained as botanist, chemists, or general agriculturalists, or were interested farmers, gardeners, or naturalists who became agronomists by adaptation. Thus, the new science of Agronomy was built up by coordination of knowledge derived from the natural and biological sciences with the written records of observations and empirical trials, and later of controlled experiments that dealt with crop production.

Better crop production follows the application of new findings, adaptation of improved machines, and breeding of new crop varieties. New developments must be publicized to inform a few enterprising farmers in each community in which such developments might apply.

There is some evidence of such development in crop cultivation, such as the universal adaptation of hybrid corn and sorghum, disease-resistant grains, and herbicidal chemicals. Farmers are eager to adopt any improvements that fit their conditions.

The Major Characteristics of Field Crops

The growth habits of crops that are grown on huge open land and are determinate as they flower and mature at the same time, they harvest at the same time. An exception to this rule is cotton and tobacco leaves, which can pick more than one time. Field crops also tolerate transportation, handling and longer storability than other crops.

Geographical Origin of Crops

Field crops, like all other cultivated food plants, are believed to have been derived from wild species. They were adapted to the needs of man long before the dawn of recorded history. The centers of origin of both agriculture and culture were peculiarly restricted to rather limited areas favored by a more or less equable climate. **Vavilov** determined the center of origin of a crop by finding the origin where the greatest diversity of type occurred in the crop.

DeCandolle concluded that 199 cultivated plants originated in the Old World and 45 in America. The crop plants peculiar to America include potato, sweet potato, field bean, sunflower, maize, and tobacco. Eurasia yielded wheat, barley, rye, oats, millet, rice, peas, soybeans, sugar beets, sugarcane; while most of the cultivated forage crops, sorghum and cowpeas seem to be indigenous to Africa.

It has also been reported that corn, beans, and cotton came from Mexico; tobacco, potatoes, and peanuts from South America; clover, from Europe; sorghum from Africa; rice, cotton, alfalfa, and soybean from Asia; and hemp, from Pacific Islands.

Each ancient civilization was based on particular crops, for example, it has been mentioned that wheat was probably grown in the Middle East as early as 10000-15000 B.C. in a very ancient Egypt. Carbonized kernels of wheat were found by American archaeologists, at the mid of nineteenth century, as 6000-7000 years old at Jarmo site in Iraqi Kurdistan Region.

The Centers of Origin According to Vavilov

1. **Center of China** - millets, broomcorn, sugarcane, and sesame.
2. **India**- rice, sorghum, cotton, Sudan grass, chickpea, Mungbean, sugarcane.
3. **Middle of Asia**- common wheat, rye, peas, lentil, faba bean, flax, sunflower, safflower, cotton.
4. **Near east**- wheat spp., barley, rye, oat, alfalfa, lathyrus, faba bean, sesame, rape.
5. **Mediterranean** -cereals, legumes, oat, clovers, lathyrus.
6. **Ethiopia**- barley, sorghum, millet, faba bean, lathyrus, safflower, castor bean, coffee.
7. **South Mexico and middle America**- maize, cotton.
8. **Latin America (Southern America)** - maize, cotton, tobacco.

Iraq and Kurdistan Region as Origin of some Crops

Archaeological found remains of barley at the Jarmo site near Jumjumal, between Kirkuk and Sulaimania Governorates about 6800 B.C.

Also carbonized kernels of wheat about 6000-7000 years old were found by American archaeologists at the Jarmo site. It appears extremely likely that chickpeas were domesticated in the Fertile Crescent 7000 years ago, which Iraq was a part of it.

Van der Maesen (1987) reported that chickpea, from earliest time (before 3000 B.C.) denotes as a staple food of minor importance in Mesopotamia.

Evolution of Field Crops

Cultivated plants have undergone extensive modifications from their wild prototypes as a result of the continuous efforts of man to improve them. The differences between cultivated and wild forms are largely in their increased usefulness to man, due to such factors as yield, quality, and reduced shattering of seed. Through the centuries, man selected from among thousands of plant species the few that were most satisfactory to his needs and which, at the same time, were amenable to culture.

All cultivated plants were divided by Vavilov, into two groups:

1. Those that originated from weeds such as rye. Cultivated rye is believed to have originated from wild rye which even today is a troublesome weed in wheat and winter-barley fields in certain parts of Asia. Oats are said to have come into culture as a weed found among ancient crops such as emmer and barley, and vetch.
2. Fundamental crops which are known only in cultivation, such as maize.

Classification of Crop Plants

Agronomic Classification

1. Cereals (or Grain Crops)

Cereals are grasses grown for their edible seeds. The term "cereal" is applied either to the grain or to the plant itself; e.g. wheat, barley, rice, maize, sorghum, oats, rye, and millet.

2. Legume for Seeds (Pulses)

Such as broad bean, chickpea, lentils, field beans, peas, cowpeas, soybeans, and Mung bean.

3. Forage Crops

Fresh or preserved, utilized as feed for animals. Forage crops include grasses, legumes, crucifers, and other crops cultivated and used for hay, pasture, fodder, silage or soilage such as clover, alfalfa.

4. Root Crops

Crops designated in this manner are grown for their enlarged roots. The root crops include sugar beets, carrots, turnips, sweet potatoes.

5. Fiber Crops

Fiber crops include cotton, flax, ramie, kenaf and hemp.

6. Tuber Crops

A tuber is not root; it is a short, thickened, underground stem such as potato.

7. **Sugar Crops**

Sugar beet and sugarcane are grown for their sweet juice from which sucrose is extracted and crystallized. Sorghum as well as sugarcane is grown for syrup production.

8. **Drug Crops**

Drug crops include tobacco and mint.

