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FLORICULTURE AND LANDSCAPE DESIGN (HORT523)

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CHAPTER ONE

Horticultural Science

The word horticulture is derived from a Latin word meaning garden cultivation (Hortus = garden + culture = cultivation). Over the years, the horticulture industry has developed far beyond this simple definition. Today horticulture includes the cultivation, processing, and sale of flowes, nuts, vegetables, ornamental plants, and flower.

The horticulture industry consists of the major four divisions:

1. **Pomology**: the science and practice of growing, harvesting, storing, processing, and marketing tree flowes.
2. **Olericulture**: the science and practice of growing, harvesting, storing, processing, and marketing vegetables
3. **Floriculture**: the science and practice of growing, harvesting, storing, designing, marketing flowering plants.
4. **Landscape and nursery industry**: the science and practice of propagating, growing, installing, maintaining, and using grasses, annual plants, shrubs, and trees in landscape.

Floricultural Production

There are five categories of the floriculture industry:

1. The production of cut flowers
2. The production of potted plants
3. The production of bedding plants
4. The production of ornamental trees and shrubs
5. The growing and forcing of flowering bulbs and corms

Each industry is highly specialized with definite requirements, facilities, and technical knowledge,

1.2 World ornamental plants trade

In 2003, the total ornamental produce was estimated to be about 75 billion Euros, of which the share of flowers and ornamental plants was 60 billion Euros (China =34 billion Euros, Europe =10 billion Euros, America's 7 = billion Euros), trees 14 billion Euros, and Bulbs 0.75 billion Euros.

The flower industry comprises the cultivation of and trade in cut flowers, cut foliage, potted plants and bedding plants. Cut flowers mainly include rose, chrysanthemum, carnation and lily. Potted plants and cut flowers have an almost 80% share of the world trade in the so-called ornamental plant products. The cultivation of cut flowers and potted plants is widely spread throughout the world and is included in the statistics of 145 countries. In addition, cut flower acreage and production value in the world are also increasing.

A look at the global cut flower trade indicates that world imports are highly concentrated geographically. Europe takes around 70 per cent of world imports, much of which is intra-European trade. Germany is the largest import market, taking close to one-third of EU import, followed by the United States. The other major importing countries in Europe include Italy, France, the United Kingdom, the Netherlands and Switzerland.

Table 1.1 Consumption of cut flower in EU countries Million €

	1996	**1997**	**1998**	**1999**	***2003**
Germany	3,983	3,478	3,494	3,343	3,492
Italy	2,025	2,001	2,101	2,152	2,557
France	2,127	1,930	2,027	1,939	2,350
England	1,439	1,628	1,803	1,908	2,197
Spain	746	667	732	1,187	936
Holland	670	551	561	543	561
Other	2,234	2,007	2,053	1,565	2,399
Total EU	**13,224**	**12,262**	**12,771**	**12,637**	**14,492**

On the export side, according to relevant resources, over 65 countries are involved in the international trade in cut flowers and foliages, the main countries exporting fresh flowers being the Netherlands, Colombia, Israel, Ecuador, Spain and Italy. Europe is the principal source of the world's exports. The main export destinations of EU exports are other EU member States. The Netherlands remains the world's leading exporter of cut flower. In fact, The Netherlands is a major importer of cut flowers but it re-exports a large proportion of its imported cut flowers, i.e., about 70 per cent of all auctioned imports.

In addition to the traditional centers of production (USA, Japan, Italy, The Netherlands, Columbia), new production centers are developing. Asian countries are moving in the direction of more intensive horticulture, the main production centers being Japan (growing for the domestic market) Israel, India and, Southeast Asian countries such as Vietnam, Thailand, Malaysia, Korea and China. In Latin America and Africa, production is also increasing very quickly.

Leading export countries in Africa are Zimbabwe and Kenya. Kenya is the largest African cut-flower grower, followed by Zimbabwe, Morocco and South Africa. Other promising countries in the market are Zambia, Malawi, Tanzania, and Uganda and also Egypt. With respect to the destination of cut flower exports from Africa, the assortment is focused on the European market because of the high transportation costs, which oblige growers to strive for a high value per kilogram.

If we look at the types of flowers, roses and carnations are the principal traded products globally, with the share of the former growing steadily. Consequently, new entrants into the cut flower trade concentrate on rose due mainly to its favorable value-to-weight ratio and high sales volumes. Consequently, rose is rapidly gaining in market share at the expense of carnations.

1.3 Floriculture in Ethiopian

In Ethiopia, as can be easily discerned from the table below, today the floricultural sector has an insignificant role as an export item. The major export destinations of Ethiopia's cut flower export has so far focused mainly on Germany, The Netherlands, UK and Italy while the other export destinations include: France, UAE, Saudi Arabia, Sweden, Norway, Djibouti, Sudan, and Swaziland.

Table 1.2 Ethiopia's Cut Flower Export Revenue (in Million Birr)

Year	**Cut flower Export (A)**	**National Total Export (B)**	**Share A/B (%)**
1997	1	3,938	0.03
1998	1.7	3,966	0.04
1999	0.9	3,496	0.03
2000	3.1	3,959	0.08
2001	1.3	3,659	0.04
2002	0.2	3,864	0.01
2003	>180		
2006	>270		
2007	>360		

Source: Ethiopian Customs Authority

If Ethiopia is to work towards making cut flower an important export commodity, it is then useful to know some of the major current developments taking place in the global floricultural production and marketing. At present, it is generally expected that consumption will grow in the near future. In fact, growth in cut-flower consumption is greatly dependent on the economic development of the different parts of world and of course on flower-minded culture, making the role of the consumer all the more important. However, more certain is the fact that competition on the world market will increase and that supply is growing quicker than demand, thereby resulting in a fierce competition in the world cut flower markets.

Consumers are becoming more demanding. They have become more aware of what they want to buy and are becoming professional buyers. There are considerable differences by country in the types of and the reasons for which people buy flowers. Besides, consumers ask for wider choices in product

quality levels depending on the purpose of the purchase, as well as for higher levels of service and a wider and deeper assortment. Consequently, in the floricultural export business, selling is no longer considered synonymous with selling simple products but so called - precisely 'fitted'- products for each individual consumer.

There is increasing market competition between floricultural products in terms of quality, environmentally sound production, a wider assortment, service, and price. Moreover, these products are also facing more and more competition from other products used as gifts on special occasions (birthdays, etc) and such products as chocolates.

With respect to the distribution network or channel, the customary tradition of selling these kinds of products by florist shops is giving way to new distribution structures. In this regard, the role of information technology is playing an important supportive role. As a result, apart from global trends towards mergers and increasing vertical and horizontal integration, the distribution of ornamental products is increasingly shifting from the traditional specialist shops to retailers and intensive use of electronic commerce.

With regard to production systems, so as to address the question of quality, to increase the possibilities for growing a wider assortment of flowers and also to be able to grow all year round, floricultural producers are increasingly resorting to using plastic covers, the establishment of more advanced greenhouses and also the application of other modern production technologies and innovations.

1.3.1 Ethiopia's potential for floriculture

Commercial floriculture is still a relatively new industry in Ethiopia but it emerged as a major non-traditional export sector. There are enormous opportunities for expansion and diversification of floriculture products in Ethiopia. Ethiopia has the following advantages in this industry,

1. Suitable Climatic and Natural Resources

Ethiopia has a favorable climate, comparatively abundant land and labor as well as reasonably good water resources, that created ample opportunities for floriculture production. The agro-ecological factors of the country give the chances of all-year-round production capability.

The country has 122 billion cubic meter surface water, 2.6 billion cubic meter ground water, 12 river basins, 18 natural lakes including the Rift Valley lakes and a potential of 3.7 million hectares irrigable land.

Ethiopia's agro-Climatic conditions make it suitable for the production of a broad range of plants used in floriculture. The range of altitude, temperature and soil variability of the country has created an enormous ecological diversity and a huge wealth of biological resources. In other words the wide range of ecological conditions that prevail in the country have created a favorable habitat for diversified forms of life including plants, animals and microorganisms. The existing agro-ecological factors also allow producing a great variety of flower crops. The major flower varieties produced in the country and entered in to export business includes: Roses, Allium, Carnation, Carthamus, Statice, geranium etc

2. **High Level of Support by the government**

The reason for the growing involvement and interest of investors in the floriculture industry is the renewed commitment of the government to reactivate the agricultural export sector.

The Government of Ethiopia has introduced various measures and launched an all-out effort towards the attainment of agricultural development. The government's relentless efforts to exploit the linkages between agriculture and industry through the private sector development is now firmly holding ground.

Ethiopia's industrial development strategy highly encourages investors engaged in the production and export of agricultural products (especially in floriculture, horticulture, pulses and oilseeds). The government has allocated a substantial amount of finance for investors who would be engaged in this sector for export and can apply loans for up to 70% of their investment project. This preferential financing scheme clearly demonstrates that the horticulture and floriculture sector is the priority area of the government.

This special loan is provided through the Development Bank of Ethiopia (DBE) and the bank has the following credit policy:-

- Interest rate is fixed at 7.5% per annum. However, this could vary from time to time.

- The Bank shall give its clients maximum grace period that involves the period up to the commencement of operation. Maximum allowable grace period is fixed at three years.
- All fixed asset of the project shall be held as collateral or loan security of the project.
- The debt / equity ratio requirement shall be 70 / 30 for newly starting projects. However, for ongoing projects which include expansion of existing projects, ratio shall be 60 / 40.
- Loan repayment period is determined taking into account the profitability and debt servicing capacity of the borrowing concern as well as the economic life of major investment items, with the maximum repayment period of 10 years.

3. Ethiopia's Investment Law and Incentives

Ethiopia's market – oriented economic development strategy embraces wide reforms with inducements to both domestic and foreign private investments. The private sector is encouraged to invest in all areas of the economy. To this end, the government has recently revised the investment law of the country offering attractive incentives.

A foreign investor can invest on his / her own or jointly with domestic investors. The minimum capital required of a foreign investor should not be less than USD 100,000 in cash and / or in kind as an initial investment capital per project to start business. The minimum capital for a foreign investor also wishes to team up with a domestic investor or company for a joint investment is USD 60,000.

The investment law guarantees capital repatriation and remittance of dividends. The investment law also provides investment guarantee.

To encourage private investment and promote the inflow of foreign capital and technology into Ethiopia, some of the major incentives which are granted to investors (both domestic and foreign) engaged in new enterprises or expansion in areas qualified for investment incentives include the following:

- One hundred percent exemption from the payment of import customs duties and other taxes levied on imports is granted to an investor to import all investment capital goods, such as plant machinery, equipment, etc., as well as spare parts worth up to 15% of the value of the imported investment capital goods, provided that the goods are not produced locally in comparable quantity, quality and price.

- Investment capital goods imported without the payment of import customs duties and other taxes levied on imports may be transferred to another investor enjoying similar privileges.

- Exemptions from customs duties or other taxes levied on imports are granted for raw materials necessary for the production of export goods.

- Ethiopian products and services destined for export are exempted from the payment of any export tax and other taxes levied on exports.

- Any income derived from an approved new manufacturing and agro-industry investment or investment made in agriculture shall be exempted from the payment of income tax for different periods of time depending upon the area of investment selected, the volume of export to be made, and the location in which the investment is undertaken.

- Any remittance made by a foreign investor from the proceeds of the sale or transfer of shares of assets upon liquidation or winding up of an enterprise is exempted from the payment of any tax.

- Business enterprises that suffer losses during the tax holiday period can carry forward such losses for half of the income tax exemption period following the expiry of the exemption period.

4. Export Potential

Despite the enormous potential of the country, foreign currency earning from the horticultural sub-sector is still at a lower stage, but the trend is positive. As it can be clearly seen from Ethiopia's export statistics horticultural export volume has shown more than 100 percent growth in 2003 compared to that of five years ago. The growth of the export level came amid intensified efforts of the government to boost the export of agricultural products of the country.

5. Proximity to the Global Market and Efficiency of the Transport System

Ethiopia is strategically located in the Horn of Africa, at the crossroads between Africa, the Middle East and Europe. It is situated within easy reach of the Horn's major ports which connects it with the Middle East and Europe, which are Ethiopia's traditional markets for its export products. Ethiopia's

geographical proximity to Europe and the Middle East, has a direct implication to its floriculture export as the major players in the global market are found in these areas.

Road transport is by far the most dominant means of transport in Ethiopia providing for over 90% passenger and freight carriage. Both asphalt and gravel roads radiate from Addis Ababa to main cities, towns and centers of commercial, industrial and agricultural activities. International highways also link Addis Ababa to neighboring countries like Djibouti, Kenya and the Sudan.

Ethiopian Airlines, renowned and reputed for its excellence in its 58 years of service, offers efficient passenger and cargo air transport services. Its international flights link the country with over 45 cities in four continents. Twenty six in Africa, twelve in Asia, five in Europe and two in America.

Its extensive domestic network serves 26 destinations. The new passenger terminal at Addis Ababa Bole International Airport matches the growth in operation and fleet of the airline. It is believed that the construction of an additional ultra-modern cargo terminal and maintenance hangar will provide the utmost competent service.

6. Abundant and cheap labor resource

With a population of more than 70 million, 80% of whom living in the rural areas, Ethiopia can provide sufficient labor force, which is competitive in terms of cost. As it is known, the long process required from seedling, cultivating, packing and exporting makes the horticulture and floriculture sector unique in absorbing huge labor force. The cost of labor in Ethiopia is not only lower than some Asian nations, but also African countries such as Tunisia, Mauritius, Kenya, etc.

