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Introduction

Crop production is a cascade of many interacting effects between plant, edaphic and environmental factors. Besides, socio-economic factors play an important role in crop production, which include timely credit, price support and availability of critical inputs. Marketing is an essential part of agricultural production. Of late yield barriers, the physiological and other factors have plateaued the yield of many food crops. The world cereals production stands at 2200 million tones but human population has made phenomenal growth which by 2020 A.D. is expected to be 7.2 billion. The Syrian scenario is no different. With less cultivable area and low per capita land availability, the challenging task is to achieve food security (ensuring both physical and economic access to a balanced diet, safe drinking water, etc). With the main objectives of sustainable crop production, environmental safety and food security, a second green revolution seems imminent. By adapting the advanced agronomic practices, sustainability of crop production can be achieved. Total food grain production increased by about four times during the last 50 years. With the concentrated efforts of farmers, agriculture scientists and the government, Syria has largely solved the problem of domestic food deficit, but still we have future challenges ahead for ever-growing population. The Ministry of agriculture assigned cultivation of specific crop varieties based on annual rainfall and climatic zones because several cultivars vary in their moisture and fertility requirements, adaptation and tolerance to drought stress are produced periodically by national (GCSAR), regional (ACSAD) and international (ICARDA) research centers. The general establishment of seed multiplication provides farmers yearly with most of their needs of the seeds of genetically improved cultivars. Economic and ecological sustainability of a crop or system is important for progressive productivity increase. Today, we are facing new generation problems affecting the productivity of major crop-based systems. Declining nutrient use efficiency, multiple nutrient imbalances, adverse changes in soil physio-chemical properties and change in pest-disease-weed syndrome are some of them. Economic sustainability can be achieved by introducing a high value crop or by adding value to the crop components and introducing cost effective crop-management practices. Integrated nutrient and pest management would bring down appreciably the inputs beside ensuring environmental safety.

We put this text book of field-crop production in English language for the third-year students for the first time in the history of The Faculty of Agriculture-Damascus University. In this humbly text book, we tried to explain the information related to field crops production in a very simple way, with best wishes to be an interesting, useful and valuable text book for all interested people and an important addition to our library.

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Chapter-1: Cereal crops

Cereal crops can be defined as those grown in order to obtain the grains, which are used in human and animal nutrition, and in various industrial purposes. The crops following this group have some similarities in many characters and some differences in some other characters. Crops include: wheat, barley, maize, rice, sorghum, rye, oats and millets. These crops form the main part in the global agriculture, where they are the basis for human nutrition, both directly and indirectly (outputs of the animal production sector) and thus play a major role in meeting the food needs of the growing population of the globe that is increasing year after year. Despite the distribution of imbalanced food, but it gives the people the required calories and keep them away from hunger.

Economic importance: Cereal crops are not a balanced diet as a result of the high content of carbohydrates and low protein content and somewhat lack of vitamin C. But the point that should be taken into account to solve the problem of securing food for the continuing increase in the number of people on the surface of the globe, is that to work on expanding cultivated areas in order to increase their productivity. We can highlight the economic importance of these crops through the following points: the value of food or feed, the ease of storage for long period of time, and the easy moving from one place to another because of low moisture content, and lack of necessary field operation compared with other crops, and the stability of prices in world markets. All this means the stability of farm resources, and responsiveness to the improvement of agricultural treatments, and its broad genetic variability which will help in the possibility of their adaptation to the agricultural conditions and, finally, its role in the development of various food industries.

Chemical composition of the grain: Cereal crops contain high percentage of starch, and this explains its name starchy crops, ranging from about 55.7% in oats and 80% in bread wheat (Table 1), and this starch consists of amylose and amylopectin, where the proportion of the first 23% and the second 77%, note that the proportion of amylose may in some varieties of starchy maize reach to 50-80%. In addition to that, grains of these crops contain percentage of protein ranging from 7.7% in rice grain and 16% in the grain of durum wheat, while their content of fatty substances is low with about 2% except maize grain 5.3%, oats and millet 4.5%. Note that the bulk of this material is concentrated in the germ of grain (14% in wheat, 26% oats, 20% in millet, 12.4% in the rye and barley, 40% in maize of the total amount). The moisture of grain in cereals is usually low to the limits allowed to store it safely at a level of 10% in most of the cereal crops. We should note that the chemical composition of grain is not constant;

Table 1: Chemical composition for various grain of various cereal crops

Crop	Protein (%)	Starch (%)	Fats (%)	Ash (%)	Fibers (%)
Durum wheat	16.0	77.4	2.1	2.0	2.4
Bread wheat	13.9	79.9	2.0	1.9	2.3
Barley	12.2	77.2	2.4	2.9	5.2
Corn	11.6	78.9	5.3	1.5	2.6
Rice	7.6	72.5	2.2	5.9	11.8
Millet	12.1	69.8	4.5	4.3	9.2
Sorghum	11.6	77.9	3.2	2.6	3.5
Oats	11.7	68.5	6.0	3.4	11.5
Rye	12.8	80.9	2.0	2.1	2.4

it changes not only depending on the cultivar, but within each cultivar depending on weather and soil conditions and the level of agricultural technology provided. For example: the proportion of protein in wheat grain with the trend in agriculture from the northern areas towards the South, and West to East, i.e, changes in conditions of drought, and land rich in nitrogen, or when adding organic fertilizers, minerals, or with planting after suitable crop in crop rotation. Protein of cereal crops consists of albumin (dissolve in water), globulin, gluotinin, gliadin (do not dissolve in water with a rate of 16-50% in wheat, 26% in rye, 2-19% in barley). Bread crops (wheat, rye, barley, millet) contain high amount of gluten, which affects the characters of the dough, in terms of increasing the pores, which gives it a property of retaining gas during fermentation. The latest helps to stretch the dough and increase its size. This is reflected in the qualities of bread product in terms of ease of digestion. While the gluten percentage is low in corn, sorghum and rice, which are used in feeding after grain boiling, weather conditions affect the amount and quality of gluten. Its percentage increase if the grain filling stage coincided with the hot weather.

The nutritional value of grain is determined through:

1) The good and proportionate ratio between the protein and starch and this amount: 1: 6-8 in cereals, 1: 1-2 in legumes, 1: 10-15 in potatoes.
2) Low moisture content (12-14% at harvest) so, it can be stored well for long period of time rather well to the ease of transfer from one place to another and can therefore be used as food reserves at the time of disasters.

3) The contents of mineral elements, vitamins, in sufficient quantity for the human body, and the most important elements: phosphorus 50%, calcium 2.8%, magnesium 12%, potassium 30% of the total amount, however, most of these elements is lost with bran.

History and center of origin: The human civilization relied on cereal crops since ancient times, where its cultivation by human being was considered the starting point of civilization and the stability of the human and the formation of societies and this could be seen in the use of wheat and barley in Mesopotamia civilization, Romanian civilization, Greek civilization, and the use of rice in the civilization of East and Southeast Asia, and the use of maize in the civilization of Central and South America, and that of sorghum by African tribes for eating and bread manufacturing. The current cereal crops originated from the wild species multiplied naturally through seed spread at maturity, and for each cereal crop, a place grew for the first time, the so-called center of origin. For example, sorghum originated in the region of Ethiopia, maize in the region of southern Mexico and Central America and wheat in the Middle East.

The cultivated area: The steady progress in various fields of science and agricultural technology helped in increasing the cultivated area of cereal crops, and its productivity and the yield of unit area. There has been an increase in productivity after World War II which doubled during the period 1948-1994, through the vertical expansion (the introduction of modern high yielding varieties which could respond to the requirements of agricultural intensification of rate and date of planting, fertilization, mechanization .etc.) in developed countries, and through horizontal expansion in developing countries with the introduction of modern varieties in some countries. According to the FAO statistics for 2009, the total cultivated area of cereal crops in the world amounted to about 683.3 million hectares, with a total production of about 2.23 billion tonnes, with an average yield of 3260 kg/ha.

India comes in first place in terms of cultivated area, followed by China, then United States of America, while China comes in first place in terms of production, followed by the United States. Egypt comes in the first place in term of yield 7460 kg/hectare (Table 2). According to FAO statistics for the year 2009 the cultivated area by the world was 672.7 million hectares, the share of the Asian continent 312.8 million hectares, followed by Europe with 122.1 million hectares. With respect to production, global production of cereals 2.1224 billion tons, Asia produced 1.006 billion tons, and then Europe, North and Central America by 422.4 million tons for each, Africa 122.5, South America 115.7 and, finally, Oceania 33 million tons. The cultivated area of wheat contribute 31.7% of the total area with 27.8% of the total production of cereal crops, followed by rice and then corn, which is ranked first in terms of yield of unit area (4527 kg / ha) of cereal crops. The total cultivated area of cereal crops in the Arab World is 31. 85 million hectares, while the production of whole cereal crops 50.13 million tons, with average yield of 1574 kg/ha (Yearbook of the Organization of Arab Agricultural, 2009). Sudan comes in first place in terms of the cultivated area, followed by Morocco, Syria, Algeria, and Egypt, which ranked first in terms of production (22.207 million tons).

Table 2: Cultivated area of cereal crops in some countries (FAO, 2009)

Country	Area (m. ha)	Production (m. t)	Productivity (kg/ha)
India	99.006	242.887	2453.3
China	83.725	444.065	5303.9
USA	52.875	338.513	6402.1
Russia	40.574	76.866	1894.5
Nigeria	19.172	28.884	1506.6
Brazil	18.424	59.149	3210.4
Australia	18.342	19.229	1048.4
Canada	15.946	48.577	3046.3
Turkey	13.307	34.637	2603.0
Pakistan	12.897	32.864	2548.2
Thailand	11.189	33.201	2967.3
Mexico	10.005	32.155	3213.9
Sudan	9.366	6.742	719.8
Argentina	9.170	34.107	3719.4
France	9.106	61.813	6788.1
Iran	8.746	22.409	2562.2
Ethiopia	8.427	13.393	1589.3
Germany	6.702	43.475	6486.9
Spain	6.310	19.353	3067.0
Morocco	5.590	9.239	1652.8
Iraq	4.683	3.335	712.2
Syria	3.215	5.823	1811.2
Egypt	3.009	22.991	7640.7
UK	2.863	20.832	7276.3
Algeria	2.672	4.018	1503.7
Japan	2.006	11.742	5853.4
Italy	3.801	20.207	5316.2
South Africa	3.011	9.454	3139.8

Yield components in cereal crops: The productivity in cereal crops depends on the optimum levels of its components. These components are: the number of plants per unit area at harvest stage, and the number of spikes (inflorescences) per unit area, and the number of grains per spike, and finally the size of these grains or what is known as one thousand grain weight. The optimum levels of these components influenced by large number of factors, especially those of environmental and agricultural factors.

Factors affecting the yield components in cereal crops:

1. Factors affecting the number of earheads:

a) The number of plants per unit area: depends on the agricultural biological value of seeds used, and the rates, methods, and dates, and the depth of sowing, and the percentage of germination, also reduced the number of plants under the influence of unfavorable factors: weather, insects, diseases, mechanical and chemical damage, in addition to competition between plants within a single variety, and competition between plants and other crops and weeds.

b) The number of productive tillers per plant: depends on genetic factors specific to the ability of variety to give tillers, and prevailing weather conditions (humidity, temperature, ... etc), and the space for plants, soil fertility and its ability to secure the needed plant nutrients, and rates, methods, and planting dates, in addition to competition between plant species and plants within the variety, and damage to plant by diseases, insects and others.

II. Factors affecting the number of grains per earhead: the genetic characteristics of earhead (length, number of spikelets and flowers in earhead), and the prevailing weather conditions during a spike formation and maturity, the size and effectiveness of the photosynthetic area during the formation period of spikes and its maturity, the plant's ability to transfer products of photosynthesis to the grain, and competition between plants within variety, and between them and other types of plants in the field. Finally, the impact of some of the inadequate conditions (diseases, insects, and mechanical and chemical damage).

III: Factors affecting the weight of grains: size and length of photosynthetic area in upper parts of the plant, and the ability of plants to transport products of photosynthesis to grain, and the period length of the grain formation, and environmental and agricultural conditions through the stages of maturity (temperature, moisture, the minerals), and the injury of leaves and earheads by diseases and insects.

Chapter 1: Wheat
(*Triticum spp.*)

Economic Importance: Wheat is most widely cultivated of all cereals crops and the principal food in most areas of the world except monsoon Asia. Grown in all temperate countries and most sub-tropical countries. It is used, due to its importance, as a tool of economic pressure on many developing countries.

Uses: In most area of the world it is the principle food of man. The properties of gluten in wheat are such that it produces bread stuffs, generally superior to those from any of the other cereal grains. Because of its excellent baking quality, wheat has become the most important source of carbohydrates in the majority of countries in the temperate zones. A small amount of wheat is also used in the manufacture of dextrose, alcohol and certain breakfast foods. The by-products derived from the milling of wheat into white flour, like wheat bran, are higher in protein content than wheat itself and serve as a valuable protein supplement in many livestock rations. The durum wheat is processed into semolina from which macaroni and related products are made. Wheat straw is used as excellent feed for livestock in undeveloped countries whereas in developed countries it is used for bedding in farms, and some is manufactured into paper. Much of the straw in the leading wheat producing areas is wasted, usually being burnt following threshing.

History and center of origin of wheat: Used as food since prehistoric times. In the Middle East: 10.000 to 15.000 B.C. (Turkey, Iran, Egypt, Syria, Lebanon and Palestine). First types, Einkorn wheat. Vavilov (1931) determined the following regions as center of origins for wheat:

1. The Syrian Region: Includes north Palestine and southern Syria. Origin for Diploid types of wheat. Rye (secale) and Aeigilops, all 2N=14. Participated in the development of Diploid and Tetraploid species of wheat.

2. **The Ethiopian Region:** Origin of Tetraploid species, 2N= 28

3. The Indian and Afghani Region: Origin of Hexaploid species, 2N= 42

4. The Turkish Region: Thought to be the origin of all types (Diploids, Tetraploids and Hexaploids). Scars and Macfadden (1945) proposed that the origin of Tetraploid and Hexaploid wheat was the natural hybridization between the genus Triticum and Aegilops because Aegilops includes genetic groups similar to those in Triticum.

Aegilops ovata (AA) 2n= 14

Aegilops Speltoides (BB) 2N= 14

Aegilops squarosa(DD) 2N= 14

The two scientists carried out an experiment to produce bread wheat through crossing of: T. dicoccoides (AABB) * Aegilops Squarosa (DD)

They obtained a species similar to the bread wheat, *Triticum aestivum* (AABBDD), 2N= 42, They concluded that: Wheat species have been derived through hybridization between the genus Triticum and Aegilops

T. diploides * A. speltoides

(2n=14) AA BB (2n=14)

↓

AB (chromosome doubling)

↓

AABB (T.tetraploides)

T. Tetraploides * A. Squarosa

(2n=28) AABB DD (2n=14)

↓

ABD (chromosome doubling)

↓

AABBDD (2n = 42) T. aestivum (Hexploides)

Cultivated area: FAO statistics during 2009 (Table 3) present world cultivated area (ha) , production (tones) and yield (kg/ha). The leading countries, former USSR, USA, China, India, Canada, West Europe, East Europe (Table 4).

Table 3: Cultivated area, production and productivity of wheat in the world.

Item	Area (ha)	Production (tones)	Productivity (kg/ ha)
World	217.432.668	607.045.683	2791
Africa	9.404.345	19.314.118	2053
America	28.342.813	98.210.029.	2596
Asia	100.154.762	285.793.841	2853
Europe	57.145.737	190.413.677	3332
Oceania	12.385.011	13.314.018	1075

In the Arab world, the cultivated area during 2009 was about 12.5 million ha produced about 26.0 million tones and the yield per unit area was about 2036 kg/ha. The Arab leading countries are: Syria (1.9), Morocco (2.6), Algeria (2.2), Tunisia, Iraq (2.8) and Egypt (1.2) million ha.

The highest yielding countries was Syria (2400), Sudan (2568), Saudi Arabia (5844), Oman (2836), Egypt (6478) kg/ha. This is because most cultivated wheat is irrigated.

Table 4: Leading countries in production, area and productivity of wheat in the world

Country	**Production (m.t)**
USA	53.603
China	109.860
Russia	49.389
India	74.890
Canada	20.641
Turkey	17.678
Iran	15.000
Country	**Area (m. ha)**
China	22.980
UK	1.820
India	28.035
US	20.643
Italy	2.034
Turkey	8.600
Iran	6.400
Country	**Productivity(kg /ha)**
France	6250
Swiss	6184
UK	7341
China	4780
Italy	3568
US	2596
India	2671
Iran	2343

In Syria, Wheat forms a major crop in importance, area and production. Syria is the only Arab country which could reach self sufficiency in wheat production. The total cultivated area of wheat is about (1.9) million ha, produced about (4.9) million tons and the yield is about 2760 kg/ha.

Table 5: Development of total wheat area, production and yield in Syria from 1998-2009.

	Irrigated		
Year	**Area (ha)**	**Production (tons)**	**Yield (kg/ha)**
1998	689868	2478440	**3593**
2009	791358	3130010	**3955**

	Rainfed		
Year	**Area**	**Production**	**Yield**
1998	1031544	1633185	**1583**
2009	876374	911090	**1040**

	Total		
Year	**Area**	**Production**	**Yield**
1998	1721412	4111625	**2389**
2009	1667732	4041100	**2423**

Notice that total cultivated area and production declined during the recent years due to overall reduction in the amount of rainfall and fluctuation of annual precipitation. Both of them are the limiting factors in the success of wheat cultivation, particularly rainfed cultivation. Two types of wheat are yearly cultivated in Syria, bread wheat and Durum wheat. In general the average yield of both bread and durum wheat is less under rainfed farming compared to irrigated one. Climatic changes resulted in sever fluctuation in the amount and distribution of annual precipitation which severely reduced wheat production. Major producing provinces in Syria are: AlHasake followed by Aleppo, AlRaqqa, Homs, Hama, Daraa and Sweda.

Climatic zones of Syria: Syria is divided according to annual precipitations into five zones:

Zone A: More than 350 mm, it is divided into:

1) Annual rainfall more than 600 mm, rainfed cultivation is almost guaranteed.

2) Annual rainfall 350 -600 mm and not less than 300 mm, major crops wheat, legumes, summer crops. The area of zone A forms about 14.6 % of the total area of Syria.

Zone B: Annual rainfall 250-350 mm/yr, but not less than 250 mm, Barley cultivation is guaranteed. Summer crops may be grown in addition to wheat, barley and legumes. The area of zone B is 13.3 % of the total area of Syria

Zone C: Annual rainfall 250 mm/yr. mainly grown by barley and some legumes. It forms 7.1 % of the total area of Syria.

Zone D: Annual rainfall 200-250 mm/yr, but not less than 200 mm, it is mainly for barley and perennial range lands. It forms 9.9 % of Syria.

Zone E: The rest of Syria (55.1 %). It does not fit rainfed agriculture.

The wheat crop yields well in zones A, B, but severe decline in productivity is noticed in zone C.

The Ministry of agriculture assigned cultivation of specific wheat varieties based on annual rainfall and climatic zones because several cultivars of wheat (bread, durum), which varies in their moisture, fertility requirements adaptation and tolerance to drought stress are produced periodically by national and international research centers. The general establishment of seed multiplication provides farmers yearly with their needs of the seeds of genetically improved cultivars.

Botanical Classification: Wheat belongs to the grass family, Poacaea (Gramineae) and the Genus, Triticum**,** several species (wild, cultivated) belong to this genus and several varieties are found in each species. Genome which is the basic number of chromosomes in a species, is 7 in wheat. Based on the chromosomes number, wheat species are grouped into 4 groups

1- Group (1): All species are Diploid, 2n = 14. The common name is Einkorn. Most important species:

T. boeoticum: wild, highly resistant to rust, smut and powdery mildew. Seed protein about 37 %.

T. urartu: wild, resistant to rust and smut.

T. thaoudar: wild, highly resistant to all types of rusts, smuts and powdery mildew, high seed protein.

T. Monococcum: cultivated, highly resistant to shattering, lodging, rusts and highly tillering, long spike.

2- Group (2): All species are Tetraploid (2n=28).

1) Wild species:

T. araraticum: drought tolerant, sterile hybrids when crossed with all tetraploids, but fertile hybrids when crossed with T. timopheevi. All types of these species are winter types.

T. dicoccoides: native to Syria, Jordan and Palestine. Large spike, highly resistant to shattering, some types are resistant to rusts and powdery mildew.

2) Cultivated species:

T. timopheevi: good baking characteristics, resistant to rusts, smuts and powdery mildew. Sterile hybrids with other wheat species. It is very important as sources for Cytoplasmic male sterility genes for producing hybrid wheat.

T. palaeo: good for lodging resistance.

T. militinae: good for large number of tillers.

T. dicoccum: good for early maturity, drought, lodging, shattering

T. carthlicum: for stem rust resistance.

T. durum: comes right after T. aestivum in area in the whole world. Named macaroni wheat due to high content of gluten. Some durum varities are tolerant to drought, heat, shattering but sensitive to rusts. Some fertile crosses with T. timopheevi, polonicum and monococcum, but the most important ones are those between T. durum and T. aestivum which are high yielding, tillering and good quality.

T. turanicum: good for heat tolerance.

T. turgidum: some types have branched spikes. high yielding but do not tolerate drought and frost.

T. polonicum: good for shattering.

3- Group (3): All species are Hexaploid, 2n =42. It includes the following:

T. macha: (cultivated), but much similar to wild types. Easily crossed with tetraploid and give fertile hybrids.

T. spelta: (winter type), awnless, frost tolerant, early maturing species, good seed quality, shattering resistant.

T. compactum: similar to bread wheat, short and condensed spike.

T. vavilovii: short stem, branched spike, highly resistant to shattering and lodging.

T. sphaerococcum: short stem, highly resistant to lodging, early maturity, good seed quality and high protein content and high tillering.

T. aestivum: the most cultivated species in the world (bread wheat). Thousands of varieties belong to this species which are different in all characters (spike length, protein, drought and frost tolerance, rust and smut resistance, maturity, productivity).

T. Zhukovsky: short spike, rust and smut resistant, good baking quality and high protein content.

4- GROUP (4): All species are octaploid, 2n=56.

T. timonovum: high resistant to diseases and insects.

T. fungicidum: Hybrid between T. carthlicum and T. timopheevi and chromosome doubling of F1, highly resistant to rusts, smut and powdery mildew. Large seeds (1000 seed weight =70 g)

Farmers have several choices, but many factors might affect his choices:

1- Maturity date: early maturing cultivars for rainfed areas.

2- Areas of cultivation: do not select cultivars that don't tolerate drought in climatic zone B, unless supplemental irrigation is practiced.

3- Lodging: in general high yielding cultivars resist lodging, we should not use susceptible cultivars in high rainfall areas or irrigated ones.

4- Quality: several cultivars for bread from T. aestivum and several durum cultivars for macaroni and Bulgur.

5- Disease and insect resistance: selection of any variety should be based on the conditions of each area.

6- Frost tolerance: susceptible cultivars should be avoided.

Environmental Requirements: Great wheat regions are found in temperate zones between 30-60˚ N of Equator and from sea level up to 5000 m above sea level, also between 25-40˚ S of Equator and up to 3000 m above sea level. Wheat can also be grown in North of Arctic circle and close to Equator. Wheat has little importance in warm humid regions because of its susceptibility to peat and diseases.

Temperature: Wheat is a cool-season crop with longer growing period and somewhat higher minimum heat requirement than other small grain crops. More than 100 days frost-free season required. Minimum growth temperature of wheat 3-4˚C. Optimum temperature about 25 ˚C, more hardy than barley and oats, but less than rye. Temperature affects both vegetative and reproductive stages; it also affects amount of accumulated dry matter. It is important to have moderate temperature during tillering, heading, anthesis and grain formation. High temperature during grain filling period results in shrinked seeds and severe reduction in yield. Hot dry wind in Syria and North Africa during the above period affect yield significantly, but low temperature delays flowering and reduces fertility.

Light: Wheat is a long day plant (plant life will be shorter under long days and longer under short days). Heading requires a minimum of 10 hours day length. Optimum daily photoperiod for heading 12-14 hrs. Number of spiklets per spike increases as light intensity increases.

Moisture: Water requirements vary based on: soil type, soil fertility, soil moisture, crop rotation, relative humidity. Wheat requirements differ according to growth stages:

1. During germination and seedling emergence 5-7 % of the total requir .

2. Tillering stage: 15-20 % of the total requirements.

3. Stem elongation and heading: 50-60 % of the total requirements.

4. Milk stage: 20-30 %.

5. Physiological maturity: 3-5 %.

The total requirements for one hectare of wheat 4200-4500 m^3 given at 5-6 times (irrigated wheat), but for rainfed wheat, the crop might be supplementary irrigated (1-2 times). wheat will be affected by moisture shortage as reduction in plant density, tiller number, number of seed and fertilization depending on the growth stage. Maximum effect of moisture shortage on yield and seed quality occurs at grain filling period, though high rainfall during this stage increases lodging and leaching of nutrients.

In general, moisture is critical during: (1) just right after seeding (Nov–Dec) (2) at tillering stage (Jan–Feb) (3) seed formation and filling (April–May).

Soil conditions: Best adapted to fertile, medium to heavy textured soils that are well drained. Silt or loam soil produces best yields. Acid or water logged soil results in a poor yield. Wheat lodges on rich bottom lands. In Syria, the plains of Homs, Hama, Alghab, Aleppo, AlJazeera, Daraa and Sweeda are all suitable for wheat cultivation.

Cultivation requirements:

1- Fertilizers: Soil analyses are necessary to determine the required amount of each kind of fertilizers. Fertilization depends on several factors: soil fertility, soil moisture, previous crop, physical properties of the soil, the used variety, type of fertilizer and time of application.

Moule (1971) proved that a yield of 4.5 t/ha of wheat in high rainfall areas requires the following amounts (kg):

Item	**N**	**P_2O_5**	**K_2O**
plants	135	70	70
Seeds	81	60	35
Total	216	130	105

It has been established that plants absorb the highest amount of nutrient during the period of tillering and anthesis.

Wheat plant requires most amount of N during tillering, stem elongation, spike formation and anthesis. Nitrogen is essential for increasing vegetative growth, productive tillers, number of fertile flowers, weight of 1000 kernels, protein % and total biomass. Generally the required amounts:

High yielding cultivars: Irrigated cultivation: 150 kg/ha units of N before seeding, at tillering stage, and at the beginning of heading.

Rainfed cultivation: 100 kg of N (areas of 400 mm), 80 kg of N (areas of 350-400 mm), added at seeding and tillering stages.

Local (low yielding) cultivars: Irrigated cultivation: 100 kg of N added as mentioned above. Rainfed cultivation: Zone (A) 60 kg/ ha, Zone (B) 50 kg/ha of N.

Wheat plant requires most of P during tillering and stem elongation. It is important for root system, lodging resistance, frost and drought tolerance, flower fertility and formation of spiklets. The required amounts:

For high yielding cultivars: 100 kg/ha of P_2O_5 before seeding for irrigated cultivation, 80 kg/ha of P_2O_5 before seeding for rainfed cultivation.

Wheat plant requires most of K at heading and grain filling period. K is important for root system. Photosynthesis, enhancing the transport of metabolites from the leaves to grains, increase plant tolerance to different stresses. Generally, no need to add K fertilizers because Syrian soils have adequate amounts of K.

2- Planting date: It depends on several factors (time of rainfall, weeds, mechanization, soil moisture, etc.). In general, rainfed cultivation (Oct-Nov) following first precipitation and irrigated cultivation (15 Oct. – end of Dec.)

3- Seeding rate: It varies based on:

1. Planting date: increased as seeding delayed.

2. Seeding method: increased amount when traditional method (broadcast) is used compared to modern planters.

3. Rainfall: rainfed farming requires less amount compared to irrigated or high rainfall cultivation.

4. Soil properties: increased amount in heavy soils and fertile ones.

5. Seed quality: we have to increase amount used in weedy soils and low quality seeds.

6. Soil preparation: good soil preparation reduces amount of seeds used

7. Seed size (variety): large seed cultivars requires larger amount compared to small seed cultivars to obtain the right plant density (250 plants/m^2).

8. Generally, lower seeding rate for high tillering types (bread wheat) and higher seeding rate for low tillering types (durum wheat).

The official recommended amount (120-150 kg/ha), but practically the used rate by the farmers is higher (up to 250 kg/ha).

4- Planting depth: The main objective is to place the seed in the bed close to the moisture and soil particles. Generally, planting depth is 4-7 cm (average 5 cm). Avoid deep seeding in heavy soils or shallow seeding in light soils. Planting depth is affected by several factors:

1. Soil moisture at the time of seeding (4-10 cm).

2. Seeding date and soil type (dry soils up to 7 cm) to avoid birds.

3. Used variety (varieties with long coleoptiles 10 cm, the opposite in varieties with shorter coleoptiles).

4. Method of planting

5- Crop rotation: in rainfed areas: Wheat - fallow: most common (in areas of 400 mm rainfall).

Wheat – legume (faba beans, lentils, chickpea), most beneficial due to biological nitrogen fixation.

Wheat – lentils – fallow.

Wheat – safflower – lentils (high rainfall areas).

Wheat – wheat (or barley), it is not advisable.

wheat–medics: good for rainfed areas (300-400 mm) this rotation is important for the following reasons: Medics is a winter annual legume which biologically fix atmospheric nitrogen, reduce amount of N fertilizers, improve quantity and quality of wheat, providing feeding material for animals, auto multiplication of medics (no need for annual seeding). In irrigated areas: wheat might follow sugar beat, potatos, cotton or an oil crop.

Care operations of crop after establishment:

The major aim of these operations to maintain soil moisture, light harrowing, controlling weeds and pests and diseases and application of fertilizers then harvesting the crop.

Maturity and harvest: Wheat should be harvested at full maturity for durum wheat and somehow earlier for bread wheat. At the end of grain filling period, seed moisture is about 35-40 %, but wheat should not be harvested at this time because of harvesting process and diseases insects. Delay of harvesting increases loss of seeds because of shattering and breakage of plants. Though harvest time varies according to cultivars, area and environmental conditions. Wheat harvest in Syria is usually between 15

May up to end of June and last till July in high cold areas (wheat crop occupy the field for 5.5 – 6 months). Harvest is conducted manually (early in the morning) or by harvest machines (seed moisture 25- 35 %) or by combines (seed moisture 12-15%).

Yield: Wheat yield is affected by several factors: variety, method of planting (irrigated or rainfed), amount of precipitation, use of modern techniques, mechanization, disease and insects. etc.

Generally, rainfed yield in Syria is about 1000 kg/ha and 5000 kg/ha in irrigated wheat, sometimes yield is about 400 kg/ha in severe conditions.

Most important characters in Breeding Programs:

1. Yield components of wheat are: Number of plants/unit area, number of spikes/plant (productive tillers), number of spiklets/spike, 1000 seed weight.

2. Breeders should concentrate on developing new high yielding cultivars through improving one or more of the yield components and resistant to diseases and insects.

3. Development of new cultivars for harsh environments (drought, salinity, heat, frost, etc.)

4. Considering the important quality components (protein, strong elastic gluten (gliaden and glutenin).

Breeding methods: The most important breeding methods which can be used in wheat are: Introduction, Selection, Hybridization, Pedigree, Bulk, and Back cross.

Environmental stresses:

1-Biotic stresses (The pests and diseases of wheat crop):

A) Fungal Diseases: Yellow or stripe rust: caused by the fungus Puccinia graminis .sp. tritici, with reddish-brown color on leaves or stem or spikes. Brown or leaf rust: Puccinia recondite sp. tritici, the disease affects leaves only and does not affect the stem and spikes. Stem rust or black rust: Caused by the fungus Puccinia graminis. sp. tritici, with reddish-brown color on the leaves or spikes or stem. Smuts: very important diseases affecting wheat and barley and some other crops. The important types stinking smut (Tilltia foetidae)**,** loose smut (Ustilago tritici) infect spikes. Downy Mildew: caused by the fungus, Sclerophthora macrospora, infecte stem and leaves.

B) Insects: Wheat Stem Sawfly: (Cephus libanensis), larvae feed on the content of the host plant. Cereal leaf miner: (Syringopais temperatella), the larvae feed on the leaf tissues, and Parenchyma. Wheat ground beetle, Caused by insect (Zabrus tenebrioides), adult insect feed on plant seeds and the spikes during grain development.

Control measures of pest and diseases in wheat crop:

1. Sanitation measures

2. Growing disease and pest-resistant varieties.

3. Following cultural practices: These include such generally recommended measures as plowing and removing stubble and other plant litter that may enable disease organisms to live from one season to the next. Crop rotation, proper land preparation, and time of seedling also may be important factors in disease control.

4. Treating seed: Seed treatment is effective against diseases carried on or in the seed. Some of the better chemical treatments also protect the germinating seed to some extent against injurious soil-borne organisms causing seed rot, damping off, and seedling blight. Stripe diseases, loose and covered smut, which can be completely prevented by effective chemical seed treatments.

5. Chemical fungicides and insecticides are applied to the plants in the field in several forms and by several methods. They are marketed either as dusts or liquids.

2-Abiotic stresses: Wheat crop can be affected by different types of abiotic stresses such as, drought, high and low temperature stresses and salt stress.

3- Physiological disorders: like lodging and grains shattering.

Chapter 2: Barley
(*Hordeum vulgare* L.)

Economic importance: Barley is grown nearly in all cultivated areas of temperate zones, in many subtropical zones and in high altitudes of torrid zones. Barley is the world's fourth most important cereal crop, after wheat, rice and maize. Much of the worlds barley is produced in regions with climates unfavorable for production of other major cereals. It has persisted as a major cereal crop through so many centuries because it has three unique characteristics, (1) Broad ecological adaptation. (2) Utility as a feed and food grain. (3) Superiority of barley malt for us in brewing.

Uses: can be used for malting, brewing and milling.

1) Malting: is a controlled germination of barley, or other cereals, during which enzymes are activated and ingredients are changed to facilitate later brewing, distilling or malsyrup production.

2) Brewing: steeping barley in water, germination, drying to 4-7 % , remove rootlets, the process requires 12 days. Amylase enzyme, which convert starch into maltose sugars and dextrins in brewing operators, probably are most important enzymes in barley malt.

3) Milling: White two rowed varieties with large kernels usually used, kernels pearled three times to remove hulls and most of bran producing pot barley. Kernels pearled three more times to remove bran and germ producing pearled barley, barley flour is sifted from ground material. Pearled grains may be milled to flour.

Utilization of barley products:

1) Feed and food: about 50 -75 % of produced barley is used as animal feed depending on the country. It forms 95 % of feed value of corn, the amounts used for food varies from one country to another. It can be mixed with wheat flour (20% barley flour+wheat flour produces satisfactory bread)

2) Other uses: hay, pasture, green manure, straw used for bedding or roughage and mulches.

Chemical composition of barley kernel:

a- protein content varies from 7.5 to 15 %

b- Starch content varies from 50-60 %

C- Moisture content when threshed 10-20 %

Diastatic power is a measure of the ability of the Kernel to convert starch into maltose (malt sugar).

Kernel quality for malting: Six rowed is preferred in North America whereas two rowed is preferred in Europe for malting. Barley must be clean, bright and free from foreign materials. Kernels should be uniform, medium size, rich in starch, poor in protein and high germination percentage.

History and center of origin: Considered by many scientists as the most ancient cultivated grain crop. It has been cultivated since the prehistoric period and used for bread making and animal feed. Vavilov believes that Ethiopia is the center of origin of barley (many wild species are found there); others believe that Southeast Asia (China, Nipal) is the center of origin, some others believe that the Middle East and Central Asia (Syria, Egypt, Turkey) is the center of origin (wild species are found there).