9. **Oil Crops**

Oil crops include flax, soybeans, peanuts, sunflower, safflower, sesame, castor bean. Cotton seed is an important source of oil, and corn furnishes edible oil.

Special Purpose Classification

1. **Cover Crops**

These crops are seeded to provide a cover for the soil. Such a crop turned under while still green would be a green-manure crop, such as clovers, alfalfa, vetches, soybean, cowpeas and rye.

2. **Catch Crops (Emergence Crops)**

These are substitute crops; planted too late for regular crops or after the regular crop has failed. Short- season crops such as millet are often used for this purpose.

3. **Silage Crops**

Silage crops are those preserved in a succulent condition by partial fermentation in a tight receptacle. Such as corn, sorghum, forage grasses and legumes.

4. **Companion Crops**

Sometimes called nurse crops, companion crops are grown with a crop such as alfalfa or red clover in order to secure a return from the land in the first year of a new seedling. Grain crops and flax are often used for these purposes.

5. **Green-manure Crops**

Those crops are grown to be plowed under or to be disked into the soil to increase its productivity. As a rule, legumes are more desirable than non-legumes for this purpose, as they often add nitrogen to the soil. Such crops as soybean, cowpeas, vetches, clover and rye are used for this purpose.

Classification of Crops According to their Growing Season

The growing season depends on climatic conditions (temperature, atmospheric humidity and photoperiod).

1. **Cool Season Crops (Winter Habit)**

They are well adapted to temperate climate. They are sown in the autumn, germinate and grow vegetatively, then become dormant during winter. They resume growing in the springtime and mature in late spring or early summer. Winter varieties do not flower until springtime because they require vernalization. These crops comprise wheat, barley, faba bean, lentils, chickpea, and clover.

2. **Warm Season Crops (Summer Habit)**

These are grown in tropical lowlands year-round and in temperate climates during the frost- free season. Rice is commonly grown in flooded fields, though some strains are grown on dry land. Other warm climate cereals, such as sorghum, are adapted to arid conditions. Other crops include maize, millet, peanut, soybean, Mungbean, sesame and cotton. These crops are planted in early springtime and mature later that same summer; these are typically requiring more irrigation. Warm season crops can be sown in two different times of year:

1. Early spring sown in end of March and harvest in July and August.
2. Midsummer sown, ripe and mature during fall.

Classification of Crops According to their Life Cycle

This involves the period from sowing to full maturity and dryness of the crop:

1. Annual Crops

The life span of these crops, from sowing to maturity is less than one year, such as wheat, barley, flax, rice, maize, sorghum, etc.

Also included crops that can live more than one year under certain conditions, but they usually grow for one season only; such as cotton and castor bean.

2. Biennial Crops

The life of these crops exceed one year, but is less than two years. Often, they store food in the first season and do not give flower or fruit until the second season; sugar beet, sweet white clover (*Melilotus alba*), are example of this kind of crop.

3. Perennial Crops

These lives for more than two years, such as alfalfa, sugar cane, sesale, and many of forage grasses.

CROPS CLASSIFICATION CHART

The famous Swedish botanist **Linnaeus** was responsible for the development of the present-day binomial system of plant classification. The binomial system includes the name of the genus (plural genera) and the species. *Species are plants that are essentially alike in the majority of their fundamental structural characters and that in reproduction, through a series of generations, produce offspring having the same fundamental characters*. The genus is considered as a group of species. The following chart is useful for understanding the classification of field crops:

Kingdom - Plantae (plants)

Division- Spermatophyte (plants bearing seeds)

Subdivision- Angiospermae (seeds enclosed)

Class - Monocotyledoneae (seeds with one cotyledon)

Order- Graminales (one seeded fruit)

Family- Gramineae (poaceae) (stem hollow)

Subfamily- Poacideae (spikelets one to many flowers)

Tribe- of oat Aveneae (callus hairy)

Genus- Avena (florets exceeded by strait glumes)

Species- nuda (caryopsis separates from glumes)

Variety - for example (record the best character)

Tribe of wheat is Triticinae

Tribe of barley - Hordeae

Tribe of rice - Oryzeae

Tribe of maize (corn) - Maydeae

Tribe of millet - Paniceae

Tribe of sorghum- Andropogoneae.

Sum Crop plant families

1. Poaceae or Gramineae: This family includes all cereal crops.

a. Summer cereal crops:

Rice	*Oryza sativa*	الرز
Corn or Maize	*Zea mays*	الذرة الصفراء
Sorghum	*Sorghum bicolor*	الذرة البيضاء
Millet	*Panicum milliceum*	الدخن

b. Winter cereal crops:

Bread wheat	*Triticum aestivum*	حنطة الخبز
Durum wheat	*Triticum durum*	الحنطة الخشنة
Barley	*Hordeum vulgare*	*الشعير*
Rye	*Secale cereal*	*الشيلم*
Sugar cane	*Sacchrum officinarum*	قصب السكر

2.Leguminoseae or Fabaceae

Alfalfa	*Medicago sativa*	الجت
Broad bean	*Vicia faba*	*الباقلاء*

Lentil	*Lens culinaris*	*العدس*
Chickpea	*Cicer arietinum*	*الحمص*
Chic line	*Lathyrus sativus*	*الهرطمان*
Mungbean	*Vigna radiata*	*الماش*
Peanut or groundnut	*Arachis hypogea*	*فستق* الحقل
Soybean	*Glycine max*	فول الصويا
Clover	*Trifolium alexandrinum*	*البرسيم*

4. Compositae

Sunflower	*Helianthus annus*	زهرة الشمس
Safflower	*Carthamas tinctorios*	*العصفر*

5. Malvaceae

Cotton	*Gossypium spp*.	القطن
Kenaf	*Hebiscus cannabinus*	*الجلجل*

6. Solanaceae

Tobacco	*Nicotina tabacum*	*التبغ*
Tunbak	*Nicotiana rustica*	التنباك

7. Linaceae

Flax	*Linum usitatissimum*	الكتان

7. Chenopodaceae

Sugar beet	*Beta vulgaris*	*البنجر* السكري

8. Tiliaceae

Hemp *Corchorus olitorius* الجوت الأخضر

9. Euphorbiaceae

Castor bean *Ricinus communis* الخروع

10. Brassicaceae

Rapeseed *Brassica napus* السلجم

The following table can be used as a general reference in differentiating agronomic crops from horticultural crops:

Agronomic vs. horticultural crops.