Conclusion

As a whole, there is a growing trend in the development of the floricultural and horticultural industry. The trend basically portrays how the government's policies and measures in support of genuine investment activities are changing the realities in the agro-business sector, which is found at the heart of the economic development strategy of the nation. The government has equally stepped up efforts that have enabled it to provide conducive investment environment as can be seen from the investment law, incentives and environment.

On the other hand, the export business in the sub-sector has shown great potential and has proven to gain higher amount of hard currency. The trend shows that the country can make more than double of the revenue it used to obtain from coffee. And more importantly, the location of Ethiopia makes it suitable for export to Europe and the Middle East.

Moreover, the floricultural and horticultural industry is labor intensive which Ethiopia has a comparative advantage over other African countries. And this uniqueness is beneficial to both the investor and the country. The investor gets cheap labor source and the country benefits by employing huge labor force, even compared to other agricultural sectors.

Based on the aforementioned comparative advantages of Ethiopia, therefore, the government of Ethiopia invites all interested companies to participate in the investment of Ethiopia's horticulture and floriculture industry. It is possible to set up wholly owned (sole) companies or invest in joint venture with Ethiopian companies.

1.3.2 Current status

More than 32 companies are exporting cut flowers and ornamental plants. Half of them are foreign investors. In addition more than 100 new investors took investment licenses

- Export earning
  - 2003: $ 20 million
  - 2006: $ 300 million
  - 2007 expected to reach $400 million

Some of the Successful companies invested in Ethiopia

Company	Owners	Area coverage (ha)	Major flower	Export destination
Golden Rose Agro Farms Ltd	UK and Kuwaiti	20	Rose and hypercium	Scandinavian countries, Italy and United Arab Emirates
Ethio Dream PLC	Italian, Saudi and Yemeni citizens	22	roses	Germany, Italy, Scandinavian countries, Saudi Arabia and UAE
Menagesha Rose farm	Ethiopian investor	7	roses	Europe
ET Highland Flora	Ethiopian and Dutch investors	30	roses	Germany, Holland, Scandinavian countries, Middle East countries
DYR Business Group	local	13	carnation	Europe
Spirit Flowers Limited	Israeli-based	32	Gypsophila	Europe
Joy Tech flower farm	Ethiopian and Israeli investors	13	Roses	Europe
Dugda Floriculture		14		
Red fox Ethiopia	German-based international flower growing company		Geranium	Japan, Europe, USA, Costa Rica and Canada, among others.
Share Ethiopian	Dutch investor	100	Roses	
Marnque flower farm	Dutch investor	30	Cut flowers and ornamental plants	European markets
Rose Ethiopia		28	roses	Dutch auction
Ethioplants	Dutch flower			
Karuturi Networks	Indian investor	50	Roses	

1.3.3 Challenges to floriculture industry

Given the conducive climatic conditions and cheap labour availability, Ethiopia, like the other African countries, can have the potential to produce and export floricultural products that have high volume and low cost price. However, the country, at the moment, uses a backward technology and has major constraints in transport and other related vital infrastructural facilities such as cooling facilities and well-scheduled air cargo transport services.

On the contrary, the major players in the field of global floricultural export such as The Netherlands and other EU as well as non-EU countries have favorable position as well as the capacity to invest in good infrastructure, and have the market knowledge, networking and innovations. Through the continual process of innovation in terms of both technologies, product ranges and marketing, The Netherlands and the other EU countries and major competitors from Africa and other developing countries, can maintain a leading position in global cut flowers and potted plants export trade.

The concerned governmental bodies and the business community of Ethiopia should, therefore, be aware that floriculture export business requires strong commitment to know and consistently apply the fast changing innovations in the realms of marketing, production and information technology, and research results related to the flower business. In relation to this, studying and selling in the EU and other consumer markets in their off-season periods need to be carefully explored to be able to get better prices for cut flower exports. Ethiopia should also see possibilities of exporting other floricultural products in addition to cut flower.

The government should also step up its current encouraging effort to create the incentive and support to local and foreign investors engaged or willing to engage in the floricultural business. This support could include global marketing information, improving transport and road conditions, the development of e-commerce trade, and the improvement of the air cargo transport, as well as cooling chain problems, overcoming other major investment and agricultural sector, related bottlenecks including economic and political instabilities.

Given the time sensitive nature of floricultural production and marketing, its requirements of well-developed knowledge, technological and infrastructural facilities, the high quality, varieties and assortments demanded by consumers and the ever increasing competition coming both from well-experienced developed as well as the developing countries' producers, the government of Ethiopia should eye and support the growth of the floricultural sector as part of a wider national export diversification effort meant to reduce the heavy dependence of the country on a handful of raw agricultural commodities dominated by coffee.

Finally, based on the current global export market situations and its future direction of development, Ethiopia should stop giving undue emphasis to the development of one or very few export commodities. Rather, the major export policy of the country should remain the simultaneous

development and promotion of various agricultural, agro-industrial and industrial export products the selection and development of which should be based on strict criteria of resource potential and global competitiveness of the country, as well as the contribution of such an export venture towards poverty reduction and economic rehabilitation for the majority of the poor people of Ethiopia.

CHAPTER TWO
GREENHOUSE PRODUCTION AND THEIR MANAGEMENT

Some of the essential facilities that may be taken for granted are a market. Personnel site and utilities.

2.1 Market Evaluation

Before a new production business is started it must be established where the market is what the market needs are and what the market prices are. It is not too difficult to locate marketplaces but it is very wise to consider what the alternative markets could be if the original market develops less favorably than anticipated

The flower and plant production facilities need to be planned and operated to satisfy a market demand at a price that gives the producer inadequate return on costs and investment.

Yes, if is true that a market demand at an adequate product price can be created, but before the production facilities are established, sound plans for the development of such market need to be made

2.2 Funds for the Production Facility

Funds are required for the establishment and operation of any business. The amount of money needed will depend on the size of the business, the kind of acquisition, the facilities provided, the method of doing business, and production and marketing results.

Funds will be for –

1. Capital investment (land, structures, some utilities, and some equipment)
2. For operation of the business (payroll, fuel, interest, taxes, purchases, shopping costs and marketing costs). These operating expenditures always precede the marketing receipts, and funds are needed for

this purpose. The individual just starting in business must anticipate a considerable time lag between expenditures and receipts and will need enough funds to tide the business over a period of time a few months when there will be no product ready for sale and no income

2.3 Personnel for Commercial Flower Forcing

Management personnel must be given first consideration. If the business is large enough to have more management personal than just the owner of the business the decisions will need to be made as to what kind of managers are needed, the number required and how they can be obtained.

Regardless of the size of the business, the various management special offices that are needed could be production, marketing, engineering, and business office.

The greenhouse workers will need to be recruited from the immediate community. In must instances these workers can be trained on the job. The workers may be male or female and on part-time or full-time employment.

Subsequent evaluations of the worker's effectiveness should be made periodically and some action taken by management to retain or release him or her.

2.4 Greenhouse

2.4.1. Advantages of greenhouse production

The major advantages of greenhouse production are:

- Allow higher productivity and quality produce
- Allows extended growing season
- Allows to produce more flower varieties
- Allow to produce early season crops

2.4.2. The Greenhouse site

There are a multitude of considerations in selecting the site for the greenhouse climate, proximity to market, and availability of inputs (fuel, utilities water and labor)

Some other factors to be considered living conditions schools, places of worship, stores, cultural and athletic events, and recreational areas.

With geographical locations- items to be considered in addition to the above are – topography, transportation cost, and present and future effects of adjacent properties such as electric power supply, and telecommunication for marketing utilities

The quality and quantity of water that is available to the site must be determined. When water has to be supplied by well or pond on the site, there' are some potential problems. The quantity might not be great enough. There might be some quality problems. But well equipped refiners are present that cleans the water for irrigations. Besides wells boreholes, rain water harvested and cemented big reservoirs are used as water supplies

-Trash disposal system must be established to or recycling the trashes plant materials

-Are bus or other public transportation services available to the site? In some instance this will be a consideration in obtaining workers.

2.4.3 Greenhouse Structures

The most obvious differences between greenhouse and other production structures is that greenhouses are covered with material that transmits light. Glass covering has been used for years and still is used effectively. Film plastics are also in use.

The supporting framework may be wood steel or aluminum although the use of wood is no longer in use.

Greenhouses may be constructed either as permanent or temporary structures. Most installations are permanent ones but temporary structures may be used for seasonal crops when the land needs to be vacated shortly.

Greenhouse business will have other structures that have opaque coverings. These may be for heat-generating equipment potting or shopping storage and cool storage.

The houses should be arranged so that labor is conserved and the crop is handled most efficiently. Consideration should be given to the ease with which flowers can be cut and moved to the grading area, and pot plants moved from area or to the shipping room.

Greenhouse frames

The choice of materials for the framework of a greenhouse is based on structural strength, durability, initial costs, and maintenance cost wooden framework is used primarily for temporary or Semi-permanent structures. The most durable wood with the least maintenance cost is redwood. Steel framework has been used widely this does require frequent painting to prevent rust, but it is very satisfactory in other aspects.

The corrosion problem with aluminum is slight and the structure does not require painting. It should be kept in mind, however, that the glazing procedure and maintenance are approximately the same for wood, steel or aluminum.

Greenhouse cover

Greenhouses require coverings that transmit light and because of the excellent light transmission properties of glass, greenhouse structures were constructed with plane surfaces so they could be covered with glass.
Greenhouse roofs must shed moisture- rain & snow and with a structure of plane surfaces, the pitched roof provides that property.

Greenhouses require a venting system of some kind.

For a structure of the same durability the greenhouse framework to be covered by plastic must be as sound as the one that will be covered by glass. The design of the structure might be different but the quality of materials and the strength of the framework must be the same.

Types of greenhouse covering materials

The greenhouse must be covered with clear material that allows maximum light transmission to the plant.

a. Glass: light transmission is excellent
b. Plastic: The plastic greenhouse coverings in most common usage are polyethylene film and fiberglass. Degradation of both types of materials in ultraviolet (UV) light has limited their usefulness in the past but the incorporation of UV stabilizers in the products has decreased the rate of degradation.

Fiberglass is a product that has glass fibers imbedded in plastic. The glass fibers provide reinforcement and the fiberglass panels are flexible but somewhat rigid.

2.4.4. Green house facilities

Conservation of Heat Energy

There is considerable interest in the conservation of heat energy in greenhouses primarily because of dwindling fuel supplies, but also because of greatly increased costs of fuels. Because of the need for a light-transparent covering on greenhouses, it is not possible to install conventional types of heat insulation material in greenhouse structures. The insulation either must be transparent or there needs to be a way to install and remove the insulation daily.

Ventilating and Air-Movement Equipment

A means of exchanging air with the outside is needed to regulate the temperature and humidity in the greenhouse. Recently there has been concern with ventilation in relation to the carbon dioxide content of the air in the greenhouse.

Carbon Dioxide Generation Equipment

Particularly with some kinds of plants there is promotion in growth and development if the amount of carbon dioxide in the greenhouse atmosphere is increased. In the portions of the country that have cool weather from fall to spring, when venting is reduced, it is possible to increase the concentration of carbon dioxide in the air. Various means have been used, but the most common method is by combustion of gas or oil in burners spaced throughout the greenhouse. These units are called carbon dioxide generators, but most of them are adaptations of heating units. The products of the combustion are heat, carbon dioxide, and water vapor.

The natural carbon dioxide concentration in the atmosphere is 300 ppm. The generators are used to increase the amount to 1,000 ppm of more.
The effective time for the increased amount of carbon dioxide is during the daylight hours when food manufacturing is taking place in the plants and carbon dioxide is being used in this process.

Greenhouse Benches

There are two reasons why benches are used in the greenhouse. They make it possible for better control of the environment around the plants, and they allow the work to proceed more efficiently.

The greenhouse bench for cut flowers needs to be level or very nearly level and deep enough to hold at least 15 centimeters of soil. It should provide excellent water drainage and isolation from disease or insect infestation. If the bench is constructed on the ground, the bottom and sides must be a solid piece. Concrete is the only material suitable for such a bench.

Raised benches may be constructed from wood, concrete, or steel. Regardless of the material, water drainage must be perfect.

Sensing Temperatures

Thermometers must be located in the greenhouse at plant level and in sufficient numbers so that they reflect accurately the temperature for the entire house. Placing a single thermometer in a house is not sufficient to determine temperature differentials from end to end or side to side. Thermometers located at eye level are easy to read, but the readings are proper only if the plants are also at that level. For young plants in ground beds, the thermometer should be placed at the ground level.

2.5 Workroom

The workroom should be located, if possible, at the north end of the greenhouse, in order to provide some protection from cold prevailing winds. Its size and design are largely dependent on the size and number of greenhouses it is to serve and the type of crops being grown. If separate from the greenhouse, the workroom should be near enough to minimize walking and make transportation of plants between the two structures simple and convenient.

The workroom should be heated, well lighted, and equipped with tables and storage bins for soil, sand, peat, and other similar materials. A cooler is necessary for the storage of cut flowers. Storage for cut-flower boxes, flats, tools, insecticides, fungicides, fertilizers, and other items necessary for the production of plants should be provided. A steam-treatment box or unit in the workroom is a desirable asset.