Cultivated area: The world harvested area in 2009 was about (55) million ha, produced (140) million tons with an average yield of (2576 kg/ha). Russia only cultivated (9) million ha, followed by Ukraine, Canada, Australia, Turkey and Spain. Middle East, West Asia and North Africa planted about (10) million ha. Barley occupied about (5) million ha in the Arab countries, mainly in Morocco (2.20) million ha, followed by Syria (1.30) million ha and Algeria (850) thousand ha. Syria comes the third Arab country in yield (578 kg/ha) after Morocco and Algeria.

In general, barley is an important crop in Europe, most of Asia, North America and Australia. The cultivated area and production have been increased during the recent years due the application of research outcomes (results) in barley cultivation.

In the Arab world, barley almost as important as wheat (and sometimes more) due to its adaptation in arid and semi-arid zones, also due to the multi uses of this crop (feed and food). In Syria, barley comes right after wheat. The total area, production and productivity of barley crop in Syria during 2009 is presented in Table 1, and the distribution of barley crop in the five climatic zones of Syria during 2009 is presented in Table 2.

Table 1: The cultivated area (ha) production (t) and yield (kg/ha) of barley crop in Syria.

	Irrigated		
Years	**Area**	**Production**	**Yield**
1997	3741	8849	**2365**
2009	51206	112539	**2198**
	Rainfed		
Years	**Area**	**Production**	**Yield**
1997	1568452	973805	**621**
2009	1256165	1089863	**868**

	Total		
Years	**Area**	**Production**	**Yield**
1997	1572193	982654	625
2009	1362800	7845000	600

Table 2: The distribution (area and yield) of barley crop in the five climatic zones of Syria during 2009.

Zone	Area (%)	Yield (kg / ha)
A	2.2	**1806**
B	35.0	**1020**
C	29.0	**482**
D	30.7	**302**
E	2.6	**231**

Notice that there has been some increase in the irrigated barley, both in area and production. The total production of rainfed barley showed some increase. In addition to a significant improvement of yield (about 250 kg/ha) due to the introduction of genetically improved cultivars and cultivation of barley in more rainy areas (zone B). Barley plays an important role in Syria due to its importance in animal feed and brewing. We should also notice that barley cultivation is concentrated in dry poor lands, because farmers leave their rich fertile lands for wheat and other crops. The leading provinces are : AlHassake, AlRaqqa, Aleppo, Hama, Homs, DairEzzor and Idleb.

Commercial classes of barley:

1. Six rowed barley: Barley of the six rowed type with white hulls which contain not more than 10% of two–rowed barley or black barley, either singly or combined. This class could be divided into three sub classes:

A. Six rowed malting barley. B. Six rowed blue malting barley.

C. Six rowed barley.

2. Two rowed barley: Barley of the two–rowed type with white hulls which contains not more than 10% of six–rowed barley or black barley, either singly or combined. This class could be divided into two sub classes:

A. Two rowed malting barley B. Two rowed barley

3. Four rowed barley: Barley which does not meet the requirements for any of the classes: six rowed, two rowed barley or which contains more than 10% of black barley.

Botanical classification: Barley belongs to the grass family, poaceae (Gramineae) and the genus Hordeum which includes two main groups:

1. Large seed group: all cultivated species have 2n=14. The most important species:

- **Hordeum vulgare**: cultivated (two rowed and six rowed varieties), tough rachis. Two groups belong to this species:

a) Ideal six rowed barley: H. vulgare: hexastichum, broad and compact spike.   b) Non ideal six rowed barley: H.vulgare: tetrastichum, long spike.

- **H. spontaneum**: wild, two rowed, fragile rachis spike.
- **H. agriocrithon**: wild, six rowed, fragile rachis spike.

2. Small seed group, 2n= 14, 28, 42, all species are wild and some of them perennials and some others are annuals. Some species are: H. secalinum, wild perennial, H. bulbosum , wild perennial, H. Meritimun , annual

Growth cycle of barley: Three main growth stages are found: vegetative stage, reproductive stage and maturity stage.

Barley, in general, is faster in germination, earlier in tillering, maturing and flowering than wheat. There are spring and winter types of barley, but those grown in Syria and the Arab countries are all winter types.

Barley is much similar to wheat, especially before heading. We can distinguished barley from wheat through:

1. Light green color of the vegetative part.

2. Leaf auricles are long and hairless.

3. Barley is higher tillering than wheat.

4. Barley root system is shallower than that of wheat.

5. The stem is weaker than that of wheat and lodging is more in barley.

6. Several varieties of barley flower before heading.

Environmental Requirements: One of the most dependable crops where drought, frost and alkaline soil are encountered. Grown from Arctic circle to Tropics, grown in very diverse environments from Sweden (North) to the Middle east, and from the sea level up to 4000 m altitude in the Himalaya.

Climatic conditions: Barley is a long day, cool-season crop. Heading requires 12-14 hr day length. Does not thrive in hot humid climates. Spring types require 1600-1700˚C accumulated temperature from planting to maturity, while winter types require 2000˚ C. Spring barley is grown farther north and at higher altitudes than any other cereal CROPS. Winter barley are generally less hardy than rye or wheat. Mature early enough to escape drought and rust in many places. Barley is shorter in life than wheat, (110-120) days for spring types, and 250 days for winter types. So it is harvested in May in early seeding. Barley tolerates low temperature up to -15 ^{o}C for a short period, but optimum temperature for vegetative growth is 20 ^{o}C, and for anthesis and maturity is 29 ˚C. Low temperature during heading and anthesis reduce fertilization and yield. High temperature (more than 35 ^oC) during grain filling period increase shrinked seeds. Barley requires moderate rainfall. It is more tolerant to drought than wheat (shallow and branched root system), so it is grown in areas less than 300 mm annual precipitation (where wheat growth is not guaranteed). Barley yields well in irrigated or high rainfall area and requires less irrigation than wheat.

Soil conditions: Best adapted to well drained, fertile, deep loam soils with PH 7-8. Low yield on sandy soils. Some varieties have high salt tolerance (more than wheat).

Cultivation requirements:

1- Fertilization: we should obtain soil test to determine amounts of (P) and (K) to apply at seeding time .Responds well to N, P and K.

Generally, farmers don't add fertilizers in semi-arid cultivation (250-300 mm), but they add fertilizers in higher rainfall areas (300-400 mm). Fertilizer should be added based on several factors: Soil fertility, variety used, Soil moisture, Previous crop (if legume, less Nis required).

In rainfed cultivation: Climatic Zone (B), 60 units of N (added as top dressing in spring) at planting and tillering, 40 units of P_2O_5 at seeding.

Climatic Zone (C)**,** 40 units of N added at seeding and tillering, 20 units of P_2O_5 at seeding

In irrigated cultivation: 80 units of N (at seeding, tillering and heading), 50 units of P_2O_5 at seeding. Notice that (N) should not be added in large amount, due to the problems of lodging and bad effect on the quality of seed used for brewing, though (N) is good for barley used for animal feed. Proper fertility increases grain and forage yields and winter hardiness.

2- Crop Rotation: Barley might come after cultivated fallow or legume or corn (in special cases) depending on annual precipitation. The first rotation is more common in semi-arid zone, but in moderate to high rainfall areas, barley comes after a food or forage legume, or an oil or sugar crop, or after corn. In irrigated areas, barley comes after sugar beet, legume or cotton.

3- Planting date: Barley should be seeded early to benefit from early precipitation (Oct – Nov). In good precipitation areas (may be delayed till Nov and Dec), and in irrigated areas (up to the end of Dec). Forage barley should be planted as early as possible.

4- Seeding rate: Amount of seed is less than that of wheat because of lodging and disease, beside high tillers of barley. Seeding rate depends on: seed size, tillering, type of cultivation (rainfed, irrigated), planting date, method of planting (broad cast, planters), purity of seed, soil fertility, variety used, purpose of planting (grain, fodder), planted area (dry, semi dry or humid). In general, the amount used is 80-100 kg/ha, general amount of seeds in barley is 10 -20 % less than that of wheat.

5- Planting depth: Depending on the soil, heavy soils (3-4 cm), medium soils (5-6 cm), dry soils (6-8 cm).

Care operations of barley crop after establishment:

Care operations of barley do not differ from that for wheat**,** light harrowing, controlling weeds and pests and diseases and application of fertilizers, then harvesting the crop.

Maturity and harvest: Barley is harvested in May (14 % moisture of grain). We should not delay harvesting because of shattering, lodging and insects. Harvesting of barley could be done by hand or using the combine.

Yield: Yield of barley varies according to several factors, such as soil conditions and environmental factors of the growing area. Generally, the yield per hectare in Syria under rainfed conditions is around (500-1000 kg/ha), whereas, under irrigated conditions may reach up to (3000-4000 kg/ha).

Most important characters and breeding methods:

Barley is 99 % self pollinated and almost the same breeding methods used in wheat could be also used in barley (introduction, selection, hybridization, pedigree, Bulk, Backcross and mutation).

Important characters: Awns: preferred awned barley, hooded grain, large seed, earliness, frost tolerance, drought tolerance, lodging, pest resistance, quality (based on purpose: high protein for animal feed and low protein for brewing purpose).

Environmental stresses:

a) Diseases of barley: the following diseases have been commonly observed in barley, among them, yellow rust, leaf rust, loose smut, covered smut, leaf spots, barley stripe disease and powdery mildew.

b) Insects of barley: the following insects have been reported to cause damage in many areas of the country; the important one, termites and aphids.

Control measures of diseases and insects of barley: use of resistant varieties, use clean and treated seeds with fungicides and insecticides, crop rotation to reduce incidence of these pests.

Chapter 3: Maize (Corn)

(*Zea mays* L.)

Economic importance: Maize (corn) is grown in most parts of the world for grain and fodder. It is the main crop of the United States of America. On global basis, the annual growth rates achieved during the last two decades have been 1.1% in area and 2.6% in grain yield. The main contributors are modern hybrids which accounted for over 16% of yield gains.

Utilization of corn and its products:

1. Human uses: Food products such as grits, corn flakes, syrup and bakery product, sugar, oil (cooking oil), mayonnaise, pop corn and sweet corn. Non food product such as perfumes, nail polish removers and cosmetics.

2. Live stock feed: About 90 % of corn grain harvested is used directly as feed. Important ingredient in mixed manufactured feeds. Fresh forage, silage, hay for cattles. Also cobs and plant residues are used for animal feed.

3. Industrial uses: Corn stalks and leaves used for paper, paperboard and wallboard. Cobs can be used as cork substitutes, fuel, etc. Corn meal, flour or grits used in adhesives, explosives, textile and soaps. Corn starch has wide variety of uses including asbestos, ceramics, dyes, plastics, oil cloth. Dextrins, soap, ink, dyes, pastes. Corn syrup for shoe polish, rayon and tobacco. Corn sugar for chemicals, leather preparations, dyes, cold process of rubbers, explosives. Corn oil important in paint, varnish and rubber substitutes. glucose and alcohol.

Chemical composition of corn kernel: 13.5 % water, 10% protein, 4.0 % oil, 1.4 % sugar, 6.0 % pentosans, 2.3 % crude fiber, 1.4% ash, 0.4 % others. Carbohydrates include starch, sugar, pentosans and crude fiber (70.7%). Ash includes minerals (K, P, Mg, S, others).

Protein: Zein is principal protein in endosperm and is deficient in tryptophane and lysine. Glutelin contains more lysine than zein. Opuque -2 corn contain 69 % more lysine than normal corn.

Corn starch: about 1.78% amylopectin, 22 % amylase, waxy corn is 100 % amylopectein.

Vitamins: Also contains precursors of vitamin (A) which are converted to vitamin (A) by animals.

Factors that affect kernel composition:

1. Protein content: Complex interactions between genetic, environmental, and physiological factors. Inversely correlated with starch content. thickness of stand and nitrogen supply in soil are most important environmental factors. Higher under drought conditions. It is an important goal to increase protein percentage to 15 % and improve protein quantity (balance of essential amino acids).

2. Oil content: per unit of weight basis, corn oil is most valuable major product of corn milling industry. Largely under genetic control, only oil of germ is commercially extractable.

Cultivated area: Corn crop is grown on all continents and in many countries. The world cultivated area during 2009 was (144.5) million ha, produced (695.5) million tons, with an average yield of (4856) kg/ha. The leading countries are: USA, China, Brazil, Mexico and India (Table 1).

Table 1; The total area, production, and yield of maize (corn) in different countries during 2009.

Country	Area (000' ha)	Production (000' tons)	Yield (kg/ ha)
USA	26304	187300	7121
China	22851	112331	4906
Brazil	13997	36276	2592
Mexico	7500	16187	2158
India	6000	9800	1633

Corn is most widely grown in North and South America, East Europe, Asia (China, India) and South Africa. Corn is the worlds third most important cereal crop after wheat and rice in area and production.

World-wide, it is expected that request for corn will increase 50% but will be 80% in developing countries, meaning that corn production should be increased 80% in the few coming years (CIMMYT). In the USA, the major producing country, corn is more widely grown than any other crop, it occupies approximately 25% of all cropping land. The yield increase of corn in the USA can be attributed to discovery of heterosis (hybrid vigor), discovery of cytoplasmic male sterility (CMS), development of hybrid varieties, improved cultural practices (fertilizers, pest control, irrigation, mechanization, utilization of genetic engineering.

In the Arab world: The cultivated area has not changed during the last ten years and the corn productivity remained below the world average yield. The cultivated area in the Arab world during 2009 is about (1594.5) thousand ha yielded about (7789.4) thousand tons with an average yield of (4886) kg/ha. The leading Arab countries in area are: Egypt (761.2), Morocco (243.8), Somalia (250.1), Iraq (164.5), Syria (45.2) thousand ha, corn is also grown in Sudan, Yemen, Mauritania. Egypt occupy the first place in average yield of corn (8374 kg/ha) followed by Saudi Arabia (5723) Syria (3515), Iraq

(2426) and Sudan (1894) kg/ha. Corn is irrigated in some Arab countries (Egypt, Syria, Iraq) and rainfed in some others (Morocco and Sudan). The actual development of corn in the Arab world occurred due to its use as a forage crop for poultry birds and dairy cattles.

In Syria: Corn is the third cereal crop after wheat and barley. Although some development in area and total production have occurred since 1970, but the cultivated area and total production as presented in Table 2, are still less than the required.

Table 2: Total area, production and productivity of corn in Syria.

Year	Area (1000 ha)	Production (1000 tons)	Yield (kg/ ha)
1997	74.4	303.3	4073
2006	45.2	159.0	1685
2009	50.4	177.3	3500

Notice that area, production and yield of corn have declined in the recent years due to competition of other summer crops (cotton, potato, sugar beet). The cultivated area varies from one season to another due to the rainfed cultivation, low yield/unit area, absence of short life varieties, drying problems, non use of hybrid varieties. The leading provinces are: DairEzzor, Aleppo, AlHassake, AlRaqqa, Homs, AlGhab. Double cropping of corn, use of hybrid varieties, improved cultural practices are all required to improve corn situation in Syria to develop animal husbandry.

History of corn culture and center of origin:

1. Pre-Columbian corn: Primary center of origin, central America and Mexico. Secondary center in South America, in Andean region of Bolivia, Ecuador and Peru. Three principal centers of intensive corn culture were Mexican Plateau, Guatemala region and Peru.

2. Post-Columbian corn: History of corn in western civilization began in 1492. Spread quickly throughout Europe, then to North Africa. Portuguese distributed corn along west coast of Africa in early 16th century and to China also. Magellan took corn to East Indies (Indonesia) and Philippine. Early explorers and settlers became dependent on corn. Modern corn belt "Dents" came from crosses of northern flints with the southern dents. Dents derived from Mexican sources.

Botanical classification: Corn belongs to the grass family poaceae (Gramineae) and the Genus (Zea) and the species (mays). Some other groups (oriental and American).

1) Oriental types: Sclerachne, Coix, polytoca, Chinoachne, Trilobachne (all of them are not important).

2) American types: The Genus Zea, 2n=20, monoecious, annual, naked grain. The Genus Euchlaena, 2n=20, monoecious, hooded grain, contains forage annual and perennial types. The Genus Tripsacum, 2n=36, forage types, Diecious. Crosses between Zea * Euchlaena (monoecious) are fertile.

Agricultural classification: Color of kernel is based entirely on the color of albumen (starch or hard). Thus types of corn are based on the ratio of each type of albumen: 1.pod corn 2. pop corn 3. flint corn 4. dent corn 5. Sweet corn 6. waxy corn.

Growth cycle: Three main growth stages:

(1) Vegetative stage (2) Reproductive stage (3)Maturity stage

Varieties: In general several types of varieties are found:

1. Open – pollinated varieties (land races)

2. Hybrid varieties (single cross, double hybrid, three way cross).

3. Synthetic varieties (broad base), several inbred.

4. Composite varieties (mixed varieties).

Advantages of hybrid varieties: high yield, short stalk, lodging resistance, purity, pest resistance, mechanization, early maturity (for double cropping).

Disadvantages of hybrid varieties: high cost (new seeds yearly), sensitivity for irrigation, sensitivity for fertilization, more time and effort needed for producing hybrid varieties. In Syria**:** Local varieties (white salamoni), Synthetic varieties (Ghouta 1, 82), Hybrid varieties (Basil 1 and 2).

Environmental requirements: More widely distributed over the world than any other cereal crop. Grown from latitude 58˚ N in Canada and USSR to latitude 40˚ S in the Southern Hemisphere, it can be produced below sea level to high altitudes.

Temperature: Requires high day and night temperature. Germination temperature is higher than that of wheat and barley. Minimum temperature for germination is 6 ºC. Total required temperature from seeding till germination is 180 ˚c during (6-20 days). Low temperature (less than 10 ºC) in the spring leads to yellow leaves. Zero temperature leads to the death of the plant. At later stage, low temperature (-2 ºC) slows down the movement of metabolites to the grains and at (-6 ºC) leads to the death of new forming embryos. Higher temperature (more than 35 ºC) and great differences between day and night temperature harm plant leaves, stalks, reduce fertilization and pollen.

Moisture requirements: Corn requires about 300 kg to produce 1 kg of dry matter. Yield of corn increases with irrigation or in high rainfall areas (500 mm) or more. Major requirement of water is during the pre flowering period (15-20 days). Corn plant is sensitive to drought during this period and extends to 20 days after pollination. Water shortage before flowering might reduce total yield up to 50 %. In Syria, corn is mostly irrigated (10 times) or grown in high rainfall areas. Relative humidity is also important in reducing amount of irrigation and increasing plant tolerance to drought. When corn planted in low rainfall areas (250-300 mm) is the case in some Arabic countries, yield will be declined to (600-700 kg/ha) or less.

Light: Corn is a short day plant (10-12 hrs). Flowering is accelerated by shorter photoperiods. High temperature, low rainfall, low relative humidity and high evaporation are main causes of low yield. High temperature near end of growing season is beneficial when rainfall or soil moisture is adequate. Day length varies based on different varieties; some are short day types and others are long day types. Very long days increase vegetative growth and plants might not flower also; very short days might lead to the formation of both male and female flowers at the top of corn plant.

Soil conditions: Best grown on fertile, well drained, loam soils. Corn is very sensitive to soil aeration. PH of 5-8 is preferred but best above 5.5. Corn is sensitive to salinity and alkalinity.

Cultivation requirements:

1- Fertilizers: Almost all soils require the addition of nutrients to obtain good yield per unit area, especially when synthetic and hybrid varieties are grown. In general, corn fertilization depends on: used variety (local, synthetic and hybrid), previous cop, planting method and type of farming (irrigated or rainfed). The required amounts, manure: sandy soils (20-30 tons/ha), heavy soils (10-20 tons/ha). Chemical fertilizers: in semi-arid zones (250-400 mm), 20-40 kg/ha N, 40 kg/ha P_2O_5 and 30 kg/ha K_2O. In humid zones (500 mm), 40-80 kg/ha N, 40-60 kg/ha P_2O_5 and 30-50 kg/ha K_2O.

In Irrigated areas: 80-100 kg/ha, 80-100 kg/ha P_2O_5, 120-150 kg /ha K_2O. Note that K is not added to soils rich in potassium; K and P fertilizers are added before planting, but N is added at planting and before flowering. Corn plants mostly require fertilizers 10 days before and up to 25 days after flowering.70 % of N from 15 July -15 August, 70 % of P at flowering,

2- Crop rotation: Rainfed cultivation: corn comes after cultivated or non cultivated fallow or after wheat or barley (not advisable) or after forage or grain legume. Irrigated cultivation: Corn follows cotton or sugar beet or oilseed crop or legume. It might follow wheat or oilseed crop (double cropping) as in Euphrates basin.

3- Planting date: varies based on varieties and purpose of planting.

Spring corn: March and April after soil warming (for local and late varieties)

Early double cropping: (early June – mid June) for late maturing synthetic.

Late double cropping: (during July) for short life varieties.

Do not delay planting because of the effect of early rainfall in late September and effect on harvesting and drying of grains.

4- Seeding rate: Related to the required density, 1000 seed weight, type of variety, seed quality and number of tillers.

-For early maturing and hybrids: density 90,000 plants /ha

-For late maturing and high tiller varieties: density 50-60 thousand plants/ha.

-Semi arid zones: density 35 thousand plants/ha.

-Seed rate under irrigated cultivation 30-50 kg/ha for grain yield and 120-200 kg / ha for green forage.

5- Planting depth: it is 4-5 cm depending on planting method, soil type, variety.etc.

Care operations of crop after establishment:

1- Hoeing: one or two hoeing during early stages of plant growth to control weeds and for earthing up of plants.

2-Replanting and Thinning: it should be done as early as possible after 10 days of planting to maintain optimum plant population.

3- Irrigation: in Syrian conditions, corn crop require 10-12 irrigations when grown as main crop, and 6-8 irrigations in double cropping system. First irrigation will be given directly after crop establishment and later on, one irrigation every 6-10 days according to weather conditions.

Maturity and harvest: Harvest is conducted when grain moisture is 30-35%. Harvest can be done manually or by machines (corn pickers or corn shellers). Grains are dried till 14 % moisture.

Yield: the main goal of corn cultivation is to increase the productivity per unit area. The number of harvested cobs, cob length, number of grain per cob and 100 seed weight are the major components correlated with corn yield. The yield per unit area around 2-3 t/ha of dried grain, and it can reach up to 6-10 t/ha, fodder corn yield around 30-50 t/ha as green fodder.

Breeding and genetics of corn: No other crop has been subjected to such intensive genetic and cytogenetic study as corn. There has been more work done on corn breeding than any other crop. Before 1920, improvement was made by selection within open pollinated varieties. Since 1920, improvement has been with hybrid varieties.

Areas of improvement: resistance to lodging, ear dropping, insects, diseases and drought, leaf number, leaf position and leaf angle, high lysine content, high oil content, high amylase content.

Cytogenetics: Corn has 10 pair of chromosomes which are recognized by relative lengths, chromosome arm rations, and knob and satellite positions (at prophase of the first meiotic division). Corn has additional chromatic material in the cytoplasm; they are called: B- chromosomes or supernumerary chromosomes. Haploids= 10 chromosomes, Diploids= 20 chromosomes. Triploids= 30 chromosomes. Tetraploids= 40 chromosomes.

Heterosis (hybrid vigor): phenomenon in which cross of two stocks produces a hybrid, superior to the parents in size, yield or general vigor.

Synthetic varieties: advanced generations of a multiple hybrid increased by open pollination (more than 4 inbreds).

Environmental stresses:

Important pests and diseases of maize crop: the important diseases that affect maize crop are: leaf blight, rust, seed rots and seedling blight, brown spot, leaf spot, downy mildew, stalk rot. Whereas the important insects are: stem borer, white grubs,, shoot fly, thrips and grass hoppers.

Chapter 4: Sorghum

(Sorghum bicolor L. Moench)

Economic importance: Sorghum is used for food, feed and forage. It is a staple food for millions in Africa and Asia. The grains are used in making some bread or eaten like rice after boiling or as popped grains. The grains also used as a feed for cattle, swine, poultry and birds. Green fodder and stover is palatable to milch and draft animals. Industrial uses of sorghum are in fortification of food, preparation of alcohol. Sweet sorghum varieties (17.8 % brix) are used in extraction of raw sugar. The cultivation of sorghum in the world increased largely during the past years due to more interest in livestock and increase in human population and more demand for animal products in addition to the grain of sorghum considered as a rich source of CHO (78%), protein (10.5%) with low content of cellulose (1.6-1.8%). The availability of sorghum grain at cheaper rate compared to maize and discovering of new techniques in sorghum production (male sterile, hybridization..etc.) gave more interest in sorghum cultivation in the world.

Center of origin: Vavilov (1926) described northeast Africa (Ethiopia and Egypt) as probable centre of origin. Harlan and Dewet (1972) on the basis of occurrence of wild and primitive race bicolor reported Africa as its centre of origin. Some believe that the regions in west Africa along the river Niger contributed to the origin of sorghum (Doggett, 1965)

Cultivated area and production: It is mainly grown in India, USA, China, Mexico, Sudan and Nigeria. India is the leader in area whereas USA is the leader in productivity (Table 1).

Table 1: Area, production and productivity of sorghum in the world during 2009.

Country	Area (m.ha)	Production (m.t)	Productivity (kg/ha)
India	11.2	9.0	1414
USA	3.8	16.7	4101
Nigeria	6.6	7.3	1107
Sudan	5.6	3.4	597
Mexico	1.9	6.3	3288
Total	45.3	64.1	1414

In the Arab world, Sudan is the largest country in area and production. In Syria, sorghum crop is grown in an area of (4165 ha) with a total production of (4457 tones) and productivity of (934 kg/ha).

Botanical classification: Sorghum bicolor belongs to family gramineae and genus sorghum with 2n =20 chromosome. Harlan and Dewet (1972) divided S. bicolor into five basic races, on the basis of spikelet types and grains as: bicolor, guinea, caudatum, kafir and durra. The important differences in spikelet and grains of each type is given below:

1. cultivated races:

Race	Spikelets	Grains
Bicolor	Persistent, pedicellate	Elliptic, attached to panicse & pigmented
Guinea	Deciduous and Persistent, pedicellate	Ovate, flattened slight pigmentation
Caudatum	Sessile, pedicellate deciduous	Flat from one side- round on other side, white or pigmented
Kafir	Hairy, sessile	Elliptic and broad, flattened
Durra	Persistent, sessile and pedicellate	Biconvex with broad tip, wedge like base

2. Wild races: S. arundinaceum, S. aethiopicum, S. virgatum, S. verticilliflorum, S. prpinqum, S. shattercane

There is cultivated species like S.vulgare, S.sativa with chromosome number 2n=20 and there are perennial species like S.halepens, S. almum with 2n=40

Agricultural classification:

1) Forage sorghum: with long stem, sweetly and juicy type. e.g. S. bicolor, S. vulgare

2) Grain sorghum: with packed grains and dense production of grains e.g. S. caffrorum, S. durra, S.grain.

3) Saccharata sorghum: with long and thick stem, sweetly and juicy type e.g. S. dochna (variety=saccharata)

4) Herbaces sorghum: e.g S.vulgare (variety=sudanense) including Sudanese herb and other hybrids which resulted from hybridization with forage sorghum.

5) Broom sorghum: with lengthy cluster blossom used for broom manufacturing e.g. S. technicum (variety=dochna)

Growth stages: The important growth stages of sorghum are: (1) seedling stage (2) flag leaf (3) booting stage (4) soft dough stage (5) physiological maturity stage.

Environmental requirements: It is a plant of warm climate. It remains dormant under unfavourable conditions. Leaves posses waxy coating rolls the leaves under moisture stress. They also possess a large number of secondary roots. The crop withstand drought better than maize. The crop is tolerant to water logging and can be grown under low rainfall area. The minimum temperature required for germination is 7-10 ^{o} C. Germination does not take place if temperature is less than 7 ^{o}C. Optimum temperature for growth is 25-30 ^{o} C. crop is sensitive to low temperature. Temperature below 15 ^{o}C affects crop growth adversely. Sorghum is a short day plant; the floral bud develops at shorter day length of less than 12 hr and is naturally photoperiod sensitive. Photo-insensitive genotypes are produced through crossing and selection. These can then be planted in any season.

Moisture requirements: The water requirements for sorghum are less compared to maize crop because of low transpiration. This is mainly due to the existence of epicutical wax on the leaves**.** The stomata is very small**.** The surface area of the vegetative parts is half of that in maize**.** Sorghum has strong and deep root system**.**

Soil conditions: Soils having good water holding capacity, rich in humus are best suited. Black soils categorized as best soils for its cultivation. Crop is grown in PH range of 6.0 – 8.5; crop needs good tilth. Field is prepared by one deep ploughing followed by 2-3 harrowing or ploughing with country plough immediately.

Cultivation requirements:

1-Cropping system: Generally it is observed that crop growth and yield is poor after sorghum. This is because of deep root system, more absorption of available nutrients and its high carbohydrate content in comparison to nitrogen, consuming available nitrogen of soil. Thus crop succeeding after sorghum may experience nitrogen deficiency, commonly called soil sickness or yellow effect. Therefore, it is advisable to supplement the succeeding crop with adequate nitrogen to overcome its deficiency.

Common cropping system with sorghum: under rainfed cultivation: sorghum comes after cultivated or non cultivated fallow or after wheat or barley or after forages. Under irrigated cultivation: sorghum follows cotton or sugar beets or oil crop or legumes.

2-Fertilizers application: Sorghum is a heavy feeds of plant nutrients. A grain sorghum crop yielding 5-6 t/ha remove nearly 130-180 kg N, 50-60 kg P_2O_5 and 100-130 kg K_2O/ha. Against such removal of nutrients, the actual addition by farmers is less. Thus, farmers are harvesting low yield.

It is recommended to add 60-80 kg N/ha, 60-100 kg P2O5/ha and 100-160 kg K2O/ha in addition to 30 t/ha of farm yard manure in good rainfall area and under irrigated conditions.

3-Varieties: Large number of varieties/hybrids with higher yield potential than that of local have been released for cultivation in different provinces.

4-Sowing: Sorghum in Syria is grown in spring (April-May) under irrigation at 40 x 20 cm using 6-8 kg seeds and total plant population 150,000 per ha. Fodder crop of sorghum is sown at 30 cm row to row spacing using 40 kg seed/ha for bold seeded and 20 -25 kg for small seeded varieties. Sowing sorghum in ridge and furrow system is recommended. Generally, the depth of sowing is 3-4 cm.

Care operations of crop after establishment:

1- Irrigation: Sorghum is drought-tolerant. High yielding varieties respond well to irrigation. Sorghum has an extensive and deep root system capable of extracting soil moisture from deeper soil layers. Maintaining optimum soil moisture at 3-4 week after sowing helps in development of secondary strong roots. Similar to other cereal crops, water stress affects growth and development of sorghum by affecting:

1. Floral initiation and inflorescence development (important in deciding grain number)

2. Anthesis and fertilization which decides actual number of grains

3. Grain filling which decides grain weight.

Based on this, early seedling stage and flower primordial stage are considered most critical for moisture stress. Generally, 6 - 10 irrigations are needed, depending on soil and climatic conditions. Also irrigation depends on available soil moisture. It is recommended to irrigate sorghum when 45 - 55 % available soil moisture is depleted. Depth of irrigation is generally 6 - 8 cm and water requirement of crop is around 80 - 480 mm.

2- Weed control: Sorghum is badly infested with both broad leaf and grassy weeds. 15-40 % loss in grain yield can be expected due to weeds. 15 - 45 days of crop growth is critical with regard to crop weed competition.

Maturity and harvest: Crop should be harvested when grains are hard and having 20 – 25 % moisture rather crop should be harvested at physiological maturity, as many high yielding varieties remain green even after maturity. Crop may be harvested either by cutting earhead or whole plant and, then, earheads are collected. Crop is threshed manually by beating with sticks or mechanical thresher after drying. Grains is cleaned and dried in sun till 10 - 15 % moisture.

Yield: Irrigated crop raised with full improved cultivation practices yield 4.5-5.0 t/ha of grain and 10-11 t/ha dry fodder under irrigated condition.

Efforts are going on to develop ideal plant type of sorghum with short stem, erect leaves, deep and extensive root system, loose panicle with more primary branches having large number of grains capable of producing in moisture stress conditions and toleratant to insect, pest and diseases.

Fodder sorghum: Single cut varieties should be cut at 50% flowering stage. In multi-cut varieties first cut is taken after 50 - 60 days of sowing; subsequent cuttings should be taken at an interval of 35 - 40 days. Crop should be cut 5-8 cm high from ground level for fast sprouting.

Sweet sorghum: Sweet sorghum (Sorghum *bicolor)* is similar to grain sorghum with a sugar-rich stalk, almost similar to sugarcane.

Advantages of sweet sorghum:

1) Wide range of adaptability and rapid growth rate
2) High sugar accumulation in stalks
3) High biomass production potential,
4) Tolerant to drought, water logging, soil salinity and acidity toxicity.
5) High potential for alcohol production.
6) Sugar content in the juice of sweet sorghum varies from 16-23% Brix.

Sorghum poisoning: Young plants (30-40 days stage) contain cynogenic glucoside called dhurrin, which is in the stomach of animals is converted into hydrocyanic acid (HCN). Thus, when young plants of sorghum are fed to animals, this causes carcinogenic death of animal. This is known as prussic acid poisoning or sorghum poisoning. HCN content is more in leaves, the concentration of HCN is more in morning and in summer season. The toxic limit of HCN is 200 ppm, its concentration decreases after 50 days of planting. To avoid HCN problem, avoid feeding animals with sorghum before 50 days stage. Hay and silage are generally free from HCN.

Breeding objectives in sorghum

1. High grain yield

2. High forage yield

3. Dual purpose

4. Early maturity for intensive cropping

5. Desirable plants (non-lodging, good threshability, large head size, etc.)

6. Resistance to biotic stresses (grain mould, shoot fly, stem borer, etc.)**.**

7. Resistance to abiotic stresses (salinity and drought)

8. Special traits (sweet sorghum/striga resistance).

Breeding methods in sorghum

Pure line selection: In this method, superior heads are selected from local uniform cultivars and grown as plant progenies in the next season for evaluation. The uniform superior progeny harvested in bulk to be grown in the next season.

Pedigree method: it involves hybridization between desirable parental lines followed by selection of superior plants in the segregating generations till homozygosity is achieved till F_5 or F_6 generation.

Backcross breeding: Transfer of one or few simple inherited traits from a donor to another desirable genotype used as a recurrent parent. Transfer of head smut resistance into combine 7078 in India, is one of the achievement made by following backcross method of breeding. Development of cytoplasmic genetic male sterility in sorghum is made through backcross method of breeding.

Population improvement: Population improvement involves generation of broad-based gene pools and their improvement through recurrent selection. The main aim of population improvement method is to maintain as much genetic variability possible.

Environmental stresses:

Pest and diseases of sorghum: the most serious pest problem for grain sorghum growers is likely to be bird damage. Grain sorghum is resistant to corn root worms, but may be attacked by corn earworms, aphids, and green bugs. The important diseases are: downy mildew, ergot, rust and Charcol rot

Control measures of insects and diseases: seed treatment should be used to control seed rots and seedling blights. Leaf diseases can be problems in areas with high rainfall and humidity, but generally do not cause serious losses. Planting resistant hybrids, providing optimum growing conditions, rotating with other crops, removing infested debris, planting disease-free seed are all methods which can be used to minimize losses from disease and insects.

Chapter 5: Rice
(*Oryza sativa* L.)

Economic importance: Rice is an important food crop of many countries. It has the world's largest area (28%) covering 42.3 million hectares with a total production of 80 million tones annually. Its area is 37% of the total area under food grains as against 20% under wheat, another important food crop. But globally, it stands next to wheat in harvested area. It is grown in diversified soil, topographical and hydrological situations, ranging from sloppy uplands to deep water areas of above I meter depth. It is adopted to cold temperatures that exist in hilly areas and also in diverse soil conditions such as salinity, alkalinity and acidity. It is a staple food crop of 60 percent of world's population. Mostly it is cooked with water. Other edible uses include rice flakes and puffed rice, rice wafers and canned rice. It is also used in starch and brewing industries. The byproducts of rice milling i.e. rice husk and bran are used as a cattle and poultry feed. Hard board and paper industries also uses these byproducts. Rice bran oil is used in cooking after refinement. It is also used in making soap. Rice straw is good cattle feed as well as it is also used in making hats, mats and ropes.