CRITERIA	AGRONOMIC CROPS	HORTICULTURAL CROPS
Ultimate consumers	Human and animals	Human
Harvest stage	Often harvested mature	Harvested at different stages
Consumption	Consumed processed in living state or dried	Often consumed fresh
Moisture content of harvested product	low	high
Aesthetic consideration	low	high
Calories	high	low
Vitamins and minerals	low	high
Life cycle	Semi-annual, annual, few perennials	Semi-annual, annual, biennial, perennial
Cultivar variability	high	low
Adaptation	limited	wide
Management	extensive	intensive
Income per unit area	low	high
Crops classifications	cereal or grain crops, grain legumes or pulses, oilseed crops, pasture and forage crops, fiber crops, sugar crops, starchy root and tuber crops	vegetable crops, fruit crops and edible nuts, ornamental crops, nursery crops, aromatic crops, medicinal crops
Terms for production units	field, pasture, range, forest	garden, orchard, grove, vineyard, greenhouse, nurseries, sometimes plantation

Agricultural Status of Iraqi Kurdistan

The Kurdistan region covered approximately 40000 square kilometers (9% of the area of Iraq) the same area as Denmark, four times the area of Lebanon and larger than that of the Netherlands.

The region produces 50% of the wheat produced in Iraq, 40% of the barley, 98% of the tobacco, 30% of the cotton and 50% of the fruits. Kurdistan has an important strategic location, with four border crossings and two major road arteries; the region is an established logistical hub for traffic from Turkey, Iran and Syria. The total dry land cultivated area of Kurdistan is about 5.4 million donums.

This comprises 33% of the total cultivated land under dry farming system; therefore, the per capita will reduce from 1.58 to 1.06 donums. The Iraqi Kurdistan region comprises a huge native pasture land, which start from the plains up to the mountain tops.

According to the FAO (2000) statistical issues, the native pastures at Erbil governorate is about 849421 donums.

During the last decades large areas were reduced due to misuses and unbalanced utilization of environmental factors. Drought is the major factor influencing the ground water table directly which reflect on land vegetation. Human being abuse involves severe cutting, continuous grazing and fires. Moreover, heavy load is imposed on pasture as the dry period extends from June to February; there is no vegetative growth for pasture plants.

FACTORS LIMITING CROPS PRODUCTION AND DISTRIBUTION

Environmental Factors:

Water supply is one of the most important factors influencing crop production and distribution. Crops are different in their requirements for water during their life, which vary according to their growth stages.

Crops can be classify as **hydrophytes**, including those that need water, such as lowland types of rice, but most of field crops are **mesophytes**, although some are highly resistant to drought conditions, those are called **xerophytes**, such as some varieties of sorghums.

Although annual precipitation is very important, its distribution through the season is also of great importance as it plays a major role in crop production.

In case of crops grown for their <u>seed</u>, the most critical period or need for moisture is during (<u>flowering) anthesis and fertilization</u>, while for <u>forages</u> grown for leaves and stems, the critical period is usually during the <u>early growth stages</u>.

The crops regions according to annual rainfall are:

1. Arid- with less than 250mm of annual rainfall (precipitation).
2. Semiarid- 250-475mm.
3. Subhumid -500-975mm.
4. Humid-1000-1475mm.
5. Wet- 1500mm or more

Temperature

Crops are different in their temperature requirements during their life, and its different stages of (germination, seedling, vegetative growth, reproductive growth-anthesis- and ripening stages). At each stage, the temperatures influence is different as there are three limits for each stage (minimum, optimum and maximum).

Many plants require exposure to low temperatures to induce flowering, such as the winter types of wheat, this process is called "**vernalization**", in its **narrowest sense**, which is means the promoting of flowering of some cereals by cold treatment of the moistened of germinating seeds (moistened seeds are stored at relative humidity 90% and 5 to 10°C for two weeks). **In its broad sense**, it means the low temperature induction of flowering in any winter annual, biennial, or even perennial species. Floral induction is accomplished in some plants by repeated exposure to low night temperatures, separated by periods of higher temperature this phenomenon is called "**thermoperiodism"**.

Day Length

This refers to the response of plant to day length for flowering. Plants have been categorized according to their day length requirements to:

Short day, **long day** and **neutral or intermediate** day plants:

The long-day plant flowers after a critical day length is exceeded, includes most of winter cereal crops, clovers and sugar beet.

A short-day plant, flowers when the day length is less than a certain critical length; an excess of this critical point will encourage vegetative growth (e.g., some short day crops include cotton, tobacco, maize, sorghum, rice, millets, some varieties of soybean and sunflower.

Day-neutral plants (**intermediate day crops**) flowers after a period of vegetative growth, regardless of the photoperiod (e.g., tomato, and some varieties of peas, faba bean, tomato, alfalfa and peanuts).

The photoperiod requirements for flowering may be qualitative or quantitative. **Photoperodism** is defined as the response of a plant to the relative lengths of light and dark periods.