2.6. Conveyors

The use of some type of conveyor is widespread in industrial plants where mass-production methods are in vogue. The florist industry, with some exceptions, has been slow to recognize the advantages of such labor-saving devices. This is partially due to the lack of knowledge of the costs of various operations, and also to the reluctance of many growers to change with the times. Conveyor systems are probably most useful where pot plants are grown. The use of conveyors to move plans for the purpose of potting, shifting from one house to another, or moving finished, plants out of the houses for delivery eliminates hours of drudgery. Trolley systems are reasonably priced and save time and money in addition to increasing the efficiency of every employee.

2.7. General Storage

For storage of cut flowers and potted plants that are fully developed in advance of the time they are wanted, some type of structure, either naturally or artificially cooled, is necessary. Refrigerated storages are ideal, as a uniform temperature may be maintained, but a shed or heavily shaded greenhouse may be used for this purpose.

2.8. Cool storage

Many greenhouse crops require cool temperatures at some stages of development. Cut flowers should be stored overnight in water in refrigerators maintained at about 7^0C or lower. Some cut flowers can be hold satisfactorily for several days in storages operated at 1^0C. Some bulbs and plants require a period of cool storage in order to flower satisfactorily in the shortage when they flower before the scheduled time.

2.9. Equipment for commercial flower forcing

Equipment for Regulating of Irrigation:

When water-distribution systems are used they may be installed with hand valves and operated manually or they may have electric vales so that they can be controlled by timers. There is a definite advantage in being able to control irrigation by means of a timer. Irrigation controllers can be set to handle watering before the workers arrive in the morning or on weekends. This allows maximum utilization of the water supply, and labor time is saved.

Misting Equipment:

Most propagation areas have misting in-stalled above the benches with cuttings being rooted the system is operated just frequently enough to maintain moisture on the surface of the levels. This reduces the rate of transpiration and the moisture content in the cutting is maintained.

Equipment for Handling fertilizer

Greenhouse growers determine the need for fertilizer applications by having analyses made of soil or leaves for the mineral nutrient content. Soil analysis should be made on regular basis, and leaf analysis is done only if there is evidence of trouble that cannot be identified by other means.

Fertilizer applications may be made either in the dry or the liquid form. Fertilizer applied in dry form may be distributed over the soil as uniformly as possible and mixed into the soil as the soil is prepared for planting, or it may be distributed evenly over the soil surface after planting. Usually, these are operations by hand. Special equipment for the distribution of fertilizer in the dry form for greenhouse crops is not commonly available.

Commercial fertilizers are available as soluble and chemical salts. Devices have been designed or adapted to add liquid fertilizer concentrate to water as it is dispensed in irrigation, some of the advantages uniform supply of fertilizer in the soil is provided. These devices usually are known as proportioners.

Pest and pathogen control Equipment

In addition to equipment for applying pest and pathogen control materials there must be a secure storage area, accurate means for measuring the materials, protective gear for personnel, and adequate place for personnel to clean themselves. The most common means of applying pesticides is by hydraulic spraying because the control materials usually are in the form that can be used in that way, it is possible that some control materials are available that may be applied as a dust, granule, fog, fumigant, or aerial.

Equipment for Application of other Agricultural chemicals

Most of the other agricultural chemicals either are sprayed over the plants or are drenched on the soil. In either instance it is a hydraulic application. Growth- regulate materials are used on several greenhouse crops. Much of the growth-regultant spraying can be handled with small compression sprayers with tank volumes form about 4 to 12 liters. However, these sprayers are more effective if they are the type that is pressurized form compressed air tanks rather they pumped by hand. The sprayers used for application of growth-regulate materials should be used for that purpose only.

In the greenhouse, weed control in crop soils is one of the results of steaming the soils before planting. Non-crop areas such as under benches and walks do need some weed-control measures. Most of the herbicides have the potential of damaging crop plants as well as weeds, and these materials muse be used in such a way that there is no contact with the crop plants. Small, hand-pumped sprayers usually are suitable for weed-control work. These sprayers, however, must be used only for weed control

CHAPTER 3
PRINCIPLES/TECHNIQUES OF HARVESTING & POSTHARVEST OPERATIONS

The basic fact regarding the post-harvest handling of horticultural produce is that they are 'living' structures. Most metabolic reactions and physiological activity continue after harvest. Flowes, vegetables and ornamentals respire oxygen and give off $C0_2$ and heat. Respiration and transpiration continue after harvest - since the product is removed from its normal source of water, photosynthates and minerals, the product is dependent entirely on its own food reserves and moisture content. Since losses of restorable substrates and moisture are not replenished deterioration commences.

Based on their respiratory behavior during ripening fruit, flowers and vegetables are classified into

1. *Climacteric* - Apple, avocado, banana, cherimoya, papaya, peach etc.
2. *Non - climacteric* - Cherry, Cucumber, Grape, lemon, Pineapple etc.

Ripening - The completion of the development of a flower and the commencement of senescence. It is an irreversible event.

Climacteric - A marked and sudden rise in the respiration rate of a flower prior to senescence.

Non-climacteric - There is no sharp rise in respiration. Flowers will not be ripe after harvest if they are picked immature climacteric sets only after harvest.

During ripening, flowers undergo major changes in their chemical and physical state. These changes can be grouped into three categories.

a) Textural changes

b) Changes in pigment and

c) Changes in flavor

3.1 Harvesting

3.1.1 Predicting Harvest Date

To most people mature and ripe mean the same. In postharvest physiology, are distance terms for different stages in flower development.

Maturity- the stage at which a commodity has reached a sufficient stage of development that after harvesting and postharvest handling (including ripening where required), its quality will be at least the minimum acceptable to the ultimate consumer.

When considering perishable commodities, there are two types of maturity.

a) Physiological maturity - Maximum growth and maturation have occurred and the plant part will continue ontogeny even if detached from the mother plant.

b) Horticultural (commercial) maturity - The stage of development when a plant or plant part possesses the prerequisites for utilization by the consumer for a particular purpose. Horticultural maturity may occur at any stage during development or senescence e.g. Inflorescence - cauliflower partially developed flowers - cucumber Apple, Banana- are usually nearly fully developed. Therefore, harvestable maturity can occur throughout the developmental cycle, with the precise time-varying with the product in question. Optimum harvest maturity is not a fixed point and varies depending on the criteria utilized to determine it.

How then do we determine when the harvestable maturity has been reached?

With most crops, optimum maturity is determined by specific physical and/or chemical characteristics of the plants or plant parts to be harvested.

Requirements for Maturity Indices.

Maturity measures to be made by produces, handlers and quality control personnel must meet the following requirements.

A. Must be simple to perform and rapid

B. Must be readily performed in the field or greenhouse

C. Should requite relatively inexpensive equipment

D. The index should preferably be objective (a measurement) rather than subjective (an evaluation)

E. The index should consistently be related to the quality and post-harvest life of the commodity for all growers, districts, and years

Methods for measurement of maturity

Physical measurements:

- ***Physical*** attributes - such as size, color, or texture This can be made either subjectively (sensory evaluation) or objectively (a numerical measurement of maturity)**.**
- ***Horticultural (commercial) maturity*** - requires measurement of some characteristics known, to change as the flower matures.
- ***Calendar date (based on flowering or planting*)** - Experienced growers. Only reliable when the seasonal climates are more or less uniform from year to year.
- ***Commodity shape and size*** - ex. Banana (some cultivars become less angular in cross-section

Objective or analytical measurements of maturity tend to be highly consistent.

- *Fresh firmness*-Dissolution of the middle lamella of the cell wall resulting in softening.
  - It can be estimated by finger or thumb pressure.
  - By using pressure testes.
- *Optical measurements* - color changes
- *Respiratory behavior* - in climactic flowes.
- *Heat units* - is an objective measure of the time required for the development of the flowe to maturity after flowering in a particular env't.
- it also measures degree days - Thus, under unusually warm conditions, maturity will be advanced and under cooler conditions delayed.
- The ratio between sugars and acids (citrus, pine apple)
- Minimum juice volume (citrus).

Chemical measurements

Many plant products undergo distinct chemical alterations that are correlated with maturity. Either objective or subjective measure of these changes can be used.

- Tss - refractometer or hydrometer
- Acidity - titration

e.g. The ratio of TSS to titrable acidity more accurately reflects the proper maturity for harvest.

- Conversion of starch to sugar - the intensity of iodine staining
- Taste and odor - as subjective measures

3.2 Harvesting

3.2.1 Harvesting date

Has a direct impact on the post-harvest life of the produce. It can be determined by the maturity indices prepared to the produce to that particular area. For many crops harvesting must proceed within a certain narrow time interval. In some spps, however, fruit may be stored well on the tree for several day/weeks. There are also some conflicting factors - e.g. In apple, storage quality is adversely affected by daying maturity, yet on the other hand, red color tends to increase with time. There are external and internal signs of ripening that aid for harvesting the produce.

Generally, the following changes occur during ripening of horticultural crops

- The crop becomes bigger until reaches full size
- Flesh gets softer
- Starch is converted to sugar
- Sucrose is converted into fructose and glucose
- the acid content goes down
- the green color disappears, other colors become visible
- the aroma and the taste develops.

Harvesting methods

1. Hand harvesting: - (picking, pulling) used for harvesting high-value crops that either sensitive to bruising or must electively picked e.g. straw berry

2. Semi-mechanized or completely mechanized harvesting (clipping, shaking). flowes dropped to the ground and collected by rakes pick up machines with revolving brush sweeps. flowe dropped (caught) on a padded catching frame (may be suitable for the fresh market) require machine-compatible plants-ripen at the same time and become uniform, resist excessive bruising. In many countries harvesting is the most expensive operation e.g. In Israel, packing represents - 40% of the no of working days.

3.3. Post Harvest Handling of Flowes

3.3.1. Post Harvest Physiology of Flowes Affecting Their Shelf- Life

Harvested flowes are still living organs. They continue to respire and lose water as if they well still attached to the parent plant. However, losses are not replaced in the postharvest environment. This metabolic process continues until a stage of over-ripeness is reached. A number of physiological and biochemical processes occur during the postharvest life of a product. These processes may result in deterioration of the produce or improvement (in climacteric flowers). Hence, the major objective of postharvest physiology and technology is the development of the information (physiology) and methods (technology needed to maximize the duration of the period between ripening and deterioration. Moreover it helps to maintain the product as close to harvest condition as possible.

Since death causes irreversible process the products should be maintained in a living state. Otherwise, these changes may involve gross deterioration and drastic differences in flavor, texture, and appearance.

Change that occurs in harvested produce

Change	**Process**	**Examples and significance**
Water loss	Transpiration and evaporation	unattractive appearance, texture changes, loss, shriveling
CH_2O conversion	Enzymatic	starch to sugar (beneficial)
Change in flavors		usually detrimental, but beneficial in crops like pears and bananas.
Softening	Pectic enzymes	-usually detrimental
	water loss	-beneficial in bananas & pears
Change in color	pigment synthesis	- May be detrimental or beneficial
Change in vit	Enzymatic	May be gain (vit - A) or loss(vit-C) content
Decay and rot	Pathological; physiological	Detrimental

3.4 Methods of Handling Flowers

Grading*;* grouping the produce on the basis of some standards. Used to eliminate unsatisfactory items. Hence, diseased injured, unripe, overripe, etc. flowers should be removed. It also This reduces variability, which has an impact on aesthetic value.

Produces can be graded by, cultivar, size, appearance, and when possible by quality. Grading is the basis of long-distance trade. Both sellers and consumers can understand each other. Without grading produces should be inspected individually.

Packaging: - has a significant effect in reducing wastage. educes mechanical damage, undesirable physiological changes and pathological deterioration during storage, transportation and marketing. Packaging can provide protection, convenience, economy, and appeal.

The two main functions of packaging are;

1. To assemble the produce into convenient units for handling (utilization)
2. To protect the product during distribution, storage and marketing (protection)

Modern packages must:

- Have sufficient mechanical strength to protect the contents during handling and transport, and while stalking.
- Be largely unaffected, in terms of mechanical strength, by moisture content when wet or at high R.H.
- Stabilize and secure the product against movement
- Not contain toxic chemicals
- Meet handling and marketing requirements in terms of weight, size and shape.
- Allow rapid cooling and insulation from external heat
- Have sufficient permeability to respiratory cases.
- Offer security for the contents.
- Accurately labeled
- Facilitate easy disposal, reuse or recycling
- Be cost-effective.

Pre-cooling: refers to rapid removal of heat from freshly harvested products in order to slow ripening and reduce deterioration prior to storage or shipment. The internal temperature of flowers harvested on a hot day may so about 100c higher than the air temperature. The removal of field heat, to reduce the temp of the harvested produce to ≈ 0-40c, must be as rapid as possible. Consequently, a great deal of energy is required.

Hence, harvesting is done at night or early in the morning to avoid excessive field heat and related expenses in removing it.

Methods of pre-cooling

I. Contact icing - crushed ice is placed in or on the package. Ice source

ii. Hydro cooling - Water flows through the containers and absorbs heat.

iii. Vacuum cooling - utilizes rapid evaporation of water at reduced pressure.

iv. Air cooling - circulation of cold air.

Transportation

Marketing depends on short-haul movement and handling by growers and upon large-scale, long haul transportation facilities.