The center of origin: Rice is regarded as a first cultivated crop of Asia. Preserved rice grains were found in China around 3000 B.C. Rice grains found during excavation at Hastinapur in India around 1000-750 B.C. considered as an oldest sample in the world. Vavilov (1926) concluded that south-west Himalayas has various types and varieties and indicated probable centre of origin. De Condolle (1986) mentioned south India as its centre of origin. Thus based on all these Archeological evidences, India is considered centre of origin of rice.

Cultivated area and distribution: Rice cultivation is limited to as far as north as 49^o in Czechoslovakia and as far as south as 35^o in New South Wales. But most of the world's rice is grown in tropics which include countries of south and south East Asia, west Africa and central and south America. India stands first in area and second with regards to production. China is first in production. Area and production of important rice growing countries is given in (Table 1).

In the Arab countries the area under rice cultivation around 859,000 ha with a production of 7.43 million tones and the productivity around 5799 kg/ha during 2009. Egypt is first in area and production and productivity around 82% of total cultivated rice in the Arab world with highest productivity of 9771 kg/ha (Table 2).

Table 1: Area and production of rice in some countries of the world (FAO, 2009)

Country	Area (ha)	Production (t)	Productivity (kg/ha)
India	42,880,000	121,812,000	2846
China	31,107,000	197,074,000	6206
Indonesia	11,332,000	51,102,000	4509
Bangladesh	9,966,000	26,531.000	2662
Thailand	10,137,000	22,016,000	2172

Table 2: Area, production and productivity of rice crop in some Arabic countries

Country	Area (ha)	Production (t)	Productivity (kg/ha)
Egypt	703770	6,876,830	9771
Iraq	124250	393000	3163
Mauritania	17250	86000	4986
Sudan	7600	30000	3947
Morocco	5000	34000	6800
Somalia	1720	10540	6128

In Syria, rice was grown in the past time in some areas of the country, but the area was less and it was unregulated cultivation. The area reduced after 1948 because of the competition with cotton crop, higher water requirements and higher cost of cultivation. The area increased during 1968-1973 and reached upto 147 ha with a total production of 5218 tones during 1975, but the area again reduced to 50 ha during 1978. Now, there is a need to do more research to grow rice in Syria, especially after the increase in rice price globally and development of new aerobic rice varieties which can be grown under less amount of water as compared with puddle rice.

Botanical classification: Rice belongs to the family gramineae. There are 24 species of genus Oryza, but only two species are under cultivation viz., *Oryza sativa* and *Oryza glaberrina*. Oryza sativa is most popular and grown in the most of the rice growing areas of the world, whereas *Oryza glaberrina* is mainly grown in south Asia.

Oryza sativa is further grouped into three types, i.e., O. indica, O. japonica and O. javonica, the characteristics of each type are given in (Table 3).

Environmental requirements: Rice plants can flourish under such widely differing climatic conditions that is difficult to define those most suitable for its growth and development. Temperature, solar radiation and rainfall influenced rice yield by directly affecting physiological processes associated

Table 3: The characteristics of different rice types.

characteristics	O. indica	O. japonica	O. javonica
Area of cultivation	India	Japan	Indonesia
Plant height	Tall	Dwarf	Tall
Leaves	Broad, light green, slightly pubescent	Narrow, dark green	Broad, hard, light green
Tillering	Very high	Medium	Low
Grain	Thin, flattened, elongated	Small and rounded	Broad and thick
Shattering	High	low	low

with grain production and indirectly through pests and diseases. In temperate regions, irrigated rice cultivation starts when spring temperature is between 13^{o} and 20^{o} C and harvested before temperature drop below 13^{o} in the autumn. In the tropics, where temperature is favourable through the year, rice cultivation starts with the rainy season. In both tropics and temperate regions, the level of solar radiation primarily determines productivity of rice provided irrigation water/rainfall is not limited.

1- Moisture: rainfall is perhaps the most important in rainfed rice cultivation. Under irrigated conditions, however, growth and yield are determined largely by temperature and solar radiation. Most of tropical southeast Asia receives abundant annual rainfall above 2000 mm where rice is usually grown during rainy season. In general, rainfed rice cultivation is limited to areas where the annual rainfall exceeds 1000 mm. Rice is the most important rainy season crop. It is also grown as rainfed crop even when the rainfall is less than 500 mm. at the other extreme, where the rainfall may be around 250 mm, excellent rice crop is cultivated under well irrigation.

2- Temperature: Temperature is one of the limiting factors for rice crop in temperate regions. It, generally, influences not only growth duration but also the growth pattern of rice plant. However, temperature is not a serious problem for rice cultivation in tropical countries since its variations are slight in regions between 15^{o}N and S latitudes. Low average yield in tropics is partly due to warm climate. It is well known that temperature coefficient for photosynthesis is 1.0, while that for respiration is about 2.0. This indicates that for every 10o rise in temperature, respiration rate increases twice as fast as photosynthesis rate. Therefore, it is logical to assume that the dry matter production would be less in tropics due to less net photosynthesis and high respiration rate under high temperature conditions.

Extreme temperatures are destructive to plant growth. The critically low and high temperatures, normally below 20ºC and above 30ºC vary from one growth stage to another (Table 4).

Table 4: Response of rice plant to temperatures at different growth stages

Growth stage	Critical temperature (ºC)		
	Low	**High**	**Optimum**
Germination	10	45	20-35
Emergence and establishment	12-13	35	25-26
Rooting	16	35	25-28
Leaf elongation	7-12	45	31
Tillering	9-16	33	25-31
Panicle primordial initiation	15	35	28-32
Panicle differentiation	15-20	38	30-32
Anthesis	22	35	30-33
Ripening	12-18	30	20-25

Poor germination, leaf discoloration, stunting, incomplete panicle initiation, increased degenerated spikelets, failure in anthesis, increased spiklet sterility, increased grain shattering and delayed heading are some of the adverse effects of low temperature. Temperature lower than critical 20ºC, however, may result in imperfect grains development. High temperature at ripening results in prematurity, mainly due to in ability of spikelet to serve as a sink to store carbohydrates. This prematurity results in partially chalky and milk white kernels. The harvest index is greater at lower temperature, food partitioning is quite apparent in rice plant and has been given as one of the reasons for higher grain yields in the temperate areas.

3- Light (solar radiation): rice crop in general is a short day plant, all the varieties grown in monsoon season are subjected to low light stress at the vegetative stage irrespective of their duration. Reproductive stage is most sensitive to low light stress. As spikelet number is determined during this period, low light affects the production of spikelets per unit area and yield. Decrease in spikelets number is attributed to limited source activity and sink capacity. Dry matter production, grain number per panicle and grain size can be reduced due to low light at ripening stage. Based on their response to photoperiod, rice varieties can be grouped as sensitive and non-sensitive. Sensitive varieties flower when the day length is decreasing and when it reaches a critical value for induction of flowering phase. Such varieties are frequently of medium or long duration period. Induction of flowering by short day length influences their ripening period, so that they are date fixed as regards to maturity date, though their growing period can be extended by early sowing. Non-sensitive varieties do not respond to differences in photoperiod, their length of life being independent of day length so that they can be grown in any season. They are period fixed as regards of maturation and early or late sowing has little influence on the length of their life. The practical application is that farmers must select wisely among the cultivars they plant, since photoperiod sensitivity will determine the growth duration, maturity date and potential yield as well as adaptation to double cropping. In tropical areas, photoperiod sensitive cultivars have traditionally been selected because they could be planted when the monsoon rains begin and are harvested at a fixed time after rain cease and food waters recede. Such varieties utilize the high solar radiation at the late growth stages, which have beneficial effects on yield.

4- Soil requirements: Rice can be grown in a wide range of soil type. In India it can be grown in alluvial soils, red soils, yellow soils and laterite soils. Despite wide variation in rice culture, there are two main systems of soil management: Dry soil management, in which land is prepared dry and the crop is seeded in the same manner as other cereal crops, referred to as upland rice culture. Wet soil management, in which the land is flooded and soil preparation is done in wet or submerged soil, referred to as wetland rice culture. The upland soils being mostly coarse in texture. Their water retention capacity is very low and, hence, the crop often suffers due to soil moisture stress with uneven rainfall distribution. Red and laterite soils contain large amounts of free iron oxide, which often leads to crust formation resulting in poor emergence of the seedlings and low crop stand. These coarse textured soils have low cation exchange capacity and hence nutrient retention capacity is low. This leads to considerable loss of nutrients, particularly nitrogen through deep percolation. Lowland soils form a major portion for rice cultivation in tropical, subtropical and warm temperate parts of the world. Under these conditions, rice crop is flooded during greater part of the growing season. The soils of lowland rice are usually on terraces where standing water can be maintained. These soils usually have strong hydro-morphic characteristics, poor internal drainage but are capable of irrigation and drainage in rice culture management. High rice yields are usually associated with soils that have a high clay content (40-60%), medium organic matter content and good drainage. Soil depth vary from 18-22 cm. The soil PH may range from 4-7 without affecting the yield.

Cultivation requirements before sowing:

(1) Rainfed (dry) system:

1-Field preparation: the fields are ploughed either immediately after harvesting of previous crop or by taking advantages of the summer shower.

Fields left in this condition till the monsoon rains are harrowed for achieving the required tilth. Farm yard manure are applied 2-3 weeks before sowing and incorporated with subsequent harrowing. The seed is sown directly with the onset of monsoon showers, either by broadcasting, dibbling behind the country plough or by drilling in lines with the seed drills. A light harrow or a wooden plank covers the seed. Line sowing is preferable, as it ensures adequate stand establishment and facilitates inter-cultivation.

2- Time of sowing: it is most critical factor in determining initial crop stand and its subsequent establishment in the field. In areas where early monsoon rains are adequate for land preparation, direct seeding of upland rice as soon as cumulative rains reaches 50-60 cm is desirable. Studies at central rice research institute, Cuttack, India indicated that sowing rice in the first half of June (5-15) produces highest yield. Sowing beyond 25 June adversely affects the crop due to excessive rains. In rainfed lowlands, sowing should be taken up at the earliest opportunity following the receipt of premonsoon showers. Light showers received during early May should be utilized for land preparation, allowing sowing in relatively dry soil conditions.

3- Method of sowing: the three commonly followed seeding methods are:

<u>Broadcasting:</u> it is the most common method under dry system. Broadcasting seed on soil surface is covered by light ploughing or harrowing.

Dibbling: in this method, seed is dibbled in plough furrows behind the country plough at regular intervals and covered same as in broadcasting. The seed requirement is less than that for broadcasting and germination is uniform due to placement at uniform depth.

Drilling: this method enables to cover large area within a given time compared with dibbling in the plough furrows. It retains all the advantages indicated under dibbling. Seed drills are used for drilling the seed.

4- Seed rate and spacing: nature of the soil, tilth, soil moisture content, duration and test weight of the cultivars and system of cultivation determines seed rate and spacing. In India seed rate of 30 kg ha^{-1} for drilling and 60 kg ha^{-1} for broadcasting is optimum. In general, seed rate of 40-50 kg ha^{-1} is required for drilling, while 60-100 kg ha^{-1} is required for broadcasting under different upland conditions. Spacing depends on soil fertility and duration of the variety. A row spacing of 15 - 30 cm is optimum under different upland rice environments.

(2). Irrigated (wet) system:

1- Field preparation: in this system the crop is grown under wet (irrigated) conditions from seed to seed. The field is brought to a soft puddle by repeated ploughings with 5-7 cm standing water. After obtaining a soft puddle and perfect leveling, rice seedlings are transplanted or sprouted seeds dibbled or broadcasted on the puddle.

2- Rice Nursery: an alternative to broadcasting or drilling is to raise seedlings in a nursery to be transplanted in the main field when they have attained sufficient development. The nursery may be situated on dryland or in wet (irrigated) situation. Main difference between them is that the seedlings may remain in the dry nursery for three months before transplanting. Where as seedlings from wet nursery must be transplanted within 25-40 days, depending on the duration of the cultivar.

3-Transplanting: the usual practice in most countries is to pull the seedlings, tie them into bundles, the roots being rinsed in water to remove soil. The top of leaves are cut off to reduce evaporating surface and give rigidity to the plants and when transplanted the leaves do not bend over into water. Time of transplanting: planting time has significant influence on grain yield of rice. In general, transplanting in the first fortnight of July gives best yield for autumn rice cultivation. And for spring rice cultivation, November is the best time for transplanting. Delay in planting may reduce rice yield. Age of seedlings: optimum age of seedlings for transplanting largely depends on the duration of the variety, system of raising nursery, soil fertility and other management practices. From experimental results in India, a seedling of 25-30 days old is ideal for autumn rice transplanting, while 45-60 days old seedlings are ideal during spring.

4- Spacing: spacing depends on season, duration of variety, age of seedlings and soil fertility. In general, spacing should be wider in autumn than in spring, wider in fertile soils than in poor soils, wider for high tillering varieties than for low tillering. From the experimental results, the spacing of 20 x 15 cm is optimum in autumn and 15 x 10 cm in spring.

5- Crop rotation: rice crop belongs to field crops that can tolerate repeated cultivation year after year in the same land (monoculture) due to growth habit and higher cost of cultivation of rice crop by establishing rice field (irrigation and drainage facilities) though rice monoculture may cause many problems like: destruction of soil physical properties, salinity and reduction in soil organic matter, nutrients depletion, pest and diseases infestation, weed problem. This may cause severe reduction in rice yield; therefore, it is not advisable to grow rice in the same field more than 2-3 years. Instead of this, it is better to introduce legume crops (lucerne, berseem, soybeans. etc.) to enrich soil fertility and to control weeds. In Japan, rice can be grown in rotation with legume crops (green manure). In Egypt rice-cotton-berseem (green manure) crop rotation can be followed.

6- Fertilization: irrigated rice responds well to fertilizer application if applied judiciously and with proper cultural management. Responses are generally higher in dry season as compared to wet season. This is mainly due to higher solar radiation and lack of rains and better possibility of irrigation water management. In India a rate of 40-50 kg N/ha may be considered desirable for wet season (autumn crop). For the dry season (spring crop), a rate of 80-100 kg N/ha may be considered as optimum. Regarding the form of fertilizers, ammonical forms are better than nitrates. A better returns can be obtained from a given amount of N when it is applied in split and the application is usually synchronized with active growth of the crop. Phosphorus fertilizers can be applied as basal dose at a rate of 40 kg P_2O_5/ha for autumn rice crop and 50 kg P_2O_5/ha for spring rice crop. Potassium fertilizers can be applied as basal dose at a rate of 50 kg K_2O/ha for autumn rice crop and 60 kg K_2O/ha for spring rice crop. Organic manures should be applied to the soil at the rate of 30-40 t ha^{-1} to get higher rice yield. Experimental results in India showed increase in rice yield by 40% when chemical fertilizers added along with organic manures.

Care operations of crop after establishment:

1- **Thinning and replanting:** under upland rice cultivation these two operations are important. It can be done after 30 days after sowing when plant is 20-25 cm length. The aim of replanting is to get regular plant population in the unit area.

2- Weed control: In upland rice weed competition is maximum. Weeds emerge along with rice crop and compete with it for light, nutrients, moisture and space. The extent of losses in yield is influenced by competitive efficiency of weeds, weed density, duration of crop weed competition, cultivar, fertility level, row spacing. etc. Weeds are effectively controlled by mechanical and chemical methods. Chemical weed control offer a better alternative cost-effective technology to hand weeding which is highly expensive and labour intensive. Under irrigated rice generally, flooded conditions eliminate grassy weeds to a large extent.

3- Water management: under irrigated rice system, rice is grown under continuously flooded condition with 2-7 cm standing water throughout the season. This practice is effective for efficient nutrient use and weed control. As the irrigation is becoming expensive day by day, the water input needs to be judiciously used. In rice, water requirements is the total amount of water needed from sowing till ripening, to meet losses due to transpiration through leaves, losses due to evaporation from soil and deep percolation and seepage losses. The total water requirements of rice in India as reported by various workers varies widely from less than 800 mm to more than 2500 mm depending upon the duration of the variety and characteristics of the soil and climatic conditions.

Maturity and harvest: under irrigated rice system, drain out water from the field when grains in the lowest portion of the panicle are in the dough stage (about 20 days from 50% flowering). Allow the grains to harden. Harvest 30-35 days after flowering when stalks still remain green to avoid grain shedding. Moisture content should be around 20% at the time of harvest. The crop should be harvested when the grains of upper portion of panicles are clean and firm. Harvesting done by man labours by using sickles in small areas, in large areas reaper winnower can be used in the case of upland rice. After harvesting of rice the bundles are kept lying in the field for sun drying for later threshing. Combines and harvesters are used now for harvesting upland rice on large scale in many countries.

Yield: yield per unit area may differ according to many factors. The yield ranges between 3-5 t ha^{-1} in many countries. In some developed countries like Japan rice yield may reach upto 7-12 t ha^{-1}.

Breeding objectives in rice crop: (1) High grain yield. (2) High nutritional value of rice grains. (3) High productive tillers. (4) Short stem for lodging resistance. (5) Environmental stresses resistance. (6) Synchronizing maturity of upper and lower spikes.

Environmental stresses:

Diseases and insects: termites and bugs are the important pests that attack upland rice crop causing severe yield losses. Termites infest rice crop at the time of sowing and after wards and reduce crop stand considerably. Bugs affect rice crop during post flowering period and increase grin sterility. Blast and brown spot are the major diseases of rainfed upland rice. Brown spot usually occurs in poorly managed rice soils and under prolonged drought spells. Irrigated and rainfed lowland rice crops affected by insect pests like, yellow stem borer, green leaf hopper, cut worm, leaf folder.etc. various aspects of pest management could be utilized in tackling pest problems.

1. Use of insect tolerant varieties

2. Use of insecticides

3. Utilization of natural enemies (biological control)

Physiological disorders: it happens because of many reasons like; increasing or decreasing irrigation water, wind, low temperature at early stages. The important Physiological disorders are: leaf yellowing and burning, lodging, stem branching, grains explosion.etc.

Section two: Legume crops

Economic importance: The problem of lack of protein in human food is consider as one of the most important agricultural problems that requires a quick solution, and because the legume crops, especially grain legumes is rich in protein of good quality, which is equivalent to animal protein had to be of interest in cultivation, where it can be a vegetable protein substitute for animal protein in the human food. In addition, this protein is cheap and available in all countries, compared with animal protein. Leguminous crops cultivation started 8000 years ago, where known to mankind and used since ancient times, especially lentils. These crops belong to the family leguminoseae which include 700 genus and 18000 type annual and perennial, including herbal and bushes and trees, and is characterized by its ability to fix the nitrogen atmosphere, increasing the fertility of the soil. The most important legume crops which are grown in Syria: fababeans (*Vicia faba*), lentils (*Lens esculenta*), chickpeas (*Cicer arietinum*), lupine (*Lupinus Sp*.), peas (*Pisum sativum*), soybeans (*Glycina max*), peanuts (*Arachis hypogaea*). These legumes are known as dry food legumes. Where as, forage legumes used primarily for animal feed like: alfalfa, clover, vetch, etc.

The importance of grain legume crops can be shown in the following points: seeds with high protein content which gives it special importance in human nutrition in developing countries, where the proportion of protein 22-25%, carbohydrates 48-54% of total dry matter. Seeds can be used in nutrition, dry or green at the start of grain formation or before they fully mature. They give a large amount of protein per unit area with the cheapest costs. They provide the needs of human or animal body from amino acids compared with cereal crops, which is equivalent in lipid content and superior in the amount of starch. The proportion of fat ranges between1-4% and can reach up to 5% in chickpeas and 2% in lentils, but they excel on the cereals in the proportion of calcium 100 mg/100 g, iron 7 mg/100 g. Legumes are rich in vitamin A, riboflavin, thiamine, and poor in vitamin C; therefore, it should be used in human nutrition directly or preserved in cans, also used in animal feed directly or in the form of silage, hay, straw. Legume crops are of great importance in terms of agricultural aspect, where formed on the plant roots nodules with the ability to fix atmospheric nitrogen, which is used in part in legume crop nutrition, and keep the other part in the soil to increase fertility and provide the needs of the succeeding crop in the crop rotation of nitrogen, thus entering legume crops in crop rotations help to compensate the loss of nitrogen consumed by the previous crop. Experimental results have shown that lupine crop add to the soil after harvest 150-200 kg nitrogen. Note that in the present day, the artificial bacterial inoculation is prepared, which is specific to crop to be added with the seeds of legume crops when grown in the field for the first time.

The center of origin: Legume crops known since eight thousand years, have been found:

1. Remains of peas plant in Switzerland dating back to about 4500 years BC, and in the tombs of the ancient Egyptians, and the remains of Trojan city.
2. Fossils of chickpeas found in the Eastern Mediterranean, and in Iraq, from which it spread to India, and East Asia.

3. Lentils grown since a very long time and was the staple food of the Greeks, the ancient Egyptians and Romans, where lentil seeds found in Egyptian tombs dating back to 2200 - 2400 BC.

4. The remains of broad bean found in Switzerland belonging to the Bronze era, also found that they were cultivated by the ancient Egyptians, where it was and still popular food.

5. The peanuts known by the Red Indians as a good food.

6. The soybeans is an important food crop and planted in China long ago, \ then in Japan, and then in the rest of East Asia.

The chemical composition of seeds: Grains and leaves of grain legumes contain high protein proportion ranging between 20-30% in most of these grain crops (Table 1). They exceed by 2 -3 times of the cereal grain content of protein, although this ratio may reach 35-45% in soybeans and lupine. The hay resulting from the legume plants also contains a higher proportion of protein than cereal plants, ranging between 8-15%.

Table 1: The chemical composition of grain of some legume crops (%)

Crop	Protein	CHO	Fats	Crude fiber	Ash
Peas	37	52	1.5	3.5	2
Broad bean	30	54	1.5	6	3.5
Lentil	28	50	2	3	3
Vetch	27	48	2	6	3
Chickpea	25	49	2	4	3
Beans	28	49	2	4	3
Soybean	34	24	19	4	5
Lupine	40	24	5	12.5	4.5

The cultivated area: The area planted globally with dry beans in 2009 about 71 million hectares, the production 59.47 million tons with an yield of about 835 kg / ha. These crops did not receive any remarkable development during the last four decades. India comes in first place in terms of area (22.25 hectares) and production, followed by Nigeria with respect to the cultivated area, and China with respect to production, while France comes in first place with respect to productivity of about 4 tones/ha (Table 2).

Table 2: Cultivated area, production and productivity of legumes in some of the world countries (FAO, 2009).

Country	Area (1000 ha)	Production (1000 t)	Productivity (kg/ha)
India	22.253	13.410	602
Nigeria	4.531	3.091	682
Brazil	4.074	3.473	852
China	3.374	5.548	1644
Canada	2.047	3.701	1808
Mexico	1.874	1.675	893
Iran	1.731	1.045	603
Pakistan	1.535	804	523
Australia	1.482	730	492
USA	1.210	2.082	1720
France	339	1.347	3973
Syria	297	305	1026
Sudan	162	252	1555
Egypt	130	401	3084

Legume crops have been less fortunate than cereal crops in terms of the study, improvement and development and that made the area, yield and finally the production fluctuate in many years (except for soybean, which has gotten a distinctive research). The area planted with food legumes in the Arab world 1170.84 thousand hectares, and production of seeds 1441.24 thousand tons and average yield of 1231 kg/ha (Yearbook of the Organization of Arab Agricultural, 2009). The major area concentrated in Morocco and Syria (310.60, 283.83 thousand hectares, respectively), and then Egypt 122.70 thousand hectares, which is ranked first in terms of production and the yield per unit area as a result of its reliance on irrigated cultivation for these crops.The area planted with food grain and forage legumes in Syria, 284 thousand hectares and it is in decline because of: a need for greater attention compared with cereal crops, non-availability of machines for harvesting legume crops, which limits the expansion of cultivation of these crops, especially in the areas of less labour availability, the exposure of the pods of the most legumes to shattering causing the loss of a portion of yield and its infection with orobanche weed.

Atmospheric nitrogen fixation: Nitrogen fixation through the nodules located on the roots of legume crops has been studied in different circumstances, where researchers found that Rhizobum bacteria that coexist with legumes can fix atmospheric nitrogen with a quantity ranging between 100-200 kg/ha in irrigated conditions and conditions of high rainfall. The quantity decrease with reduction in rainfall. The estimated amount in Syrian agriculture between 20-50 kg/ha, this is due to the fact that these crops are grown under rainfed conditions where rainfall ranges between 250-400 mm. The researchers indicated that the quality of rhizobum differ in different legume crops. The process of nitrogen fixation starts in the cells of bacteria and is transmitted to plant cells and that there is a symbiotic relationship between plants and rhizobum bacteria, where plant provides bacteria with various organic substances necessary for bacteria life and bacteria provide plant with fixed nitrogen. It should be noted that the studies in the Syrian Arab Republic on the types and numbers and activity of rhizobum bacteria are very few; so in the year of 1988, the Department of organic and biological fertilization has been established in the Ministry of Agriculture with the issue of conducting research and studies on the rhizobum bacteria in different legume crops. This Department started working on soybean bacteria for being a modern introduced crop to Syrian agriculture and, therefore, bacterial inoculation should be used when this crop is grown.

Environmental Requirements: Legume crops differ in their environmental requirements, which helped in their spread and cultivation in diverse environmental conditions. Depending on the length of the growing season it is divided into two groups: shorter growing season crops (peas, lentils, lathyrus) and longer growing season crops (broad bean and soybean), although each crop include varieties of early, medium and late maturity. **I- Temperature**: Legume crops differ in their need for heat according to the growth stage (Table 3).

Table 3: Minimum and optimum temperature for different growth stages of grain legumes

Crop	Growth stage							
	Germination stage		Vegetative stage		Reproductive stage		Fruiting stage	
Temp.	Min.	Opt.	Min.	Opt.	Min.	Opt.	Min.	Opt.
Peas	5-4	12-6	5-4	16-12	12-10	20-16	12-10	22-16
Lentil	5-4	12-6	5-4	16-12	15-12	21-17	12-10	22-17
Vetch	5-4	12-6	5-4	16-12	12-10	21-17	12-10	23-19
Lupine	6-5	12-9	6-5	16-14	10-8	20-16	10-8	20-16
Broad	6-5	12-9	6-5	16-12	10-8	20-16	10-8	22-16
Chickpe	6-5	12-9	6-5	18-17	15-12	21-17	15-12	24-20
Soybean	11-10	18-15	11-10	18-15	18-15	22-18	12-10	22-18
beans	13-12	18-15	13-12	26-16	18-15	25-18	15-12	23-20

It is clear from this table that the crops, peas, lentils and vetch require less temperature, and lupine, beans, chickpeas require more temperature, but the highest heat demanding crops are soybeans. Legume crops differ in their tolerance to the cold and frost, especially in the early growth stages, the crops, beans, chickpeas, lentils and vetch can tolerate frost until -8 ºC at germination stage. Lupine and faba beans until - 6 ºC and soybeans until -4 ºC, while beans can not tolerate frost and its seedlings affected by low temperature of -1 ºC.

II- Moisture requirements: Grain legume crops need a large amount of moisture compared with other grain crops and its growth is affected in water logged areas. Faba beans and lupine of grain legume crops require large amount of water, while chickpeas, vetch and some varieties of lentils and peas need little amount of water. The optimum soil moisture percentage between 60-100% of field capacity ensures the process of atmospheric nitrogen fixation, high yield and good quality.

III- Light: Legume crops can be divided into 3 groups depending on the length of photoperiod: day long crops (peas, lentils, faba beans, chickpeas, lupine, and vetch), and short day crops (soybeans and some varieties of beans), and the other is not affected by the length of photoperiod (most types of beans and chickpeas).

IV- Soil: Legume crops vary in their need for proper soil, where some of them succeed in the light soils and other in heavy soils. The clay soils of moderate or low acidity with sufficient amount of phosphorus, potassium and calcium are the most appropriate. Yellow lupine can grow in soils even with PH upto 4 - 4.5 and gives a good productivity. Legume crops differ in terms of their requirements of soil pH, depending on the effectiveness of the bacterial strain.

Agricultural requirements:

1- Fertilizers requirements: Legume crops are more demanding for nutrients compared with cereal crops. One unit of yield contains a large amount of nutrients, which can be expressed in what is known of the extreme need and the quantity of nutrients carried with yield. Extreme need means the largest quantity of the nutrients involved in the process of formation a single unit of the crop and are larger than the quantity of nutrients carried with yield. The carried quantity is the amount of nutrients absorbed from the field by one unit of yield (1 ton of grain and other plant residues of the stem and leaves) (Table 4). It is determined with the period and date of harvest. The difference between extreme need and the quantity of nutrients carried with yield is called amount of nutrients left by the crop in the field through the root and other falling plant parts. In an average to get 1 ton of leguminous grain and other plant residues, it carries from the soil 69 kg of nitrogen versus 34 kg in cereal crops; so, in the case of a weak job of the strains of rhizobum bacteria or non-existence of these bacteria, the yield of legumes will be half yield of cereal crops. Note that the lack of moisture reduced absorption of nitrogen from the soil and thus reduced the proportion of protein in the grain, compared with years with adequate moisture, as the lack of moisture affects the activity of the bacterial strain.

Table 4: the extreme need and the quantity of nutrients carried with yield (kg) for obtaining one ton of grains and plant residues.

Crop	Extreme need				Carried quantity			
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
Peas	64	21	29	114	50	16	24	90
Chickpeas	64	25	60	149	52	21	49	122
Faba beans	65	26	55	146	52	20	44	116
Beans	66	25	40	131	53	22	29	104
Vetch	70	19	39	128	58	16	30	114
Lentils	70	23	38	131	59	20	28	107
Lupine	80	22	50	152	68	19	42	129
Soybeans	82	26	47	155	72	23	38	133

2- Agricultural intensification technique in the production of grain legumes: It is the use of all means of agricultural technology in an organized manner in order to obtain high yields without the need to increase the expenses of the manual labour. This technology includes: improving the level of soil fertility, following the appropriate crop rotations, the use of high yielding varieties which respond well to mechanization, the use of optimum rate of mineral fertilizer and finally the doing of all agricultural operations on time according to the biological requirements of the legume crop.

3- Crop rotation: Legumes can be grown after any agricultural crop except perennial legumes and grain legume itself, where the repetition of growing grain legume in the same field will increase the spread of some pathogens and insect its accumulation in the soil causing a reduction in the yield in the subsequent years. It is believed that it is possible to repeat cultivation of legumes in the same field after 3-4 years, where the pathogens and insects level will be reduced to minimum. The legume crops considered a good preceding crop of cereal and commercial crops because of large amounts of fixed nitrogen in the soil. The crop rotation legumes followed by cereals is the principle crop rotation of rainfed cultivation in the Syrian Arab Republic, where the government strives for the application of this crop rotation, especially since recurrence of cereal crops in the same land for many years created many problems in terms of reduced production and spread of pests and weeds.

Chapter 1: Lentils
(*Lens esculenta L.*)

Economic importance: Lentils (*Lens culinaris/Lens esculenta*) is the fourth most important legume crop in the world after beans, pea and chickpea. The primary product of the cultivated lentil is the seed, which is a valuable human food product containing a high amount of protein (22- 34.5%), carbohydrate (65%) and other minerals and vitamins and in many countries, lentils are used as a meat substitute. However, while the seeds have large concentrations of lysine, they are deficient in sulphur-containing amino acids, methionine, and cysteine. Therefore, a combination of cereal grains, which are rich in sulphur-containing amino acids and poor in lysine, and lentils provides a very nutritionally well-balanced diet. The seeds are mostly eaten as dhal or in soups, and the flour can be mixed with cereal flour and used in cakes, breads and some baby food. There are also some dishes in which the lentils are mixed with cereals, and in some parts of India, the whole seeds are eaten salted and fried. Young pods can also be used as green vegetables, and the seeds can be a source of starch for textile and printing industries. Additionally, lentil residues can be used as a livestock feed as they have high average of protein and crude fiber.

Origin and Distribution: *Lens culinaris* (Medic) originated in the Fertile Crescent and Near East and Asia Minor. Since its domestication, lentils have become one of the most important food crops in the semi-arid regions of the world, especially in the Indian sub-continent and in the dry areas of the Middle East. Lentils are also sown in the USA, Bangladesh, Afghanistan, Pakistan, Morocco, Ethiopia, Egypt, Mexico, Chile, Peru, Argentina, Colombia and Spain. Lentils are one of the few crops which can be grown in marginal agricultural areas without fertilization, irrigation and other inputs.

Botanical classification: Lens is a Latin word that describes exactly the shape of the seed of a cultivated legume now known as *Lens culinaris* which is a name that was given by the German botanist Medikus in 1787. Lentil (*Lens culinaris* Medic) is classified in the genus Lens, which is in the sub family Papilionaceae and the family Leguminosae. The genus *Lens* comprises of many species like: L. lenticularis, L. nigucans, L. orientalis, L. culinaris, L. esculenta.

The cultivated species (*Lens culinaris*) divided into two type:

1- Macrosperamae: large seeds, flat pods, found in Africa, Asia Minor

2- Microspermae: small pods, seeds are smaller, found in India, Pakistan, south and west Asia.

Cultivated area and production of lentil: Lentil production has increased considerably since the 1980's. The world production in 2009 exceeded 4 million metric tonnes with over 4 million hectare harvested. Over 90% of the global production takes place in North America, the Indian subcontinent, Turkey and other countries like Australia, Iran, Syria and China. According to the FAO, the largest producer in the years 2009 and 2010 was India followed by Canada and Turkey. The highest average yield in the same years however, was reported in China (2205.8 and 2400 kg. ha^{-1} respectively), whilst the mean yield in the largest producer, India, was only 629.14 and 949.10 $kg.ha^{-1}$ respectively (Table 1).

Table 1: Total production and productivity of lentil in major producing countries of the world during 2008 and 2009.

Country	***Production (tones)***		***Productivity (kg ha^{-1})***	
	2008	**2009**	**2008**	**2009**
India	950000	1400000	629.14	949.10
Canada	692800	669700	1249.41	1258.30
Turkey	622684	580260	1415.51	1184.20
U.S.A	235000	154584	1426.75	1294.80
Syria	165000	165000	1137.93	1137.93
Nepal	157963	164694	832.69	870.50
China	150000	180000	2205.88	2400.00
Bangladesh	120000	119000	921.66	820.60
Iran	113225	115000	502.02	511.10

In the Arab world the area under lentils cultivation during 2009 was (223 thousand hectare) with a total production of (173 thousand tones) and the average yield 776 kg/ha. Syria occupies the first place in area and production (158 thousand hectare and 162 thousand tones) around 70% of the total area and production of lentil in the Arab world, followed by Morocco and Yemen

Growth stages of lentil crop: The following growth stages have been identified in lentil:

1. Seedling stage: plant is small, tender and with one leaf

2. Branching: plant with fully developed three leaves, 4th leaf in developing stage and primary branches begins to develop.

3. Flowering: plant with 10-11 leaves, 1-2 flower nodes and 11-15 vegetative nodes.

4. Pod formation: pod begins to develop.

5. Maturity: 90-95% leaves starts withering.

Environmental requirements:

1- Temperature: Lentils are well adapted to cool temperatures, and the crop is usually sown soon after the autumnal rains and grown in winter in the Mediterranean regions as well as in Pakistan and northern India. In extremely cold countries such as USA, Turkey, Canada, Chile and

Argentina, lentils are seeded in spring, as the crop is incapable of surviving very cold winters. Optimum temperatures for germination in lentil are reported to be 18 – 21 ºC, with a minimum of 15 ºC, and a maximum of 27 ºC. The seeds however, can germinate over a wide range of temperatures in light or in darkness, and the optimum temperature varies between genotypes age and size of the seeds. Germination in small seeded cultivars is usually faster than the larger ones at temperatures of 15 - 25 ºC. Warmer temperatures are required for vegetative development and temperatures around 24 ºC are optimum for yields, but this varies among cultivars. Some lentil genotypes respond to vernalization which can lead to earlier flowering.