Humidity

Humidity is water vapor in the air. Relative humidity is the vapor pressure in the air. Evaporation and transpiration increase with increases in temperature and decreases in relative humidity.

Air

Air not only supplies carbon dioxide for plant growth, but also nitrogen indirectly. It supplies O_2 for respiration of the plant as well as for chemical and biological processes in the soil. Air sometimes contains gaseous in concentration harmful to plant growth these gases usually come from fuel combustion or industrial fumes.

Nutritional Status

The nutritional status of a plant is also important, since construction of the flowering parts dependents on food availability and translocation. The carbon nitrogen ratio (C/N ratio) is particularly influential.

Soil

Crops are different in their favorite soil to survive, thrive, and grow well to give a high yield. This is related to soil texture, porosity and aeration, their water holding capacity, that determine irrigation schedule, in addition to soil nutrients and fertility.

Soil properties, comprising ***soil texture*** *which refers to the size of its individual grains or particles, grouped on the basis of diameter as sand (2 to 0.05 millimeter), silt (0.05 – 0.02mm) and clay (0.002 mm and less). Soil class is recognized on the basis of the relative percentages of these separates*.

Soil texture *has an important influence upon crop adaptation. Medium or heavy soils are best for rooted grasses (wheat and oats), whereas the coarse grasses (rye, corn and sorghum) can thrive and commonly grow on sandy soils*.

Soil structure *refers to the manner in which the individual particles are arranged. An aggregated or compound structure, in which the particles are grouped into crumbs or granules from 1 to 5 mm diameters, provides irregular spaces through which water and air can circulate.*

Table: Some characteristics of Iraqi Kurdistan region soils.

Governorat	Organic	Exchange capacity, ml/100g	pH
Duhok	0.8	36.6	7.73
Sulaimani	0.9	33.1	7.86
Erbil	0.5	11.7	7.77

In general, root crops favor soils of light texture (loamy sandy) to allow free root growth and expansion, while other crops, such as grasses and small grain favor heavy soils, but rice favors heavy soil with slightly impervious subsoil to retain water and prevents excessive water losses from leaching.

Soil pH also is a detrimental factor in crop production, some crops require neutral soil (wheat), others favor alkali or tolerate alkaline soil (barley), and others tolerate acidic soils (rice). Generally, heavy soils contain more nutrients than light soils and give more profitable returns.

Soil Salinity

Some crops are considered being salinity tolerant such as barley, sugar beets, cotton, all of which can grow where the soil solution from the root zone contains as much as 0.8 to 1.6 percent salts (8 to 16 millimhos). (Millimho is a unit of electrical conductance which is the reciprocal of a milliohm).

A soil is classified as saline by the USDA salinity laboratory when the soil saturation extract is (4) millimhos or more per centimeter at 25°C. White, red and clovers and field beans have a low tolerance, i.e., the salt content does not exceed 0.3 to 0.4 %; most of the other field crops have a medium tolerance, i.e., the salt content does not exceed 0.8%.

Soil Acidity

Soil acidity is measured as hydrogen-ion activity; soil with a pH of 7 is neutral; one higher than pH 7 is alkaline, while a soil with a pH below 7 is acidic.

Soil Constituents (الماء الأرضي)

Water the most important constituent in the soil occurs in three forms besides occurring in the form of vapor. **Capillary water** is the water used mostly by plants. When plants wilt, the soil may be containing 2-17% moisture depending upon its texture and humus content.

Water below this permanent wilting point is largely unavailable to plants. **Gravitational water** is move downward and may percolate beyond reach of the roots of crop plants.

Hygroscopic water is adsorbed water on soil particles and that is not available to plants.

Supply of plant nutrients is essential for the growth of crop plants. About 25-30 chemical elements are found in plants. C, O_2, H_2, is most abundant. The essential elements are N, P, K, but Ca, mg, S, also essential are absorbed by crops in considerable quantities.

The minor elements are Mn, Fe, Bo, Cu, Zn, Mo, Co, which plants need in small quantities. Zinc is essential for plant growth and development including cell division, starch synthesis and seed formation. Manganese and iron serve as catalysts in chlorophyll synthesis, while chlorine is involved in electron transport, during photosynthesis. Molybdenum is for nitrogen fixation and as a compound of enzymes. Cobalt is for nitrogen fixation. Copper, is for Oxidizing enzymes and boron in cell division and growth processes.

Crops for Special Soil Conditions

1. Crops tolerant to salinity:

A. Barley, sugar beet, rape, and cotton may be grown in soil contains 0.8-1.67% salts (8-16 millimhos)

B. White and red clover, field bean have low tolerance (0.3-0.4%)

C. Most of the other field crops have a medium tolerance which salt content should not exceed 0.8%.

2. Crops tolerant to acid soils:

A soil with pH 7 is neutral, one higher than 7 is alkaline while less than 7 is acid.

Biotic Factors

The inter-specific and intra-specific relations between plants have influence on both crop production and distribution, these interrelations involves: symbiosis, competitions and antagonism.

The term "**symbiosis**", means living together of different species not necessarily, only those of mutual benefit are often used for mutual benefit called "mutualism".

Symbiotic, such as the nodule bacteria of the genus Rhizobium formation on the roots of legumes of different physiological races or strains includes: *R. meliloti* for Alfalfa; *R. trifoli* for white, red clovers; *R. leguminosarum* for faba bean, lentil, and peas; *R. phaseoli* for phaseolus (beans); *R. lupini* for lupines; *R. japonicum* for soybean, peanut and chickpea.

Competition

Inter and intra-specific competition between the same species or a competition of weeds with the crops for essential elements, water, minerals, and light. Optimizing crops density will minimize the adverse effect of weeds on crop yield and quality.