The products is effected by -

- Road, truck (refrigerated containers fit), air freight

- Boat uncooled but well ventilated - a short distance
- Sophisticated ships.

In general, flower crops are exported as rapidly as possible after harvest since the majority have short postharvest lives.

Storage and Preservation

- Flowers have continuous demand. In order to ensure extended supply storage is essential. Extending supply of flowers requires retarding the natural physiological deterioration as well as preventing decay by micro-organisms. The method of choosing different storage's depends on the product, its use and the required storage time.

Types of storage

a. *Common storage:* Caves, mounds, trenches etc.

- In places where the temp is low
- Temp is regulated by natural circulation & insulation.

b. Cold storage:

- Temperature and RH are regulated by refrigeration
- Large structures with better insulation can be built e.g. Nura era and Etflowe A.A. store

C. Controlled and modified atmosphere storage (MA and CA)

- The level of 02, CO2, Temp and RH are controlled
- Provide an overall reduction in qualitative and quantitative losses.

Processing

Long- term preservation achieved by a physical and chemical process.

- Sterilizing the food or
- avoids the growth of microorganisms.

This includes –

- Drying
- Fermenting
- canning
- pickling
- freezing

Canning: (thermal preservation): Sterilizing food by heating on the air-tight containers. The heat destroys human pathogenic and food spoiling microorganisms. it also inactivates enzymes that may decompose the product during storage. Heat may affect color, texture and nutritive values. The Cost of glass or metal containers sometimes exceeds the cost of the food they contain & are sometimes uneconomical. And its use is limited to few products.

Freezing- (doesn't remove moisture): Inhibition of microbial activity by reducing temperature It also ceases enzymatic activity

CHAPTER 4
PRODUCTION TECHNOLOGY OF MAJOR FLORICULTURAL CROPS PRODUCED IN ETHIOPIA

Rose (*Rosa hybrids*) Production

Introduction

- Roses have always been the top-selling cut flowers worldwide-ahead of chrysanthemums and carnations.
- This has brought about significant developments in the rose culture and supply.
- There has been a dramatic improvement in the quality of the rose varieties as a result of the significant increase in rose breeding
- There are more roses on offer to the consumer due to the emergence of new, out of season producing countries, including the highland tropics
- New and parallel home and export markets have been increasingly evolved overtime
- The most significant improvement in the rose market
    - Roses that have good lasting quality with a minimum vase-life of 12 days
    - Part of the same development is the ability of the rose flowers to take up water once they have been cut.
    - the development of varieties that can resist fungal diseases
    - tolerance to the effects of heat (high temperature) as to stand the rigors of transport.

4.1. Types of Roses

There are five types of roses grown for cut flower production

1. **Large-Flowered Roses**:

- This are also known as Hybrid Tea roses
- They are generally grown between 50-120 cm in length and yield 100-150/year/m^2
- They become ready for harvesting in pronounced flushes, approximately 40-60 days apart, depending on the temperature and variety.
- These flowers are normally sold through the gift market in the West, such as the Valentine's Day.
- And through most of the rest of the year, they get on average 50% more than the smaller roses
- Generally, large flowered HT roses are difficult to handle. They too frequently fail to take up water when they finally arrive at the florist and they have a shorter vase-life than the Floribunda type
- from the growers point of view, large flowered roses are
    - less expensive to harvest, package, transport and sell,
    - therefore more profitable.
    - they are the roses that most consumers want to purchase as gifts, where price is not so important
- The main producing countries: USA, Colombia, Ecuador, Mexico, Japan, Zimbabwe, Morocco, France and Italy

2. **Medium Flowered Roses**

- Even though they can grow to 50-70 cm and have a bigger flower, they are still classified as short-stemmed.
- They yield up to 220 blooms/m^2/year, and have handling advantages.
- Medium roses are particularly popular with growers in Kenya, where they respond well to the growing conditions.
- Their popularity is also increasing in Holland, Germany, Italy, Israel, Zimbabwe, Japan, Mexico, and Colombia.

3. **Small Flowered Roses**

- Short stemmed or small-flowered roses are most popular in the producing and consuming countries in Europe, such as Holland and Germany, where they are sold relatively cheaply but in large numbers.
- But, they are barely known to the USA
- They produce large number of stems/m2/year (i.e b/n 250-350 stems/m^2/year)
- They are easy to handle and some of the new varieties have exceptionally good vase-lives.
- The disadvantage, however, is that since harvesting is 80% of the labor costs in growing roses, in countries where labor costs are high, production of short-stemmed varieties is not always profitable.
- There are now major areas planted to short roses in Israel, Kenya and more recently Colombia and Zimbabwe
- Main production areas include. Holland, Germany, Israel and Kenya.

4. Spray Roses

- Spray roses produce many blooms per stem
- They grow in much the same way as small flowered roses and often yield a large proportion of singles to sprays.
- They make up a relatively insignificant, but increasing proportion, of the trade in Europe and Japan.
- In the USA, they are not commonly used as cut flowers.
- The spray fetch approximately the same price as long stemmed roses but the price of the singles is a lot lower.
- The main problems with this type of rose is that their yields are generally low and the stems are heavy, and therefore, expensive to airfreight.
- Recently a major area of spray roses that can be grown in the open field has been planted in the highland tropics. Consequently, the prices fallen sharply

5. Miniature Roses

- Miniature roses such as the original Garnet and Carol have stem lengths of b/n 20-40 cm.
- They have much smaller flowers than the small roses.
- Interest in these roses has been reawakened recently by the new popularity of the pot rose.

- Selections from these, together with specially bred varieties for cut flower production, are proving popular in Japan, South Africa and Italy.
- They can yield up to 500 stems/m^2/year but require more labor in harvesting and packing than other varieties.
- The overall scale of production is small when compared with that of long and short-stemmed varieties.

4.2. Basics of Rose Production

- To achieve export standards, roses must
    - be protected from harmful climates (plastic greenhouse or glasshouse).
    - They must also be of a recognized variety.
- The main objective of greenhouse production is used are Powdery mildew and Downy mildew on the leaves and *Phytophtera sp*. in the bloom.
- The planting rate is 5.5-8.0 plants/m2 or 55000-80000 roses/ hectare
    - Normally it is 60000 plants/ha in the warmer climates and
    - 70000 in glasshouses.
- The number of stems cut/m2/year varies according to the climate, variety and the length of the cropping season
- Humidity should be high, especially when it is hot, but not above dew point when it cools down
- Labor requirement:
    - Rose production is labor intensive, requiring b/n 10-15 fulltime equivalent/ha/yr.
    - About 80% of this labor is required in harvesting, grading and packing
- Principal problems area:
    - Dieback in roots, caused by oxygen starvation
    - Powdery and Downey mildew
    - Red spider mite
    - Phytophtera sp in the bloom
    - Crown gall in the roots
    - Aphids
    - Trips

- Damage in transit (slipping forward in the box and damaging the buds)
- Inability to take up water after travel
- Thorns which slow harvesting and handling and damage
- Disbudding

Variety Trends

Selection criteria now include

1. High yielding varieties: some short-stemmed roses are now yielding up to 400 stems/m2/year
2. Long vase-life; new varieties can now last up to 16 days in the vase, thus dramatically increasing the potential market
3. Varieties that take up water easily
4. Thornless varieties for ease of handling
5. Color: Reds are still the most popular but pinks, pastels and bicolors that do not fade are all fast gaining in popularity flowers with more unusual colors such as purple, lilac, orange, and apricot can fetch especially good prices, but the market for theses individual colors might be shallow

Table-color classification

Color Type	**Description**
Single color	Petals similarly colored throughout, although some slight changes may occur as blooms get older
Bi-color	Color of the outside of each petal distinctly different from the inside hue
Multi-color	Color of the petals changes distinctly with age. As a result, flower trusses bear several colors at the same time
Blend	Two or more distinct colors on the inside of each petal
Striped	Two or more distinct colors on each petal, one of which is in the form of distinct bands

Table-Flower Classification

Flower Type	**Description**
Single flower	5-8 petals, e.g. Dortmund, Dog rose

Semi-double	16-25 petals, e.g. Alison Wheatcroft, Virgo
Full	26-40 petals , e.g. Super Star, Fragrant Cloud
Very full	Over 40 petals, e.g. Chicago Peace, Chrysler Imperial

6. Scent: unfortunately, fragrance and good vase-life do not yet go together, especially when the blooms are closed up for some time in a transport box.
7. Resistance to diseases and mechanical damages in harvesting and transport.

4.3. Rose Propagation

A. Cutting

Age

- Make sure you take cuttings from firm but young stems.
- Cuttings are made at any time of the year: shoots are allowed to mature for 7 to 10 days after the usual harvest stage to increase food storage and rooting response.

Leaves

- The cutting can be one, two, or three nodes
- the top leaf is retained
    - to delay growth of the upper axillary bud
    - to provide food for the developing shoot.
    - to provide root-promoting hormones.

Cuts and "wounding"

- Roses can form roots at any point along the stem, so the exact site of the cut is not important.
- Many people "wound" the base of the cutting enhance rooting

Rooting hormones

- You can root most rose varieties without the use of hormone preparations.

- But some roses apparently don't produce adequate supplies of auxin and are difficult to root. If they produce any roots at all, they are few and weak.
- Many growers apply a commercial hormone preparation to stimulate the production of strong roots.
    - Auxin (IBA) and/or (NAA).

Spacing

- Planted 11/2 inches in the row and 3 inches between rows.
- The medium should have good water retention and excellent aeration
- Rooting occurs quickly at a media temperature of 70^0 to 75^0 F

Moisture

- Essential for successfully
- Rooting cuttings is maintaining adequate moisture, both in the soil and in the form of humidity in the air.
- Place the cuttings in pots of moist sand or potting soil,
- then cover them with a plastic bag to maintain high humidity around the cuttings.

Light

- Roses root best in bright light.
- when using the mini-greenhouse method, it's important to avoid overheating by giving some shade from hot, midday sun.
- Put the cuttings in bright shade to allow rooting without too much heat build-up.
- Decrease in misting frequency should begin when roots are observed, in 11 to 14 days,
- to harden the plants for medium temperature.

B. Budding and grafting

- Budded plants are still the most popular.
- They are larger and can produce quality flowers in a relatively short time.

- Plant reproduction by grafting is a minor part of propagation today
    - costs for greenhouse space are high,
    - plants care is expensive,
    - labor is not available for plant maintenance, a
    - grafted plants require a long growing period before quality flowers are produced.

Common Rootstocks

- Modern roses are not grown on their own roots. They budded on to the roots of wild and semi-wild roses or close relatives Rootstock commonly used by nurserymen are

1) *Rosa laxa:*- popular. Almost thorn less for easy budding Rarely suckers transplant well
2) *Rosa canina* (Dog rose):- Most popular of all. Produces hardy bushes, which transplant well.
3) *Rosa multiflora:* sometimes used for standards. Suckers freely and is best suited for light soils

4.4. Environmental requirements

- If possible, the chosen site should be close to the market, or within easy reach of an international airport from where flights go out at least three times per week to the chosen destination.
- If the land is steep, it has to be leveled before it can be developed as a flower farm, though the costs of leveling can be substantial
- The site should be well drained, ideally with a slope of 2-3%
- Rainwater must be taken well away from the greenhouses; otherwise, it can seep back into the growing area raising the ground water level and damaging the root system

Choice of the Greenhouse Structure

- The choice of a greenhouse structure depends entirely on
    - The climatic conditions, the resources (capacity) of the grower,
    - The availability of construction materials.
- But, in the highland tropics, the climate is much kinder.
- Climate control may not be attempted,

Well-ventilated plastic greenhouses can be used.

Soil

- The greenhouse rose is perennial crop with a potential production life of 8 to 10 years.
- Cultivar selection and soil preparation are fundamental decision because they are not correctable during crop life.
- The aim should target to start with a good soil, productive soil, and keep quality by reducing compaction, salinity, nematodes, and soil borne diseases**.**
- Ideally, the soil for roses should be a rich well-aerated loam.
- A sandy soil can be used provided the organic matter level is kept high.

Climate

All cut roses require a similar climatic conditions, the basic essentials of which are:

Temperature

- Growth rate of the rose is very responsive to temperature; growth rate increases with temperature increase.
- Flower quality is affected in opposite direction, as temperature increase petal number and flower bud size decrease.
- Temperatures between 15 ^{0}C and 20 ^{0}C is ideal.
    - Below 15^{o}C, but growth will be slower considerably.
    - above 28 ^{o}C, RH must be kept high to slow evapotranspiration.
- The ideal average temperature for rose production is 22 ^{0}C (roses respond to changes in temperature between day and night and too big a variation may cause problems).
- Excess variation of temperature and RH can cause a high incidence of either Powdery mildew in heat or Downey mildew in the cold and wet conditions
- In highland tropics of 1800-2500m, provided that there is sufficient water, conditions for the production of roses are good almost all year round.
- Comparatively little needs to be spent in the form of greenhouses but a well-ventilated plastic-house is essential to keep the rain off the flowers and to keep the RH high.