2- Moisture: About 95% of the lentils produced worldwide is from rainfed areas and therefore, the amount and the distribution of the rainfall are major factors in determining the crop productivity indicated that the crop requirements of annual rainfall are about 750 mm, with dry conditions, before harvest. In West Asia and North Africa, the crop is grown in winter (sown in Dec- Jan and harvested in May) with a yearly average rainfall of 300 - 400 mm, which occur mainly during the vegetative growth period. However, the rainfall is reduced considerably from March to May which coincides with the reproductive stage of lentils and this significantly reduces the yield. In general, lentil has a moderate tolerance to drought but the degree of tolerance varies among cultivars. Small seeded cultivars showed greater tolerance to drought mainly because they mature earlier than larger seeded cultivars, and in this way they avoid the stress. Lentils are very sensitive to water logging and usually the damage caused by water logging can be greater than that of drought. In general lentils yield increase considerably with irrigation, but special consideration should be taken not to overdo the irrigation because of high sensitivity of the crop to water.

3- Light and day length: In general, lentils are long-day plant and flowering occurs sooner in longer photoperiod compared to shorter photoperiods, but some cultivars are day-neutral.

4- Soil conditions Lentils can be grown in many types of soils ranging from light loams to black cotton soils, and can grow best on clay soils. The crop is frequently grown in marginal lands with poor fertility, low rain fall, and with pest and weed. Lentils are very sensitive to soil acidity and a minimum pH value of 5.6 is required for maximum yield and the yield is considerably reduced below this value. In addition, nodulation can be restricted in soils with high or low pH because of a direct effect on the survival of the *Rhizobium* bacteria. Furthermore, lentils response to soil salinity differs between the growth stages, and while germination and seedling emergence is not affected by NaCl for values up to 7.9 $dS.m^{-1}$, the total dry matter was reduced by 48% and seed yield by 92% when salinity increased from 1.3 to 5.3 $dS.m^{-1}$ Additionally, lentil plants are considered to have a moderate tolerance to alkaline soils.

Lentil varieties: Research, particularly by ICARDA (International Centre for Agricultural Research in the Dry Areas- Aleppo) is trying to produce cultivars which tolerate stress conditions and which resist major diseases and pests. It is also seeking to improve cultivars suitable for mechanical harvesting. Generally in Syria the important varieties are: Hoorani (red lentil) with large seeds, Hoorani with small seeds and white lentil.

Cultivation requirements:

1- Seeding and sowing date: Lentils can be grows manually by hand or by seeder which can put the seeds at optimum depth inside the soil. The optimum time for sowing is November with optimum plant density of 200-300 plants/m^2.

2- Crop rotation: Lentils can be grown in crop rotation with cereals like wheat and barley (cereals –lentils), which forms the important crop rotation in semiarid region of Syria. Lentil is a leguminous crop, so, it can be grown in multiple cropping system like wheat-fallow-lentil to improve soil fertility by fixation of atmospheric nitrogen. Lentil crop requires more labours for growing, weed management and harvesting .etc. so, farmers sometimes do not prefer lentils in the crop rotations.

3- Fertilizers application: Lentil is a leguminous crop, the application of nitrogen will be limited to 30 kg N/ha as a starter dose. With respect to phosphorus around 50-80 kg P_2O_5/ha can be added depending on the area of growing. The potassium can be added to poor soils at 50 kg K_2O/ha.

Care operations of crop after establishment:

1- Water requirements It is chiefly grown as a rainfed crop and comes up well under residual soil moisture. Lentil has low water requirements ranging from 300 - 350 mm. The transpiration ratio ranges from 200-500 in humid conditions with 800 to 1500 liters of transpired water per kg dry matter. The higher the water supply, the greater the transpiration ratio.. Lentil responds well to irrigation but excessive irrigation is detrimental for the crop growth in heavy clay soils. Flowering and pod development stages are critical. The water use efficiency (WUE) varies from 4.2 to 5.6 kg grain/ha/mm and for biological yield, the WUE is 10.3-16.4 kg/ha/mm.

2- Harvesting and maturity: Harvesting of lentil is an expensive process and in Syrian conditions still the harvesting of lentil is done manually after physiological maturity. Early harvesting is not desirable because it will reduce the quality of produce. Late harvesting of lentil may cause severe loss of seeds. The manual harvesting of lentil is not economic and less availability of labours, on the other hand the mechanical harvesting require long and erect plants**,** the first pod should be at least 25 cm away from the soil and lodging resistant varieties with synchronized maturity of all plants.

Breeding objectives in lentil:

(1) High yielding varieties. (2) Drought resistant varieties.

(3) Higher protein content with valuable nutritive quality. (4) Long plants for mechanical harvesting. (5) Varieties resistant to shaterability.

(6) Resistant varieties to insects and diseases.

Environmental stresses:

1- Diseases: The important diseases affecting Lentils in our area are: Root rot, Sclerotinia, Anthracnose, Ascochyta blight, Fusarium wilt**.** Control measures involve: avoiding other susceptible crops in rotation including sunflower, dry beans, canola, field peas and soybeans and using small grains and corn in the rotation to reduce populations of these fungi in the soil, using resistant cultivars to these diseases, spraying effective foliar fungicides.

2- Insects: Lentil is not bothered much by insect pests. Cutworms can damage the crop, wireworms can also damage emerging seedlings, Blister beetles have been noticed occasionally, but damage has been minimal, Grasshoppers may be a problem.

Chapter 2: Chickpea
(*Cicer arietinum* L.)

Economic importance: Chickpea is an important legume crop rich in protein (19-22%) and CHO (49-55%) in addition to vitamins and minerals. Can be used as a food for human and feed for animals. The sprouted seeds are eatable after frying. The plant parts and pod husk are a good nutritive fodder to milch animals. The crop also builds soil fertility; it fixes about 70-90 kg N/ha. An acidic liquid (oxalic and malic acids) from granular hairs of plant at flowering stage can be collected and can be used to prepare vinegar which has also medicinal value.

The center of origin: The origin is in the Fertile Crescent in southeast Turkey and Syria. The cultivated chickpea is not found in the wild and C. reticulatum is its progenitor, while C. echinospermum is a close relative. From west Asia it spread to Europe. In more recent times it was introduced in tropical Africa, central and southern America and Australia.

Cultivated area and production: The global production of chickpea is 8.7 m.t raised from an area of 10.6 m.ha and the productivity (819 t/ha) according to FAO, 2009. India occupied the first place in area and production. In the Arab world, Syria occupies the first place in area and production followed by Morocco, Tunisia, Algeria and Iraq. In Syria the area under chickpea cultivation is (85.59 thousand hectare) and the production (50.04 thousand tones) with productivity of about (585 kg/ha). It is grown under rainfed conditions in provinces of Daraa, Sweeda, Aleppo, Damascus, Tartoos, Edleb, Homs, Hama and Latakia. There is a small area grown under irrigated conditions near large cities. Its grain used green or dry as food for human and feed for animals.

Botanical classification: Chickpea belong to the family leguminoseae and genus Cicer. There are 39 species, 38 wild species and one cultivated species (*Cicer arietinum*). It posses 2n=16 chromosomes. Vavilove reported that the region of Mediterranean sea and south west Asia are the origin of cultivated chickpea. There are two types of chickpea, the large seeds (>26 g/100 seeds) more or less rounded, pale cream colour are the Kabuli types. Smaller seeds (17-26 g/100 seeds) of irregular shapes and various colours are Desi types. Cultivated chickpea can be divided into four groups:

1. Oriental chickpea: with small seeds cultivated in Iran and Ethiopia

2. Asian chickpea: its seeds large and wrinkled compared to oriental chickpea cultivated in China, Afghanistan, Egypt, Sudan and Turkey.

3. Asian-European chickpea: the seeds are large and round cultivated in Syria, Palestine and middle Russia.

4. Mediterranean Chickpea: the seeds are very large, round with light colour.

Environmental requirements: Chickpea is a summer crop grown in spring months and harvested in summer. Thus, it is sensitive to low temperature which affects fertilization and seed formation. Spring varieties require cool dry climate, frost free with dew; it cannot tolerate heavy rains. Optimum temperature for germination (6-10 ^oC) flowering (11-18 ^oC) and maturity (20-25 ^oC) with relative humidity of 60-80%. It is a long day plant requiring 12-16 hours bright sunshine per day. Recently, winter varieties can tolerate low temperature upto -3 ^{o}C without harmful effects on its growth, especially at early stages. Chickpea does not tolerate excess of moisture; it requires rainfall of 250-350 mm under rainfed conditions and 4-5 irrigation under irrigated conditions.

Soil conditions: Chickpea can be grown in deep fertile soils, well aerated and drained with PH range 5.7 - 7.2. It does not withstand water logging, saline and alkaline conditions.

Cultivation requirements:

1- Manure and fertilizers: As it is a leguminous crop, its nitrogen requirements is low, on very poor soils 10-20 kg N/ha required as a starter dose to boost nodulation, 50-80 kg P_2O_5/ha and 50 kg K_2O/ha in poor soils. Organic manure like farm yard manure can be applied if it is available with the rate of 20-30 m^3/ha.

2- Crop rotation: Chickpea can improve soil fertility; thus, it can be grown alternatively with cereal crops under rainfed conditions or with summer crops under irrigated conditions. Rainfed cultivation: areas receiving more than 350 mm, wheat-chickpea, barley-chickpea. Areas receiving 250-350 mm, wheat-chickpea-fallow, barley-chickpea-fallow. Irrigated cultivation: Chickpea-wheat/barley-cotton, chickpea-wheat/barley-sugar beet, chickpea-wheat/barley-maize.

3- Varieties: Selection of variety for region is important for getting higher yield. Winter varieties of chickpea developed by GCSAR and ICARDA are: Ghab1, Ghab2 and Ghab3**.** The important characters of these varieties:

1. High yield compared to the local spring varieties (up to 4000 kg/ha).

2. Possibility of growing these varieties in December-January and ultimately utilization of winter rainfall.

3. Resistant to frost and Ascochyta blight disease and Caterpillar and Heliecoverpa insects.

4. Early maturity, thus can keep the land free for next crop.

5. Suitable for mechanical harvesting because of stem height.

6. It ensure stability in area and production.

4- Sowing date: Spring chickpea grown during the second fortnight of February**.** Winter chickpea grown between 15 November till 15 December.

5- Seed rate: it depends on the method of sowing, but it is preferred to select new seeds with high germination percentage with high percentage of purity. Normally 8-85 kg/ha by hand or line cultivation.

6- Seed treatment: the seed should be treated with thiram (3 g/kg seeds) for protecting crop from seed born diseases; seeds should be treated also with Rhizobium leguminosarum for enhancing N fixation.

Care operations of crop after establishment:

1- Irrigation: Chickpea does not prefer excess moisture, 4-5 irrigation can be given under irrigated conditions depending on soil type and regional conditions. First irrigation after sowing, second one after germination, third one before flowering and fourth irrigation after fertilization and last one before harvesting by 20-25 days. In case of soil having high water holding capacity chickpea required only 2-3 irrigations.

2- Nipping: It is a process of plucking the apical buds at 30-40 days after sowing. This operation promotes lateral branching and plants and plants become more vigorous. Thus, they produce more flowers and pods and yield per plant is substantially increased. It is suspected that nipping improves partitioning of metabolites to sink (pods).

Maturity and harvest: When the leaves and pods fully yellow in colour and seed dry the crop should be harvested. Harvesting is done manually by hand or mechanically by harvester; the pods should be dried in sun for 4-5 days and there-after threshed by thresher. The grains are stored when moisture contents in grain are 8-10%. With improved cultivation practices, crop can yield upto 1750-2000 kg/ha.

Breeding objectives in chickpea:

1) Breeding for high yield, more pods and seeds per plants, more weight of 100 seeds, more nodes on the stem and more stem height and more branches.

2) Breeding for high resistance to biotic and abiotic stresses

3) Breeding for new varieties which can be grown in winter season

4) High responsive cultivars to fertilizers and irrigation and rhizobium treatments.

5) High content of protein in the seeds.

Environmental stresses:

Insects and Diseases of chickpea crop: The important diseases affecting chickpea in our area are: Alternaria blight, Dry root rot, Ascochyta blight, Fusarium wilt and Collar rot.

Important insects are: grain pod borer, chickpea cutworm and termites.

Control measures involves: avoiding other susceptible crops in rotation to reduce populations of these fungi in the soil. using cultivars that have shown some resistance to these diseases and insects, spraying effective foliar fungicides and insecticides.

Chapter 3: Faba Bean
(*Vicia faba* L.)

Economic importance: Faba bean is one of the most important legume crops in many countries of the world, including the Syrian Arab Republic and the Arab Republic of Egypt, cultivated under rainfed or irrigated conditions. Its economic importance can be highlighted through the following uses: Faba bean seeds are highly nutritious, rich in protein content (30-35%), used in human nutrition, where the green pods are used in cooking and preparing some meals, while dry seeds can be used to prepare some dishes like falafel in Egypt, also the dry seeds can be used in the composition of concentrated diets for farm animals in many countries. The plants used as green feed or silage preparation and in both cases the entire plant is uprooted, dry crop residues can also be used to prepare hay for feeding animals. Faba bean has great importance in the crop rotation, which is characterized by its ability to fix the nitrogen in the soil by bacteria in root nodules (*Rhizobium leguminosaru*m), which fixes the atmospheric nitrogen, and this provides the need of legume plant of nitrogen, increases soil fertility and improves soil properties, and provides part of the need of the succeeding crop of nitrogen. The tap root of broad beans penetrate the soil vertically. This leads to improve the properties of the soil. Faba bean flour mixed with wheat flour to improve wheat bread in protein content. It also has medical uses; the flowers and fruits of faba bean contain comfort and palliative and diuretic materials.

The cultivated area: Faba bean comes in fourth place among the legume crops in terms of area and production in the world. Agricultural statistics indicate that China is the top producer of green faba beans, followed by Indonesia, Turkey. With regard to the production of dry faba beans, Brazil occupies first place followed by India and China (FAO, 2009), (Table 1).

Table 1: The production of green and dry faba beans (thousand tones) in some world countries.

Country	Production (thousand tones)	
	Green faba bean	Dry faba bean
China	2466	1233
Indonesia	867	320
Turkey	520	220
Brazil	105	3169
India	420	3000
USA	120	1150
Mexico	97	993

Faba bean grown in the Arab countries under rainfed conditions, the cultivated area at the level of the Arab world during 2009 was 434 thousand hectares with a production of 765 thousand tons of dry seeds yield with an average yield of 1763 kg/ha (Yearbook of the Arab Agricultural Organization, 2009). Morocco comes in the first place followed by Egypt, which ranked first in terms of production and the yield of unit area. Syria occupies the sixth place in area and production (Table 2). In Syria Faba beans ranked third place in importance among the legume crops after lentils and chickpeas; it is grown near the major cities to ensure the market need of green pods.

Table 2: Area and production of dry faba beans in the Arab world.

Country	Area (000' ha)	Production (000'tones)	Productivity (kg/ha)
Morocco	162	178	1099
Egypt	89	301	3390
Sudan	69	140	2014
Tunisia	56	67	1192
Algeria	31	27	894
Syria	15	25	1700
Iraq	5	15	3158
Yemen	4	7	1713

Source: Yearbook of the Arab Agricultural Organization (2009).

The chemical composition of seeds: The seeds of faba beans contain 25% protein, 47% carbohydrate, 7% cellulose, 3% minerals, 1.2% fatty substances. Seed protein is characterized by high content of amino acid lysine and tryptophan and low content of sulfur amino acids.

The center of origin: Faba bean is an old crop, where it was known thousands years ago, the Russian scientist Zhukovsky believed that the native place of faba bean is the Mediterranean basin, this with respect to varieties of small size grain (some believes the South-West Asia). The varieties of large grains are believed to be from African origin (North African). The discovery of faba bean (2N = 12) since 6500 BC and known as horse beans. The wild types is unknown, but Zohary and Hope (1993) believed that the type *Vicia marbonensis* (2N = 14) is the closest wild forms. It was grown in West Asia. Known in China since 2800 BC as wild crop, then known in Italy, France and Spain, later on become cultivated crop, then moved from Europe to North America. It was cultivated in the Nile Valley since 2004 BC and, then, reached to Ethiopia and finally to Afghanistan and northern India.

Environmental requirements:

I- Temperature: Faba bean crop is sensitive to chilling, frost and the high temperatures. So, its cultivation is not possible in areas with low temperatures during the season of growth to low temperature below zero. The convenient growing season for faba bean suits cultivation of all legumes in general is warm and temperate weather. The seeds of faba bean can germinate in 3-4 ºC and the seedlings emerge at 5-6 ºC. The temperature of

15-18 ºC is suitable for seed germination, but germination will be slow. The seedling can tolerate low temperature upto -6 ºC. The minimum temperature for vegetation growth is 4 ºC. The high temperature during flowering stage with hot and dry wind lead to flower falling and reduce fertilization. The low temperature is not suitable for flowering, fruiting and maturity of the plant, while the frost stop the growth of the plant.

II- Moisture: Faba bean crop sensitive to drought. Increasing drought period may cause: reducing the rate of vegetative growth, a clear reduction in plant height, shortage of flowering period, and this in turn leads to a decrease in number of pods and grains; and; therefore, a clear decrease in production, in addition to decrease in the proportion of dry matter in pods and grains, also the symbiotic relationship between plant and bacteria may be affected. Faba bean is grown under irrigated conditions in most areas of Syria, and can be grown in areas with a minimum rainfall of 300 mm/year, but with good distribution during the growing season. It is well known that an increase in water and rain for a long time during the flowering period leads to poor pollination and loss of flowers; and; thus, decreases fertilization. The crop requires from 3-5 irrigations or more in some cases, increasing irrigation may cause more vegetative growth of the crop.

III- Light: Faba bean is classified as long-day plants. However, the process of vernalization of the seeds on 10 ºC leads to accelerating the process of growth and flowering. The plant needs a period of light relatively long, ranging from 8-12 hours a day, because the increase in photoperiod leads to accelerated plant growth, where the length of the period from planting to flowering can be reduced from 60 days to 20 days with increasing the length of the day from 8 to 24 hours. The light intensity is of great importance, since increasing the light intensity will increase the efficiency of the plant in production of dry matter and increases the speed of formation of the leaves and pods, while a decrease in the light intensity will lead to weak and thin stem, lodging and flowering delay.

IV- Soil: cultivation of faba bean succeeds in clay fertile or medium fertile soils with good drainage, but not rich in nitrogen to avoid vegetative growth. It can be grown successfully in light soils containing a high proportion of organic matter and a small percentage of lime. Poor, dry and sandy soils are not suitable for growing faba bean. Faba bean tolerate salinity up to 9 ds/m. The appropriate pH of the soil should be 6-8. Saline and acid soils are not suitable. Soil infested with orobanche weed does not fit faba bean cultivation, because of the weed spreading between plants which causes weakness and death of the roots due to parasitism and absorption of its food.

Cultivation requirements before sowing:

1- Fertilization: Faba bean responds well to organic fertilizers, where increasing the yield of grain and increasing the growth of shoots, where organic fertilizers are added either before the primary tillage or to the previous crop in crop rotation at the rate of 20-30 tones / ha. With respect to chemical fertilizers, the experiments showed that to obtain yield of 2400 kg / ha of grains, the crop will absorb from the following quantities of fertilizer: 115 kg of nitrogen, 48 kg of phosphorus, 120 kg of potassium, 95 kg of calcium. Faba bean does not need nitrogen fertilization at the success of Rhizobium bacteria inoculation, which can provide about 80% of nitrogen requirements through fixation of atmospheric nitrogen. It is recommended to add 20-25 kg / ha of nitrogen at planting to promote the nitrogen fixation process later, while the addition of 120-150 kg / ha active ingredient is must when the soil is poor with Rhizobium bacteria. It is recommended to add 400 kg/ha of super phosphate as a source of phosphorus and 250 kg/ha of sulphate of potash as a source of potassium. In Syria, it is recommended to add 20 units of N, 40 - 60 units of P_2O_5, 20-40 units of K_2O/ha for rainfed areas. In irrigated areas 20-30 units of N, 60 - 80 units of P_2O_5, 40-60 units of K_2O/ha, in addition to organic manure at the rate of 30 t/ha.

2- Bacterial Inoculation: In case of planting faba bean for the first time in the virgin land, it is preferred to add its own Rhizobium bacteria (*Rhizobium leguminosarum*), which fixes the atmospheric nitrogen. The amount of fixed nitrogen around 840 mg/plant, equivalent to 210 kg/ha helps to increase production, where it is found that the addition of these bacteria led to increased yields up to 50%. The process of adding bacteria with seeds at planting or to the soil directly before planting is known as bacterial inoculation. Note that the rate of addition of a solution of bacteria to the seeds of faba bean, 3 grams to 1 kg of faba bean seeds.

3- Crop rotation: Faba bean comes, as the case with any legume crop, at the top of crop rotation with cereals, cultivated summer crops like sugar beet, cotton or vegetables. Usually it is not recommended growing faba bean after legume crop because of lodging problem due to more nitrogen accumulation in the soil. Note that the presence of faba bean in crop rotation increases soil fertility, which results in improving succeeding crop in quantity and quality. Under irrigated cultivation, faba bean can enter in bilateral crop rotation (faba bean + summer crop or vegetables), or trilateral crop rotation (faba bean + wheat + summer crop), while under rainfed cultivation (faba bean + fallow + wheat).

4- Land preparation for cultivation: Land is tilled deep up to 25-30 cm after removing the previous crop, followed by solarization of soil to more than 15 days and then plowed again and leveled before planting. Note that in the case of growing faba bean after cultivated crops (potatoes, sugar beet) a surface plowing is enough to add organic and phosphorus fertilizers, followed by several surface plowings to soften the soil and eradicate weeds.

5- Planting date: Winter varieties are grown in sowing dates of wheat and barley in most regions of Syria and the Arab world due to less decline of temperature below the critical lower temperature. Usually preferred early sowing (October). Spring varieties are grown in cold high regions of Syria, where the temperature will not raise in summer during blossom stage, these can be grown during late spring. In the warm areas, it is grown from 15 September to 30 October (Lattakia, Tartous, Daraa). In temperate weather areas (Hama, Homs, Aleppo) it is grown from 15 October to 30 November.

6- Seed rate: The amount of seed to be planted varies depending on the cultivar to be grown, the method of planting, for broadcasting (150-200 kg/ha in case of small seeds, 300 - 400 kg/ha in the case of large seeds). This amount can be reduced by two-thirds in case of using local plow, and by third in the case of growing faba bean in lines.

7- Planting methods: Faba bean can be grown in four methods: broadcasting, sowing behind local plow, lines sowing, and automatic seeding on the lines where the land is prepared and divided into beds, fit to leveling degree of the field, and with the available amount of irrigation water, and then grown by using an appropriate method.

Care operations of crop after establishment:

1- Replanting and Thinning: The seedling appear after 10-14 days from the date of sowing according to the prevailing climatic conditions, after the completion of the emergence of seedling above the soil surface. The process of replanting (gap filling) is done as early as possible using seeds soaked in water for 12 hours from the same variety. Thinning can be done after 2-3 weeks of germination. Note that after the completion of replanting and thinning, we can give one irrigation.

2- Hoeing: The process of hoeing to move the soil, fill cracks, eliminate the weeds in the field, repeat this process once every 20 days depending on the nature of the soil, and the degree of the spread of weeds.

3-Earthing up: Sometimes it is advised to make the process of earthing up of the plants when they reach a height of 15-20 cm to minimize the lodging.

4- Pruning the plants: This process is done a month before harvesting the crop by cutting off the tops of plants with a length of 10-15 cm in order to direct products of photosynthesis to the seeds, where the results showed an increase in the yield seeds up to 250 kg/ha compared with non-pruning. **5-Irrigation:** Faba bean needs 3-5 irrigations in the irrigated cultivation depending on the nature of the soil and climate. First irrigation is given 15-20 days after emergence of seedlings above the soil surface and the second one after fertilization stage, while the third one after completing the blossom formation, whereas, the fourth one during seed formation stage.

Maturity and harvest: Faba bean can be harvested after 4 months from planting to get green pods (green pods can be collected in two batches) and one hectare can yield around 20 tones depending on variety and rainfall. For dry seed purpose, faba bean harvested 5 - 5.5 months from the date of planting, after the emergence of signs of maturity viz, full pods, yellowing of plants, drying and falling of bottom leaves, yellowing of pods and its color turned to black and the stem turned brown. The process of harvesting or collection of plants is done in the early morning (dew) manually with machetes, then plants are piled in small piles then transferred to clean floor for threshing and separating the seeds from the plants, or by harvesters, which reduces the effort and costs involved in the case of harvesting by hand. We should avoid early harvesting of the dry seeds to reach its normal size. Note that the delay of harvesting leads to pod shattering and loss of seeds and, therefore, a significant reduction in yield. In some Europen countries and USA, faba bean is grown for making hay or silage, also can be used as green manure.

Yield or productivity: The yield of dry seed ranging between 2-6 tones/ha, and between 10-20 tones/ha in case of green pods. This quantity is affected by soil fertility, the used variety, the availability of rainfall in rainfed cultivation or availability of water in irrigated cultivation, care operations provided to the crop and the degree of pollination, which can increase the yield up to 50%, so it is usually recommended to put two groups of bees hives/ha for the high rate of pollination. In Syria dry seeds yield ranges between 1.5 to 1.9 tones/ha.

Important characters in breeding programme:

1) High yields of grain and stable over the years by increasing the number of seeds per pod in addition to its good quality.

2) High proportion of fertilization and limited loss of flowers.

3) Good adaptation to environmental conditions.

4) Earliness and production of green pods for long period of time.

5) increase the stem stiffness and resistance to lodging,

6) Diseases and insects resistance.

7) Drought and frost resistance.

Environmental stresses:

Faba beans are exposed to many problems, which may cause a significant reduction in the yield and lack of stability over the years, including:

1- Orobanche weed: parasitic weed causes great loss as being a parasite on the roots of faba bean and absorbs food from the sap of the plant, causing weakness of the plant and reduced productivity may lead to the death of the plant, as well as the lack of the possibility of replanting in the same field for several years, as the seeds remain dormant in the soil and maintain their viability and their ability to germinate up to 8 years, and germinate only when faba bean crop is cultivated. Orobanche may cause severe reduction in the yield up to 50%. The control measures include: following appropriate crop rotation (avoid leguminous and solanaceae crops) and hand weeding of orobanche before they are flowering, and then collecting and burning it away from the field, tilling the soil after harvest of faba bean during the summer, and exposing the soil to the sun for more than one month, chemical control using glyphosate herbicide at the rate of 60 ml active ingredient solved in 500 L water/ha.

2- Drought: drought often reduces the ratios of flowering, and pollination and thereby forming the pods, which reduces the yield of grain, as well as rolling the leaves on the plant and its death in the case of severe drought.

3- Frost: Symptoms appear in the upland areas at low temperature of -8 ºC in the form of Nicroses on the leaves, anthocyanin substances accumulation The symptoms may appear also near the roots, so it is recommended to do earthing up to protect the plants.

4-Lodging: bad phenomenon affects the process of photosynthesis and decline in the amount of carbohydrates. It causes difficulty in harvesting operations, especially using harvesters, in addition to, exposure of pods that touch the surface of the soil to rots.

5- Shattering: bad phenomenon, especially for dry seeds crop, the delay in the harvesting process leads to opening the pods and seeds falling resulting in severe reduction in the yield.

5- Insects and Diseases: like; aphids, whitefly, leaf spot and powdery mildew.

Section three: Oilseed Crops

Economic importance: Oilseed crops are those grown in order to obtain oil from its plant parts, especially from seed. This oil is used in human nutrition as well as the use of its byproducts (oil meal or oilcakes) as feed for animals which contains 35-40% protein of its weight. Oil-seed crops are many in the world and play an important role in both commercial and agricultural levels. Important oilseed crops are: soybeans, sunflower, peanuts, safflower, sesame, rapeseed and castor. etc, In addition to that there are some crops, where we get oil from them as a minor product, including: cotton, maize, flax. etc. The oil is the seed reserves of nutrients that are characterized by high thermal energy; each gram of fat or oil gives 9500 calories, 4400 calories from protein, and 4180 calories from carbohydrate. The seeds of oilseed crops serve as a source of protein as well as a source of fat.

Kinds and characters of vegetative oil: The oil content differs according to crop and even within a single crop (Table 1), depending on environmental conditions and cultural practices. Many of vegetable oils dry up when combined with oxygen and turn into a solid mass, and this is the most important characteristics of the oil to determine its quality and this so-called iodine number (the number of grams of iodine reacting with 100 g of oil to satisfy the links in the unsaturated fatty acids).

Table 1: The content and qualities of oil in some oilseed crops.

Crop	Oil content (%)	Iodine number	PH	Speed of drying
Sunflower	57-29	144-119	2.4 – 0.1	moderate
Safflower	37-25	155-115	5.8 – 0.8	moderate
Rapeseed	49.6-45	112-94	11 – 0.1	moderate
Castor	58.2-47.2	86-81	6.8 –1.0	slow
Sesame	63-48	112-103	2.3 – 0.2	moderate
Peanut	55.2-41.2	103-90	2.24-0.03	slow
Soybean	24.5-15.5	137-107	5.7 – 0	moderate
Flax	47.8-30	192-165	3.5 -0.5	fast
Cannabis	30-35	165-140	3.7-0.6	fast

Whenever this number is high it will dry faster. According to this, vegetable oils can be classified depending on the speed of drying into three groups:

1) **Quick drying oils:** iodine number of 170 and even 203 or more, used in the areas of technology, especially in the preparation of paint and varnish. The important oilseed crops that belong to this group are: cannabis and flax.

2) **Slow drying oils:** iodine number 85-160 and are generally used in nutrition. The important oilseed crops that belong to this group are: cotton, soybeans, sesame, safflower, sunflower and rapeseed.

3) **Non-drying oils:** iodine number less than 85 and are used in nutrition (olive oil, peanuts, oil palm) or in an industrial and medical areas (Castor).

This classification is not accurate. In some cases, oil from the same crop differs from one region to another. In addition to the iodine number, there is an indicator that can be used and that is pH, which is expressed as the number of milligrams of potassium hydroxide that needed to counter-balance the free fatty acids in one gram of oil, and this number differs according to crop and within the single crop in different regions. It is increased where we go towards the north and west and decreased in warm areas and in the south areas depending on cultural practices, and its value increases in the case of oil storage for a long time. Due to the use of many of the oils in the manufacture of soap, some use the saponification number, which reflects the ability to saponification, which is the number of milligrams of potassium necessary for saponified one gram of oil, and its value is between 70-200 for most oils.

Oilseed crops follow different families in terms of anatomical and biological characteristics. So, it is difficult to study it in one group, as is the case in the study of cereal crops, leguminous crops or others. The oilseed crops have great flexibility from the point of geographic aspect. There are tropical oilseed crops: oil palm and coconut; tropical and sub-tropics oilseed crops: cotton, peanuts, soybeans, sesame, castor; and temperate oilseed crops: rapeseed, sunflower, flax and early varieties of soybeans, peanuts and castor.

Sunflower
(*Helianthus annuus* L.)

Economic importance: Sunflower is an important source of edible oil. Its oil content 39-49%, stands second ranks in the world among oilseed crops after soybean. The quantity of sunflower oil represents about 15% of the total world production of the major vegetable oils. Sunflower oil is considered as most suitable for human consumption because of high level of linoleic acid and absence of linolenic acid. The oil has unsaturated: saturated fatty acid of 18:2, with pleasant taste and odor and it is high in vitamin E. The unsaturated fatty acids content is 86.8%, of which 34.9% is oleic acid and 51.9% is linoleic acid. Thus it forms a good source of edible oil for heart patients. Roasted kernels can be used as snacks. After extraction of oil from kernels, the meal may also be used as feed for poultry and livestock as a rich source of protein. Sunflower oil is also a major ingredient in some margarine and shortening products. In western countries, sunflower can be used as a forage crop (green or converted to silage). Sunflower oil can be used to some extent in certain paints, varnishes and plastics because of good semidrying properties. Sunflower hulls are used as roughage in animal food and as fuel. Sunflower being a day neutral, drought- tolerant short duration and salinity-tolerant crop with high potential yields and wide adaptability.

Center of origin: According to Heifer *et al*. (1969), sunflower is a native of southern USA and Mexico from where it was taken to Spain before the middle of sixteenth century and from Spain to other Europe countries. In the nineteenth-century, cultivation sunflower as an oilseed crop began in former USSR and the majority of present day varieties grown all over the world trace back their origin to the former USSR.

Cultivated area and production: Globally the area under sunflower cultivation is around 23 m. ha with a total production of about 27 m. t and the productivity around 1200 kg/ha during 2009. Former USSR occupies the first place in area and production followed by France, Argentina, China, Turkey and the USA. In the Arab world, Morocco occupies first place with an area of about 150 thousand hectare followed by Syria, Iraq, Egypt and Tunisia. In Syria sunflower crop grown under irrigated conditions with an area of 7574 ha, production 13913 tones and productivity 1837 kg/ha. Whereas, under rainfed conditions the area 728 ha, production 758 tones, and productivity 1041 kg/ha. Cultivation of sunflower in Syria takes place in the provinces of Aleppo (6213 ha), AlGhab (408 ha), Edleb (300 ha), Hama (262 ha), Tartoos (249 ha), Homs (118 ha), Latakia (13 ha) and AlRaqa (11 ha) according to the statistics of 2009.

Botanical classification: The sunflower (*Helianthus annuus* L.) having chromosome number 2n=34 belong to the family compositae. The genus name for sunflower is derived from the Greek word 'Helious'. meaning "sun' and the species name from the word 'anthos' meaning 'flower'. The genus Helianthus is comprised of sixty seven species. There are three subspecies (chromosome number 2n=34, 2n=68 and 2n=102):

1. Helianthus annuus, subspecies=Annuus: most of ornamental varieties belong to this subspecies which spread naturally in northwest USA.

2. Helianthus annuus, subspecies=Lentcularis: it is the relative wild progenitor to the cultivated oilseed type.

3. Helianthus annuus, subspecies=macrocarpa: all commercial varieties grown for seed production are derived from this subspecies.

Ahlawat et al (1998) classified cultivated sunflower into three groups:

1) Giant type: plants 180-420 cm tall, late maturing (over 130 days), capitulum 30-35 cm in diameter. Seeds are large white or gray with lower seed oil content.

2) Semi-dwarf type: plants 130-180 cm tall, medium maturity duration (110-130 days), capitulum 18-24cm in diameter. Seeds are small black gray with higher seed oil content.

3) Dwarf type: plants 60-130 cm tall, early maturing within 90-95 days, capitulum 12-17cm in diameter. Seeds are small with higher oil content.

Environmental requirements: Sunflower is a plant of warm temperate zone but varieties adapted to wide range of environments have been developed. Sunflower is grown from the latitude 40 ^{o}S. Equator to 55^{o} N. Equator but major production is between latitudes 20-60^{o} N and 20-40^{o} S. It can be grown to an altitude of 2500 m above mean sea level. But given highest oil yield below 1500 m, sunflower grows well within a temperature range of 20-25^{o} C. Temperature affects the rate of development and seed oil content. In general, temperature above 25^{o} C at flowering reduces seed yield and its oil content. Low temperature below 16^{o} C also reduces seed set and oil content. Sunflower crop is classified as photoperiod, insensitive as it can flower at wide range of day lengths. But day length of 12-14 hrs is desirable. Sunflower is considered to be drought resistant but oil yield is substantially reduced if plants are stressed at peak growth period and flowering. Number and size of leaves are reduced if crop faces moisture stress at peak vegetative stage. If the sub soil moisture is adequate a good can be harvested with 500 mm of irrigation. It will give a moderate yield on rainfall of 300 mm. Sunflower is susceptible to water logging because of its height.