Antagonism التضاد

The inhibitory action of one species on another, for instance; the action of exudates substances from the plants into the soil which inhibits growth of nearby plants; it also called (**Allelopathy**).

Parasitism التطفل

A parasite has its influence on the host such as (dodder) or other diseases and pests.

Essentials for Growing Crops

Good Quality Seeds

Seeds are the protectors and propagators of their kind, thus farmer's demand crop seeds of high quality to use for sowing or planting. In their general characteristics of good quality, seeds should be:

1. True to the variety.
2. Healthy, pure and free from inert matters and weed seeds.
3. Viable and their germination capacity should test recently and meet the minimum standard.
4. Uniform in their texture, structure and appearance.
5. Truthfully labeled and produced under all due cares and strict supervision so that they do not degenerate quickly.
6. The seeds must not be affected by any seed-borne disease.
7. Seeds must be of high germination and purity percentages, and from an authenticated source, for instance, the certification agency must be available.

Land Preparation

Tillage Practices:

Purposes of Tillage:

1. To prepare a suitable seedbed.
2. To eliminate competition from weed growth.
3. To improve the physical condition of the soil.

Implement Use in Preparation of the Seedbed:

The implement use in preparation of the seedbed differs in the depth, their effectiveness in destroying weed and they stir the soil. **Seedbed** can be defined as the place where the seeds are placed or sown in to germinate and the medium from which the resulting plants, through their roots secure moisture and minerals. There are various implements to prepare a suitable seedbed like plows and harrows.

Depth of plowing:

It seems that extremely deep plowing is not necessary for ordinary field crops. Deep plowing does not necessarily decrease the yield, but increase. Under ordinary conditions with the common field crops a desirable and practical -depth to plow seems to be about 5-8 inches. The depth to which land should be plowed will vary with:

1. Time of plowing.
2. Kind of soil.

Plowing in the late fall and winter, when the land is to be planted in the spring, many frequently be deeper than when the land is to be planted soon after plowing especially in the heavy soil. Sometime plowing deeper than 7 inches does not generally result in increased crop yields. Deep plowing increases crop yields in two ways: plants can obtain more nutrients from clay than from sand particles and the soil with higher clay content can hold more moisture for longer periods than soil with lower clay content.

Time of plowing

The time to plow varies with the climate, crop and soil conditions. In the drier regions of the country, the land should be plowed and kept prepared for as long a time as possible before the crop is planted. In the humid areas, the time of plowing will depend on the crop and soil conditions. For growing wheat and barley, which is fall-sown, plowing should be done in the summer, while for corn, cotton, cowpeas, soybean, and other spring-sown crops, the plowing must be done in the fall or in spring. Heavy soils, such as clay and clay loams, which are to be planted in the spring, should be plowed in the fall or winter and the seedbed further prepared in the spring.

Summer fallow: In the drier regions, the primary reason for summer fallowing is to conserve moisture and store it in the soil for use by a later crop. Summer fallowed land is usually used in rotation with small grain crops. The three objective of tillage between harvest and seeding on dry farms are:

1. Control weed and save moisture.
2. Provide a good seedbed, well supplied with moisture at the time of planting.
3. Keep crop residues on the surface to help control erosion.

There are some notes for summer fallow:

1. Fallow land need not be plowed deeper than 8 inches.
2. Plowing should be done in the fall or early spring.
3. Sub soiling 15 an 18 inches deep did not increase wheat yield.
4. Frequent cultivation of fallow is unnecessary.

5. The moldboard plow gave higher yields than the one-way disk and harrow.

Benefits of good preparation:

1. Conservation of moisture.
2. Destruction of weeds.
3. Better aeration of the soil.
4. Utilization of organic material to the best advantage.
5. Pulverization and loosing of the soil.

Seed and seeding practices

The Value of Good Varieties:

In the following of the variety to be used, the following qualifications should be taken into consideration:

1. Adaptability.
    a. Adaptation to soil.
    b. Adaptation to climate.
    c. Length of growing season.
2. Yielding ability.
3. Purity.
4. Quality of product for market or feeding purposes.
5. Diseases and insect resistance.

The Value of Good Seed

The use of seeds of good quality is of great importance in crop production. Not only must good seeds belong to a good variety but they must have:

1. Strong germination.

2. Proper size.

3. Uniformity.

4. Freedom from seed borne diseases.

5. Freedom from noxious and other weeds.

6. Freedom from mixtures with other crop seed.

Conditions that Affect Quality of Seeds:

The conditions that affect quality of seeds are:

1. **Method of production.**

In order to produce good seeds, well developed and disease-free should be used. The benefits to be derived from good seed will more than pay for the extra care labor necessary to produce them.

2. **Method of handing.**

Seeds for planting should be very carefully handled at harvest time and care should be taken at harvest the crop until the seeds are mature.

3. **Method of storage.**

The chief precaution to be observed in the storage of seeds is to see that the seeds are dry before storage and to keep them dry in storage. Seeds that are subject, while in storage, to the attacks of insects such as weevils, should be treated before storing to destroy these insects and should be kept in tight bins or receptacles.

Seed Germination

The most important external conditions, necessary for germination of matured seeds are moisture, oxygen, temperature and for some seeds, certain light conditions. A deficiency in any factor may prevent germination. Good seed shows a germination of 90 - 100 % in the laboratory or under good field conditions. In a poor seedbed, the emergence may be much less.

Factors of Germination

1. Moisture

Water is necessary for rapid germination which the soil contains about 50-70 % of its water holding capacity. Field crop seeds start to germinate when their moisture content reaches 26-75 %. The water usually enters the seed through the micropyle or hilum, or it may penetrate the seed coat directly. Water inside the seed coat is in imbibed by the embryo, scutellum and endosperm. The imbibed water causes proteins and starch of the seed to swell.