Light

- Generally, rose growth and quality increase with increasing light about 1200µmolsec^{-1}m^{-2} photosynthetically active radiation (PAR).
- It must be remembered that increased PAR will be increase greenhouse temperature and decreased relative humidity.
- High pressure mist and fogging system are essential part of humidity management.
- Daytime humidity of 60 to 80% is optimum for rose production.
- It is also important to have good light for as long as possible throughout the day.
- It is also an advantage if the morning sun is available because this is the coldest part of the day and it helps to raise the temperature quickly

Water

- Roses require plenty of water and a well-aerated soil or growing medium (substrate).
- It requires a lot of water especially when it is hot.
- As a rule of thumb, the grower needs to be able to supply the plants with a minimum of mm/day i.e. 60 cubic meters/ha/day.
- The water can come from a well, borehole, river, lake or reservoir, But it should be tested for-pH, salts, and mineral content and for bacterial count.
- The pH for roses should be around 5.8-6.5

Irrigation System

- The irrigation system should be set below the level of the leaves, ensuring that the leaves stay dry and there is a little danger of Downey mildew.
- In the hydroponic production system, water is applied through drippers so the evaporation area is much less.
- In fact, when it is hot, some growers attempt to keep the RH up by spraying a fine mist overhead. This may help control Powder mildew, but if overdone is inclined to cause Botrytis in the bloom.
- So, it is better if the water is applied below the level of the blooms.
- The drip irrigation system normally carries fertilizers.

Nutrition

- In practically all cases, roses are nowadays fed through the drip lines, a process known as "fertigation".
- A liquid fertilization schedule is designed based on soil test, especially pH and salinity, and on occasionally foliar analysis.
- A pH range of 5.5 to 6.3 allows moderate solubility of the micronutrients
- Rose fertilizer solution contain N, P, Mg, Ca, S, and Fe as a regular constituents, and periodically,
- a micronutrient supplement of B, Cu, Mn, Mo, and Zn will be added.
- The amounts required depend entirely on-the growing conditions.
- The elements that every cut stem remove from the soil, have to be replaced, so the more flowers are cut the more fertilizer is required.
- The elements must be applied in a form in which the plant can take them up and so the pH must be right.

Disease management

- A regular preventative spraying program should be carried out against Powdery and Downy mildew
- Sulphur Burner; every night. The dish heats up and the chemicals get released into the greenhouse usually for over eight-hour period.

Integrated Pest Management: -

- is the prevention and control of powdery and Downey

Components

- Hygiene/sanitation
- Supervision,
- Use of resistant / tolerant varieties,
- Biological control (parasites and predators),
- Mechanical and chemical control.

Disbudding:

- Disbudding is removing the 2nd and sometimes 3rd buds that may form alongside the main bud.
- These take away energy from the main bud (i.e. the seriously compete) and if left on the stem can make it unsaleable quality.
- Disbudding is a time-consuming and expensive operation to carryout.

-Another time-consuming aspect of harvesting is avoiding the thorns. This is so where thorny varieties are still cultivated.

Bending

- Axillary shoots at the base of the plant should be bent to maximize assimilate production which is assumed to be important for quality flower production and new shoot regeneration.
- From those shoots. The flower buds must be pinched to restrict flower formation otherwise the growing flowers will compete for limiting factor.

4.5. Harvesting and postharvest handling

- Harvesting is a slow and a painful job
- No one has yet found a way of mechanizing.
- Harvesting can be speeded up by:
    1. Choosing varieties that need little or no disbudding
    2. Choosing varieties that have as few thorns as possible
    3. Reducing the amount of walking involved (i.e. reducing the size of the farm block and keeping the bed lengths short, preferably not more than 35 m)
    4. If possible, providing a monorail or simple transport system along the beds
    5. Internal path for collection of the flower stems
    6. Transportation for the harvested stems to the packinghouse

    1. Roses are cut two times per day
    2. The stage of cutting varies
        - With cultivar

- Season
- Distance of market,

3. Generally rose is cut at the tightest stage at which the flower will open in plain water.
4. The position of cut on the shoot will vary with
    - Market needs for stem length
    - On the height of the plants,
    - The season, and
    - The leafiness of the plant.
5. As a general rule, the cut will be made to the first 5-leaflet leaf above the point of origin of the flowering stem.

Yield

- Depends on-the type and variety of rose, the temperature and light, and the growing medium
- The two most important factors determining the yield are
    - The commercial cut rose varieties will not form flowering stems at all when temperatures are below 14^0C and
    - If there is insufficient light to go with the temperature, the stems will be too weak in quality to be saleable..

Grading

Grading is based on the following major quality parameters

1. Length of stem:-the grade lengths for roses are: 30-40 cm, 40-50 cm, 50-60 cm, 60-80cm, 80-90, 90-100 cm, and 100-120 cm
2. Strength/thickness of stem:-the thicker the better
3. Size, shape and fullness of the bud
4. Color of flower
5. Quality of leaf surface, size and color

Hydration Procedure

- This is done to prevent vascular blockage in the flower stems, which is usually caused by build up of bacteria.

- The wound that opened up, when the stem is cut or damaged, is infected by bacteria in the water.
- The infection builds up rapidly blocking the end of the stem and stopping water reaching being taken into the stem and carried up to the leaves and the flowers.
- One of the first signs of this blockage is neck drop.
- To stop this happening the water and the buckets must be clean as possible at all times and contain a biocide.
- Any produce showing a high bacterial count at export destination markets are downgraded.

The objective of hydration is to remove the blockage;

- by cuttings off the worst section which is at the bottom of the stem
- putting into warm water in which the pH has been lowered,
- through the addition of a preservative or a compound such as citric acid or aluminum sulphate.

The following procedures are nowadays recommended in handling cut flowers at packinghouse, or at the auction centers:

1. Re-cut flower stems, do not remove the lower leaves or thorns at the production packinghouse unless the customer specifically requires it, since this simply opens the stem up to further infection. The lower leaves should be removed at the florists or by the customer.
2. Place in clean containers, in clean warm water (40-43^{0}C), adjusted with preservative (citric acid) to pH 3.0-3.5. Test with litmus paper of pH meter.
3. Remove from the citric acid after approximately 30-60 minutes or when turgid.
4. Place in preservatives in the cooler (cold rooms)

- Please note the flowers when cold are inactive and will not hydrate easily. For about the first 20 minutes of hydration, the water used should be warm enough. Once the water has been taken up, then the flower stems as well as the water can be cooled down again.

Sleeving

- The heads of the roses are only wrapped when the flowers are going to be packaged and transported over long distances.

- The idea of wrapping is to cushion the buds and prevent them from jamming up against the end of the package and bruising.
- materials used: corrugated wrapper paper and foam rubber

Packaging

- The packaging boxes used for roses often vary in size according to their source and destination.
- Depending on the market, the packages are either filled with one variety one grade, or mixed colors one grade.
- The bunches in the boxes should be packed tight.

Airfreight

- The biggest marketing cost to the rose growers is airfreight.
- it is crucial that roses are air freighted as soon as possible after harvesting.
- when air freighted the temperature level must be 2-4^{0}C

Marketing

- skill in marketing is to get the highest possible return
    - Getting the best possible price
    - Minimizing the selling costs
    - Selling the maximum number of flower stems

Summary of Post Harvest Handling of Roses

1. The newly cut or harvested roses are stood in clean water in clean buckets in the production block. This is at ambient temperature so that they can pull water and preservatives into their stems through the normal processes.
2. The roses are then brought to the packinghouse where they are cooled and kept cool, still in water with preservatives, until they can be graded. The temp. in the cool store should be around 2^{0}C.
3. After a few hours, the roses are taken out of the cool store and graded for stem length and other qualities
4. The bunches are stood into water with preservatives again in the cool room.

5. On the day of dispatch, the heads are wrapped and the bunch is sleeved.
6. They are then packaged, cooled (to around 2^0C) and transported to the market or airport in a temperature-controlled truck (of the same temperature level).

Color trends under the world market of roses

1. Big flowers are sold before small
2. Consumers want roses with fragrance in all the color ranges
3. Red is still the predominant color regardless of how the flowers are moved. Reds still account for over 50% of all the sales
4. Yellow and pink are about equal with which together account for about 30% of the market
5. Whites are about 5%

4.6. Quality attributes

- Generally in export rose production, quality is more important than yield
- Hence, the method of growing for roses should be such that it produces;
  1. Long flowers that open easily
  2. Large flowers that open easily
  3. Good flower color and shape
  4. Short internodes
  5. Good leaf surface with no damage from insect and disease
  6. Maximum yield

The size and color of the flowers also be affected by poor growing practices like

a) Allowing water to get onto the flowers can cause Botrytis in the flower
b) Spraying at the wrong time, at too high on air temperature or with the wrong concentrations, can cause burning with petals
c) Too strong light will cause burning of the petal tips.
d) Too little light will cause weak stems, stretched internode and petioles, drooping necks and poor vase-life
e) Leaf quality will be damaged by
   - Deficiency,

- Fungal disease problems such as Mildews,
- Too little water to the plants,
- Leaf Roller and Red Spider Mites

f) If a bud is cut too early, it will fail to open

CHRYSANTHEMUM PRODUCTION

Scientific Name: *Dendranthema* × *grandiflora*

Common Name: Pot Mum

Family: Asteraceae

History

The Florists' potted chrysanthemum is a complex hybrid composed of crosses among several annual and perennial species native to China. Most of the species in the lineage of present day cultivars are from china. Though grown by the Chinese for over 2000 years, cultivars were not available in Europe until the 1800s. In the United States around hybridization started around 1889 and development of the chrysanthemum as a pot crop has occurred since the 1940's. The chrysanthemum used in pot culture today is a hardy or semi-hardy herbaceous perennial with flowers in a wide range of colors.

Flower

The chrysanthemum is a composite inflorescence with the individual flowers borne on a flat or convex receptacle called a capitulum. The heads are borne on long peduncle in cymose clusters. The capitulum is surrounded by an involucre of bracts. A single flower head has one or more outside rows of ray flowers, which are pistillate and a center (brown or green "eye") composed of disk flowers, which are dioecious and usually fertile.

Some of the most common inflorescences form grown commercially and in the garden are described below.

1. **Singles (daisy-like)**:- composed of one or two rows of outer pistillate flowers (rays) and flat bisexual flowers (disk) borne centrally.
2. **Quilled** - similar to the single except the petals are narrow at the base and flair toward the end to form a "spoon" shape.
3. **Anemones**: similar to the single form except the disk flowers are elongated and tubular, forming a cushion. Disk flowers may be the same color as or different color than he ray flowers.
4. **Spider** - similar to the anemone except the petals of the ray and disk flowers are long and tubular.
5. **Pompons**:-a globular head formed by short uniform ray flowers. The shape is considered formal; disk flowers are not apparent.
6. **Decorative**: similar to pompons because they are composed mainly of rays flowers but the outer rows are longer than the central flower, giving the inflorescence a flat and informal shape.
7. **Large flowered blooms**: these are greater than 4 inches and classified in many shapes like incurved double, reflexed double, tabular ray flowers etc.

Cultivars

Chrysanthemum are available in a wide range of flower colors, flower types, and plant sizes. Of these, some are more suited for cut flower production and others for outdoor planting, often called Hardy mums or Fall mums. Cultivars suitable for pot culture today must exhibit the following characteristics: 1) form a well-shaped plant, 2) branch readily, 3) flower quickly on relatively short stems, and 4) have flowers in the desired shape, size, and color.

For cut flower production in the highlands: Golden Princess Anne, Bowl of Gold, Otome (White and Pink), Taiwan Yellow, Taiwan White,

For potted chrysanthemum: Kikubiyori, Snowball, Genie, La France, Rhapsody, Red headline, Miss Hiroshima, Algiers, Capistrano, Autumn Fire

Classification

Chrysanthemum cultivars can be classified based on the following ways: 1) based on flower form, 2) based on cultural type, 3) based on height, and 4) based on response to photoperiod.

Cultural Types

This classification is based on how the cultivars are handled in production.

1) Standards - these types are usually grown single stem with all the lateral flower buds removed to develop one large, terminal flower head. This is usually used for cut flower production.

2) Disbuds - these types are usually grown multi-stem (plants are pinched as rooted cuttings) with the lateral flower buds removed to develop one large, terminal flower head on each lateral. This is usually used for pot crop production.

3) Sprays - these types are usually grown multi-stem with only the terminal flower bud removed to allow all lateral flower buds to flower. This is usually used for pot crop production.

Propagation

Plants are propagated by rooting terminal cuttings. These vegetative cuttings are removed from stock plants maintained under long day conditions that inhibit flower bud formation. Terminal cuttings 3 to 4 inches long that are removed from stock plants can be placed directly in to rooting medium or may be stored at 35 to 38 ^{o}F for several weeks in cartons lined with polyethylene to prevent desiccation.

Propagation Environment

The propagation area should be isolated so the relative humidity can be maintained close to 100% and be large enough to accommodate about 3 weeks of production. Larger, unused areas make the environment more difficult to control.

Sanitation - the propagation should be constructed and equipped to keep everything that may come in contact with the cuttings disinfected. Bench surfaces and floors should be easy to clean and free of weeds.

Temperature - facilities should be available to keep the air temperature 70-85 ^{o}F. Heating in winter should not drop below 68 ^{o}F. Bottom heat to keep the propagation medium 70-74 ^{o}F dramatically speeds rooting.

Light - light intensities should be 3200-3800 ft.ca. Shading in the summer is usually needed not only to reduce the light intensity but to also control heat. Night-break incandescent lighting to simulate long days is mandatory. Supplemental light from HID lamps to improve vegetative growth is often used during low-light period.