Soil conditions: Soils with an appreciable sand content is considered better than more clay. However, sandy loam soils and clay loam soils are best suited for cultivation of sunflower. Irrespective of type of soil, the soil of good drainage is best suited. Sunflower grows well on neutral to moderately alkaline soils, with a PH range of 6.5 to 8.0 but acidic soils are not suitable. Poor drainage conditions are un-suited because they increase susceptibility to fungal disezses and lodging. Soil salinity affects plant growth and development and also reduces disease resistance. Increase in exchangeable sodium percentage will delay ermination and development of head flower.

Water requirements: Sunflower crop has deep root system, extending beyond 2 m depth, especially on deep soils. It has the ability to withstand short period of severe soil water deficit up to 14 atmospheric pressure. Under moisture stress conditions, size of capitulum and filling of seeds are also adversely affected. Hence, availability of sufficient moisture at critical stages is equally important for obtaining higher yield from the crop. Most critical stages for irrigation are: bud formation, flower opening, seed filling.

Cultivation requirements:

1- Crop rotation: Sunflower is grown usually in a crop rotation with wheat, safflower, sorghum, corn. This will help in reducing weed infestation, diseases and insects in the succeeding crop. Sunflower should not be grown in the same piece of land for more than two years; otherwise, we should remove the sunflower plants which germinate early in the field from the last season to avoid genetic mixing and inter-specific competition. Growing of sunflower after sugar beet may reduce the yield because of high requirements of sugar beet to water and minerals in addition to its infection with sclerotinia and verticillium which may infect also sunflower crop. Crop rotation: wheat-sunflower, legume-sunflower, corn-sunflower, corn-potato-sunflower, corn-groundnut-sunflower, corn-sunflower-legume crop.

2- Fertilizers application: Sunflower crop yielding one tone of seeds removes 63 kg N/ha, 8.5 kg P_2O_5/ha and 40 kg K_2O/ha. Sunflower crop supposed to deprive the soil fertility besides producing allelochemicals. Sunflower responds well to applied nutrients effectively when FYM is added at 10 t/ha especially under rainfed condition due to soil-moisture retention.

Nitrogen: application of nitrogen fertilizers may increase seed yield due to increase in capitulum size and 100 seed weight. However, application of 50-80 kg N/ha is required depending on soil type and availability of nitrogen in the soil. Nitrogen applied as basal dose when plant height is 30cm.

Phosphorus: phosphorus deficiency may cause reduction in oil content in the seeds. Application of 20-30 kg P_2O_5/ha as basal dose is sufficient to get higher oil yield.

Potassium: potassium application in sufficient quantity will increase oil content and seed number in the capitulum and will ultimately get higher seed yield. Application of 40-60 kg K_2O/ha is required to satisfy the crop needs depending on soil type and initial K_2O.

3- Varieties: Large number of varieties/hybrids with higher yield potential than that of local have been released for cultivation in different provinces. Always there is releasing of new hybrids with higher yield and resistant to pest and diseases and high quality seeds. However, selection of cultivars depends on the purpose of growing (human snack food, bird seed crop, oil seed crop..etc.). All varieties are of Russian origin, there are oilseed varieties and forage varieties and non-oilseed varieties and multipurpose varieties.

4- Sowing, seed rate and seeding depth: Seed bed must be well prepared to ensure germination. For quick germination and optimum stand establishment, especially under rainfed conditions, the seed should be soaked in fresh water for about 14 hrs, followed by shade drying and should be treated with Captan or Thirum at 2-3 g/kg seeds to protect them from seed-born diseases. Sowing of sunflower is done as main season crop in the month of April, for intensive cultivation can be grown in the month of June-July. Line sowing using seed drills is the best method of sowing. Optimum sowing depth 3-8 cm depends on variety and seed size. The recommended seed rates 3-8 kg/ha when spacing is 75 × 30 cm. Seed rate depends on the purpose of growing. However, accurate seed rate will reduce cost of cultivation, especially for hybrid seeds. The plant population for tall varieties 30-40 thousands plants per hectare and for hybrid varieties 35-60 thousand plants per hectare in case of rainfed cultivation (rainfall not less than 500 mm per year). Under irrigated conditions, the seed rate can be increased by 25-50% depending on soil structure and soil fertility.

Care operations of crop after establishment:

1- Irrigation: In the areas where there is naturally high subsoil moisture content, sunflower can produce good yield with 300-500 mm irrigation water. When crop is fully dependent on irrigation, water required by sunflower varies between 600-750 mm. A pre-sowing irrigation is essential to ensure germination. Irrigation should be avoided at the time of high wind velocity as plant is easily uprooted in wet soils. Plants are most vulnerable to lodging at seed filling stage because of heavy capitulum. Sunflower crop can be grown under rainfed conditions in areas receiving not less than 500 mm/year. The well distribution of rainfall during crop growth period is highly important than the total rainfall, especially at critical stages. Sunflower may require 3-4 irrigation (as in our country) depending on soil type and weather condition. Irrigation of sunflower in alternate furrows will reduce the exposure of the plant to lodging and will reduce water loss and this can increase the water use efficiency as compared to furrow irrigation. Recently sprinkler irrigation is being used especially for hybrid cultivars. However there are disadvantages of this method because it increases fungal infection due to increase in humidity around the crop. Saline water is not suitable for irrigation of sunflower as it causs reduction in oil content up to 50% and increases the root rots.

2-Weed control: Sunflower is sown in wider row spacing which provides enough opportunity for weeds to establish. Weeds cause enormous loss to sunflower as they compete for nutrients, water and light. Reduction in seed yield of sunflower to the extent of 42-67% has been reported. Competition from weds is more severe during early stages of crop growth; the critical period of crop weed competition is 4-6 weeks after seeding. Hence, weeds emerging after this period do not pose serious problem.

Maturity and Harvesting: Harvesting of sunflower crop at its optimum stage of maturity is very important post production operation to minimize field losses and to get best quality seeds with higher viability. Delay in harvesting causes field losses as sunflower is very prone to bird damage. Sunflower is harvested when colour of the capitulum turns to lemon yellow and colour of seeds turns to darker and seeds become hard and easily removed from capitulum. At the time of harvesting, sunflower moisture content should not exceed 15%. Harvesting of sunflower can be done manually or automatically.

Yield: The productivity of sunflower varies from region to region, season to season, selection of cultivars and level of management. At our national level we can get yield of 4-5 t/ha in case of growing hybrids and 1-1.5 t/ha in case of local varieties.. The yield can be improved by best cultural practices because the effect of environment factors on seed and oil yield is greater than genetic factors.

Breeding objectives in sunflower

1. High seed yield
2. High oil content with good quality oil.
3. High kernel:hull ratio
4. Early maturity for intensive cropping
5. Short varieties resistant to lodging
6. High 100 seed weight.
7. Resistance to insect and diseases and birds.
8. Resistance to abiotic stresses (salinity and drought).

Environmental stresses:

Insects and Diseases of sunflower: _Although sunflowers can be affected by some disease problems, rarely is this an issue, as these plants are typically quite hardy. Various leaf spot diseases may cause surface spots or yellow patches. Rust, verticillium wilt and powdery mildew can also affect sunflower plants on occasion. However, the most common threat to these plants is Sclerotinia stem rot, also known as white mold. This fungus can cause sudden wilting of leaves, stem cankers and root or head rot. Crop rotation can reduce the likelihood of this disease as well as proper watering practices. About 30 diseases of sunflowers have been recorded throughout the world

Important sunflower insects: sunflower beetles, Cutworms, sunflower borers, maggots, sunflower moth, grasshoppers and caterpillars.

Other pests: the birds are considered as an important pest that attacks sunflower crop during seed formation and maturity. Many techniques have been used to control birds in sunflower fields like scarecrows and fright owls, but it was not effective because of bird adaptation to these control measures.

Soybeans

(*Glycine max* Menill)

Economic importance: The world population is increasing at a rate far exceeding any other period in the world history. Increased crop production is a world-wide important need, particularly in the developing countries where people are gradually loosing the ability to feed themselves. Soybean is one of the most important crops that has the potential to provide the world's increasing demand for food and forage. Soybean has become the major source of edible vegetable oils and high-protein feed supplements for live stock in the world. The world importance of soybean has been derived from its importance as a major source for human food, animal feed and industrial uses due to its high contents of oil and protein, which drove many scientists to call this unique crop (the gold that grow). Soybean is an ancient, east Asian crop. First grown in old China 7.000 years ago, also grown in neighboring countries (Korea, Vietnam, India, Pakistani, Japan). History of soybean shows that it was first grown on a farm in the USA (Georgia) in the year 1765, in Europe, in 1779. The soybean was highly praised for its high productivity and yield, ability to grow in many different climates and soils, and quality as a silage and forage crop. Soybean was primarily a forage crop and grown for hay and silage with other crops (maize, sorghum, millet, etc).

Successful use of soybean as an oilseed in Europe from 1900-1910, then in USA in 1911. During the mid 1920s soybean meal became an accepted ingredient of live stock and poultry feed rations. There are seven major oilseeds traded in international markets: soybean, cottonseed, peanut, sunflower, rapeseed, flaxseed and palm kernel; they account for 97 % of all world oil seed production. Soybean production has dominated world oil seed production. It is followed by cottonseed, peanut and sunflower. Since 1970, soybean production has been at least double that of any other oil seed. The share of soybean in world oil seed production has increased from 32 % in 1965 to over 50 % in 1980. Peanuts share of production, by contrast, has experienced a reduction of world oil-seed share from 18 % to only 11 % during the same period. Soybean will probably maintain its dominate role for the foreseeable future. Relatively few countries produce soybean, thus giving soybean producing countries significant economic power in the world oil seed trade. Until 20 years ago, the USA and China had long been the only major producers and world suppliers of soybean. Remarkable increases of soybean production in Brazil since 1970 have changed the soybean market structure tremendously. Brazil is now a major producer (second largest soybean producer and world supplier after USA). Argentina recently became the newest major soybean producer since 1975. The four major producers are: USA, Brazil, China and Argentina together account for 90-95 % of the world production.

Cultivated area: World soybean cultivated area was about (84) million ha. in 2003 produced about (190) million tons with an average yield of 2261 kg/ha. The cultivated area increased to (91) million ha in 2009 produced about (214) million tons, out of which 60% is planted with GM soybean (grown by USA, Argentina, Brazil, Canada, China and Paraguay). In the Arab countries, soybean is still a new crop in most countries. Egypt is the leading country, followed by other countries such as Iraq and morocco.

In Syria: Experiments started in 1967 and continued during the 1970s. Soybean research continued in the 1980s (variety testing). In 1988 the cultivated area was (5.000) ha, the total production in 1988 was (4646) tons with an average yield of 915 kg/ha. The cultivated area in 2003 was (1900 ha) decreased to (1300 ha) in 2009. The total production in (2003) was (3500 ton) decreased to (2100 tons) in 2009, and the average yield in 2003 was 1900 kg/ha, decreased to 1600 kg/ha in 2009. Notice that, more research is required on all aspects of soybean production (cultural practices, genetics and breeding, etc.). Reduction in cultivated area could be attributed to the large water requirements of this summer crop. Much more encouragement is needed to the farmers to grow this crop. Effort should be provided to produce inoculants locally.

Utilization of soybean: Soybean is often called, the Miracle crop, due to its various uses as a food, feed and industrial crop.

Soybean for human consumption: Chemical analysis of soybean seed shows each 100 gram contain moisture 7 g, protein 35-45 g, oil 18-22 g, carbohydrate 12-14 g, also contains fiber, minerals (Ca, P, K, Na), vitamins (B_1 and B_2). The green seeds (fresh) are also rich in many components. The demand for soybean is derived mainly from the oil and meal products, and only to a small extent from whole bean products.

The importance of soybean as food crop:

1. High protein (good quality, essential amino acid).

2. Oil (high content of unsaturated fatty acid).

3. Vitamins and minerals.

4. Whole seed (fresh or dry) as oriental food.

5. Soy-flour (cereal flour, baked food, meat products, food drinks, baby food, high protein food).

Soybeans for animal feed: Forage crop, hay, silage (secondary uses). Soy-meal (main use) for cattle, poultry (70-75% of all meals in the market) Soy-meal (live stock feed, protein concentrates, fish, pet food and fertilizers. Recently soy-flour and concentrates are used in a large proportion in cattle industry. Soy-meal protein is 44% (whole meal) to 48% (dehulled meal)**.**

Industrial uses of soybeans: Soy-flour (adhesives, yeast and antibiotic manufacturing) edible oil products (margarine, shortening, salad oils, desserts, drugs, industrial oil products (drying oils, soaps, inks, insecticides, adhesives, sterols, fatty acids, glycerol).

Center of origin: According to all references, China is considered as the center of origin of soybean. *Glycine Soja* (wild type) is one of parents of the cultivated species *Glycine max* where found in China.

Botanical classification: The genus Glycine is a member of the family Leguminosae, the sub family Papilionaceae and the tribe phaseoleae which is the most important one in this family.

Linnaeus (1737) classified Glycine as: G. apios, G. bracteata, G. javanica, G. Tomentosa, G. abrus, G. frutescens, G. bituminosa, G. comosa.

Modern classification (Hymowitz and Newell, 1981):

<u>Sub genus Glycine:</u> includes the followings; (all perennials).

- G. clandestina, 2n=40 (Australia, long pods).
- G. clandestina (var. sericea), 2n=40 (Australia, short pods).
- G. falcate, 2n=40 (under ground pods)
- G. latrobeans, 2n=40 (short pods)
- G. canescens, 2n=40
- G. tabacina, 2n=40,80 (diploid, tetraploid, large seed)
- G. tomentella, 2n=38, 40 ,78 , 80

Sub genus soja: includes the followings:

- G. Soja, 2n= 40 (wild, annual, short pods, wild ancestor of G. max)
- G. Max, 2n= 40, includes all cultivated varieties.
- G. gracilis (semi cultivated in China).

Crosses between the three species are fertile.

Growth habit of soybeans: Soybean varieties are divided into two main groups**:**

1- Determinate cultivars: Complete 70 % of their vegetative growth, and then shift to reproductive growth. Another definition, determinate cultivar is the type in which the growth of the stem stops suddenly at the beginning of flowering. These types are short-day types and most varieties are unbranched. These types are adapted to Japan, Korea and southern USA. 2- Indeterminate cultivars: Complete 30% of their vegetative growth, then start the reproductive growth. Both types of growth are observed in these types. These types are traditionally adapted to north east china and northern USA. These types are long day types and most varieties are branched.

The effects of photoperiod: Soybean varieties are highly sensitive to the length of photoperiod (narrow range of latitudes). When determinate type is grown in the north (long day), the plant keeps up its vegetative growth and late flowering. Thus, we should grow these types (if grown in the northern regions) for green manure and as forage crop. When indeterminate type is grown in the south (short day), the plant growth stages are shortened (not enough vegetative growth) and enhanced flowering and pod formation meaning a drastic reduction in final yield. Certain varieties are not sensitive to photoperiod length and flower in 30 days (12-24 hrs). These types could be grown in both northern and southern regions. Determinate growth is gradual and the difference in yield of determinate and indeterminate is due to competition between vegetative and reproductive growth. Some results showed superiority of determinate cultivars (around 5%) in final yield.

Maturity groups: Great variation among soybean cultivars in their sensitivity to the length of photoperiod resulted in the establishment of maturity groups as a base of response of each variety. This classification permits the addition of new cultivars into the right group. Based on this system, 13 maturity groups (000 - X) were established, require 75-200 days for maturity. Early maturing groups (000, 00, 0, 1) are grown in the northern part of the world, the rest are grown down south. Generally, the interval between each maturity group is about 10-15 days. In general, early maturing cultivars are indeterminate and late maturing cultivars are determinate (with some exceptions). Maturity groups (000, 00, X) are new groups found to fit super early and super late cultivars. Some super early cultivars are grown 50º N (where accumulated temperature above 10 ºC is only 1800 ˚C and frost free season is only 85 days. In Syria, located between 32-37 º N, we might grow cultivars of maturity groups (2 - 5), but the most suitable are (3 and 4).

Phonological stages:

1. Germination and seedling emergence: Imbibition starts right after seeding when temperature (25-30 ºC), moisture and planting depth (2.5 -3.5 cm) are suitable. Wild types have hard seeds which are generally late in germination. Germination and seedling emergence occurs within 10 days (Plate 1).

2. Root growth**:** The root system of soybean covers available space in 5-6 weeks and goes down up to 150 cm at the end of growing season, but most of it is located at 60 cm.

3. Nodule initiation: Nodules of *Rhizobium japonicum* initiate on soybean roots after a week of planting and become abundant in 10-14 days.

4. Shoot development: Seedlings emerge in 4-7 days of planting. Dry matter accumulation is slow at the beginning, and then increases until plants reach physiological maturity, then it slows down. Flowering starts during 6-8 weeks of germination and continues for 10-14 days based on varieties. Maturity occurs within a week.

5. Pod and seed formation: In indeterminate cultivars, flowering, pod and seed formation are interacted. Pod formation starts during 10-14 days of flowering. Dry matter accumulation is accelerated with flowering and remains constant for 30-40 days. Variation among varieties in dry matter accumulation is narrow, but the difference in yield is due to length of dry matter accumulation. Seed filling period in soybean is critical and affected severely by growth factors.

6. Maturity: Seed moisture decreases gradually and reaches 10-15 % at the end of dry matter accumulation in 7-15 days. Drastic loss of seed moisture

causes reduction in yield due to seed shattering. Dry matter accumulation continues even when leaves are yellowing.

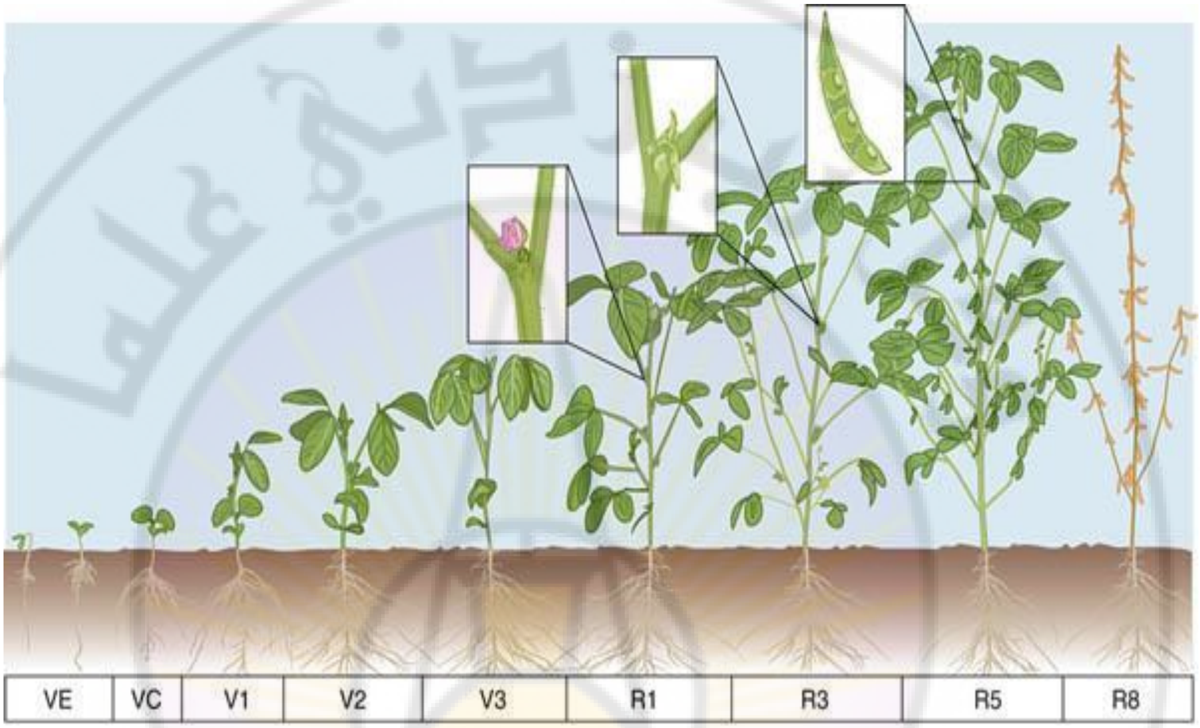

Plate 1: phonological stages of soybean

Environmental requirements:

1- Light: Soybean varieties are highly affected by soil and climatic changes. Flowering and maturity are also affected by the length of day and night. Sensitivity to photoperiod is the most important factor that affects the adaptation of soybean cultivars and planting date; thus, soybean cultivars are adapted to specific areas and we can not grow the same variety over a large area. Soybean is a short day crop. The major effect of day length is on flowering. Short days induce plants to flower in 30-40 days. In long days, plants will continue their vegetative growth and initiation of flowering is a reversible reaction (short days induce nodes). Length of photoperiod affects photosynthesis, pod formation and seed filling rate.

2- Temperature: Soybean is a warm loving crop and requires 1700-3200 ºC accumulated temperature. Cool soils, low temperature and late spring frost are the limiting factors of early planting; also severe drought at the end of the season and early frost in the fall are limiting factors of late planting. Seeds germinate at 10-40 ºC; some cultivars may germinate at 6-7 ºC and some others at 2-4 ºC. Best temperature for seedling emergence is 25-30 ºC (Table 1), but seedling emergence is delayed as temperature goes down, seedlings are affected at -4 or -6 ºC.

Table 1: Temperature requirements during different growth stages.

Growth stage	Temperature		
	Min.	Opt.	Max.
Germination	6-7	12-14	20-22
Seedling emergence	8-10	15-18	20-22
Formation of reproductive parts	16-17	18-19	21-23
Flowering	17-18	19-20	22-25
Seed formation	13-14	18-19	21-23
Physiological maturity	8-9	14-18	19-20

The effect of low temperature is greater when accompanied with high light intensity, due to the role of radiation in increasing leaves water loss. Low temperature affects: photosynthesis, water and CO_2 absorption, leaf elongation. Low temperature affects root system more than soybean shoot. Low or high temperature leads to pod falling, but moderate temperature increases formation of pods, branches and flowers. Temperature affects during seed maturity extend till the next season due to its effect on seed quality. High temperature during seed maturity in early cultivars reducs seed germination in the next season. Frost is more harmful than temperature during maturity. Effects of high or low temperature is on synthesis of some proteins which are formed in the last stages of seed formation. Main problems in warm areas are the effects of temperature on seed viability, nodule formation, reduction in yield and seed quality.

Moisture: Soybean seed requires 130-160 % of its weight to germinate. Transpiration rate is 600-1000 (3-4 times more than wheat). Relative humidity 70-80 % and soil humidity 70-75 %, meaning that it can not be grown in low rainfall areas. Effects of moisture depend on growth stage (number of leaf cells. Stomata conductivity, chloroplast, photosynthesis and growth). Effect of moisture is more in cool soils (roots, and seedling emergence). Soybean mostly absorbs water from 15 cm depth (only part of the root system), meaning that soybean can tolerate drought only for a short period of time. Soybean requirements increase in advanced growth stages and in dry, hot climates. Metabolic activity, height, number of nodes and flowers, rate of pod formation and number of seeds and its weight are all positively related to soil water content. Soybean is highly affected by moisture shortage during reproductive stage (flowering and pod formation). The main cause of seasonal variation in yield is due to variation in rainfall or irrigation during flowering and pod formation. Effects of moisture shortage increase as plant proceeds toward maturity. Effects of low moisture are on yield components (number of pods per plant, number of seed per pod and seed size), in addition to its effect on flowering and pod dropping and small seeds. The greater effect of moisture is during seed filling period. If moisture shortage occurs before initiation of seed filling, photosynthesis might resume and there will be no seed growth, but if this reduction in moisture supply occurs after pod formation and seed filling, the size of sink can not be enlarged and a severe decline in yield might be observed. Generally, early cultivars are more sensitive to moisture stress compared to late maturity cultivars, and this probably explains the differences in yield between determinate (late) and indeterminate (early) soybean cultivars.

Soil conditions: Soybean is highly responsive to all nutrients. Fertile deep and high content of organic matter in the soybean soil is essential for high yield. Soybean does not perform well in poor or saline soils. In acid soils (PH: 4.5-5.5), Al and Mn become toxic to soybean, Nitrogen fixing bacteria (*Rhizobium japonicum*) is also affected. Generally, soils with PH (5.8 – 7.0) are accepted for soybean. The Syrian red and loamy soils and well drained soils are also accepted. Avoid alkaline soils which give low yield and low oil content in the seeds.

Cultivation requirements:

1- fertilizers: Chemical composition of soybean plants and harvest index (the ratio of seed yield to the total biomass) vary according to growing area, soil and climatic conditions. Seed yield of 4000 kg/ha contains: 250 kg N, 28 kg P and 78 kg K, while the straw contains: 80 kg N, 11 kg P, 50 kg K. Most of N and P are accumulated in maturing seeds, but K is located in the seeds and other parts of the plant equally.

Nitrogen: Soybean, sometimes, is characterized as nitrogen non– responsive crop. If soybean has been inoculated and adequate number of nodules are formed, the plant is able to fix adequate amount of N through symbiotic nitrogen fixation, in addition to that found in the soil or added as a fertilizer.

Amount of fixed N depends on soil N, as the amount of NO_3 and NH_4 decreases, the amount of fixed N increases. The fixed amount of N is about 40-70 % of soybean plant requirements. Most studies indicated that N fertilization before seeding has negative effect on N fixation; however, it is necessary to add 30-50 kg/ha of N as a starter dose to enhance nodule formation, especially in cool soils. It is advisable to add about 50-110 kg/ha of N to poor, acid and badly drained soils. Results of N fertilization and its effect on yield and protein vary from one area to another. Maximum consumption of N (84-94%) occurs during flowering and pod formation. It has been found that soybean yield of 3600 kg/ha contains 300 kg/ha of N. Thus, it is important to add some N as foliar application during these two stages. In Syria, where fixing bacteria (*Rhizobium japonicum*) is rare in Syrian soils, you can add 30 kg of N before planting if nodules are formed, or 200 kg/ha added twice later in the following growth stages.

<u>Phosphorus:</u> It is important in many processes in soybean plant, especially, formation of nodules. Large amounts of P affects plant absorption of Zn. Drought stress affects soybean plant absorption of P. Maximum requirement of P occurs during pod formation and seed filling, but less amount during vegetative growth (9-13%). Soil analyses are important to determine the

required amount of P. Generally, we can add about 70 kg/ha of P before seeding.

Potassium: Maximum requirement occurs during early phase of seed filing. It is important for nodule formation. You might add 60 kg/ha before seeding.

Micronutrients: Fe deficiency is a major problem in calcareous soils. S is also important for all legumes including soybean. Mn affected seed yield (foliar application is recommended). Mo is highly important for symbiotic relation with rhizobium.

2- Crop rotation: It is advisable to rotate soybean with wheat, barley, corn, and cotton for the benefit of other crops. The rotation corn – corn – soybean or corn – soybean- wheat increased soybean yield (14%) and (11%) when introduced with corn. Studies showed an increase in soybean yield 21% in double rotation and 26% in the system of reduced tillage.

Amount of N left in the soil of soybean reported to be 57-94 kg/ha/yr. and might reach 112 kg/ha in cases of good inoculation. Growing soybean with corn or wheat reduced their requirements of N by 40 kg/ha for corn and 10 kg/ha for wheat. In Syria, you might grow soybean in double or triple rotation with wheat, cotton, corn or legumes, but not after peanut, tobacco, or sugar beets because of Nematodes.

3- Bacerial inoculation: Treating soybean seed with inoculants of *Rhizobium japonicum* is essential for good growth and yield. Number of required bacteria to produce adequate number of nodules is 5000 in each cm of planted row. Different forms of inoculants are: granular, peat-based inoculants, and liquid inoculants.

4- Seeding rate and planting depth: Soybean varieties vary in their response to planting depth in relation to soil type (clay heavy soils or sandy soils). Optimum depth is (2.5 – 4.0 cm). Depth more than 5 cm delays seed germination, in addition to soil diseases, insects and herbicides effects. Due to the great variation among soybean varieties in seed size, it is better to use seed number per unit area instead of seed weight. High seeding rate leads to tall plants, formation of pods on higher nodes and lodging. Generally, when good quality seeds are used, a plant density of 35000-50000 plant/ha is adequate for good yield. Lower rates may be used when lodging sensitive cultivars and wide row spacing are used. In Syria, 80-100 kg/ha for original main planting date and 100-120 kg/ha for double cropping.

5- Planting date: Planting date is affected by temperature. It has been found that seeding soybean from late April till early July reduces required germination period from 18 days (early planting) till 5 days (late planting). Soybean could be grown from April till July, but best date is in May (according to area and cultivars used). In Syria, late April till May for full season crop and from mid June (after harvest of wheat and barley) till early July for double cropping.

Care operations of crop after establishment:

1- Fertilizer enrichment: When no. of nodules formed on soybean roots is not adequate, meaning the failure of *Rhizobium* inoculation, then we treat the crop as any other legume i.e we add about 200 kg/ha of N (2-3 times) with irrigation. Foliar application of (Mn, Mo, Fe) is also advisable.

2- Irrigation: Soybean is a rainfed crop in the major producing areas of the world (North and South America) and as an irrigated crop in the rest of the world. The required amount of irrigation varies according to several factors (area, length of growing season, transpiration ratio, soil type, variety, etc). Studies showed different amounts (330-766 mm) in South and West USA, (451-748 mm) in Australia. The least amount required is during germination and seedlings. Amounts increase during rapid vegetative growth and maximum amounts are during reproductive stage, 65-75% is during flowering and seed filling periods. Soybean is a C_3 crop and the water use efficiency (WUE) is lower than that of other C_3 (wheat and sugar beet) and much lower than that of C_4 crops (corn and sorghum). Short varieties are higher than tall varieties in their (WUE). In Syria, soybean should be irrigated every 15-20 days according to soil and climatic conditions. Make sure not to delay irrigation during reproductive stage. Generally, 7-12 irrigations should be applied.

Maturity and harvest: Physiological maturity occurs at the end of dry matter accumulation. This occurs when the color of pods is changed from green to yellow and brown, where seed moisture is 40-60 %. Soybean is harvested within one week of falling leaves where seed moisture is about 15%. Harvest should be on time to reduce seed loss and can be done by machines (combines) in large areas or by hands (in small areas).

Drying and storage: Drying soybean seeds is important to maintain its quality and viability. Storage moisture (10-15%). As the seed moisture increases, the storage period is reduced.

Yield: Soybean yield varies with cultivars, fertilization, irrigation, length of growing season and cultural practices. Generally, yield varies between 1000-3000 kg/ha. In special cases yield was 7 tons /ha (in USA). In Syria, research results showed that yield may be up to (2-3 tons/ha).

Breeding and important characters: The important breeding methods (introduction , mass selection , pedigree, bulk , back cross, SSD) and CMS may be utilized to apply recurrent selection and hybrid varieties.

Most important characters: Yield, pest resistance, maturity, lodging and shattering, seed size, seed quality, protein and oil, quality of protein and oil, tolerance to micronutrient deficiency and herbicide effects, low content of trypsine inhibitors, morphological characters.

Environmental stresses:

Important diseases of soybean: bacterial blight, brown spot, pod and stem blight, downy mildew, rhizoctonia stem rot, sclerotinia stem rot, charcoal root rot, soy bean nematode, soybean mosaic.

Management of diseases: Resistant cultivars, plant pathogen-free seed, crop rotation, foliar fungicide, plow under crop residue, crop rotation, timely harvest, fungicide seed treatment, good weed control, avoid moving infested soil with equipment or seed.

Important insects of soybean: stem fly, griddle beetle and caterpillar.

Groundnuts/Peanuts

(*Arachis hypogae* L.)

Economic importance: The peanut crop is one of the most important oilseed crops. It stands in fifth place globally in terms of the amount of extracted oil from the seeds after soybean, sunflower, rapeseed and cotton. The proportion of oil in the seeds ranges between 42-52% and up to 60% in some varieties, the proportion of protein about 35%, in addition to the presence of carbohydrates (14.3%), vitamins and some mineral elements needed by the human body, such as iron, copper and magnesium. The importance of this crop concentrates in the following points:

1. Fresh or roasted seeds used in direct eating or in the manufacture of some types of sweets each 100 g of which is equivalent to 349 calories.

2. The extracted oil from the seeds is eaten raw with salad or used in cooking to prepare a lot of food as well as for use in the medical industry, manufacture of soap and margarine. Note that the proportion of oleic acid (unsaturated) ranges between 65-75% and that of palmitic acid (saturated) between 6-7%.

3. Peanut protein includes all necessary amino acids which cannot be compensated; so it is one of the most important oil crops in terms of

nutritional value due to the presence of lysine, tryptophan, thus close to the animal protein.

4. The meal which is the byproduct of oil extraction from the seed can be used as concentrated feed for animals, where the percentage of protein up to 45% and 8% fat, and thus, peanut meal occupies the fifth place in the world after the meal of soybean, sunflower, rapeseed and cottonseed.

5. The dry residues of the plant is having high forage value not less than the value of alfalfa forage, where it contains 11% protein.

6. The introduction of the peanut in crop rotations can improve soil fertility and enrich the soil with nitrogen through the process of atmospheric nitrogen fixation; so it can be grown widely as mixed crop with cereal crops.

The center of origin: South America is considered the center of origin of peanut, where the relative types of the cultivated species still grow there. It is believed it has originated in the mountainous areas in northern Argentina or Brazil or Peru, where it is planted there about 1000 years BC, and from there moved to the Philippines, Japan, China, India and transferred to Africa by the Portuguese, where cultivated in Senegal, Nigeria and Sudan. Some consider the continent of Africa the secondary center of origin of peanut crop, known in Europe in the sixteenth century.

Cultivated area and production: Peanut cultivation spread currently between latitudes 44º North and 35º South of the equator. Statistics of the FAO for the year 2009 indicated that the area planted with peanuts reached 23700 thousand hectares and production 30169 tons with an average yield of 1273 kg/ha. The major area concentrated in Asian continent (Table 1).

Table 1: Area, production and productivity of peanut in different continents during 2009.

Continent	Area (000 ha)	Production (000 t)	Productivity (kg/ha)
Asia	13680	20156	1473
Africa	8842	7551	854
central and north America	711	1794	2523
South America	427	612	1431
Australia	285	425	1481
Europe	126	146	1235

India comes in the first place in terms of cultivated area followed by China in second place and then Nigeria, and China is first place in terms of production, followed by India, while the United States comes in first place in terms of yield per unit area (Table 2).

In the Arab world, Sudan comes in first place in terms of cultivated area and production (1380 thousand hectares and 1051 thousand tones) followed by Egypt and then Morocco, whereas Lebanon comes in first place in terms of productivity (3635 kg/ha). In Syria, peanut is grown under irrigated conditions only. The estimated cultivated area during 2009 around 5743 hectares with 16232 tons of production and productivity 2826 kg/ha.

Table 2: Area, production and productivity of peanut in different countries during 2009.

Country	Area (000 ha)	Production (000 t)	Productivity (kg/ha)
India	8100	8000	988
China	3769	9700	2574
Nigeria	2252	2531	1124
Sudan	1380	1051	762
Senegal	855	680	795
Indonesia	645	980	1519
USA	596	1609	2828
Argentina	282	403	1429
Turkey	35	82	2356
Australia	25	39	1560

The cultivated area concentrated in Tartous (2128 hectares), Hama (1057 hectares), Homs (900 hectares), AlGhab (816 hectares), Deir AlZour (500 hectares), Latakia (277 hectares) and Idleb (65 hectares) (Annual Agricultural Statistical, 2009).