2. Oxygen

Many dry seeds like peas and beans are impervious to gases, including oxygen. Absorption of moisture may at the same time render the seed permeable to oxygen. Seeds planted too deeply or in a saturated soil may be prevented from germination through an oxygen deficiency except rice seeds.

3. Temperature

The T. range for the germination of field crop seeds is from 32-120 F. In general, cool season crops germinate at lower T. than warm-season crops.

The optimum T. for wheat is 59 F.

= = = = soybean is 77 F.

= = = = tobacco is 88 F.

$F-32\times(5/9)={}^{o}C$ (Celsius) $\qquad {}^{o}C\times 9/5+32=F$

Warm weather crops germinated best at 86-97 F. Most crops seeds are germinated at alternating night day temperature, which simulate field conditions, favors better germination. At T. too high for germination, the seed may be killed or be merely forced in to secondary dormancy as a result of ascribed destruction of enzymes and coagulation of cell proteins.

4. Light

Most field-crop seeds germinate in either light or darkness. Many of the grasses germinate in the presence of light especially when the seeds are fresh. Light is necessary for germination of some types of tobacco, except at low T. of about 57 F. The light requirement in all cases is small which may induce germination in seeds that are wet and swollen. Some weed seed is dormant when buried in the soil or when the light be absence. Red light initiates the germination but for red light of 730 millimicron (μm) wave length inhibits germination.

Process of Germination:

When seeds placed under the proper conditions:

Seed capable of immediate germination gradually absorb water.

Soluble nutrient particularly sugars go into solution, and diffused from cell to cell and synthesized into cellulose.

Emerging seedling exports to light begin photosynthesis early. The growing embryo ruptures the seed coat; the radical is the first organ to emerge. It is soon following by the young shoot (plumule). There are two types of germination:

A. **Epigeal germination**: which the cotyledons are above the set surface by the elongation of hypocotyls.

B. Hypogeal germination: the cotyledons are remaining in the soil, the plumule grows or is pushed upward by the elongation of an epicotyls. There are coleoptiles in grass plants, which protect the first leave when it emerged. The roots are well developed by that time.

Dormancy in seeds

Definition: Dormancy is a condition in which a seed fails to germinate in the presence of appropriate environmental conditions.

Seeds of some crop species show dormancy i.e., they fail to grow immediately after maturity even through external conditions favor until they have passed through a rest- or after-ripening period.

Causes of dormancy:

Dormancy may result from seed characteristics or environmental conditions as follows:

1. Thick or hard seed coats prevent intake of water and probably also oxygen. The hard seeds in many legumes are an example.
2. Seed coats interfere with the absorption of oxygen, e.g. oats and barley.
3. In some species the embryo is still in mature and has not yet reached its full development at harvest.
4. The embryo in some seeds appears to be mature but must undergo certain changes before they will germinate. Such green seeds found in wheat that has been frosted before maturity.
5. Germination inhibitors, which must undergo natural or applied chemical hangs to permit germination.
6. High temperature during seed maturity may induce dormancy.

Registered or Certified Seeds

The international crop improvement association defines the classes of seed as follows:

1. **Breeder seed**: بذور المربي seed or vegetative propagated material directly controlled by the originator, breeder, or institution, which provides the source for the initial and recurring increase of foundation seed.
2. **Foundation seed**, بذور الأساس which includes elite seed, shall be seed stocks that are so handled as to must nearly maintain specific genetic identity, purity, and that may be designated or distributed by an agricultural experiment station. Foundation seed shall be the source of all other certified seed classes.
3. **Registered seed**: البذور المسجلة the progeny of foundation seed that is handled as to maintain satisfactory genetic identify and purity. This class of seed should be of a quality suitable for production-of certified seed.
4. **Certified seed**: البذور المصدقة the progeny of registered that is handled to maintain satisfactory genetic, identity and purity and has been approved and certified by the certifying agency.

Planting Methods

1. Broadcasting الزراعة نثراً

The seeds are distributed by hand over the land surface without any rows. This can be done in the case of small areas that machines cannot reach, or in the case of acute slopes or in pastures. In Iraqi Kurdistan Region the farmers generally cover the seeds with a duck foot cultivator or one way disc plow.

The **advantage** of broadcasting is that it is simple and a large area can be covered in a short time. It is suitable for grass and other crops for which the seeds are very small and it is necessary to get a thick growth. The **disadvantages** of this method are that seed germination will not be uniform and the distribution will be irregular added to the large quantity of seeds that is required. However, airplane can also be used in sowing presoaked rice seeds and pasturelands.

2. Drilling الزراعة في خطوط

Some other crops are drilled by seed drill, which places seeds in lines or rows that are usually close together, such as wheat and barley.

The most efficient and ideal method of sowing is by mechanical drilling which allows the deposit of the seeds in the desired amount at a uniform depth.

The seeds are placed in lines, the distance between the lines for cereals crops is about 15-20cm and for legumes, it will be a little more depending upon the type of crop, soil and other conditions. Seeds are placed in a uniform depth and this helps in good germination and uniform stand.

For dry farming, drilling is very suitable in order to cover large areas in a short time and fertilizers have to be applied. This operation can be carried out at the same time as sowing.

3. Planters الغرس

Others are sown in ridge or furrows with proper recommended distance, such as maize, cotton, sunflower, etc. It is used for sowing in ridges that are at a little distance from each other. It is normal to plant three or more seeds in one pit.