Mist - Uniform mist to keep cutting turgid during rooting is vital. Excessive mist will leach nutrients from the medium and leaves, over-saturate the medium reducing aeration, and stretch the cuttings. Inadequate mist causes wilting, necrotic leaf margins, and hard cuttings that do not root uniformly. Cuttings should never wilt! Thus, a continuous film of moisture should cover the leaves until roots form. Tests of the quality of the water supplied to the mist system should be done to determine alkalinity. High alkalinity can increase the pH of the propagation medium and cause chlorosis of the foliage during propagation.

Media - Almost any well-drained, course medium can be used to root chrysanthemums. This may be cells, flats, strips, or pots containing peat-lite media, Rockwool, foams, or other artificial media. Cutting are usually stuck 1" apart in rows and 1-2" between rows.

Rooting Hormone - Rooting hormones containing IBA or NAA may not speed rooting but increase rooting uniformity. Liquids or talks containing 1500 ppm IBA should be applied to the lower -¼" of the cutting.

Growth Retardants - This is used on certain vigorous cultivars during warm times of the years to prevent stretch and produce a compact plant. Cutting are dipped into B-Nine at 1000 ppm and placed in plastic bags in a cooler overnight, then stuck the next morning.

Nutrition - Many growers begin fertilizing chrysanthemum cutting as soon as callus forms (4-7 days) using a balanced fertilizer at 200-250 ppm N. Some growers apply a dilute solution of potassium nitrate through the mist system for the first several days.

Direct Stick

Many growers stick unrooted cuttings directly in the final container. The method reduces labor costs by eliminating the transplant step and can produce a more uniform product because root growth precedes unchecked. Production time is also often reduced. However, a larger, more controlled propagation area is required. Death of one cutting in a pot can ruin the marketability of a 6" pot. Also, cutting must be graded to the same size in each pot for a uniform final product.

Containers for direct sticking should be filled close to the top with medium and watered before sticking. One or two lower leaves should be removed from the base of the cuttings so they may be stuck ½-1" deep.

Potting Media

Many different combinations of media components are used in media for growing pot chrysanthemums. However, a media should be course, loose, and well drained with a high moisture holding capacity and cation exchange capacity. The pH of the medium should be adjusted to 5.7-6.2 using dolomitic limestone. Phosphorus is supplied using superphosphate and a micronutrient fertilizers is also mix in the media.

Transplanting

Rooted cuttings should be graded by size so that individual pots receive the same size cuttings. Unequal cutting size in the same pot inevitably results in and uneven pot at finishing. This can be compensated for only to a limited extent by pinching. Cuttings of a single may be graded into: 1) short - thin stem diameter and not well rooted, 2) average - medium stem diameter and fairly well rooted, and 3) tall - thick stem diameter and well rooted.

Cutting should be planted shallow with the roots just covered with medium. They are planted as close to the pot rim as possible and leaning out from the rim about 45. This allows the maximum space for lateral shoot development and light penetration. Cuttings should be planted in a moist medium and watered in twice soon after planting. The first watering should be clear water followed by a fertilizer solution.

Number of Cuttings per Pot

Chrysanthemums may be grown in pot sizes ranging from 3 to 7", but by far the most common size is the 6 or 6½". The next most common is the 4" pot. Each pot size requires a different number of cutting to produce an acceptable product. Six inch pots require 4 to 5 cuttings per pot in the late spring, summer, and early fall, 5 cuttings per pot are used at other times. Four inch pots always contain one cutting.

Newly transplanted cuttings should be placed pot-to-pot in an area of reduced light where the humidity can be raised with periodic mist (often by hand) for 2-3 days until root growth begins. The plants are often maintained pot-to-pot until the time of pinching. Pot-to-pot spacing conserves greenhouse space, helps maintain humidity around the plants, and minimizes the area required to provide long days.

Fertilization

Pot chrysanthemums require large quantities of fertilizer during the vegetative stage of production, especially nitrogen and potassium. It is vital that they be supplied ample nutrition beginning the day of potting. Many growers will water-in mums using 300-400 ppm N using a balanced fertilizer. This high rate may be applied at each watering until the roots reach the bottom of the pot, then the fertilizer rate is reduced to 200-250 ppm N on a constant liquid feed basis.

Benefits have been observed on pot chrysanthemums when liquid fertilization is combined with a slow-release fertilizer. Application of the slow-release fertilizer is more beneficial when applied to the media surface compared to mixing with the media. Slow-release fertilizer can be applied several days after potting. Follow the manufacturers recommendation for a rate. Liquid fertilization rates should be reduced in combination with slow-release fertilizers.

Soluble salts and pH should be monitored at least every two weeks during production. These readings can be charted to detect significant trends. The soluble salts for pot mums should be 1.5-2.0 mmhos/cm (2:1 extraction) but should not exceed 2.5. pH should remain in the range of 5.8-6.2 Soil and/or tissue test can be taken at least once per month.

Fertilizers high in ammonium (20-40% NH_4) in the vegetative stage during the warmer periods of the year benefit rapid growth. However, the ammonium content should be reduced to <20% during cooler, low light periods of the year.

Fertilizer rates should generally be reduced once flower buds become visible to about 125-150 ppm N. Several studies have shown that post-production keeping quality is improved when fertilization is stopped all-together 3-4 weeks before finish or about the time of disbudding.

Irrigation

Pot chrysanthemums require plentiful amounts of water and fertilization. The media should be moist and enough water should be applied at each watering to completely saturate the medium plus 10-15% leachate.

Manual watering cannot provide the degree of control over soil moisture required for quality pot mum culture and the cost in labor is high. Most good pot mum growers have the crops on some form of automatic watering system when placed at final spacing. Microtube systems are the traditional method. Other methods such as capillary mats and sub-irrigation are used successfully.

Light Intensity

Potted chrysanthemums require the maximum light intensity (5000-6000 ft.ca.) available as long as temperature can be controlled. Generally, keep the greenhouse glazing material clean and replace old polyethylene as soon as light reductions are evident.

Pinching

Terminal buds of pot chrysanthemums are pinched to develop lateral branches and increase the number of flowers on the final product. Before pinching, several requirements must be met: 1) the plant must have a root system that has reached the bottom and sides of the pot, and 2) the development of 1½-1¾" of new growth on the cuttings, generally 12-14 days after planting. A soft pinch is used, removing about ½" of the stem tip, allowing 6-8 nodes to remain on the cutting. Hard pinches are not desirable..

Photoperiod

The application of methods to alter photoperiod and control the vegetative and reproductive state of chrysanthemum revolutionized the culture and marketing of pot mums during the 1940's and 1950's. Previously, chrysanthemums were grown only during a narrow time frame in the fall to take

advantage of a natural change in photoperiod. Today, pot mums can be precisely forced into bloom each week throughout the year.

The chrysanthemum is a qualitative short-day plant with respect to flowering with temperature modifying the photoperiodic response. Plants flower when the day-length is shorter than the critical day-length and grow vegetatively when the day-length is longer than the critical day-length. The usual photoperiodic sequence for producing pot mums is to provide long days for vegetative growth followed by short days for flowering. The amount of time that the plants are provided long days determines the vegetative size of the plants at floral initiation and ultimately influences how big the plants will be at the finish. Long days for vegetative growth are maintained throughout propagation, early growth, pinch, and until the lateral are about 1-1½" long, however, this may vary with the pot size and response group. Artificial short days must be supplied to chrysanthemum during to ensure flower initiation and development. This is accomplished by pulling opaque material (black cloth) over the plants for 12-15 hours per day.

Temperature

The primary goal during long days (vegetative period) is to develop plant size. In chrysanthemum, leaf unfolding rate increases linearly with an increase in temperature up to about 68 ºF, levels off, then declines above about 75 ºF,. Therefore, the optimum temperature range for growth is 68 to 75 ºF. The optimum temperature for flowering generally declines from the beginning of short days to open flower. The optimum temperatures from the beginning of short days to visible flower bud is 68-72 ºF, night and day. Temperatures above and below 68-72 ºF, will delay flowering. After visible bud, optimum temperatures decrease to 65F to about the "showing color" stage and to 60 ºF for the last two weeks. Temperatures below 60 ºF will delay flower development. The optimum temperatures for flower development is lower than for many other crops. Therefore, chrysanthemum crops should have a dedicated finishing area for temperature control.

Carbon Dioxide

Chrysanthemum benefit from the application of supplemental carbon dioxide during the vegetative period with increased dry weight, increased lateral branching, larger leaf area, and shorter production

times. Growers who utilizer supplemental carbon dioxide apply it mostly during propagation and the early vegetative period at 800-1000 ppm.

Disbud and Spray

The purpose of disbudding is to remove all lateral flower buds from each main stem on a pot to redirect the resources of the plant into developing a large, high-quality terminal flower. Disbudding should be performed as soon as the lateral buds are large enough to 'roll out' without damage to the terminal bud. At this time, the tissues are soft enough that the task goes quickly. If disbudding is not performed on time, the lateral buds become 'woody' and becomes difficult to remove, requiring more labor.

The operation required for those cultivars grown as sprays (typically decorative and daisies) involves removal of the terminal flower bud (called Central Bud Removal) to allow lateral flower buds to develop. This operation should be performed as soon as the peduncle supporting the terminal bud begins to elongate and the terminal bud can be removed without damaging the lateral buds.

Growth Retardants

The ideal pot mum is about 2-2½ times the height of the pot. To some extent, this can be controlled by the amount of growth (time from pinch to begin SD) which is allowed to occur under long days. B-Nine (Daminozide) was one of the first growth retardants developed for controlling plant height of chrysanthemum and is still probably the most widely used. B-Nine is applied at 2500-5000 ppm (depending on the cultivar) when the lateral shoots from the pinch are 1½-2" long. A second or third application may be needed depending on the cultivar and time of year. A-Rest, Bonzi, and Sumagic is also labeled for chrysanthemum.

Scheduling

Differences in the rate of growth among chrysanthemum cultivars has lead to their classification into short, medium, and tall groups. The response group combined with the height group has a large effect on how a given cultivar is scheduled. In order to achieve the ideal plant height in a 6" pot, cultivars

in the short group are given 3 weeks of long days, those in the medium group are given 2 weeks of long days, and those in the tall group are given 1 week of long days after the pinch. This allows longer for growth to occur on the short cultivars and less time for growth to occur on the tall cultivars so that short, medium, and tall cultivars finish at about the same height.

Creating a Schedule

1) Determine the finish (flowering) date.
2) Establish total crop time: response time + height time + propagation time.
3) Count back the total crop time.
4) Count forward 2 weeks for rooting cutting in propagation to determine potting date.
5) Count forward the number of weeks required for the height group to determine the pinch date.

Examples:
Cultivar 1: 8 wk / medium. 8 (response) wks + 2 (height) wks + 2 (rooting) wks = 12 wks
Cultivar 2: 9 wk / short. 9 (response) wks + 3 (height) wks + 2 (rooting) wks = 14 wks
Cultivar 3: 10 wk / tall. 10 (response) wks + 1 (height) wks + 2 (rooting) wks = 13 wks

Finish Mothers Day: May 12, 1996						
Cultivar	Stick cutting	Pot rooted cutting	Pinch	Long days	Short days	Finish
C1	Feb 18	Mar 3	Mar 17	Feb 18 - Mar 17	Mar 17 -	May 12
C2	Feb 4	Feb 18	Mar 10	Feb 4 - Mar 10	Mar 10 -	May 12
C3	Feb 11	Feb 25	Mar 3	Feb 11 - Mar 3	Mar 3 -	May 12

Harvesting

Spray mums are generally harvested at the two thirds to the three-fourths open stage; standard mums at the three-fourths to full open stage of development. Flowers to be shipped long distances should be harvested when approximately one-half open. Flowers must be harvested late in the afternoon or early morning.

CARNATION PRODUCTION

Dianthus *caryophyllus* L. family Caryophyllaceae, is native to the Mediterranean area. The genus name comes from the writings of Theophrastus about Dios Anthos, the flower of the gods. Linnaeus chose the species name, caryophullus, after the genus of clove, as the fragrance from carnations is reminiscent of clove. The name carnation probably comes from its use by the ancient Greeks as a coronation flower.

Today's commercial carnations are the products of more than 200 years of breeding Carnations are flowered year-round and have a wider color range, larger flowers, and stronger stems than their wild ancestors. Most commercial cultivars are diploids as tetraplpids are less productive although tetraploid flowers are larger.

Extensive breeding efforts continue worldwide to provide carnations of higher quality and productivity. Present-day breeding objectives include increasing flower color range; offering new flower forms; extending low light and wider temperature tolerance; eliminating disbudding; improving branching on sprays; increasing yield distribution, post harvest longevity, stem strength, compactness, and resistance to insects and diseases; reducing calyx splitting; and enhancing fragrance.

Carnations have cymose inflorescences, hence they can be cultivated as either standard carnations or sprays. Standard carnations are produced by removing all the lateral flower buds and leaving the terminal flower bud development.

1. VEGETATIVE GROWTH

A. Propagation

Cuttings can be purchased from specialty propagators who produce culture- and virus- indexed cuttings. Some growers purchase clean cuttings and produce there own stock in a mother block

program. The mother block is kept isolated from production and is used only for cutting production. However, for most producers it is not economically advantageous to maintain stock plants.