Environmental requirements:

1- Temperature: the temperature of the soil is an important environmental factor which determines seed germination and seedling emergence and establishment. Usually the rate of germination and seedling growth is low if the soil temperature decreased below 18 °C. Optimum temperature for vegetative growth ranges between 27 °C and 30 °C, depending on the variety. The low temperature below 13 °C will stop vegetative growth completely. The optimum temperature for the fruiting stage ranges between 24 - 27 °C. The high temperature during the flowering stage above 33 °C affects negatively the vitality of the pollen. The low temperature during the flowering stage to below 20 °C negatively affects the proportion of fertilized flowers. The rate of pods formation is increased at high temperature of 19 - 23 °C. The thermal requirements for peanut from cultivation to harvest about 1600 °C. There is a positive correlation between the temperature and oil content of the seed.

2- Light: The peanut crop is day-neutral plant with respect to flowering and photoperiod. Plants can be affected greatly at low-light intensity during the first stages of growth and the stage of flowering. Cloudy weather during flowering stage may reduce the number of flowers. The peanut crop is a C_3 plant. The light will affect the processes of photosynthesis and respiration. It was noted that the low light intensity during the period before flowering resulted in a decrease in the rate of vegetative growth significantly due to lower photosynthetic efficiency of the plant and then the amount of accumulated dry matter available for plant growth and development. Low light intensity during the period of rapid growth of the plant increases the plant height, reduces its leaves weight and number of formed flowers. When peanuts are grown under short day conditions, the plant blooms delayed and gives a little number of flowers compared with the conditions of long day.

3- Moisture: The peanut crop is drought-tolerant especially after the completion of the germination and seedling establishment. It is more drought-tolerant than cotton crop, but it is less tolerant than sorghum. Peanut can tolerate water logging for more than seven days, but with a condition of rapid disposal of excess water. It can be grown successfully under rainfed environments that receive a total rainfall between 500 - 1000 mm, depending on the structure of the soil and its ability to retain water and climatic conditions prevailing during the growing season. About 300 mm of total rainfall must fall during the period between the emergence of seedling and flowering stage to ensure maximum access to good vegetative growth. Some studies have shown that exposure of peanut plants to water stress during the early stages of the life cycle of the crop resulted in increased seed yield by about 13-19% compared with plants irrigated with adequate quantities of water, due to the ability of the plants to form a deep and branched root system which helps in the absorption of larger amount of water and minerals from the deep layers of soil, especially during the stages: flowering, formation of the pods and seed filling. The stage of plant life cycle from the beginning of flowering until two weeks before maturity are more sensitive to drought. The lack of water during this critical stage may cause decline in the quantity of dry matter by 20-50% and decline in pod yield by about 29-61%, depending on the variety and soil moisture. The latter determines the penetration of pegs into the soil. In general, peanut cultivation succeeds in warm, humid areas (coastal zones of Syria) and can be grown successfully in the Euphrates basin if sufficient quantities of water is available, particularly during the critical stages of the crop life cycle. The planting date is important when peanut is grown under rainfed conditions. The productivity can be reduced considerably if the growing period did not synchronize the better climate requirements for each stage of crop growth and development.

4- Soil conditions: Light-colored and well drained soils, sandy and loamy soils, which contain a sufficient amount of calcium and a moderate amount of organic matter are considered the best soils for successful growing of peanut crop. The seed germination and seedling emergence are greater in well drained sandy and loamy soils. The pegs can penetrate such soils easily and can be harvested easily, thereby contributing to the increase in number of harvested pods and reduces the loss of pods during harvesting compared with heavy clay soils. The availability of an adequate amount of calcium in the soil will ensure production of large and matured seeds in the pod, while moderate amount of organic matter (less than 2%) increases in the efficiency of the soil to retain water and minerals nutrients to ensure all the crop plants requirements of water and mineral elements. Peanut crop prefer soils with light acid reaction (pH = 6.0 - 6.5) and can be grown successfully in soils ranging in pH between 5.5 - 7.0. Low pH below 5 inhibits significantly the growth of crop plants and its development and limits the effectiveness of atmospheric nitrogen-fixing bacteria. Alkaline soils are also inappropriate. The high soil pH (5.7 to 5.8) may cause leaf yellowing and pods with black colour. The saline soil is unsuitable for the cultivation of peanut, because it is very sensitive to salinity.

Cultivation requirements before sowing:

1- Fertilizer requirements: The peanut crop requires large amount of fertilizers; for production of one ton of pods and two tones of plant parts, it requires about 63 kg N, 11 kg P_2O_5 and 46 kg K_2O. It was noted that 50% of the nitrogen and phosphorus and about 80-90% of potassium, calcium and magnesium remain in the non-economic plant parts. The period of flowering and pods formation is a critical stage in the life of the plant for food requirements. Inadequate fertilizers in this stages result in very low yield of the seed. Overall, peanut plants absorb about 10% of the full needs of nitrogen, phosphorus, calcium and magnesium during the vegetative growth stage and approximately 40-50% during the fruiting stage and the rest during the stage of maturity.

Nitrogen: Peanut belongs to the leguminoseae family where nodes on the root can fix atmospheric nitrogen, which reduce the needs of the nitrogenous mineral fertilizers, the estimated amount of biologically fixed nitrogen under optimal growth conditions at about 200-260 kg N/ha depending on bacterial strain and host genotype and environmental factors. Some studies showed the response of peanut plants to small amount of nitrogen fertilizer before planting as starter dose (20-30 kg. ha^{-1}), which helped in the increase of the yield of pods to a tune of 4 tones/ha. The addition of an excessive amount of nitrogen will decrease the seed oil content and increase protein content, so growing peanut to produce seed for oil extraction requires less nitrogen.

Phosphate: It is a very essential element for roots, seeds and bacterial nodes development and can significantly increase the absorption of other minerals. Generally, the required amount of phosphorus is around 20-30 kg P/ha, and can sometimes be twice this amount.

Potassium: The addition of potassium fertilizer is economically feasible only in the lands that suffers from a severe shortage of potassium, which requires adding of potassium annually. The absorption of potassium is more in the first six weeks of the life cycle then declines gradually with the progress of plant age. Availability of potassium to the plant leads to an increase in the number of pods per plant. Usually, it is preferred to add potassium to the previous crop of peanut crop in the crop rotation or with the last plowing before the date of sowing.

Calcium: It can increase the number of seeds formed in the pod, by increasing the proportion of seeds that can reach the stage of maturity. The symptoms of calcium deficiency are formation of the empty pods or brown-colored seed embryo. Calcium can be added in the form of calcium sulfate ($CaSO_4$) or gypsum with a quantity of 250-500 kg/ha.

2-Crop rotation: Despite the fact that peanut can enrich the soil with nitrogen, it should be taken into account that the plant takes large amounts of nutrients from the soil in case of growing peanut to obtain high yields of pods; this is due to collecting all parts of the plant while harvesting for feeding animals because it is rich in protein (11%). It is advised to introduce peanut in rotation with other crops. Peanut are often grown in the coastal areas of Syria as double crop after wheat or barley. Notice that we should not grow peanut in the same field for 2-3 years because they cause low yields, which are less than a rate of 100-200 kg / ha in the second year, 500 -

600 kg / ha in the third year; this is due to the severity of plant pests, especially Sircospora, and also because of depletion of nutrients from the soil. It is not advisable to grow peanut after tobacco or cotton due to the increasing incidence of diseases in the soil, or after soybean because of Nematode problem that infects peanut also. Important crop rotations of peanut: peanut–wheat-legume crop, wheat-fallow-peanut, peanut-wheat-legume crop-fallow.

3- Seedbed preparation: The land must be loose and smooth to facilitate the penetration of peanut pegs. After harvesting previous crop, first deep tillage (30-35 cm) can be done to invert the topsoil layer and to bury the remains of previous crop to reduce the chances of spread of disease and to expose the soil to sunlight (Solarization), which help in eliminating a large proportion of the seeds of weeds and the insects in the soil, and improve the efficiency of soil to store a sufficient quantity of rain water. Second tillage in the spring is required to eliminate weeds that can grow. The last tillage is done before one month of sowing to add phosphorus, potassium and starter dose of nitrogen. Crop sown with a distance of 40-90 cm between the lines, and 25 cm between plants, depending on the variety, nature of the soil and the aim of cultivation.

4- Seeding rate: plant density, rate of plant growth and development and crop yield are determined by quality of seeds used in cultivation. Seeds must be pure, heterogeneous in size and weight and free of pathogens. Generally, seed rate depends on variety (types) and total rainfall, 80-100 kg/ha for erect types, and approximately 40-60 kg/ha for spreading types if rainfall about 750-1000 mm. This quantity of seeds should be reduced if rainfall is less; the plant density will be reduced to 50-60 thousand plants per hectare in case if rainfall is not over 600 mm/year, and can reach to 150 thousand plants per hectare in case of growing erect types under irrigated conditions.

5- Planting date: in Syria, time of planting of peanut depends on spring frost which must be done after making sure that spring frost will not happen completely. It is grown as a main crop from 10 April to 10 May; always early sowing is preferred when weather and soil conditions permit. Usually, peanut grown in the coastal area of Syria yields double crop after harvesting wheat or barley in late June and early July, but it is often less productive compared with the main crop.

6- Depth of sowing: It is recommended to grow peanut seeds at a depth of 5-7 cm in light soils and at a depth of 4-5 cm in heavy soils; any increase in the depth will reduce the number of mature formed pods.

Care operations of crop after establishment:

1- Replanting and thinning: replanting is done to compensate the missing plants and maintain appropriate plant density and this depends on: the quality of seed used, method of cultivation, the nature of the soil. Thinning is done to reduce the number of plants per single hole, while seeding by hand behind the plow; preferably it should be done early at 3-4 leaves stage.

2- Weed control and hoeing: Weeds cause low productivity of groundnut because of their competition for moisture, light, and nutrients as well as increase the loss of pods at harvest. Many studies have shown that the critical stage to compete with weeds for the peanut plants are 4-8 weeks after planting. So we must remove the weeds either chemically (herbicides) at the right time or mechanically by hoeing. Peanut needs hoeing more than once during the season of growth, the first one immediately after the emergence of seedling, which eliminates 60-68% of the weeds and helps to break the surface layer of dry soil and fill the cracks, the second one is done deeper for earthing up the plants and eliminating the weeds and for soil aeration.

3- Irrigation: Peanut requires large amounts of water due to its wide cultivation in light soils which retain less moisture. The importance of irrigation for peanut plants in particular during the following critical periods: first period before sowing and during germination and seedlings emergence, The second period after 50-100 days from sowing during pegs and pods formation. The third period extends from 100 days up to pods maturity stage. Peanut crop grown under irrigation requires amount of water equivalent to 1000 - 1200 mm of water during the growing season to produce high yields of seeds. The crop responds well for regular availability of moisture in the soil ranging from saturation to about 50% of field capacity. The interval between two irrigation depends on the type of soil and its ability to retain moisture and the availability of irrigation water. Peanut needs 8-12 irrigations according to variety, climate and soil, irrigation should be stopped before extraction 15-25 days of harvesting depending on soil and maturity of the pods and seeds filling.

Maturity and harvesting: the maturity of peanut will affect the yield of pods and the quality and the proportion of grains and thus the final economic return. The virtual signs of maturity: yellowing and wilting of leaves and start of leaves falling, but it is better to set a date of maturity and harvest by uprooting several plants at random from the field and checking the pods for durability and the difficulty of breaking it, as well as checking the black color of the inner face of the pods; generally, crop mature after 4 - 6 months of planting according to the variety and growing conditions. Harvesting of peanut is done by using machines similar to some extent to harvesting machines of potato or using special plows or simple hand tools or by hand. Then the plants are left in the field for 2-3 days and then the pods are separated by special machines or by hand and transported to the threshing floor for drying.

Drying and storage: Peanut drying is done immediately after the separation of the pods in order to reduce the moisture content of the seeds from 40-50% at the time of harvesting the pods to 8-10% to ensure the safe storage of seeds at normal temperature .This process ensures storing the seeds without rot or insect infection in the store and keeps the seeds in good quality for seeding in the next season or the direct use or for oil extraction.

Yield: Yields vary according to varieties, soil type and its moisture content, and fertilization and planting date. One hectare can give an average of 2-3.5 tons / ha of peanut pods. In Syria yield ranges between 1.0 - 3.5 tons/ha and an average of 2000 kg/ha. According to the USDA (United States Department of Agriculture), one ton of peanut pods consists of 55-60% of edible seeds, and 15-17% of the crushed seeds and the remaining is hulls.

Important characters for breeding programme: The most important characters that interest the breeder to improve the yield of peanut are:

1. High yield of the pods.
2. High proportion of oil in the seeds.

3. Resistance to disease and insects.

4. High ratio of seeds to the hulls.

5. High adhesion of peg with the pod.

6. Drought tolerance.

7. Low linoleic percentage and high oleic percentage in the oil.

Environmental stresses:

Important insects of groundnut: leaf miner, aphids, thrips, white crub and red hairy caterpillar,

Important diseases: early leaf spot, late leaf spot, collar rot and stem rot

Sesame

(*Sesamum indicum* L.)

Economic importance: The sesame is an ancient oilseed crop in the world. It is grown in order to obtain seeds which are considered one of the richest crop seeds with fatty substances, containing oil of about 50-65% known as Alserg oil, protein 16.5-23% and carbohydrates 16-17%, in addition to vitamins and some minerals. Sesame oil consists mainly of unsaturated oleic acid (35-48%), linoleic (37-48%), in addition to stearic (4-6%) and palmitic (7-8%). Sesame oil can be stored for longer period of time. It is mid drying oil (iodine number 102-106). Sesame oil which is obtained by cool-pressure of high-quality can be used to save the sardines. The demand for sesame oil is increasing in the food industry despite its high price due to its high quality for cooking and its good taste. Sesame oil remains for a long time without decomposition, in addition to being easy for manufacture and purification. The oil is used in many food industries like, tihini, halva, baked food, margarine, soap and cosmetics and a lot of medical formulas. Oil obtained by hot-pressure is used to get high-quality Chinese ink. Sesame protein is characterized by its high content of the amino acid (Methionine) and low content of the amino acid (Lysine); therefore, the mixture of equal amount of soy-meal and sesame-meal is an excellent and balanced source of animal feed in terms of its high content of essential amino acids. Meal obtained by a cool-pressure (it contains 8% oil, 40% protein) is used in some food industries, but meal obtained by a hot-pressure is used as animal feed (10% oil, 45% protein), where every 100 kg of meal is equivalent to 132 forage units. The crop residues (stubbles and hulls) can be used for multiple purposes; the most important one is for burning as fuel.

The center of origin: sesame is very old crop in Asian and African continents; some indicated that Africa is the center of origin of this crop due to the spread of a large number of species there, specifically in Guinea and Ethiopia. Then it moved to India and China (it is possible to be native to Northern India and Pakistan, as reported in old Indian literature) and became a common food in Southeast Asia, Northeast Africa and southern Europe about two thousand years BC. It was known in Latin America in the seventeenth century. It is grown now in a vast region extending between 40º latitudes North and South of the equator.

Cultivated area and production: Sesame is an ideal plant in the tropics and subtropics. Around 60% of the cultivated area of this crop is concentrated in the countries of South and South-East Asia (India, China). It is also grown in Africa in large areas (35.6% of the global area), especially in Ethiopia, SierraLeone, Nigeria and Sudan, and in a small area in the American continent. According to FAO statistics for the year 2009, the area planted with sesame reached 6566 thousand hectares, and production 2942 thousand tons of seeds with an average yield 448 kg/ha. Asia occupies the first place in terms of area and production (Table 1), while South America comes in the first place in terms of yield per unit area.

Table 1: Area, production and productivity of sesame crop (FAO, 2009).

Continent	Area (000 ha)	Production (000 t)	Productivity (kg/ha)
Asia	4494	2179	488
Africa	1846	611	331
central and north America	123	68	549
South America	102	82	806

The major cultivated area is concentrated in India (more than 2 million hectares), Sudan, China, Mexico, Colombia, Venezuela, Niger, and Ethiopia (Table 2). Sesame grown in India in those areas does not exceed a height of 1200 m above sea level with total rainfall not less than 500 mm. often; this crop is grown in allay with other field crops.

In the Arab world, Sudan comes in first place in terms of area and production and then Somalia followed by Egypt, according to 2009 figures. Lebanon comes in the first place in terms of yield per unit area (Table 3).

Table 2: The cultivated area of sesame in some countries in the world (FAO, 2009)

Country	*Area (000 ha)*	*Production (000 t)*	*Productivity (kg/ha)*
Sudan	850	122	144
India	1940	620	320
Manimar	1200	390	325
China	751	826	1099
Uganda	211	110	521
Nigeria	166	75	452
Pakistan	120	62	513
Bangladesh	80	49	612
Turkey	50	22	440
Tanzania	105	41	390
Niger	42	22	524
Shad	95	35	368
Guatemala	54	32	605
Mexico	44	23	511
Iran	40	30	750

In the Syrian Arab Republic, sesame is grown both under irrigated and rainfed conditions, the irrigated area around 3936 hectares, the rainfed area reached 2985 hectares in the 2009 season.

Table 3: The cultivated area of sesame in some Arabic countries during the year 2009.

Country	Area (000 ha)	Production (000 t)	Productivity (kg/ha)
Sudan	1122	242	216
Somalia	74.88	36.9	493
Egypt	31.74	41.53	1308
Iraq	24.25	18.0	742
Yemen	21.0	21.99	1047
Syria	7.24	4.46	617
Saudi Arabia	3.01	5.34	1775
Palestine	0.43	0.19	450
Jordan	0.11	0.07	660
Lebanon	0.08	0.25	3125

Environmental requirements:

1- Light: sesame is a short day plant, grown in the tropics with high solar radiation, where the amount of rainfall is not less than 650-750 mm, responding well to good light (most varieties). The exposure of the plants to long photoperiod will prolong the period of vegetative growth resulting in large sized plants and delay in reproductive stage, then a decrease in the number of fruit capsules formed on the plant.

2- Temperature: Sesame is a heat-lover plant that needs a frost-free growing season. The temperature of 22 ºC is optimal for germination and seedling emergence, low temperature leads to prolonging the period of germination and seedling emergence and weaken their ability to compete with fast-growing weeds. The temperature of -1 ºC is lethal to the plant and the infection with diseases increases when the temperature is low and soil moisture is high. Occurrence of frost prior to maturity may cause plant death and seeds degeneration.

3- Moisture: Sesame responds well to moderate ground moisture but is affected hard by excess moisture during the growth stages, which often does harm to plant growth if combined with low temperature. It can be grown under rainfed or irrigated conditions.

4- Soil conditions: Sesame prefers light, deep, fertile, well drained, free from weeds soils, with pH 5.5 to 8.2, and gives better growth and higher productivity in the fertile soils. It grows poorly in a soil with a high level of ground water and a high content of salts.

Cultivation requirements:

1- Fertilization: Sesame plant responds to fertilization. Although it does not required a large amounts of nutrients, this response is high when the content of the leaves is 2% nitrogen, 0.2% phosphorus and 0.8% potassium, It is not affected by adding mineral fertilizers when the content of the leaves of the three previous elements is 3.9%, 0.34%, 2.2%, respectively. The highest increase in the yield obtained when nitrogenous fertilizer is added, but for the addition of phosphorus and potassium fertilizers, they do not always affect well in yield of seeds. Sesame requirements of nutrients differ according to the growth stage; it needs 67-70% of NPK during the flowering stage. Note that sesame crop needs some amount of copper element which can be added in the form of a copper salt with mineral fertilizers.

Nitrogen fertilization: sesame needs 75 kg N / ha added in three splits, the first one after thinning and the second after two weeks, and the third after two weeks of the second addition, note that excessive nitrogen fertilization cause an increase in vegetative growth and reduce oil yield.

Phosphorus fertilization: Phosphorus is added at 200 kg P_2O_5 / ha during land preparation for poor lands, and 100 kg / ha for fertile land added once at the time of land preparation.

Potassium fertilization: potassium added at the rate of 50 kg K_2O/ha in the fertile lands, added once after thinning, while in the poor land and sandy soils or after cereal crops, potassium dose should be increased to 100 kg/ha added in two splits; first one directly after thinning, the second after two weeks of first addition.

2- Sesame culture: Sesame cultivation for the wide production purpose and for getting higher yield is done as sole crop on lines or broadcasting. It can be grown in a mixed cropping with other crops; the success of this cropping system depends on the good choice of accompanied crops and the moisture and fertility levels in the soil, where sesame seeds are mix with the seeds of accompanied crop. Usually sesame crop is grown in intercropping system with African millet, sorghum, maize, cotton and chickpea, where the cultivation is done in overlapping and alternate lines with specific portion of each crop. For example: Sesame + sorghum (3:1) means three lines of sesame seeds and a single line of sorghum.

3- Crop rotation: It is preferred to introduce sesame crop in rotation which ensures the land free from weeds, It can be entered in double or triple crop rotations with cereal crops, legume crops, sugar beet and cotton and preferably after legume crops, maize, wheat. For example, in India, it is entered in the following crop rotations: chickpea - fallow - sesame – fallow, and in Guinea it is grown in succession after the rice crop.

4- Seed bed Preparation: Sesame seeds are characterized as very small, with very slow growth in the first stages of growth and this imposes the need to prepare the soil with great care because it requires loose and smooth lands. Usually land is cultivated 2-3 times to break the clods and soften the soil and eliminate weeds. Under rainfed conditions and when the rainfall is adequate, chemical fertilizers can be added in early spring, but in case of irrigated cultivation, fertilizers are added with the last tillage before planting.

5- Sowing methods: The methods of sowing varies depending on the type of the soil and the nature of cultivation (rainfed or irrigated); it can be sown by broadcasting method in light soils, in the case of dry farming, or in heavy soils, in the case or irrigated farming. It can be sown on lines with 25-35 cm interval between the lines, if adequate moisture is provided, and the distance between plants varies according to the soil (around 8-12 plants in one meter line length). In some countries a line spacing of 50-70 cm interval is made for branching types and 30-40 cm for non-branching types. Sometimes sesame sown in wide lines 45-75 cm depending on soil in a depth of 2-3 cm.

6- Seeding rate: Seeding rate varies depending on used variety, method and date of sowing, the number of plants which can be left (8-20 plants) per meter of line length without any effect on yield, and this rate varies in general between 8-15 kg/ha. Research carried out in India showed that the difference in yield of sesame seeds was not significant when the plant density was between 100-300 thousand plants / ha. The optimum plant density in some countries ranges between 120-125 thousand plants/ha for branching varieties and 300-350 thousand plants/ha for non-branching varieties. It is preferred to mix the total amount of seeds for the unit area with sand or soft soil at a rate of 2:1 or 3:1 to ensure the homogeneity of seeds distribution in the field.

7- Sowing date: sesame is a summer crop that can be grown under rainfed conditions in the years of intense spring rains, as the soil moisture is the limiting factor to the yield. It can be grown in humid tropical regions in any month of the year but preferably grown at the beginning or mid of the monsoon season. In the dry tropics, it can be cultivated in any month of the year under irrigated conditions. Generally, sesame cultivation begins when the soil temperature is around 15-18 ºC. In the Syrian Arab Republic, sesame crop is grown as a summer crop, in March and April in warm coastal areas and in April and May in the interior areas. According to some studies carried out in some foreign countries, sesame requires early planting to mature early and to escape from autumn frost, which prevents fruit ripening.

Care operations of crop after establishment:

1- Replanting and Thinning: The increase in the proportion of seeds that are incapable to germinate forces the farmers to do the process of replanting; then it is preferred to use a good and not stored seeds to compensate for the empty spaces and irrigate immediately. In the case of using higher rates of seeds or following the methods of traditional sowing to get higher plant density per unit area according to the type of the soil, this forces the farmers to do thinning process to remove the excess plants. The process of thinning is done preferably after 4-5 days of irrigating the soil and when the plants reach 8-10 cm height (appearance of the second pair of true leaves).

2- Hoeing and weed Control: One of the most important care operations because sesame crop have weak competition with the weeds. Hoeing is done to maintain the field clean from weeds with loose surface layer, so this operation aims to get rid of weeds either by hand or by using hoeing machines in the case of line sowing, taking into account earthing up the plants during hoeing. Hoeing is implemented according to the degree of the subsequent emergence of weeds and can be made between two irrigations manually or automatically. Finally, appropriate herbicides can be used before or after planting to eliminate weeds.

3- Irrigation: sesame crop can be grown under rainfed or irrigated conditions, its deep root system may help it to tolerate drought relatively. The crop is sensitive to excess moisture in all growth stages. The number of irrigations depends on soil, the growth stage, moisture content and environmental factors. 3-4 irrigations can be given in medium textured soils with intervals of 10-15 days between one irrigation and the other, while the crop requires a larger number of irrigations up to 10 in light and sandy soils and in hot dry weather. Note that irrigation must be stopped before harvesting the crop by 15 days, and not to irrigate heavily after sowing to avoid seeds erosion. It was found that irrigation of sesame crop when plants complete three quarters of its life cycle, often delays the maturity without any significant increase in yield. For getting higher productivity, takes into account the following:

1. Discharge the stagnant water from the field to avoid plant wilting disease.

2. Irrigate at regular intervals during the growing season.

3. Avoid water stress in the first period of plant life because this affects the strength of vegetative and reproductive growth.

4. Avoid irrigation in the afternoon due to high temperatures that help in the spread of wilt disease.

5. Avoid irrigation after the appearance of maturity remarks.

Maturity and harvest: The maturity of sesame does not happen simultaneously, at the time of maturity of upper capsules, the bottom capsule is opened and the seeds will fall from it. So, it is recommended to harvest sesame crop at physiological maturity stage when bottom capsules and the seed inside them turned to yellow waxy colour. Harvesting the crop is done either by hand or by sickle, and then bundle the plants and place them on a clean floor up to appropriate drying for a period of 2-3 weeks, and then shake well to get the clean seed then pack and store the seeds at 9% moisture content. Some machines called Windrower can be used in harvesting sesame crop, which cut the plants at specific height from the soil surface and then combiner can be used to collect the plants from the field for threshing, winnowing and cleaning.

Yield: The yield of sesame vary depending on the varieties, the nature and method of cultivation and soil type. Yield per hectare in rainfed cultivation ranges between 250-750 kg/ha, and in irrigated cultivation 1000-1500 kg/ha. In Syria, sesame yield ranges between 130-300 kg/ha.

Important characters in breeding programme: The most important characters of interest to the breeder to improve sesame crop and for the development of new varieties are:

1) High yield of seeds. 2) High percentage of oil.

3) High content of lysine. 4) Resistance to lodging.

5) Resistance to wilt disease. 6) Resistance to drought.

Environmental stresses: It is reported that sesame is affected by 20 species of insects and mites and 19 species of pathogens (fungi, bacteria and virus). The reported yield loss in sesame is around 40% due to pests and diseases. The important diseases are: phyllody (green flower disease), powdery mildew, black stem wilt.

Section four: Sugar crops

Economic importance: White sugar is a food item with high quality, characterized by its purity and sweet taste and easy digestion and contains a large amount of thermal energy. Sugar crops are grown in order to obtain white sugar material from one of its botanical parts after being subject to different technological stages. Globally, the sugar is extracted economically from the following crops. First: Sugar cane crop, which is grown in the hot tropics, sugar is extracted from the stem which contains about 12-18% sugar.

Second: Sugar beet crop, which was selected mainly from fodder beet. The improvement in crop characters and sugar has been made using different methods of breeding. Sugar beet is grown in temperate and cold regions of the globe. The sugar is extracted from the root which contains 16-22% sugar

Cultivated area and production: The global production of sugar for the year 2009 was nearly 181 million tones. More than 80% of sugar production comes from the ten largest sugar-producing countries (Figure 1).

More than 100 countries in the world produce sugar; around 55-60% of the global production of sugar comes from sugar cane which is grown in the tropical and subtropical zones of the globe and the rest is produced from sugar beet which is grown in the temperate zones of the globe. Overall, 69%

of the world's sugar is consumed in the origin country and the remaining enters in the global sugar trade. The figure (2) shows the first ten countries exporting sugar for the year 2009.

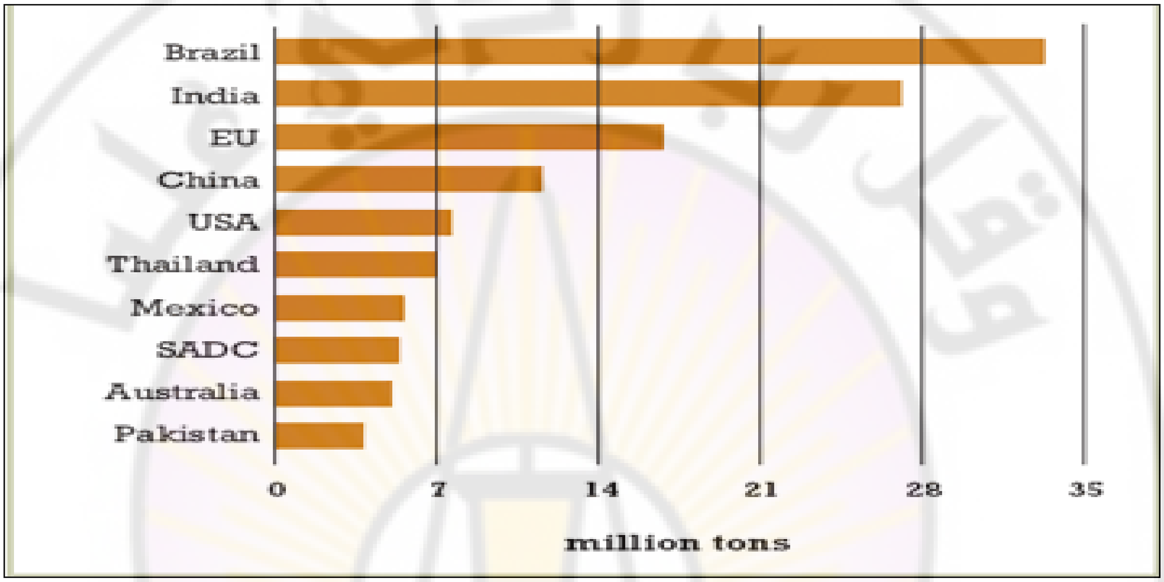

Figure 1: The top ten sugar producing countries during 2009

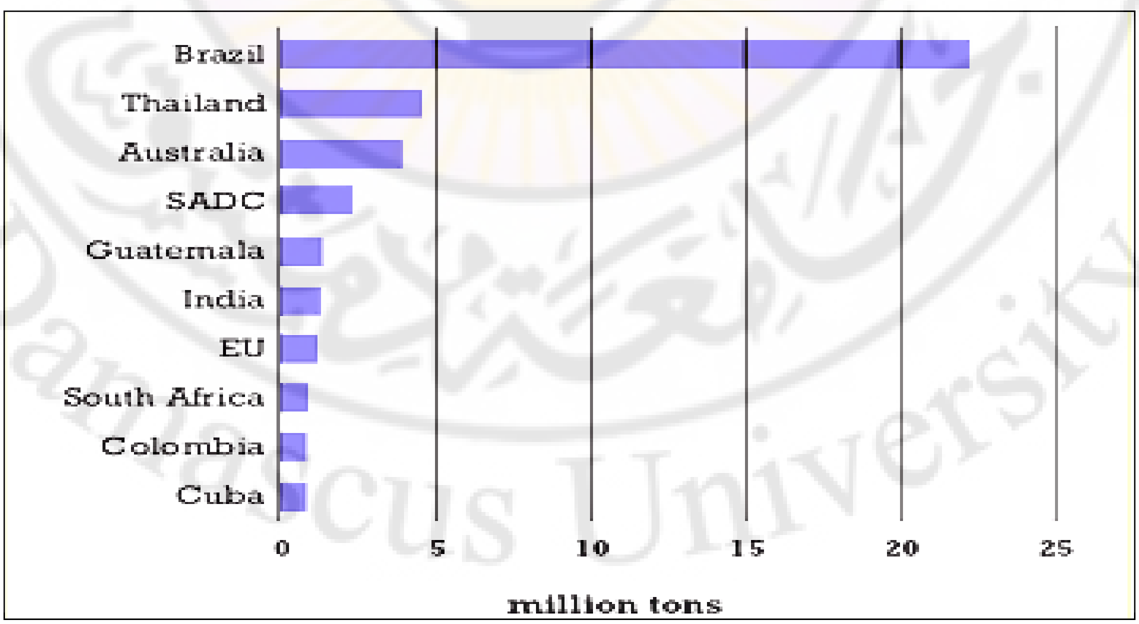

Figure 2: The top ten sugar exporting countries during 2009

It is clear from the above figure that the largest exporters of sugar in the world during the year 2009 were Brazil, Thailand and Australia. The statistics indicate that world-sugar consumption is increasing annually at a rate of 2%, it has reached nearly 154 million tones in 2007 (Figure 3).

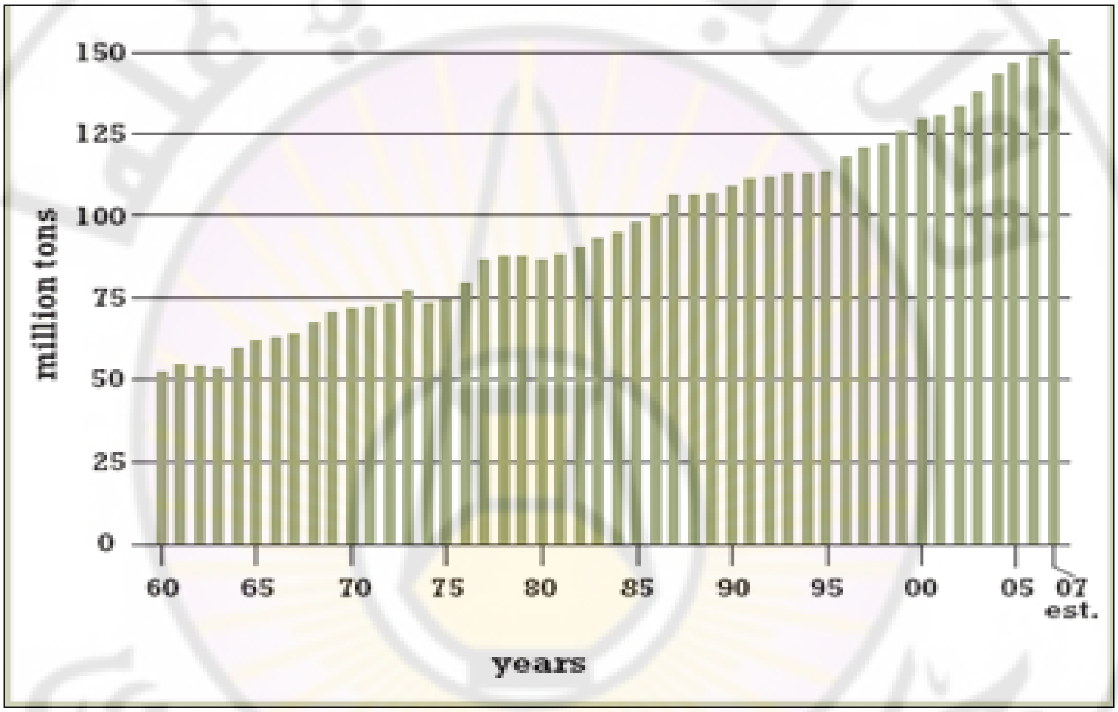

Figure 3: The global consumption of sugar between 1960-2007

Finally, it must be pointed out that the environmental conditions in the Syrian Arab Republic are suitable for sugar beet cultivation and unsuitable for growing sugar cane, which can be grown only in warm coastal areas, where it needs availability of high temperatures somewhat during the different growth stages.