Sowing or Seeding Rate

The rate of seeding refers to the amount of seeds sown per a unit area, which is the Donum in Iraq (2500 square meters). It depends on crop type, seed size, date and depth of sowing, method of sowing, soil texture and its properties. Under irrigation, the amount must be increased. The sowing rate depends on the seed germination percentage and seed purity.

Fertilizers and Fertilization

Object of Fertilization

Fertilizers are applied to the soil to promote greater plant growth and better crop quality. Soluble compounds of nitrogen, potassium, calcium and magnesium are leached down-ward into the subsoil. Phosphorus compound become fixed in the upper soil.

Soil is the cheapest source of most fertilizer elements. High yields of crops remove more fertilizer elements from the soil.

Any practice other than fertilizer application that improve total crop yield such as plowing and crop rotation. The total depth of soil in which annual crop -plant roots is 3-6 feet. Phosphorus is distributed uniformly through the surface, subsurface and subsoil layers. Potassium is also distributed throughout the different soil horizons.

Role of Bacteria in Nitrogen Fixation

Bacteria that multiply in nodules on the roots of legumes fix nitrogen from the air into forms that the plant can utilize. This is called symbiotic fixation of nitrogen. Alfalfa and clovers fix more nitrogen than other the large -seeded legumes.

These Rhizobium bacteria, which require molybdenum, cobalt and iron in order to function, are most effective in soils low in nitrogen. The Rhizobium bacteria enter through the root hairs of the germinated seedling and from the nodules in the cortex of roots.

Legume plants obtain their nitrogen from the soil when the bacteria are absent.

The Function of N, P and K elements.

Nitrogen: Nitrogen produces a good leaf and stem development and gives to plants dark -green color. Nitrogen is a constituent of protein and is thus apart of every living plant cell but an oversupply may cause a weakness of stem with resultant lodging and inferior grain. It may also delay maturity of the plant and sometimes decrease resistance to disease. When a soil is poor in nitrogen, plants do not grow large and have-poor color.

Phosphoric Acid.

Phosphoric acid induced the maturity of crops. It increases the proportion of grain to straw and stimulates root development in young plants. It also strengthens the straw and greatly improves the quality of certain crops, which is increase the resistance of some plants to disease. It also influences cell division. In the absence, starch will not change to sugar.

Potassium

Potassium appears to aid the plant in resisting certain diseases. It is essential to the formation of starch, sugar and cellulose and where it is insufficient, plant do not mature well. It strengthens the stems. One of the most striking indications of an insufficiency of potassium is the early ripening or drying of the stems and leaves of plants while the seeds or fruit are still immature.

Factors and Theories Relative to the Use of Fertilizers

The primary object in the use of fertilizer is to obtain a profile from the increase in yield of crops, from the land on which the fertilizer is supplied; there are a number of factors that have either a direct or an indirect influence upon the profits that may be obtained from the fertilizers.

A few of the more important of these are:

1. Soil types.
2. Weather conditions.
3. Crop grown.
4. Productivity of the soil.
5. Length of growing season.

Manures

A. Barnyard Manure:

Barnyard manure consists of a mixture of animal excrements and bedding material. The results obtained from the use of manure vary with the:

1. Locality.
2. Type of soil.
3. Crop.

The chief benefits from manure are indirect.

1. By supplying humus.
2. It improve the physical character of the soil as well as
3. By improve the water -holding capacity.
4. Aeration.
5. It effect on the activities of lower organisms to give nutrient in the soil.
6. It increases the intake of water and decrease evaporation.
7. It reduces erosion.

B. Green manure:

Legume and non legumes crops are use as cover and green manure. The difference between them is that legumes add both organic matter and nitrogen to the soil where as non legumes add organic matter only, winter legumes used for green manure is vetch, winter field pea, some kind of clover and blue lupine.

The summer crop used for green -manure and soil improvement are such legumes, red clover, soybeans, cowpeas, and sweet clover. Non legumes crop can used under certain condition when the period during which the green manure crop can occupy the land is very short, under such circumstances Sudan grass and pearl millet often can be used.

Irrigation

Land use is affected by physical, economic and social condition, Altitude, topography, climate, soil, location and relation between land water, when each is considered either alone or in combination, are the principle factors that affect land use. The length of the growing season and fertility of the soil are recognized for their importance in influencing productivity but the amount and distribution of rainfall, of the supply of water otherwise made available or controlled, are the prime factors that limit the productivity of land.

Essentially, irrigation is a method by which water is provided for plant growth when the natural rainfall is inadequate, it also aids in the control of soil and air temperature and to leach the soil of excess soluble salts.

There are many different factors to determine whether irrigation is feasible under a given condition,

1. The adequacy and suitability of available water.

2. The characteristics of the soil.

3. The topography.

4. Field size and shapes.

5. Pump and power requirement.

6. lands possible to be irrigated.

Dry Farming

Dry-land farming is the production of crops on land that receive limited rainfall and to which no irrigation water is applied. In some low rainfall areas, crop yields are so uncertain that production should be limited. Other areas are well suited to grow crops such as wheat or barley.

<u>How Increase Available Soil Water in Dry-Land</u>

There are number of practices which regard soil -moisture conservation and utilization:

1. Fallowing

2. Wide-Spaced Row Crops

3. Reduce Water Losses

Type of Erosion:

1. Water erosion.

2. Wind erosion.

Control of Soil Erosion:

The rate of removal of soil by water and wind erosion depends upon slop, soil, climate and land use.