Typically, cuttings are harvested with four to five nodes, 4 to 6 inches in length, with a mass of 0.35 ounces. Cuttings are broken, not cut, to prevent pathogen transfer. Cuttings are stored in polyethylene-lined boxes, but the polyethylene is not sealed. Cuttings are stored dry as cuttings stored wet are more susceptible to pathogens.

Cuttings can be stored for several weeks at 32°F. Increasing the storage temperature reduces the time the cuttings can be stored; however, storing cuttings at temperatures above 32°F improves root initiation.

Media and benches should be steam-pasteurized so that they are free of pathogens. Attention to sanitation is essential to successful propagation of carnation cuttings. Rooting of carnations occurs within 2 to 4 weeks depending on the cultivar and medium temperature. At a 50°F medium temperature, cuttings root in about 3 weeks increasing the medium temperature to 70°F decreases rooting time. Rooting hormones such as napthaeneacetic acid (NAA), enhance rooting. It is advisable to use powder, rather than liquid rooting hormones to reduce the chances for the spread of pathogens. Full light and mist are recommended or optimal and rapid rooting.

B. Planting and Media

Planting dates depend on market demand. It is common for standard carnations to be grown for 2 years with half of the production area planted each year. Spray carnations are usually replanted each year with plantings staggered every 3 to 4 months to even out production. With ground beds or in field culture, a 1-year cropping schedule is recommended to reduce pathogen potential during the second year. Raised beds are preferred over ground beds for improved pathogen and insect control labour usage aeration and nutritional concerns.

Excellent drainage and aeration are prerequisites for producing high quality carnations. Benches or beds should be well drained to prevent the build-up of excess water and soluble salts. Sphagnum peat can be added to improve the porosity of the medium. Over time, however, peat decomposes and can actually reduce porosity. For maximum porosity, coarse inert media such as calcareous gravel coarse sand, perlite, fired clay aggregates, or volcanic scoria can be used successfully, but irrigation frequency is higher and uniformly of watering must be maintained ideally, the pH of the medium should be maintained between 6.0 and 6.8.

Fumigation with methyl bromide/chloropicrin or steam pasteurization is necessary prior to planting to eliminate pathogens, nematodes, and weed seeds. However, since carnations are susceptible to bromide toxicity, methyl bromide should only be used on sandy soils with adequate aeration and leaching poor to planting. Aerated steam is preferred over steaming at higher temperatures ad energy, costs are reduced and more beneficial organisms survive this treatment.

Cuttings should be planted at the same level as they were in propagation. Cuttings that are planted shallow establish faster due to increased aeration and are less susceptible to stem rot caused by *Rhizoctonia*. If 25% of the cuttings fail over after initial watering they have been planted at the proper depth. A fungicidal drench should be made at planting time to reduce fungal infection. Cuttings should be misted or syringed for the first few days following planting to maintain turgor.

C. Spacing and Support

Spacing depends on the cultivar, light level, liming, and pinching programs High-density spacing is used for 1-year crops, and more generous spacings are used for 2 year crops to maintain high yields. For spray or 1-year standard carnations cuttings should be planted at a spacing of 4 x 6 inches or a plant density of six plants per square foot. Two-year crops are planted on 6 x 6 inch or 6 x8 inch spacings or four and three plants per square foot, respectively.

Support wires reduce the incidence of weak and crooked stems, which decrease quality and productivity. Wires also reduce wind damage in field production. Layers of box wire are stretched

over the bed prior to planting and serve as marking guides for planting. As the crop grows. Layers are raised. Plastic mesh, string, and bamboo canes can be used for upper layers, but metal wire is required for lower layers. On standards four to six levels of wire may be required for 1-year crops and up to eight on 2-year crops. The lower layer should be 6 inches above the soil lire with successive layers 8 inches apart. Labor is required to continuously maintain the plants within the wire support.

D. Pinching and Pruning

Pinching is done by hand to reduce the possibility of transmitting pathogens by using knives or clippers. Most spray-type cultivars break freely without pinching but some require a soft pinch. Most standard cultivars are not freely branching and are pinched by using one of four pinching systems that affect time to flowering yield and quality.

The “single pinch” method result in the most rapid flowering but all stems flower about the same time. After the plants have become established, about 3 to 4 weeks after planting the shoot apex is pinched leaving four or five lateral shoots to develop. Plants are pruned to four breaks on outside rows and to three on interior rows. The amount of pruning influences both yield and grade permitting the maximum number of shoots to develop increases yield, but mean flower grade suffers, whereas punning decreases total yield but more flowers of higher grades are produced.

Carnations can also be pinched using a method called a “pinch and a half.” After the initial pinch. One –half of the breaks from the first pinch are pinched a second time after they have attained size, about 5 to 7 weeks after the first pinch. Although this method result in lower yields on the first harvest compared to the single pinch method, it permits more evenness of production over time.

In the “double pinch” method, breaks from the first pinch are pinched when they are 4 to 5 inches in length, approximately 5 weeks after the first pinch. This method is not commonly used because production is extremely high at one time. Weak stems after harvest are also a problem.

A fourth method, “single pinch plus pull pinches” is similar to double-pinching except the second pinch consists of only removing the growing tip rather than a harder pinch. The larger shoots are pull-pinched for 2 months. This method evens out production for an extensive cropping.

If optimal production temperatures cannot be maintained during the summer, the plants are lopped to 12 to 16 inches or gradually pruned back. Severely pruning the plants eliminates unwanted summer production and renews plants for production

E. Irrigation

Although overhead irrigation can be used until flower buds are visible, surface irrigation systems are commonly used throughout carnation production. The types of irrigation systems used include the Gates sprinkler system, plastic soaker hoses, drip irrigation, and furrow and flood irrigation. Drip lines covered with white plastic mulch are quite popular in Holland (Van den Heuvel, 1987). The white plastic increases the utilization of available light and provides the benefits of decreased evaporation and greenhouse humidity, increased irrigation efficiency, and enhanced upper root growth.

For carnations the optimal moisture for the medium should be between 300 to 500 cm tension. Under low light levels, tensions less than 300 cm produce soft elongated growth and low flower quality. Toning the plants by withholding water until they are almost wilted increases stem strength on plants grown under low light. Water tensions greater than 500 cm under high light intensities result in poor flower quality, smaller flowers, and hard growth. Irrigations should be frequent once flowers begin to develop to enhance flower color, size, and longevity.

F. Nutrition

The optimal nitrate level in the medium is between 25 and 40 ppm. During low light conditions nitrate rather than ammoniacal nitrogen, is applied for toning and for stronger stems. However, excess nitrogen causes weak stems in carnations. Low nitrogen levels inhibit flower bud initiation. Steam sterilizing at 2120F may cause ammonium toxicity. Nitrate fertilizers should be used until nitrifying bacteria have been re-established.

The optimal potassium level in the medium for carnations is between 25 and 40 ppm. Low potassium levels reduce yield, grade, stem strength, and longevity Calyx tip dieback is associated with potassium deficiency.

Phosphorus deficiency reduces growth and causes stunted plants. The optimal phosphorus level in the medium is 5 to 10 ppm and is attained by adding superphosphate or triple supaerphosphate. This fertilizer is added and mixed into the soil before adding limestone to optimize phosphorus availability.

Optimal medium calcium levels are 150 to 200 ppm. Calcium deficiency appears as crescent-shaped necrotic lesions 1 to 2 inches from the leaf tip and as calyx scorch. Depending on medium pH, dolomitic limestone or gypsum is added to attain the desired calcium level.

Boron deficiency increases calyx splitting (Adams et al., 1979) and indces bud abortion. Less than optimal foliar born levels (less than 20 to 25 ppm) casues shortened internodes, clubbiness distored flower buds, and “witches – broom syrrptoms. Boron deficiency is more evident with carbon dioxide injection and varying light levels. Borentoxicity appears as leaf tip necrosis on young leaves.

The duration and temperature of the steam pasteurization, low pH (below 5.5), or poor drainage may lead to manganese toxicity on carnations. Manganese toxicity reduces carnation yield and quality and is diagnosed by stunted an dhard growth, leaf distortion, and a distinctive purplish leaf tip burn on the lower leaves. Reducing the length of steaming, using aerated steam (140 F), increasing the soil pH, and adding chelated iron will reduce the incidence of manganese toxicity. The recommended foliar manganese level for carnations is about 35 ppm.

Soluble salt levels should be kept low while maintaining optimum fertility. High salinity levels will decrease yield, fresh flower weight and mean flower grade. A specific conductivity of 25 millimho/cm, using the saturated paste extract, is optimum.

G. Temperature

Temperatures must be adjusted to light intensity to enhance grade and growth. Temperatures should be reduced with decreasing solar radiation and short photoperiods during the winter. production temperatures should increase in the spring with increasing duration and amount of ambient light.

Warmer temperatures are required for producing high quality cuttings than for producing high quality flowers. Moreover, because low temperatures enhance reproductive development on cuttings, stock plants are grown at temperatures higher than for flowering plants. The optimum day temperature for young plants is 5^0 to 9^0F higher than for flowering plants. Spray carnations will tolerate greater temperature extremes than standard carnations.

H. Carbon Dioxide

Carbon dioxide levels affect both growth and quality. Low levels of carbon dioxide, 100 to 150 ppm, in closed greenhouses during the day inhibit growth as the rate of photosynthesis becomes equal to the respiration rate. Thus, ventilating or adding supplemental carbon dioxide is necessary to maintain adequate growth and enhance quality.

Carbon dioxide injection is done during the day, and the amount injected varies with light level. The greenhouse carbon dioxide level should be maintained at 300 to 500 ppm on cloudy days and at 750 to 1500 ppm on sunny days. Carbon dioxide injection (1000 ppm) can increase yields 30 to 35%, reduce the time between harvesting, and increase percent dry weight. Increased yield and reduced time between harvests adds up to increased and more uniform production. An increase in percent dry weight is manifested in enhanced stem strength and flower longevity.

With supplemental carbon dioxide, irrigation and fertility levels must be increased to ensure that optimal growth is maintained. Light level and temperature must also be optimal with the addition of carbon dioxide into the greenhouse environment. Slightly higher temperatures are advantageous with carbon dioxide injection as benefits are not realized until the day temperature, reaches 68^0 to 72^0F.

2. FLOWERING

The strategy in carnation production is to maximize productivity during periods of high demand. Timing of flowering can be predicted as long as the environmental conditions are monitored and adjusted accordingly. Time to flower varies with photoperiod, temperature, light intensity, and cultivar. Hence, flowering is programmed by planting date, temperature, pinching method, light level, photoperiod, and cultivar response.

A. Disbudding

Disbudding of standard carnations is done as soon as lateral buds can be easily removed and should be done on a continuous basis. For the reason, it is the most labor-intensive aspect of standard carnation production but is essential to maintain flower size and quality. Most standard carnation growers remove lateral buds 12 to 16 inches down the stem, or to six nodes below the terminal flower bud.

In spray carnations, the terminal flower bud is removed to give a more uniform and open spray. This can also be done with standard carnations. Removing the ferminal bud on standards will allow the laterals to flower at about the same time and increase yield, but reduces flower grade.

B. Light and Temperature

Dianthus caryophyllus is a long-day plant that naturally flowers in the summer. Breeding has resulted in carnations being perpetually flowering, but photoperiod, light intensity, and temperature can modify the flowering responses.

Carnations have been classified as quantitative long-day plants as long days promote and short days delay flower initiation. Photoperiod does not affect subsequent flower development. Long –day treated plants flower sooner and more uniformly, but have fewer nodes and longer internodes than plants produced under short days. More rapid bud initiation translates to reduced harvest period and total crop time. Lighting, however, does not enhance quality or increase flower size. Most cultivars respond to 2 to 3 weeks of lighting. The effectiveness of the long-day treatment depends on the cultivar, the shoot position, and the stage and rate of development.

Although there are cultivar differences in response to photoperiod, the critical photoperiod for most spray and standard carnations is about 13 hours. Long days can be given as an extension, or as a night-break treatment cyclic lighting is as effective as continuous lighting on standards and sprays provided that it is given throughout the dark period and the total amount of light per dark period is similar.
The rate of flower initiation in carnation is also affected by irradiance. The amount of light has had a tremendous influence on determining the world's carnation production centers. A minimum amount of light to sustain carnation growth is 21.5 klx.

Long-day treatments inhibit lateral branching, so stock pants are produced under short days to increase lateral shoot production and cutting quality, and to ensure the production of vegetative cuttings. Carnation cuttings from short-day treated stock plants root better than plants from long-day stock plants; however, long days during propagation promote rooting (Pokorny and Kamp, 1960). After pinching, short days are given to promote branching and are continued until 70% of the shoots have 10 visible noodes (Healy and Wilins, 1983). Long days are only effective after a certain critical leaf number has been attained. Long days are provided for one to several weeks to promote flower initiation and to increase lateral stem length. After long days, plants flower in about 12 to 16 weeks depending on temperature, cultivar, and light intensity. Short days are then given as extended lighting will delay or even completely inhibit the formation of new shoots.

There is an interaction between amount of ambient light and the number of long days necessary for flower initiatio. Twenty to thirty long days are required for low light levels and 7 to 14 long days under high light conditions. Similar to the effect of photoperiod. light level had little effect on the rate of flower development. This response is related to the effect of light intensity on photsynthetic assimilate supply. High plant densities or low light intensity reduce the number of flowering shoots, flower quality and dry and fresh weight (Mastalerz, 1983). Supplemental lighting during low light periods can increase growth and development and can enhance flowering.