Chapter one: Sugar beet
(**Beta vulgaris L.**)

Economic importance: The second most important source of sugar after sugar cane. The importance of sugar for human is well established (a source for energy and many other products required for human food). The importance of sugar beet is not only for its sugar content (18-20% and in some types 27% of root weight), but for its by-products. Feeding the by-products of beet culture and manufacture forms the basis of an extensive sheep and cattle fattening industry around each sugar beet factory. The vegetative part of the beet forms 30-50% of the root weight which could be used as a green manure or for silage or as a fodder. The by-products of sugar beet manufacture are pulp, molasses and lime cake or waste lime from filter presses. The pulp (80% of root weight) is used for animal feed. Molasses (60% of its weight is sugar) is used as an additive in silage or hays for feeding animals. In addition, sugar beet requires large amounts of nutrients which are left for next crops in the rotation, besides the involvement of labour in sugar beet production and manufacturing. Sugar beet provides 40-45 % of the world's sugar, and the other 55-60% is provided from the first source of sugar (sugar cane).

Cultivated area and production: The world production of sugar beet during 2009 was (250) million tones concentrated in former USSR, China, USA , France , Poland, Germany , Turkey , Romania , Spain , and the UK. The overall area of the Arab world in 2009 was (188) thousand ha, produced (7900) thousand tons with an yield average of (42) t/ha. The major producing countries are Morocco (71.1, 3284 and 46.3), Egypt (70.1, 3429.5 and 48.8), Syria (25.9, 1360 and 42.3), and Lebanon (11.6, 848 and 73.4) of area, production and yield, respectively

In Syria, sugar beet farming is relatively new in comparison to other countries. Sugar beet cultivation started in 1946 along with the establishment of Homs factory. The real development occurred in 1975 with the establishment of new factories. The total area in 1978 was (14063 ha), produced (231938 tons) average yield (16.5 tons/ha). In 2000 the area was (26934 ha), produced (937614 tons), average yield (48.5 ton/ha). In 2009, the area was (28200 ha), produced (1366500 tons) with average yield of (48.5 tons/ha). The sugar content in the three periods was (16.04%, 11.98%, 12.00%, respectively). The amount required of sugar in 1997 was (520346 tons) increased in 2009 to (674727 tons). The imported amount in 1997 was (294895 tons) and in 2009 (443229 tons). Major producing providences are Homs, Hama, AlGhab, Idleb, Aleppo, AlRaqqa and DeirElzour.

History of sugar beet: The beet root was a common part of the diet in Egypt during the building of the pyramids, but the potential of the sugar beet (*Beta vulgaris*) as a source of sugar was not discovered until the middle of the 18th century. The cultivation of sugar beet in the Mediterranean goes back to 300 years B.C when the wild beet (*Beta maritima*) was used for food and medical purpose. Although sugar beet has been used since long time age, discovery of sugar types happened only in 1550, and sugar was not extracted before 1800 in Europe from the fodder beet. In 1747, the German chemist A. S. Margraf found that the kind of sugar in two cultivated species of fodder beet was identical to that in sugar cane. The first factory for the extraction of sugar from sugar beet, built in Silesia in 1802 was a failure. The sugar beet used then was very low. Louise Vilmorin in France selected beets by progeny test method and raised the sugar content from 7.5 to 16-17%. By 1880 sugar beets had practically as high a sugar percentage as the varieties of today. The first successful commercial factory in America was erected at Alvarado in California in 1870. Beginning in the second half of the 19th century, plant breeders transformed the fodder beet into an efficient producer of sugar (sucrose). The sugar beet industry is concentrated in the temperate climates of Europe, USA, Canada and the former USSR.

Center of origin: All references indicate that the first cultivation of sugar beet was from the species perennis and maritima which are found in Europe and the Mediterranean coasts. Some believe that the center of origin of sugar beet is west Asia and some wild types which belong to chenopodiaceae are still found in old Mediterranean basin and North America. This family contains some shrubs and annual and perennial herbs.

Botanical classification: Sugar beet belongs to the family chenopodiaceae, the genus Beta and the species vulgaris. The genus Beta contains several wild types could be hybridized with each other or with the species vulgaris for the transfer of disease resistant genes and some other traits.

Coons (1975) classified sugar beet as follows:

1) The division vulgaris includes:

B. vulgaris: 2n=18, cultivated

B. maritime: 2n=18, wild

B. macrocarpa: 2n=18, large fruits

B. patula: 2n=18, branched beet

B. atriplicifolia: 2n=18, Bending leaves

These species are diploids (annuals or biennials) multigerms and sensitive to diseases. B. maritima carries the resistant gene for cercospora disease. These species give fertile hybrids with B. vulgaris. It is believed that cultivated varieties originated from B. maritima.

2) The division Patellares includes:

B. patellaris; 2n=36, tetraploid

B. procumbens: 2n=18, Diploid

B. Webbiana: 2n=18, Diploid

The above three species are characterized by: Hard coated monogerm seed, Viny growth habit, offer the breeder a valuable source of genes for diseases and nematode resistance. Successful crossing and gene transfer is difficult from species in this section to species in the vulgaris section. Intensive hybridization has been conducted between B. vulgaris and species of B. patellaris because they are the only species that are immune or highly resistant to the sugar beet nematode (*Heterodera schachtii*). As a rule, these hybrids failed to grow because F1 seedling do not form secondary root system and most of the few F1 seedling that have survived were sterile.

Two methods have been used for growing hybrid plants from crosses with species of the section B. patellaris:

A) Grafting small interspecific F1 seedling on to the root system of young sugar beet seedlings.

B) The use of intermediate or bride hybrids. For example:

swiss chard * wild patellaris

(B. vulgaris)

↓

F1 (fertile)*B. vulgairs

↓

fertile hybrid

Some forage and red garden beet (B. vulgaris) also have been used as successful bridging hosts.

3) The division corollinae, includes:

B. macrorhiza: 2n=18, diploid

B. trigyna: 2n=(36,45,54)

B. foliosa: 2n=18

B. lomatogona: 2n=18

B.corollinae: 2n=36

These species are characterized by: Corolla like perianth. Hybrid between these species and cultivated sugar beet are sterile.

If the problem of fertility could be solved, the species are important to the breeder (including monogerm seed, apomixis and disease resistance).

4) The division nanae includes:

B. nanae: 2n=18, Known as the dwarf sugar beet, small plants with (rosettes of leaves) generally not more than 10 cm a cross. Plants have single flowers and hard nut like monogerm seeds. Hybridization with sugar beet have not been reported.

Sugar beet varieties: Sugar beet varieties are classified based on:

1- Number of embryos in the fruit (seed boll):

I- Multigerm seeds: old varities, less yielding (roots and sugar), higher cost because of thinning in comparing to monogerm.

II- Natural or Genetic monogerm: advantages of these varities have been recognized all over the world. Its yield of roots, sugar content and manufacturing is always superior to multigerm. Also, it is more resistant to diseases and insects and does not require thinning because the fruits give 100% single seedlings.

Using this type of seeds requires mechanical seeding and sprinkler irrigation.

III- Artificial (man-made) monogerm: gives 85% single seedlings, and does not fit mechanical seeding. Thus, it is usually coated with a substance (fertilizer and pesticide) for protection and mechanical seeding.

2- Chromosome number in cells:

I- Diploid varieties: (2n=18) very old varieties.

II- Tetraploides varieities: (2n=36) developed by autoploid duplication by treating seedlings with Colchicine. It is better yielding than diploids.

III- Polyploid varieties: results from crossing diploids with tetraploid. It is widely grown and characterized by large roots, high sugar content , early maturing and disease resistance (Cercospora resistance).

IV- Hybrid varieties (triploids): these varieties have high heterosis and yield best root and sugar content. They are developed in the same way of producing polyploids (hybrids between diploids and tetraploids):

P: Diploids * Tetraploids

2n=18 2n=36

↓ ↓

9 18

↘ ↙

Triploid (2n=27)

The use of CMS resulted in producing 100% triploid varieties.

3- Planting date: Varieties of sugar beet are divided into fall, winter and spring types.

4- Size of leaf Rosettes: Varieties of sugar beet are divided into small, medium, large.

5- Sugar content: varieties are divided into several types:

I- Type (Z): sugar content is more than 16%, but lower root yield .

II- Type (N): sugar content is about 16%, normal root yield

III- Type (E): sugar content is less than 16%, higher root yield.

IV- There are sub-types such as: ZZ,EE,EN,NE.

In Syria: the types of varieties are mostly multigerms (80%), imported from several sources of seed companies. Less amounts of genetic monogerm (5%) are also imported and about (15%) of artificial monogerm.

Biological characteristics of sugar beet: The sugar beet is a herbaceous dicotyledon, usually completes its vegetative cycle in two years, This property is changeable, the plant could be annual or perennial. During the first year it develops a large succulent root, in which much reserve food is stored. During the second year it produces flowers and seeds. Prolonged cool periods cause a seed stalk to be sent up the first year, a behavior known as bolting. Some strains of beets bolt more readily or at higher temperature than do others. Bolting is an undesirable phenomenon in commercial cultivation of sugar beet. The main objective of beet cultivation is producing roots which is sugar in the first year, formation of flower stalks leads to formation of fibrous roots low in sugar (1.5-2%) which cannot be manufactured. Although this character is affected by some environmental factors such as planting sugar beet in cool areas or exposure of sugar beet plants to low temperature in their early growth stages, this character is genetically controlled by one pair of recessive genes and the environment helps in the appearance of it. Sugar beet varieties vary to a large extent in their response to bolting; this requires more advanced studies and researches to determine the optimum planting dates and their effects on root weight and sugar content. We might be able to reduce the effect of bolting by selection of the optimum date of planting for each area and selecting the most resistant varieties, besides early removal of flowering stalks from the field. Stubbornness or sterility: Another undesirable phenomenon in sugar beet is stubbornness. This appears when the objective of planting sugar beet is to obtain seed in the next season. Roots must be exposed to low temperature (4-7 ºC) to promote production of the glutamic acid to stimulate the buds at the tip of beet root (crown) and enhance formation of flowering stalks. Premature harvesting of roots, storage of roots at temperature higher than

4 ºC promote occurrence of this phenomenon. Hogaboam (1982) observed a great varietal variation among sugar beets in their flowering and seed formation under controlled conditions of light and temperature. Some varieties did not form flowering stalks after (52) days of planting, While the varieties gave 30-70% of flowering stalks in the same period; some other gave 100% of flowering stalks in 41 days of planting.

Phenological stages of sugar beet:

Vegetative stage: Lasts from planting till formation of 16 leaves. The phases identified in this stage are; Formation of preliminary tissues: from planting till formation of first two true leaves. It lasts (8-10) days of emergence of these leaves, i.e (15-30) days of planting. Formation of secondary tissues: formation of (2-6) leaves. Third phase: formation of (6-16) leaves. Number of leaves formed during the first season (150-170 days) is (30-60) leaves and might reach (90) leaves based on availability of nutrients, moisture, and other factors.

Growing stage: In this stage, leaf emergence continues; root growth also proceeds and the daily increase in root weight is about (10 g). Sugar accumulation in the roots also increases till the end of this stage when daily increases in sugar is 0.07- 0.1%, the crown forms (5%) of root weight when roots are picked up and sent to factories.

Maturity stage: Also called flowering and seed formation stage which happens in the second season of the plant life. This stage is handled by concerned companies and organizations.

Physiology of sugar accumulation: We already mentioned that several types of sugar beet (annuals, biennials, perennials) exist, and sugar beet is grown as an annual crop for sugar production. Sugar beet requires low temperature for flowering (zero – 10 ˚C) which is accelerated if it is followed by long days. Bolting resistant varieties are used for early planting and in temperate areas where sugar beet might stay in the field during winter. Seedling development is slow even after formation of 4-6 leaves which takes a month even when growing conditions are acceptable. The fist 20 leaves which emerge from the crown form the (juvenile group). Leaves length area is related to variety, number of leaves, climate and nutrients availability. Continuous growth of taproot results in the formation of a large storage root with slight growth of secondary roots. Maximum growth of storing root occurs when sugar content reaches 5-8%. Sucrose is the main sugar in sugar beet (75% of root dry weight and 18% of fresh weight). Root sugar content is genetically controlled under a certain environment.

Sugar beet varieties are divided into:

1. Large roots and moderate sugar content (high yielding varieties).

2. Small roots and high sugar content (Sugar types) which is characterized by limited growth. Most commercial varieties are from the first type (high yielding). Availability of water, nitrogen and rapid growth leads to large roots (10-14% sugar content). Night temperature and availability of N are the most important factors affecting sugar content of roots. Higher sugar content results under low night temperature and shortage of N. Maximum vegetative growth which follows the juvenile stage is characterized by constant sugar content and higher growth rate. In California, sugar beet gave 60 tons/ha vegetative biomass and 80 tons/ha of roots during 5-6 month growing season. Total dry matter production was 20 tons/ha out of which 40-50% sugar, meaning that root and sugar production increase in less growing season. Generally, sugar content is higher in the mid part of the root and lower in the center and outer part of the root.

Environmental requirements: Sugar beet is a temperate region crop. Sugar beet requires good sunshine during its growth period. Sugar beet can be grown during October to March with a well distributed rainfall of 300 – 350 mm across the growing period or through irrigation. This condition favours vegetative growth and acts as a base for tuber enlargement. However, high soil moisture or continuous heavy rain may affect development of tuber and synthesis of sugar. The sugarbeet crop requires an optimum temperature range of 20 to 25^{0}C for germination, 30 to 35^{0}C for growth and development and 25 to 35^{0}C for sugar accumulation.

Soil conditions: All kinds of well drained deep soil (45 cm) with stable and porous soil structure and sandy loam to clayey loam texture are suitable. Optimum pH range is from 6.5 to 8.0 but it can also grow in saline and alkaline soil. The soils with good organic matter status are more favourable for sugar beet cultivation.

Cultivation requirements before sowing:

1- Field preparation: Sugar beet being a root crop requires deep ploughing (45 cm) followed by 2 to 3 ploughings to obtain a good soil tilth condition for favorable seed germination and tuber development (Plate 1). After proper levelling to ensure adequate drainage, ridges and furrows are formed at 50 cm apart.

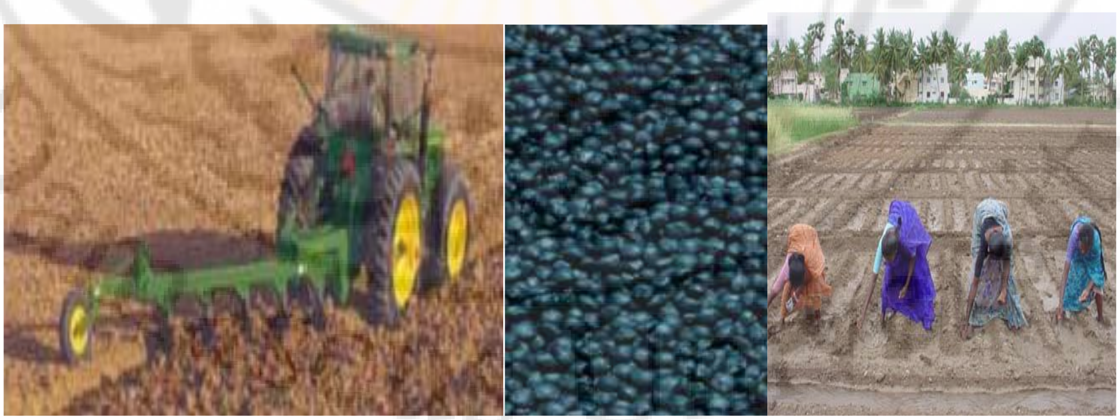

Plate 1: field preparation and sowing of sugar beet crop

2- Spacing and seeding depth: To maintain the required plant population of 100,000/ ha, the recommended spacing is 50 x 20 cm, the seed is dipped at 2 cm depth on the top of the ridges at 20 cm apart, at one seed per hole.

3- Fertilizers: 180 units of nitrogen/ha (equivalent to 390 kg urea) added in three batches. 10% pre-plant with phosphorus and potassium. 40% after planting during emergence of sixth leaf, 50% after a month of the second batch; do not add nitrogen fertilizer after 90 days from sowing. Phosphorus: 120 units/ha (equivalent to 260 kg triple super phosphate) before planting. Potassium: 120 units/ha (equivalent to 240 kg potassium sulfate) before planting. Sulphure: 50-100 kg/ha before planting. Boron: When there is shortage of boron in the soil, we can add 10 kg borax/ha (10% concentration), or spray on the leaves.

Care operations of crop after establishment:

1- Weeding and earthing up: The crops should be maintained weed free up to 75 days after planting. Application of herbicides to control weeds or hand weeding on 25^{th} and 50^{th} days after sowing. The earthing up operation coincides with top dressing of N fertilizer.

2- Irrigation: Sugar beet is very sensitive to water stagnation at all stages of its growth. Irrigation should be based on soil type and climatic conditions. Pre-sowing irrigation is essential at the time of sowing, since sufficient soil moisture is a pre-requisite for proper germination. First irrigation is crucial for the early establishment of the crop. For light textured sandy loam soil, irrigation once in 5-7 days and for heavy textured clay loam soil irrigation once in 8–10 days is recommended. Light and frequent irrigation is recommended for maintaining optimum soil moisture. The irrigation may be stopped at least 2-3 weeks before harvest. At harvest, if the soil is too dry and hard; it is necessary to give pre harvest irrigation for easy harvest.

Harvest and yield: The sugar beet crop matures in about 5 to 6 months. The yellowing of lower leaves, whirls of matured plant and brix reading of 15 to 18% indicate the maturity of beet roots for harvest. The harvested beet tuber should be handled as gently as possible to remove soil and trash to minimize the beet breakage and bruising to get quality beet tuber. The average yield of beet tuber is 40 to 50 tones/ha.

Environmental stresses: The major insect pests that affect the sugar beet crop are aphids, tobacco caterpiller and diamond backmoth. Integrated pest management programme has to be adopted to control these insect pests. To control these insects we can spray efficient insecticides. The major diseases that affect the sugar beet crop are rhizoctonia wilt, powdery mildew, cercospora leaf spot and fusarium yellow. To control these diseses we can spray the fungicides.

Section five: fiber crops

Economic importance: Fiber crops are defined as those plants that are grown in order to obtain plant fibers, and used by man as the raw material in textile industry and various needs: clothing, ropes, bags, carpets, tents, fishing nets, and the paper industry. etc. The number of fiber crops in the world is more than 2300 species that vary in their distribution zones according to their favorable climatic conditions for their growth and their environmental and agricultural requirements. Fiber crops belong to various plant families, in terms of plant taxonomy, such as Malvaceae, Linaceae, Moraceae, Agavaceae (Table 1).

Table 1: The most important fiber crops, deployed in the world according to their economic importance (FAO 1996).

Fiber crop	Scientific name	Family
Cotton	Gossypium Sp.	Malvaceae
Jute	Corchorus Capsularis	Tiliaceae
Flax	Linum Usitatissimum	Linaceae
Sisal	Agave Sp.	Agavaceae
Kenaf	Hibiscus Cannabinus	Malvaceae
Ramie	Boehmeria Nivea	Urticaceae
Hemp	Cannbis Sativa	Moraceae

The development of the use of fibers: The human use of fibers differ according to the stages of human evolution, where in prehistoric times, man used the branches of shrubs and trees to cover his body, then began using animal leather during the stage of hunting and grazing, and after he domesticated sheep and goats in the Paleolithic, he started using wool and hair. This is famous for the region of Mesopotamia and surrounding hills about 4 thousand years BC, and with the transmission of human from grazing to the settlement and agriculture, he started cultivation of flax, where studies indicated that the ancient Egyptians showed special attention to this plant 3 thousand years BC. The ancient Indian civilization was well known in using cotton fibers 3000 years BC, although it was noted that remnants of cotton fabrics were found in South America, specifically in Peru. The legends indicated the widespread use of silk in China around 2700 years BC, and remained a secret of the secrets of China until the invasion of the great Alexander, who conveyed silk manufacture method to Europe. The modern development in the human use of plant fibers occurred with the development of machinery and steam power in the 18th and 19th centuries. At the beginning of the 20th century with the development of the use of machinery and improved human knowledge on the properties of fiber in addition to the development in the field of applied science. All this helped to open broad areas to improve the quality of production and technological characteristics of fibers to produce blends of different fibers with multiple uses.

Cultivated area and production: The number of fiber crops which having an economic importance does not exceed 10 species. The increase in the economic importance of any fiber crop depends on the use of fiber as a raw material in many industrial uses like: fabrics, threads, cordages, hunting nets, bags, papers.etc. and starting from 1950, the plant fibers were exposed to the competition from synthetic fibers. The global production of fiber crops and percentage of fiber are presented in (Table 2), and the cultivated area of fiber crops in the Arab World during 2009 is presented in (Table 3).

Table 2: The global production of fiber crops and percentage of fiber.

Fiber crop	Production (000' t) in 2005	% of fibers	Production (000' t) in 2009	% of fibers
Cotton	18430	79.4	24352	85.93
Jute	3125	13.5	2619	9.24
Flax	673	2.9	524	1.85
Sisal	383	1.65	327	1.15
Kenaf	196	0.85	142	0.50
Other fiber crops	406	1.7	374	1.32
Total	23223	100	28338	100

Source: Yearbook of FAO, 2005, 2009.

Table 3: Cultivated area of fiber crops in the Arab World during 2009

Country	Area (000' ha)	Production (000' t)	Productivity (kg/ha)
Egypt	282.9	1309.31	4628
Syria	238	1022	4294
Sudan	199.08	255	1281
Iraq	27	43	1593
Yemen	17.61	20.57	1168
Morocco	2.67	2.24	839
Somalia	2.31	0.74	320
Total	769.57	2652.86	3447

The types of fibers:

First: the division based on their uses: The fibers can be divided into 7 main groups according to their use, regardless of their origin or their structure or their type, where the fiber in each group has its distinct characteristics, that makes it valid for industry:

1) Textile fibers

2) Cordage fibers

3) Bruch and mat

4) Bagging fibers

5) Stuffing and upholstery fibers

6) Paper-making fibers

7) Miscellaneous uses fibers

We note from this division that the possibility of using single crop fiber in several groups: for example, using high grade of cotton in the textile industry, and low grade in the manufacture of paper or upholstery, same thing for flax. This division reflects the industrial groups that use the fiber more than its indication to the division of fibers. Therefore, we must use the other classification that is morphological classification.

Second: Morphological Classification: This classification depends on the origin of fibers, the simplest divisions is a division of Cook (1960) which divided the textile fibers into 3 major groups:

I. Natural Fibers: Are defined as those fibers provided by nature to man in the form of fibers ready directly for spinning (ready-made fibrous form). These fibers are some of the most commonly used and most prevalent fibers. The role of human is restricted in the extraction, preparation, cleaning and purification for use in the essential needs of clothing, including cotton fibers, wool, silk, linen and others. Fiber in this division is divided according to the nature of origin into three sections:

A) Plant or Vegetable Fibers (Cellulosic fibers): These are considered the largest sources of fiber and the most common. They are obtained from different plants known as fiber crops, where cellulose is the basic material.

Depending on the nature of origin, these fibers are divided into 5 groups:

1) Seed or fruit fibers: like, cotton and coconut.

2) Leaf fibers: like, Sisal

3) Bast fibers: like, Jute, Flax, Ramie, Kenaf.

4) Wood fibers: like wood pulp of some trees

5) Miscellaneous fibers: like, fibers taken from palm tree or sorghum.

B) Animal Fibers: Also known as protein fibers. Their source is of animal protein and they different from plant fibers that the protein is the basic building material. The most important fibers of this group are: wool and silk.

C) Mineral fibers: Which is of little significance in the textile industry like; asbestos fibers and glass fibers.

II. Man-made fibers (Synthetic fibers): In this type, man plays an important role in its manufacturing by using various raw materials provided by nature to him to make fibers like: Rayon, Nylon, Dacron.

III. Fiber blends: Are mixtures of several natural or synthetic fibers, the mixture is composed of natural fibers as the case in a mixture of wool and cotton or natural with synthetic fibers as the case of cotton with nylon.

Chapter one: Cotton

(*Gossypium spp*.)

Economic importance and history: Cotton is a unique crop species that has been a participant in many epics of history. It is one of only a few species that were domesticated in both the Old and New worlds. Cotton was central to the success of the industrial revolution in Northern Europe, and it was a major thread wove through the development colonial empires. Cotton played a major role in the USA Civil War and in the economic recovery of the South after the war. Cotton also has participated in the development of several technologies. The saw gins, which separate lint from seeds, permitted cotton to become an important source of fibers. Competition from man-made synthetic fibers resulted in the development of processing technology that made cotton into a wash and wear fabric. Cotton has shared in the establishment of many principles. Cytogenetic studies on cotton have promoted similar research on other species and provided the knowledge needed for the introgression of genes from ancestral and sister species. Cotton is at once a fiber, food and feed crop. The cotton plant is a warm season woody perennial shrub that is grown as an annual field crop.

Worldwide, over 30 million ha of cotton are grown between 47º N and 32º S latitude with over 50 % of the production above 30º N latitude. From these crop plants comes cotton lint, an industrial raw material. Thus a renewable agricultural resource enters into competition with synthetic fiber in the textile industry. These crop plants produce not only lint but also the world's second most important oilseed. Cotton has played a great role in the economy and politics of the world. Today the increased trade in grains and competition from synthetic fibers has reduced cotton's relative importance, but its world consumption continues to grow. Cotton will continue to be a significant commodity in future world trade. Cotton (from the Arabic quoton) are useful in that some species produce spinnable fibers (lint) on the seed coats such fibers begin as elongated cells growing out ward from the surface of the ovule. There are four domesticated species of cotton. Gossypium arboreum and G. herbaceum (both diploids) are native to the old World. G. arboreum remains an important crop in India, whereas G. herbaceum, important in early times, is today grown mostly for local use in the drier areas of Africa and Asia. G. barbadense and G. hirsutum evolved in the New World (both are allotetrapolid). G. barbadense, commonly known as extra-long staple, Egyptian and Pima cotton, and other names, supplies about 8 % the current world production of fiber. The fiber is used mostly for the production of luxury fabric and sewing threads. G. hirsutum, known most widely as upland cotton, contributes about 90 % of the current world production of 65 million bales of fiber (I bale weighing about 218 kg). Upland cotton fibers are used in the manufacture of a variety of textile products, cordage and other non- woven products. Linters, the short fibers removed from seeds before crushing, are an important source of industrial cellulose. Although cotton is grown mostly for fiber, the seeds are also important. Cotton seed oil is used for culinary purpose and the oilcake residue is a protein rich feed for ruminant livestock. Cotton is grown around the world in tropical latitudes and as far north as 43º N latitude in the former USSR and 45º N in China. Generally, cotton is the most important fiber crop in the world from the stand point of cultivated area, high yield and various uses (fibers, oil and meal). Cotton comes right after soybean as a source for oil in the international market (17% of the world vegetative oils) mostly from former USSR, USA, China, India and Pakistan (75% of the world cotton oil seed). Cotton seeds after ginning provide about 16% oil, 45% cotton meal which contains 44% protein, 9% linters and 26% hull.

Cotton production recovered at a remarkable pace after 1865, but production techniques changed little over the following 60 years. Planting and cultivation continued to be performed with mule-drawn gear and the hoe remained the tool for weeds. Use of fertilizers also remains poor and hand picking was a major practice.

Beginning in the mid 1930, yield began to rise and that was because of higher prices, reduced cultivated area and use of fertilizers.

The period just prior to World War-II saw the first steps toward mechanization of the crop. The post war era saw a move toward total mechanization not only in the USA, but in many of the other cotton producing areas of the world. Multi row planting and cultivating equipment became standard. Weeds are controlled today largely through the use of herbicides and insect control through the use of various insecticides gives a degree of plant protection earlier cotton growers could not have dreamed of. By 1966 yields of lint in the USA had reached 561 kg/ha, a two-fold increase in yield in 30 years. Since that time the yield has plateaued. Some reasons frequently cited are that insect control has become more difficult, especially with (bollworm) complex which has adapted to resist pesticides, and that larger areas of traditionally low productivity per hectare have come increasingly into production. Another factor is that cotton farmers have become more conscious of production costs and now seek to optimize lint yield rather than maximize it. On a world basis, the future of cotton growing and utilization seems bright. The crop continues to increase in volume as the world population grows.

Cultivated area and production: The world cultivated area in 2009 was (30791) thousand ha, produced (53143) thousand ton of seed cotton with an average of 1726 kg/ha. Asia's share was (61%) of the area and (63%) of total production. India came first in (area) but China was the first in production.

In the Arab world, cotton is one of the most important crops and comes right after wheat. The major producing countries in 2009 were Egypt (297) thousand ha, produced (820) thousand ton, followed by Syria (200) thousand ha, produced (802) thousand tons, then Sudan (144) thousand ha, produced (173) thousand tons. The other producing countries are: Yemen, Iraq, Morocco and Somalia. Egypt came first in total production of cotton fibers (285) thousand tons and (512) thousand tons of cotton seed followed by Syria (272) and (350) thousand tons of fibers and cotton seed, respectively. Sudan came third in both fibers and cotton seed. Syria came first in productivity (4015) kg/ha in 2002 compared to (2935) kg/ha in the period of 1989-91. Egypt was second (2761) kg/ha followed by Sudan (1197) kg/ha.

In Syria: Cotton is the cash crop number one. Cotton cultivation in Syria began in 1923 (800 ha) then in 1924 (35660 ha). The area remained constant till 1948 (36780 ha) when the area reached (217) thousand ha in 1951 as a result of the Korean War. Currently, cotton forms 4% of all cultivated area and 35-40 % of irrigated area. More than million people are involved in this crop (cultivation, ginning and textile industry). It also provides about one million tons of animal feed. It comes second as a source of foreign currency after oil. Cotton provides about (800) thousand tons of seed cotton, (140) thousand of fibers, and (600) thousand tons of cotton seed for oil extraction.

Yield per hectare in 1970 averaged (1.7) tons, improved to (4.1) tons in 2001 and to (4.4) tons in 2005. Total area in 2009 was (192.8) thousand ha produced (111.5) thousand tons of cotton seeds with an average yield of 3700 kg/ha. Major producing provinces are: AlHassake, AlRaqqa, Aleppo, DirElzour, AlGhab, less area in Homs, Hama and Idelb.

Center of origin: The age of cotton is unknown (several stories about its origin). Some see that G. arboreum (diploid) was first domesticated for animal feed. The new world cottons were domesticated after the introduction of G. arboreum which has been crossed with the wild species G. raimond in Central America. Some believe that India is the oldest place to grow cotton 3000 years B.C, G. hirsutum was domesticated in 2 or 3 separate regions:

1. The upland cotton: forms a center of diversity near the border of Mexico and Guatamala.

2. The domesticated forms of G. hirsutum var. mariegalante might have been derived from a center of diversity in Northern Colombia.

3. Wild and common forms of mariegalante along the pacific coast of middle America .

Generally, cotton was grown in many places of the world:

India, China and Africa: first center of origin of old world cottons.

South and Central America: the center of origin of new world cottons.

Botanical classification: Cotton belongs to the family Malvaceae. Several species belong to the genus Gossypium. Parlatore (1866) mentioned only (7) species belonging to Gossypium. Todaro (1877) mentioned (54) species belonging to Gossypium. Watt (1907) mentioned (29) wild species.

In general, classification of Gossypium could be divided into two phases conducted by Zaitizev (1928), early phase and modern phase.

It is based on cytology, he proposed that:

1. Old world cotton are diploids, 2n=26

2. New world cotton are tetraploids, 2n=52

He also proposed that cotton of old world could be grouped into:

1-African cottons   2-India – China cottons

and the cottons of new world could be grouped into:

1. Central America cottons   2. South America cottons.

Hutchinson classification (1947):

A) Old world cotton, diploid, 2n=26

1. G. herbaceum (African cotton) appeared for a period in India, Iran, Turkey, Iraq, Syria and North Africa. Now it is grown only in dry areas of Asia and Africa. Plants are shrubs up to 150 cm in height.

2. G. arboreum (Indian or Asian cotton) is grown in India, China, Korea, Japan, perennial shrubs up to 200 cm or short annuals (50-140 cm)

B) New world cottons, tetraploid, 2n=52

1. G. hirsutum, grown all over the world including Syria provides 90% of world cotton, Shrubs (1-2 m).

2. G. barbadense is grown in Central and South America and some areas of Africa, India, USSR and Egypt. It provides 8% of world cotton, long fibers (35-45 mm) used for luxury textiles, shrubs (perennial or annuals)

3. G. tomentosum, mainly in Hawai, shrubs (1-2 m)

Fryxell (1979) divided Gossypium into 4 sub-genus, 8 divisions, 10 sub-division, 39 wild and cultivated species.

We may summarize the range of variations which are potentially available for exploitation in cotton improvement programs as follows:

1. Growth habit: (weak, procumbent, erect, scandent), 2. Pubescence on vegetative parts (none to dense), 3. Waxy epidermis, 4. Leaf form (ovate to lobed), 5. Gossypol glands (absent from the embryos: G. bickii, G. austral), 6. Forms of bracts, 7. Calyx, 8. Petals, 9. The style length, 10. Forms of capsules (fruits), 11. Size of seeds, 12. Fibers (colour, length).

Environmental requirements: Production practices on a large farm and on a small family unit both reflect the grower's effort to fit this crop to climate and soils in his area. Climate generally sets the geographic limits for cotton across the world. Cotton originated in the tropics, and the plant becomes inactive at temperatures below 15ºC, activity slows as this temperature is approached. The crop needs more than 160 days above 15 ºC, almost any soil used for commercial production of any other field crop can be used to grow cotton if temperature and moisture are favorable. Soils used for cotton may require special pre-plant preparation and may need nutritional supplements. If temperature and soil are acceptable for cotton, the crop still may not be grown unless sufficient moisture is available. An acceptable cotton crop requires at least 50 cm (500 mm) of water during its growing season. This water must be in the soil or be provided by rainfall or irrigation. More than half of the world's cotton crop is produced with essentially all its moisture provided by irrigation. Temperature, sunlight, rainfall, soil, supplemental nutrient and water for irrigation are the major resources available to cotton growers. These are the key elements used by cotton growers to obtain control of the crop, that is, to have the crop develop as a planned progression.

1- Moisture: Adequate amount of moisture is an essential requirement for cotton growth, in addition to a frost-free season and adequate light (sunshine). Cotton plant needs for moisture vary according to growth stage, variety, temperature, winds and relative humidity. In germination, cotton seeds require larger amount of moisture due to lignin and waxes which hinder water absorption. Seeds absorb 55% of their weight during 4-5 hrs at 30º C (vary with varieties). Cotton tolerates drought to a certain degree due to its deep root system. As the plant grows, it can absorb water at 50-100 cm depth. Cotton requires at least 50 cm moisture to give good yield (Table 1).

Shortage of moisture leads to failure of seed germination; excessive soil moisture also leads to death of seeds and more vegetative growth (especially in fertile soils). Excessive soil moisture accompanied with low temperature and cloudy sky for a long period keep the cotton plant in the vegetative growth and delay formation of reproductive parts, shallow roots, rotten bolls and low yield of lint. Low relative humidity and high evaporation increase the cut-out of bolls. Moisture availability is the limiting factor for lint yield.

Table 1: Water requirements during different growth stages of cotton to obtain acceptable yield:

Water needs by stages of growth	Yield in bales /ha			Approximate no. of days
	0.75	**3.75**	**7.50**	
Seeding (planting to flower)	8	8	10	40-60
Fruiting (through 4th week of blooming)	12	14	20	40-50
Maturing (5th week of blooming to 1st week of open boll)	18	23	32	15-25
Opening (1st week of open boll to all open)	12	27	18	35-60
Total	50	72	100	130-195

Note: 1 bale = 218 kg of lint

Rainfed cotton in areas of 350-400 mm is common in some areas but distribution is limited. But irrigation is always better especially in rich soils.

2- Temperature: Cotton is a heat loving plant, but more than 50% of the world crop is grown in temperature zones above 30 º N latitude. Cotton requires a frost free season, warm, sunny not less than 180-200 days.

Optimum temperature for seed germination is 35º C; it will be slow at 17º C and terminate at 15º C. Germination is enhanced at 35-37º C and is reduced above 37º C. Temperature of 24-28 is the optimum for emergence and growth of cotton. Low temperature increases rotten roots and diseases.