Method of Soil Erosion Control:

1. Use a thick vegetative cover (grass, alfalfa).

2. Good preparation of the surface- of the soil such as deep tillage.

3. Contour tillage and planting.

4. Strip farming.

5. Crop rotation.

Weed control

A weed may be defined as:

1. A plant out of place or

2. A plant growing where it is not desired or,

3. A plant that does more harm than good.

Disadvantages of Weeds:

Weed cause a direct loss to yield in the following ways:

a. It lowers the selling value of the land.

b. It reduces crop yields.

c. It increases the expense of cultivation and harvest.

d. It reduces the market value of crops.

e. It harbors disease and insect that attack crops.

f. Some of them are poisoning plant.

Advantages of Weeds:

a. It added organic matter to the soil.

b. It added mineral nutrient to the soil.

c. Prevent the leaching of nutrients from the soil.

d. It control water or wind erosion.

Classification of Weeds:

Weeds may be classified into three groups according -to their duration or length of life:

1. **Annual weeds:** It is two kinds: Summer or winter annual.
2. **Biennial weeds**: It lives 2 years during the first year they grow rather slowly producing root, leaves close the ground, during the second year, they send up flowering stems that produce seed and then die.
3. **Perennial weeds:** They live over winter from year to year either above or below ground. The underground parts may consist of underground stems, or bulbs. These parts supply food material for renewing growing. Perennial weeds are often difficult to eradication.

Control of Weeds:

Weed control is the process of inhibiting weed growth and limiting weed infestations so that crops can be grown profitably. Weed eradication define as the complete elimination of all live plants, plant parts and seeds of a weed infestation from an area.

The more common methods used are:

1. Plowing.
2. Smothering.
3. Mowing.
4. Pasturing.
5. Chemical herbicides.
6. Flaming.
7. The use of clean seed.

Crop rotation

Crop rotation may be defined as a more or less regular recurrent succession of different crops on the same land, through a considerable period of years; rotation may be any length most commonly of 3-7 years duration.

Reasons for Crop Rotation:

There are many benefits, both direct and indirect to be obtained from a good crop rotation.

Crop rotation:

1. Helps to control weeds, insects and diseases
2. May aid in maintaining the supply of organic matter in the soil.
3. May aid in the maintenance of the soil nitrogen supply.
4. Often saves labor.
5. Keeps the land occupied a greater part of the time with crops.
6. Allows for crop alternation.
7. Regulates the use of plant nutrients from the soil.
8. Systematizes farming.
9. Increase crop yields.
10. Improve crop quality.

Exercises in Crop Rotation

Rotation usually is named after the name of the major crop involved in the process. We must know the residence period of the crop in the field, In addition to whether also we must know if the plant is sown in winter or summer, and to take in to consideration, whether the plant is of soil fertility enhancement or fertility consumed.

$$\text{Rotation cycle in years} = \frac{\text{Staying period (years) of major crop}}{\text{Area occupied by major crop}}$$

$$\text{Number of portions in the rotation} = \frac{\text{Rotation period in years}}{\text{Staying period (years) of major crop}}$$

All annual crops are considered as if they are grown for one year

1. A crop rotation for wheat involves 50% percent of the land, whereas the other half of the land remains fallow.

Rotation cycle (period) = $\frac{1}{1/2} = 2$

Number of rotation portions = $\frac{2}{1} = 2$

	1st year	2nd year
Portion 1	Wheat 50%	Fallow
Portion 2	Fallow50%	Wheat

2. In case the farmer decides to grow 50% of his land with wheat and the other half of his land is partitioned to grow clover and fallow; therefore:

Rotation cycle (period) in years = $\frac{1}{1/2} = 2$

Rotation portions = $\frac{2}{1} = 2$

<table>
<tr><th></th><th>1st year</th><th>2nd year</th></tr>
<tr><td rowspan="2">Portion 1</td><td rowspan="2">Wheat 50%</td><td>25% Fallow</td></tr>
<tr><td>25% Clover</td></tr>
<tr><td rowspan="2">Portion 2</td><td>25%Clover</td><td rowspan="2">Wheat 50%</td></tr>
<tr><td>25%Fallow</td></tr>
</table>

3. In case 33% of the field is allocated for growing wheat and 20% for faba bean, therefore:

Crop cycle (period) in years = $\frac{1}{1/3} = 3$

Rotation portions = $\frac{3}{1} = 3$

	1st year	2nd year	3rd year
Portion 1	Wheat 33%	2	3
Portion 2	Clover 20% Fallow 13%	3	1
Portion 3	Fallow 33%	1	2

4. Design a rotation for growing each of the following crops (cotton, wheat and corn) by one third of the farm area and we want to involve rice.

Rotation duration (cycle) in years = $\frac{1}{1/3} = 3$

Rotation portions = $\frac{3}{1} = 3$

	1st year	2nd year	3rd year
Portion 1	Cotton 33%	2	3
Portion 2	Clover 33%, then corn	3	1
Portion 3	Wheat 33% then rice	1	2

Rotation portions = $\frac{3}{1} = 3$

	1st year	2nd year	3rd year
Portion 1	Wheat 33%	2	3
Portion 2	Clover 20% Fallow 13%	3	1
Portion 3	Fallow 33%	1	2

The first portion used only 33% of the land, but the second portion grows crops twice 33% and 33%, in the third portion also grown twice 33% and 33%, therefore:

33 + (33 +33) + (33+33) = 165 % of the land exploited in the rotation which describes as an intensive rotation.

5- Half of farm area needs to be grown with alfalfa and to stay for three years; the other half is divided equally for growing wheat and flax.

Rotation duration (period) in years = $\frac{3}{1/2} = 6$

Rotation portions = $\frac{6}{3} = 2$

1st y	2nd y	3rd y	4th y	5th y	6th y
Alfalfa 50%	Alfalfa50%	Alfalfa50%			
Wheat25% Flax 25%	Flax25% Wheat25%	Wheat25% Flax25%			