Optimum temperature for the growth of cotton plant is 25-32º C. The growth of main stem and branches stops when the temperature is above 37º C. High temperature increases rate of stem growth, shortens flowering period and decrease the number of buds formed. Cotton does not tolerate cool weather and death might occur at 1º C. High temperature (above 40º C) in July and August causes high rate of bud and small bolls cut out due to low rate of fertilization and higher evapo-transpiration, stomata closure, slow photosynthesis, higher dark respiration, reduced dry matter accumulation and as a result low yield. Egyptian varieties are more sensitive to cool climate than American ones (growth of fiber stops at 10-12º C). High temperature above 40º C during the day and above 21º C during the night not only affects growth and yield of cotton, but also affects ginning rate and fiber quality (length and strength of fiber).

3- Light: Sunshine is vital to cotton, and areas with more than 50% cloudiness are not suited for cotton, regardless of temperature and moisture; solar energy is essential for a rapid warming and drying of soil in the spring. The heat required to raise the temperature 1º C is five times greater for water than for an equal weight of an average soil. This point relates to the need for effective field drainage system and seedbed preparation that extend the number of cotton growing days. Rapidity and consistency of spring warming determines where cotton can be grown successfully. Within the past 20 years new areas with water for irrigation have been developed in several places of south west USA (Texas and Arizona) failed because of unexpected late frosts in the spring and early freeze in the fall (similar to what might happen in AlGhab in Syria). Considerable evidence is accumulating to assign (smog) a significant role in reducing yield. Smog can be considered as an interaction of man with climate and may have a wider impact on cotton in the future. Cotton is considered as a short day plant and extensive sunshine enhance cotton growth and overall plant size. Most of growth occurs at night due to its sensitivity to direct radiation. Cloudiness reduces growth rate (vegetative and reproductive). Barkley found that cotton plant may give high yield under certain day length and temperature and considered cotton as a mid or neutral plant. Effect of CO_2 concentration on photosynthesis and yield of cotton was evaluated through carbon exchange rate (CER) and found a yield increase of 15% (cotton), 2% (sorghum) , 41% (soybean) , and 7% (sunflower) at 630 micro letter/L compared to 330 micro letter/L and the lint increase was 18% in cotton. Selection for this physiological trait will increase yield of indeterminate (soybean, cotton) and not determinate species (sorghum, sunflower), also photosynthesis is higher in the absence of O_2 due to photorespiration which is normal in C_3 crops including cotton.

4- Soil conditions: Any soil used effectively to grow any row crop can also be used to grow cotton, except where flooding restricts the number of days that equipment can have excess to the field. The basic needs of cotton from the soil are water, oxygen, available nutrients and anchorage for roots. Soils provide the cotton's crop only source of water between rains or between irrigations. Soils vary greatly in water holding capacity and in water movement potentials. The most desirable soils, in terms of moisture relationships with the growing plant, are the silt loam. Sands and clays must have special attention. In sandy soils a pre-plant irrigation and by the second week after first flower buds are visible. In contrast, silt loam soil should hold moisture until after first bloom or 2 to 3 weeks later. Clay soils require special water delivery system to avoid saturation and oxygen stress. The amount of water available for cotton in any soil is a function of rooting depth, soil texture (storage) and resistance to evaporation losses. In considering any specific soil as a medium for growing cotton, soil properties may alert growers to potential problems associated with internal drainage, erosion, PH and attending toxic materials, salt potential, etc. Cotton can be grown on most soils, but the question of economic feasibility rests largely with the properties of the specific soil in question. These basic properties largely determine how well the soil in question can meet the nutritional needs of the cotton plant. The cotton roots system occupies 1-2% of the soil surrounding the roots. O_2, temperature and toxic materials affect cotton absorption of water and nutrient (O_2 less than 10%, temperature below 15º C). PH 7-8 is the best for cotton. In Syria soils on the basins of rivers, AlGhab red soils are suitable for cotton. Salinity is a major problem that must be considered when fertilizers and irrigation are practiced.

Cultivation requirements:

1- Crop rotation: It is well established that crop rotation has several benefits especially in relation to root diseases. Studies in the USA showed 300 kg increase in cotton yield when legumes were used. Other benefits are leaving weed-free field due to practices required for cotton. In Syria, traditionally the Syrian farmers applied the system of continuous cotton planting due to the ownership of land and the higher prices of cotton. We might apply double or triple rotation where cotton is rotated with winter legume, cereals, sesame, sunflower, tobacco and vegetables in rainfed areas. In irrigated areas, we can also apply double rotation: Winter legume – cotton or cereals – cotton or sugar beet-cotton could be also introduced and the triple rotation containing peanuts, cotton, vegetables and cereals.

2- Fertility and fertilizers: Cotton is a large responsive to all nutrients. The amounts absorbed by cotton is little compared to the high yield which varies from 150 kg /ha to 2000 kg/ha of cotton lint. This reflects soil properties which provide cotton with moisture, O2, nutrient, and the right depth for cotton roots. Cotton yield of 2.5 bales (540kg/ha) absorb: 40 kg N, 16 kg P_2O_5 , 17 kg K_2O , 7 kg MgO , 4 kg CaO. Higher yield (3.75 bales or 900 kg/ha) takes up: 62-25-26-11-6 kg of the above nutrients. A yield of 7.5 bales/ha (1600 kg/ha) takes up: 125-50-52-22-13 kg/ha of the above nutrients. Thus, to achieve the minimum yield of (2.5 bales), soil must contain 100 kg N, 50 kg P_2O_5, 80 kg K_2O and adequate amounts of other nutrients which should be provided from the soil or added as fertilizers.

White estimated that cotton obtain 1/3 of N, P, S, K, Ca, K and Mg during early stage of its growth (formation of reproductive buds) which last for 30 days. The second third is obtained at the beginning of flowering (30 days). Cotton obtain 86-90 % of these nutrients from planting until the end of the third growth stage (beginning of ball opening). The rest (10 %) is obtained during maturity. Dry matter accumulation occurs as 1/8 (1^{st} stage), 1/8 (2^{nd} stage), 1/4 (3^{rd} stage) and 1/2 of it during maturity. It has been found that cotton grown in rich soils is higher in N, P and K than that grown in poor soils. Ginning rate is higher in poor soils but less in oil compared to rich soils. We might add 200 kg of N (two times) in March during seedbed preparation and in May (at thinning) for low yielding soils, reduced to 150 kg/ha in high yielding soils. 100 kg/ha of P_2O_5 at seedbed preparation in March for both low and high yielding soils. It is advisable to add N at seedbed preparation after thinning and before flowering (3 times). Response to N varies with location, irrigation, residual N; organic fertilizers are also important (40-50 tons/ha) plus 100 kg of K_2O before planting.

3- Planting date: Planting date is important in early maturity, reducing insect effects, and avoiding some physiological disorders which might affect cotton growth and yield. Recent studies emphasized the importance of early planting and maturity. Enhancing cotton maturity through ending irrigation in mid Aug instead of Sep. did not affect yield, but reduced insect effects. Generally, early planting (15 March – 1^{st} week of April) is advisable. It has been found that long fiber cottons require longer growing season, i.e planting during the month of March is necessary. Intermediate fiber cottons could be grown in April and first week of May. In Syria, planting cotton in April is optimal to give the plant enough time for flowering, full maturity, and to avoid heat and insect effects. Early harvesting results in good quality cotton. We might delay planting till 1^{st} week of May in heavy logged soils.

4- Seeding rate: Amount of seed per hectare varies with soil type, method of planting, date of planting and viability of seeds. Generally, 80 kg/ha of unshaved seeds is adequate plus 30 kg for replanting and 20 kg as a reserve, but the amount is reduced to 60 kg/ha + 10 kg in case of shaved seeds. It is not advisable to increase plant density per unit area unless we use varieties that fit narrow planting date, and determinate varieties response better to high plant density than indeterminate varieties.

Care operations of crop after establishment:

1- Thinning and replanting: replanting should be done 15-20 days after planting. Thinning should be done 28-35 days after planting (1st half of May)

2- Irrigation: More than 60% of world cotton is irrigated (flood, furrow, sprinkler). Advantages and disadvantages of each method and selection of irrigation method depend on water availability, method of planting, and soil type. Cotton is sensitive to shortage of moisture due to its high transpiration rate (500-600). Plant welting for 3 days results in large decrease in boll weight and boll cut out. Generally, flowering and maturity are the critical stages for moisture shortage. Cotton is irrigated (in dry planting) for the first time directly or after 20-30 day in moist planting, then every 15 days according to soil and climatic conditions. Soil with high water table should be treated logically in irrigation. irrigation is ceased in mid September after opening large portion of bolls.

Maturity and harvesting: Harvesting is related to cultivar used, date of planting, irrigation and climatic conditions. Harvest should not be conducted only once but at 3 intervals: 1st one when 30-40 % of bolls are opened in October (get best prices and quality). 2nd harvest (large amount and fewer prices). The last harvest gives what is left on the plant. Cotton pickers or strippers are used in many countries for harvesting of cotton.

Yield: Seed cotton yield per hectare varies with variety, planting date, soil fertility, fertilization, irrigation, etc.

In Syria more than 3000 kg/ha and in some cases 4500-5000 kg/ha (irrigated), but in rainfed cotton yield is very low.

Cotton ginning: Ginning, in its strictest sense refers to the process of separating cotton fibers from the seeds without affecting their properties. The principal function of the cotton gin is the conversion of a field crop into a salable commodity. Thus, it is the bridge between cotton production and cotton manufacturing. At one time the sole purpose of a cotton gin was to separate fibers from seed, but today's modern cotton gin is required to do much more. To convert mechanically harvested cotton into a salable product, gins of today have to dry and clean the seed cotton, separate the fibers from the seed, further clean the fibers, and place the fibers into an acceptable package for commerce. The cotton gin actually produces two products with cash value, the fibers and cotton seed. Cotton seed are usually sold to cotton oil mills for conversion into a number of important and valuable products, but in some cases they may be saved for planting purpose. The fibers are the more valuable product; however, the design and operation of cotton gins are usually oriented toward fiber production. In essence, the modern cotton gin enhances the value of cotton by separating the fibers from the seed and by removing objectionable foreign matter, while preserving as nearly as possible the inherent qualities of the fiber .

Two types of gins are used in the world:

1. The saw gin: found in 1794 by Eli Whitney, used for short and medium lint cottons (upland) and those with dense linters, and does not fit long fiber cottons, produce 200-400 kg/ha of cotton lint .

2. The roller gin: found in 1840 by McCarthy, used for long fiber cottons (pima) and sometimes for short fibers, less productive than saw gins, but less naps are found in the lint. In Syria: there are 113 saw gins and 844 roller gins distributed in Aleppo, Homs, Idleb, Damascus and DeirElzour.

Effects of ginning on fiber quality: Ginning might affect fiber quality. This depends on the mechanical action effectiveness of ginning and moisture percentage of cotton. Some effects are:

1. Increase the percentage of short fibers.

2. Increase the percentage of naps.

3. Reduce grade.

4. Coarse appearance due to moisture percentage (knots), acceptable moisture percentage is 6.5 – 8%

Most important properties of fibers (lint):

1. Grade: determined by colour, foreign matter content and ginning preparation (extra, zero, one, two, three).

2. Length: most important property of lint, it is an inherent character but is affected by temperature and moisture.

According to this property, cottons are classified as:

- Short lint types (0.5-1 inch), Asian and African cotton.
- Medium lint types (1-1.5 inch), upland cotton.
- Long lint types (1.8-2 inch).

3. Strength: resistance of fibers to various forces.

4. Fineness: determined by wall thickness.

5. Fiber maturity: reflects the accumulation of cellulose.

Ginning rate = weight of lint / weight of cotton seed ×100

Ginning rate varies based on: Variety, Soil fertility, growth and crop culture and effectiveness of ginning.

Most important characters and breeding methods:

Cotton is self-pollinated crop, but cross pollinated (up to 50%), places this crop as (often–cross pollinated crop) often by insects.

Breeding methods: (1) Selection within existing varieties. (2) Recurrent selection. (3) Inter–specific hybridization. (4) Pedigree and bulk method.

(5) Hybrid varieties (using CMS). (5) Intra-specific hybridization

Current objective:

1. Producing small – size cultivars (for mechanical harvesting).

2. Early varieties, improving fiber and seed quality.

3. Producing low or free- gossypol varieties.

4. Producing a biotic stress tolerant varieties (heat, drought and salinity).

5. Increase boll size and pest resistant varieties.

Bolting: Noticed in cotton fields in Syria for the first time in 1978-1979. Tall plants, weak, no bolls in the middle and lower parts of the plant (vegetative growth with little or no reproductive growth).

Some causes of this phenomena:

1. High temperature (40º C) during flowering and boll formation which causes low fertilization.

2. High plant density (more than 7-8 plants/m^2)

3. Irrigation (stop irrigation for more than 50 days from April till mid June)

4. Nitrogen fertilizers, 5. High water table, 6. Miridi bug insects.

7. Late planting (effect of high temperature)

Some solutions of this phenomena:

1. Reevaluation of all above practices.

2. Select the optimal variety (Deir 22, Raqqa 5).

Environmental stresses:

Important insect and diseases of cotton are: American bollworm, pink bollworm, spotted bollworm and cutworm (*Agrotis* sp) aphids (*Aphis gossypii*), white fly, red cotton bug, spider mites, cotton jassids and thrips. The important diseases are: Root rot, wilt and browning of leaves.

Section six: Narcotic crops

Economic importance: Narcotic crops (Tobacco) are cultivated in many parts of the world because of its high economic value. The history and the status of the world's tobacco industry signify that tobacco and its products will persist for a long time, in spite of the fact that tobacco products are harmful to health. In Syrian agricultural scenario, tobacco occupies a unique position though the area under this crop is relatively small. Tobacco, besides being one of the major sources of revenue to the government, provides employment to many people**.**

Cultivated area and production: The different types of tobacco grown in the world is presented in (Table 1), and the World's leading tobacco producing countries during 2009 is presented in (Table 2).

Table 1: Different types of tobacco grown in the world.

1.	FCV Tobacco	Cigarettes manufacturing
2.	Bidi Tobacco	Bidi manufacturing (rolled wrapper leaves flakes)
3.	Cigar and Cheroot	Cigar manufacturing
4.	Hookah Tobacco	Hookah
5.	Chewing and Snuff	Chewing & snuff
6.	Burley, Oriental	Cigarettes manufacturing

Table 2: World's leading tobacco producing countries during 2009.

Country	Production (tonnes)	% of world total
China	2,013,735	35.1
Brazil	757,075	13.2
India	596,000	10.4
United States	357,612	6.2
Zimbabwe	172,111	2.98
Rest of world	**1,735,292**	**32.12**

Quality parameters for tobacco production:

Quality factors are extremely important to the marketability of tobacco. High-quality leaves are high in carbohydrates and potash; low in nitrogen, fiber, calcium, and ash; and of uniform color. Surprisingly, moderate to low nicotine levels are preferred for high-quality tobacco, despite the fact that nicotine is the chemical responsible for the stimulating effect of tobacco use. Factors affecting crop quality include soil type, fertilization, cultural practices, season, and climate. The quality of tobacco is made up of many complex components and they should always be viewed in combination. Tobacco quality may be defined as the sum of physical, economical and chemical attributes which make it desirable or undesirable for a specific use.

Thus quality is made up of many complex components, and quality evaluation becomes the net balance of good and bad features.

1. Manufacturing characters: is largely governed by physical properties and covers such matter as losses in handling and manufacturing the important physical properties are:

(i) Colour

(ii) Hygroscopicity or equilibrium moisture content

(iii) Filling value

(iv) Shatteribility/Elasticity

(v) Combustibility

(vi) Maturity / ripeness

2. Smoking characters: are influenced by the chemical compositions of tobacco. The important chemical properties that contribute towards smoking characters are:

(i) Nicotine

(ii) Sugar

(iii) Total nitrogen

(iv) Total ash/water soluble ash

(v) Chloride and potassium

(vi) Petroleum ether extracts (waxes, resins and oils).

3. Exportability characters:

(i). Tar and nicotine content

(ii). Pesticide residues.

The above mentioned qualities of tobacco are greatly influenced by the following production factors: (a) Genetic potential (b) soil type (c) climate conditions (d) cultural practices (e) curing methods and (f) grading index.

Quality in non flue-cured tobacco:

Burley tobacco: Among non FCV tobacco, burley tobacco is the principal type that has got good export markets. Good quality burley has low total volatile bases, high ratio of nicotine to total alkaloids, moderate range of nitrate nitrogen and reasonably high range of mineral content, fluffy and open textured having high filling value and pore volume, elastic with high shatter resistance and optimum equilibrium moisture content and moderately good burn rate. Low nicotine content (less than 1.2%) in the leaf is another significant feature of Indian Burley compared to the American Burley.

Bidi tobacco: is valued on the basis of (i) its physical characters viz., colour, thickness, size, spangling of the leaf, granulation, brightness of luster (ii) its smoking qualities viz., strength, sweetness and aroma and (iii) its burning qualities *viz*., consistency in burning, ash colour etc. The purchasers prefer tobacco mild in strength and sweet in flavour and it should not leave any undesirable after-effects in the mouth, parrot green colour is most preferred.

Cigar tobacco: leaf of dark brown colour, with moderately heavy body, having a nicotine level of about 2.5-3.5% are desirable characteristics. The smoking product should have good burn with whitish ash.

Chewing tobacco: should posses dark mahogany colour, without any blemish. Development of spangles in the matured leaf is the most essential quality and is associated with important physiological changes in the leaf. nicotine level of 2.5-5.0% is desirable, the chewing product should give chewing taste.

Quality in flue-cured tobacco: The concept of quality in flue-cured tobacco has attained a new dimension in the present days because of higher mobility in international market. So the quality characters of FCV tobacco are divided into visual characters, manufacturing characters and chemical characters. The visual characters are colour, body, texture, maturity/ ripeness, graininess, hygroscopicity, blemish, elasticity, fluffiness, aroma, leaf size, vein colour etc. These characters are subjective based on which the tobacco leaf is graded and purchased by the trader. Objective quality criteria have been developed for the manufacuring characters and chemical characters. The manufacturing characters are filling value, equilibrium moisture content, pore volume, elasticity, shatterability, combustibility, lamina-midrib ratio (Strip yield), No. of leaves/kg, lamina weight/unit area etc. Though tobacco leaf contains hundreds of chemical constituents, only few of them will have a dominating influence on quality. Nitrogenous and carbohydrate fractions are the two groups of chemical constituents having outstanding effect on smoking quality. Chloride in leaf is also very important as it influences the combustibility and keeping quality of leaf (Table 3).

Table 3: Acceptable limits for the important quality constituents and quality indices in flue-cured tobacco.

Constituent/Quality Index	Acceptable Limits
Total Nitrogen %	1.0 - 3.0
Nicotine %	0.7 - 3.0
Total Sugars %	10.0 - 26.0
Reducing Sugars %	8.0 - 24.0
pH	4.6 - 5.5
Reducing Sugars/ Total N	7 - 13
Reducing Sugars/Nicotine	7 - 13
Total N/ Nicotine	< 1.2
Chloride %	< 1.5
Filling value at 60% R.H. & 20^{o}C	3.3 - 3.8cc/g shreds
Equilibrium moisture content	11 - 15%
Pore Volume	0.13 - 0.18 ml/g
Combustibility	2.5 - 3.5 mm/min
Leaf burn	3 - 6 sec.

Chapter one: Tobacco

(*Nicotiana tabacum* L.)

Economic importance: Tobacco (*Nicotiana tabacum* L.) is the only commercial nonfood crop that enters the world trade as a leaf. It is priced for aroma, taste and flavor. Tobacco is an important commercial crop in view of revenue generation, export earnings and employment potential. It is aptly called as the golden leaf. As a crop, tobacco is very valuable but also very labor intensive. Even with modern mechanization. As such, it is considered a good enterprise for small family farms. Tobacco leaves can be used for cigarette manufacturing, cigar, snuff, chewing, and hookah. Minor uses like extraction of nicotine from the leaves to prepare nicotine sulphate which can be used as insecticide. Citric acid and nicotine acid for food and medicinal purpose. There are several species of tobacco, all of them native to the Americas. *Nicotiana tabacum* is the most widely grown, providing virtually all the domestic leaf used in commercial production of cigars, cigarettes, and smokeless tobacco products. Another species, *N. rustica*, more commonly grown overseas, has generated interest because of its high nicotine content, useful in the making of insecticides and for other specialized uses. However, *N. rustica* is not a well-domesticated species and is difficult to grow. Quality factors are extremely important to the marketability of tobacco. High-quality leaves are high in carbohydrates and potash; low in nitrogen, fiber, calcium, and ash; and of uniform color. Surprisingly, moderate to low nicotine levels are preferred for high-quality tobacco, despite the fact that nicotine is the chemical responsible for the stimulating effect of tobacco use. Factors affecting crop quality include soil type, fertilization, cultural practices, season, and climate.

The center of origin: The genus Nicotiana includes more than 60 species, of which N. tabacum and N. rustica are the two commonly cultivated for producing commercial tobacco. N. tabacum is widely cultivated in most countries of the world while N. rustica is restricted to India, Russia and few other Asiatic countries. The primary centre of origin of N. tabacum is South America and that of N. rustica is Peru. The red Indians used to inhale its smoke from burning leaf through nostrils by means of a hollow forked cane and the name of this instrument was given to the plant came to be known as tabako in Spanish and tobacco in English. Jean Nicot, the French Ambassador in Portugal introduced tobacco to France in 1560. The botanical name of plant Nicotiana and the word nicotine are derived from his name.

Cultivated area and production: The tobacco producing countries are China, India, Brazil, USA, Zimbabwe and Turkey. Global production of tobacco during 2009 is 12.5 million tones from an area of about 4.8 million hectare. More than 50% of the world tobacco consists of flue cured Virginia. In the world nowadays, China is having the maximum area, production and average yields (Table 1), followed by the USA, Brazil, India and Russia (China is having more than 50% of area and production in the world).

Table 1: Area, production and productivity of tobacco leaves in leading countries of the world during 2009.

Country	Area (m ha)	Production (m t)	Productivity(kg/ha)
China	2.60	8.01	3295
India	0.42	0.58	1358
Brazil	0.34	0.58	1694
USA	0.31	0.76	2430
Russia	0.23	0.46	2005
Turkey	0.35	0.42	1112

In the Arab world the area under tobacco cultivation is about 60 thousand hectare with a total production of 76 thousand tonnes. Syria occupies the first place in area (22000 ha) and production (26000 tones) followed by Morocco, Tunisia, Yemen and others.

Economic importance of tobacco in Syria: Tobacco is grown in coastal areas, especially in Latakia which grows the largest area of tobacco followed by Tartoos, Edleb, Daraa, Alghab, Homs, Aleppo, respectively. The area under tobacco cultivation in our country reduced mainly because of expansion in growing citrus, summer vegetables and green house crops, especially in Latakia and Tartoos. But later on, it has been compensated by growing tobacco in other areas of Daraa (Mzereeb) and Hama (Alghab). Tobacco crop occupies a prominent place amongst field crops in Syria. It stands third after wheat and cotton as commercial crops. Its importance comes from the following:

1. It plays an important role as cash crop (foreign exchange) in the country.

2. It gives employment to more than 350 thousand people in our country in different aspects of tobacco cultivation, manufacturing, marketing and research development.

3. Some varieties of tobacco (oriental tobacco) can be grown in low fertile soils which are not suitable for other crops and can give acceptable yield.

4. Higher yield per unit land area and higher remunerative crop to the farmers as compared to other field crops especially after introduction of high yielding American varieties of flue cured Virginia and burley tobacco.

Botanical classification: The genus Nicotiana is one of the five large genera of solanaceae and is represented by about 60 recognized species which are grouped in three sub-groups:

1. Subgenus Rustica,   2. Subgenus Tabacum,   3. Subgenus Petunioides

Out of the 60 species, only two species, i.e. *Nicotiana tabacum* and *Nicotiana rustica* are cultivated extensively. Syria grows only N. tabacum, which is having tall plants with broad leaves and usually pink flowers. The N. rustica is having short plants with round puckered leaf and yellow flowers. The chromosomes number of tobacco, 2n=12 or 2n=24.

Agricultural and commercial classification:

1. All cultivated tobacco from the species N. tabacum can be classified in four groups according to leaves and flowers characters.

(i) Havana tobacco   (ii) Brazilian tobacco

(iii) Virginia tobacco   (iv) Purpurea tobacco.

2. Classification depends on the length of the tobacco leaf:

- Tobacco with small size leaves (Oriental tobacco)
- Tobacco with medium size leaves (Semi-oriental tobacco)
- Tobacco with large size leaves (American tobacco)

3. Classification depends on aromatic content of the leaf:

(i) Ornamental tobacco (ii) Semi-ornamental tobacco

4. Classification according to the method of curing:

- Flue cured tobacco
- Fire cured tobacco
- Air cured tobacco: This can be divide into light air cured tobacco and dark air cured tobacco

5. Classification according to tobacco use:

- Cigarette tobacco
- Cigar tobacco
- Snuff and chewing types
- Hookah tobacco

6. Classification according to nicotine percentage:

- Tobacco with high nicotine content (up to 12.65%), e.g. N. rustica
- Tobacco with medium nicotine content (5-6%), e.g. oriental and semi-oriental tobacco
- Tobacco with low nicotine content (2%), e.g. Virginia and burley tobacco.

Growth stages: Tobacco is having four growth stages viz.

- Seedling establishment (soon after transplanting)
- Early growth stage
- Grand growth stage
- Ripening (maturity) of leaves

Environmental requirements: Though, tobacco is tropical in origin and thrives best in warm climate, it is grown in subtropical and temperate regions. It grows as for north as central Sweden at 60 ^{o}N latitude and as for south as NewZeland at latitude of 40 ^{o}S, the most important factor being temperature. Being a short duration crop, it can be grown at any latitude and altitude if a mean temperature of 20-30 ^{o}C prevails for a period of 80-120 days at any time of the year. A mean temperature of about 27 ^{o}C appears to be optimum. The growth will slow down if temperature is below 15 ^{o}C. Tobacco is sensitive to high temperature especially when accompanied with water stress. On the other hand, tobacco is sensitive to frost. However, cultivation of tobacco requires an adequate growth period free from spring frost and autumn frost and this period is available in our country climate. The crop is grown under irrigated conditions in Syria. Under rainfed cultivation (in other countries like India) the rainfall should be more than

500 mm/year and well distributed with about 100 mm/month. Relative humidity may vary from 70-80% in the morning and 50-60% at mid day. Drier weather is required for harvesting tobacco and ripening. Crop is susceptible to severe injury by hailstorm and strong wind. Tobacco respond well to good sunshine during growth period. Tobacco is photoperiod insensitive. The soil moisture plays an important role in tobacco growth. Tobacco can tolerate drought but not prolonged and severe drought; the growth and yield were adversely affected in drought years. Excess moisture may cause harmful effects on the crop. In light soils excess moisture may cause minerals loss due to leaching; in heavy soil excess of moisture may cause oxygen deficiency and root death. Climatic factors play an important role in the quality of tobacco leaves.

Soil conditions: Tobacco can be grown in a wide range of of soil types but the ideal soils for tobacco are the sandy loam soils with internal drainage, good aeration and moisture holding capacity, the PH range 5.0 - 6.5. Tobacco does not withstand water logging or flooded conditions. The soil will affect on the yield and quality of tobacco. This depends on the physical and chemical properties of the soil, in addition to other factors like aeration, drainage, etc. Saline soil and saline water adversely affect the quality of tobacco leaves.

Varieties: A lot of tobacco varieties is grown recently in Syria; all of them of the species N. tabacum except the variety (Hasan keif) which follow rustica species. The general organization for tobacco provides the farmers with new varieties by the introduction of new varieties or by breeding and improvement of our local varieties. The varieties which are grown in our country can be grouped into five groups depending on botanical, agricultural and quality parameters as follow:

1. Strong tobacco: very hot tobacco with higher nicotine percentage.

- Shak albent: a local origin
- Tarabzoon: the origin is Turkey
- Hasan keif: a local origin

2. Semi oriental (semi ornamental) tobacco: light tobacco with low nicotine and ornamental odour.

- Owtelia: Yugoslavian origin
- Ravenak: Yugoslavian origin
- Kromovkrad: Bulgarian origin
- Kabakolak: Greek origin
- Zegreen: Bulgarian hybrid and locally improved

- Mendrisco: Romanian origin
- French variety: Algerian origin
- Sadi variety: Bulgarian origin

3. The oriental tobacco: with ornamental odour and small size leaves

Breleeb: Yugoslavian origin

Basmakzanty: Greek origin

Samsoon: Turkish origin

Abhath-5: Bulgarian hybrid and locally improved

4. Hookah tobacco (Tenbak): Local tenbak and Iranian tenbak

5. American tobacco: high yielding varieties with large size leaves and ornamental odour, include Burley tobacco and Virginia tobacco

Tobacco Culture: The culture of tobacco can be divided into several key areas: 1) transplant production; 2) field growing; 3) harvest; 4) and curing.

Cultivation requirements before transplanting:

1- Transplant production: Traditional bed preparation: Traditionally, tobacco is seeded into beds or cold frames, and then transplanted to the production field when plants reach a height of 10-15 cm. Seedling beds are located on well-drained sites that have been well cleared of weeds and trash.

Sloping beds on southern exposure produce the strongest transplants. The soil is sterilized using chemicals on most conventional farms. Wood fires and steam may be used as alternatives. Soil solarization may be another option; planting bed locations should be changed each year. The seedling bed should be manured in the previous fall, shallow-tilled, and planted with a cover crop if possible. This cover crop should be incorporated in early spring, well in advance of seeding. The seedling tobacco bed typically receives additional supplementary fertilization. Rates vary depending on the type of tobacco being grown. Flue-cured tobacco receives relatively high rates of fertilizer, while fire-cured, burley, dark, air-cured, and shade-grown cigar-wrapper types receive low rates. Medium rates of fertilizer are provided to other cigar types and to aromatic tobaccos. Float bed transplant production: An alternative system of seedling production using hydroponics is coming into wider use. Tobacco is seeded into trays with a soil-less potting mix. The trays are then floated on a bed of water.

2- Crop rotation: Growing tobacco in a planned rotation with other crops is a good way to manage fertility and suppress many weeds, insect pests, and plant diseases, particularly black root rot (*Thielaviopsis basicola*), nematodes, and bacterial wilt (*Pseudomonas solanacearum*). Since the economic value of tobacco is very high, it is at the top of the pecking order with regard to planned rotations, and the welfare of other crops is of secondary concern. As a rule, tobacco does very well following corn, soybean, sugar beet, sunflower and cereal crops. Leaf quality is usually reduced following leguminous forage crops and cover crops, because of excessive soil nitrogen and organic matter. Quality has also been observed to vary following legume crops of groundnut, soybeans, cowpeas etc.

3- Manures and Fertilizers: Fertilization of tobacco using standard commercial fertilizers is the routine practice for tobacco cultivation. Nitrogen is managed carefully to avoid excessive growth and accumulation of nitrogen compounds in the leaves. Phosphate is also managed carefully, as excessive amounts in the leaves alter burning characteristics of the leaf. High potash levels, on the other hand, are desirable. Adequate soil potash is also important in suppressing angular leaf spot and bacterial leaf spot. Chlorine-based fertilizers, however, such as potassium chloride, cannot be used, as they too reduce burning quality of the tobacco. Application of fertilizers depend on tobacco type:

Nitrogen: 750-1250 kg/ha ammonium nitrate (33%) for burley tobacco

70-200 kg/ha for Virginia tobacco in poor soils; in fertile soil no need to add any nitrogenous fertilizers. 500-750 kg/ha for hookah tobacco.

200-300 kg/ha to other types (varieties) of tobacco.

The variety Shak Albent prefers animal manure to get good taste and strong smoking quality. So, adding of 20-40 m^3/ha every three years and 300-500 kg/ha of ammonium nitrate in the second and third year of growing. With respect to phosphorus and potassium normally we add 20-200 kg/ha of tri-super phosphate (46%) for most Syrian varieties. Manures can be used in tobacco production. Dark tobacco, especially, responds well to fertilization by manures; though it is advisable that they be applied and incorporated the previous fall. Application of animal manures to flue-cured and other lighter tobaccos is much more risky. It is advisable that manures be used on other crops in rotation, to minimize any possible side effects on the tobacco crop.

4-Transplanting of tobacco: The optimum transplanting date in our country extends from April till first week of May. Transplants are set out in rows, which may vary depending on different factors such as tobacco type and variety, soil type, and equipment determine the precise spacing used.

Care operations of tobacco crop after establishment:

1- Irrigation: Tobacco is a mesophyte plant. About 80-85 of the plant weight is water but it can tolerate drought more than excess moisture. It has deep and vigorous root system; an early drought is preferred for better establishment and it enables the plant to face any moisture stress during the growth of the plant. The total water requirements of tobacco is about 500 mm. Part of this can be supplied by the stored moisture in the soil and remaining quantity can be met by irrigation. The number of irrigations depends on soil type and tobacco type. Virginia tobacco in light soils can receive 7 - 8 irrigations, whereas, oriental tobacco in heavy soil will receive less irrigation. The quality of irrigation water should be optimum to get superior quality.

2- Weed management and inter-cultivation: Mechanical cultivation and hand hoeing are used for weed management. Deep cultivation is allowable shortly after transplanting, but may damage crop roots if continued into the season. Cultivation and hoeing have the additional value of breaking the soil crust, allowing proper air exchange, and improving crop yield and quality.

3-Topping and Desuckering: When the tobacco crop is about half-grown, flower buds begin to appear.These flower heads are removed or topped to prevent seed formation, forcing the plant to focus on leaf production. The result is larger, thicker, darker leaves that mature more uniformly and contain more nicotine. Topping may be done by hand or with special machines that cut the flower heads and sacrifice a few leaves. Topping requires two or three trips over the field to catch all the plants.

Topping of plants also stimulates the growth of secondary stems from the base and/or leaf axils. These suckers must also be removed to assure uniformity and quality. While chemicals are available to suppress suckering, removal by hand is to be done every seven to ten days. Suckering is one of the most labour intensive activities in tobacco production, as many plants sucker two or three times before harvest.

Maturity and harvest: There are primarily two harvesting methods: priming and stalk-cutting. Priming entails the picking of individual leaves as they come into their prime. Usually five to six pickings are required at five to ten-day intervals to complete harvest. Leaves may be strung on special sticks or handled in loose bulk form for curing. Priming usually results in higher total yields than stalk-cutting. It is used in the harvest of flue-cured types, shade-grown cigar wrappers, and several other cigar tobacco types.

Stalk-cutting of tobacco is done by cutting the stalk at the base. In the case of burley and fire-cured types, the stalk is often split to hasten drying and to facilitate placement on wooden laths for curing.

Curing: Curing is the process of drying, chlorophyll decomposition, and other natural chemical changes that result in the desired tobacco product. Proper curing is essential to quality. There are three primary forms of barn curing: air curing, flue curing, and fire curing.

All curing takes place in large tight barns in which temperature and humidity are carefully controlled, usually through the use of ventilation and artificial heat. Air curing requires from four to eight weeks. Flue curing entails the use of higher temperatures in the early stages of curing, which results in a lighter color. Fire curing utilizes natural drying for the first three to five days, followed by the use of hardwood fires for higher-temperature drying and to impart a characteristic odour and taste to the tobacco.

Breeding objectives in Tobacco:

1. High yield and quality of the leaves

2. Good agriculture characters like strong leaves, synchronized leaf maturity, erect types, less axiliary buds types.

3. Resistance to insects and diseases and nematodes.

Environmental stresses: Tobacco is affected by several important fungal, nematode and viral diseases; among them, damping off, frog eye, leaf spot and nematodes are major diseases in nursery. While mosaic, black shank and leaf curl are serious diseases in the field. The important insects are: tobacco caterpillar, grass hopper, the white fly, aphids and shoot borer. The broom rape or root parasite orobanche reduces the yield of tobacco by 24-52%.

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