Temperature affects the rate of growth and flower development, productivity, quality, and longevity. Temperatures less than optimal will improve flower quality, but yields will be lower, development will be slower, and the incidence of malformed flowers and splitting is increased. Temperatures

higher than optimal enhance flower development and productivity but cause weak stems, small flowers, and poor flower color.

Flower bud initiation is most rapid and most uniform at temperatures less than 60ºF and is delayed by temperatures above 60ºF. Subsequent flower development is promoted by higher temperatures, but the amount of light determines the optimal temperature for flower development. Supraoptimal temperatures, above 90^{O}F, delay development. Low finishing temperatures increase harvesting time.

C. Calyx Splitting

Calyx splitting is a major problem is standard carnations as flowers are asymmetrical and value is reduced. Carnation flowers with split calyxes are worth only 20 to 25% as much as flowers with intact calyxes. Cultivars vary in susceptibility to splitting. Those with short and broad calyxes are less likely to split than those with long and narrow calyxes. Splitting is attributatable to conditions that favor the proliferation of petals and accessory flowers of conditions that prevent normal calyx expansion.

Low temperatures cause an increase in the production of extra growth centers inside the calyx, but the calyx is not able to contain these extra petals of petaloids and splits. Rapid temperature drops at night enhance growth center proliferation. A gradual, reduction in night temperature (over several hors) will not cause splitting. Carnation buds are most sensitive to this rapid temperature drop approximately 3 to 5 weeks before harvest or when buds are beginning to open. One night at 40ºF will greatly increase the incidence of splitting. Warm night temperatures (55º to 60ºF) are not conducive to splitting. Moreover, wide variations in day versus night temperatures also favor splitting. Day and night temperatures should not vary more than 18ºF to reduce the incidence of calyx splitting.

Both the boron and nitrogen contents in carnations are important factors in calyx splitting (Adams *et al*., 1979). Low nitrogen, high ammoniacal nitrogen, or low boron levels enhance splitting by attributing to weak calyxes. Higher nitrate to ammoniacal nitrogen rations during low light periods are recommended to reduced splitting.

Small rubber bands and clear tape have been used to maintain calyx integrity. Calyxes can be banded when the bud shows a small opening. Banding is often done when carnations are grown in nonheated outdoor or open house production where temperature control is not possible.

Precisely controlled temperatures and optimal fertility levels can virtually eliminate calyx splitting. Additionally, Choosing cultivars that are less prone to splitting will reduce this problem.

3. Postharvest Handling

Carnations are extremely responsive to postharvest treatments. Longevity can be increased two to three times with various postharvest treatments. However, postharvest procedures can account for 30% of the total-cost of production.

Longevity is also contingent on production conditions. Because longevity is dependent on the carbohydrate status of the stems at harvest, temperature, light, and carbon dioxide levels influence longevity. Thus, bolstering the percent dry matter will increase longevity.

A. Harvesting

Flowers are harvested with sharp knives or pruning shears. On standard carnations two to three nodes and on spray carnations three to four nodes are left on the shoots for the next flowering. Flowers should be cut in the early morning when plants are turgid. Standard carnations are harvested as open flowers or in the bud stage. Spray carnations are harvested with two flowers open and the rest showing color. Flowers are handled carefully to avoid breakage and bruising. It is important to expose flowers to a 40^{o} to 48^{o}F environment as soon as possible to reduce plant temperature. Precooling the flowers maintains quality and increases longevity.

B. Storage

Carnations can be stored longer than almost any other cut flower crop without a decrease in quality or longevity. Peak demands can be met by storing carnations over periods of time. Long-term cold,

dry storage is commonplace in carnation production, however, low pressure or hypobaric storage can also be used for carnation flower storage.

Cold storage and shipping environments should be maintained at 33° to 34°F and provide good air circulation and high relative humidity (90 to 95%). At these low temperatures the production of ethylene is inhibited, thus the rate of senescence is reduced.

Cardboard shipping and storage cartons are lined with polyethylene and newspaper. Newspaper is placed on top of the polyethylene, in between layers of flowers, and on top of the flowers to absorb condensations and excess moisture and to prevent bruising. Flowers should not be in contact with the polyethylene, and it should not be sealed. Cross cleats are used in the boxes to prevent the bunches from shifting during transport. The cartons are precooled to 32°F prior to closing the cartons.

An air space should be maintained around the cartons in storage and during shipping to maximize air circulation. Moreover, shipping cartons should have holes to ensure that the cold air can flow freely through the carton to avoid ethylene buildup in the carton. The air is forced through the vent holes in the cartons at a flow rate of 600 to 900 feet per minute, and the polyethylene and newspaper should not restrict the flow.

The water balance in the cut carnation should be at an optimal level for maximum longevity. Moisture stress and low humidity can lead to reduced longevity and petal burn. At the other extreme, excessively high humidity or freestanding water on the flowers and leaves can promote *Botrytis* and other petal blight diseases. Preventing condensation is the best method to avoid petal blight problems. Petal blights not only reduce quality but also increase ethylene evolution from infected flowers.

C. Ethylene

Carnations are sensitive to endogenous and exogenous ethylene. Therefore, carnations should not be stored with fruits, vegetables, cuttings, or cut flowers that release ethylene gas. Exposure of carnation flowers to ethylene accelerates senescence and "sleepiness" and reduces water uptake. Senescence is characterized by a decrease in fresh and dry weight, a climacteric rise in respiration and ethylene production, and an increase in membrane permeability. Sleepiness refers to the upward curling,

cupping, or bending of the petal margins to the extent that the flower is partially closed. Besides exposure to ethylene gas, sleepiness can also be caused by calcium deficiency, lack of water uptake or dehydration, or high temperature during storage.

The stage of flower development influences the response of the carnation to ethylene (Camprubi and Nichols, 1978). With increasing stage of flower development, carnations become increasingly sensitive to ethylene. Buds or immature flowers are relatively tolerant of ethylene and are increasingly so at low temperatures.

D. Stage of Development

Carnations harvested in tight bud or partially open stages store for longer periods of time and have greater longevity than flowers harvested when fully open. Tight buds produces less ethylene, have lower respiration rates, and are more resistant to fungal pathogens. Open flowers can be stored at low temperatures for a maximum of 2 to 3 weeks. Buds can be stored for longer periods of time, such as 6 to 10 weeks. However, for maximum longevity, buds are not stored for longer than 4 to 5 weeks. It has been demonstrated that carnations harvested in the tight bud stage and preconditioned in silver thiosulfate and sucrose can be successfully stored dry for 20 to 24 weeks at 32° to 34°F.

There are additional benefits to harvesting buds rather than open flowers. Cutting at the bud stage helps to meet peak demands, increases yield, salvages flowers that would be discarded before replanting, and decreases the time between croppings (Mynett *et al*., 1983). Moreover, buds are easier to handle and can be packed tighter than open flowers, hence more buds can be stored per unit area, and transportation costs are lower.

E. Postharvest Treatments

Silver is a powerful and specific inhibitor of ehtylene action, hence silver delays flower senescence. Although silver nitrate can be used to enhance carnation longevity, silver thiosulfate (STS) is preferred due to the lower phytotoxicity potential. Carnation buds are conditioned with STS and sucrose before storing to improve longevity. A 20-hour STS pulse treatment can increase flower longevity three to four times compared to nontreated carnation flowers, and longevity is similar to

nonstored flowers. Pulsing temperatures of 68° to 80°F maximize uptake of STS. Because of environmental concerns with silver, however, other inhibitors of ethylene action or synthesis, such as cytokinins, are being tested and have shown promise as carnation pretreatments.

Adding sucrose (10%) to the STS pulse or conditioning solution further increases carnation quality and longevity. Sucrose serves as an energy source and helps maintain membrane structure, function, and favorable osmotic potential.

Fungicides and bactericides are also used in the pulsing and conditioning solutions to reduce fungal and bacterial infections (Farnham *et al*., 1978). Bacterial or fungal contamination of the solution reduces water uptake by plugging the vascular system. Distilled or deionized water is recommended because of the problems with water quality and bacterial content.

Flowers cut in the bud stage are subsequently opened in bud opening solutions at 76° to 80°F. Development is accelerated by this treatment compared to opening in the greenhouse, and quality is typically higher than flowers cut at an open stage. Bud opening solutions contain high sucrose levels (10 to 12%) that promote opening and enhance longevity. Generally, STS and a biocide are added to the opening solution. Nonionic surfactants or detergents are sometimes added to reduce surface tension. Successful opening of buds requires constant light, at an intensity at least 10.8 klx, and 70°F. Tight buds require 4 to 6 days to open, while more mature buds harvested with the petals straight up require only 2 to 3 days to open.

F. Grading

After low-temperature storage, long-term transport, or both open flowers are graded, bunched, recut, and rehydrated in a warm preservative (Fig.2). Bunches of standard carnations are sold 25 stems to the bunch, and spray carnation bunches have 35 opened or partially opened flowers on seven to ten stems.

Carnations are graded on measurable characteristics such as stem length, stem strength, and flower diameter. Other characteristics such as the presence of pathogens; insects; damage caused by either

pathogen, insects, or both; foliar or flower blemishes; sleepiness; malformed flowers; crooked stems; split calyxes; and faded or off-color flowers are determined judgmentally.

Quality Parameters

The major ones are:

6. Length of stem:-the grade lengths for roses are: 30-40 cm, 40-50 cm, 50-60 cm, 60-80cm, 80-90, 90-100 cm, and 100-120 cm
7. Strength/thickness of stem:-the thicker the better
8. Size, shape and fullness of bud
9. Color of flower
10. Quality of leaf surface size and color
11. Freedom from powdery and downy mildew
12. Freshness

The most common mistake and/or fault found in the rose markets is

- damage to the heads,
- bruising of the buds, and
- breaking of the necks.

Physiological Disorders

1. Bullheads:

- Characterized by shorter petals that give the rose a flattened appearance.
- Common in some cultivars grown at cool temperatures
- it is also seen in flowers distorted by thrips
- by excess stem vigor as in the case of renewal shoot
- some cultivars that have a tendency to produce bullheads.

B-Blind shoots

- Rose shoots initiate flowers at an early stage of development but blind shoots abort most flower buds soon thereafter.
- Blind shoots increase in periods of low lights
- Increased carbon dioxide & light levels help to minimize numbers of blinds

C- Leaf Drop

- Is not uncommon in the rose.
- causes are
    - shading from foliage,
    - about inconsistent irrigation & nutritional practices,
    - plant age and
    - a reaction to a pesticide application.
    - heavy infestation of mites & powdery mildew

D-Leaf Distortion

- Spray applications to very young leaves can damage the leaf & prevent normal growth, producing distortions.
- Water stress, usually caused by high light intensity & low humidity, causes a tissue burn.

E. Volatiles

- Rose is sensitive to chemicals from
    - mercury metal and
    - mercuric compounds fungicide,
    - ethylene gas,
    - ammonia,
    - sulfurdioxide,
    - phenoxy-type herbicides.

Pests and Diseases

1. Diseases

Powdery mildew (*Saphaerotheca pannosa* var. rosae)

- The most common disease of roses in greenhouse.
- It attacks leaves, stems, and flower.
- Spores are wind borne from fruiting bodies to new leaves and can germinate in 3 hr.
- Following penetration of the tissue, the fungus develop along outside of the tissue and fruiting bodies are developed to complete the life cycle.
- Development of the disease is related with temperatures and humidity.
    - spore germination, infection and spore production favored
        - Low night temperatures (60^{o}F)
        - high humidity (90 to 99%) favor,.
    - favor spore maturation and release.
        - High temperatures and low humidity (35 to 70%)
- In hot dry periods, the incidence of Powdery mildew can be wide spread especially when there is a significant difference b/n the day and night temperature.
- It appears as a powdery white mark on the leaves
- It does not kill the leaf but marks it and reduces the quality when the flower is sold
- Control of the RH is the best way to slow down the spread, also by using sulphur burners every night as a preventative measure
- Failing that, the only way to get rid of it is to spray daily with different range of fungicides.

Downey mildew (*Peronospora aparsa*)

- Downey mildew is every tropical rose grower's dread
- It is found when the weather is cold and damp and there is limited air circulation around plants.
- The disease enhanced by cool temperatures and high relative humidity, rainy period when relative humidity exceeds 85% is favorable.
- After spore germination, the fungus grows within the leaf and depending on the humidity, spores may be seen on the underside of the leaf.
- The leaf shows black spots and starts to turn yellow, and after a while it drops off causing a major loss of crop
- These is little care for it except by ensuring that the leaves are kept dry by improving the air circulation

- It is not such a problem in heat greenhouses b/s of the air circulation caused by the heating.

Botrytis (*Botrytis cinerea*)

- Botrytis or gray mold is a common disease of flowers.
- Under cool and humid condition, it is a serious problem of roses in transit.
- Spores need up to 12 hrs continuous freestanding water on plant surface to germinate.
- protect the heads from water (damp moisture) that causes Botrytis in the bloom.
- This rots the bloom and causes it to shatter either when it is being handled or transited.
- All irrigation should be a low level
- One or two varieties have been found to be more tolerant to Botrytis.
- Proper heating and ventilation are important control measures

Pests (insects and mites)

A. Red Spider Mite

1. Found throughout the world Particularly prevalent in hot dry conditions in which they can build up very rapidly
2. In the earlier stages, the leaves underneath start to discolor while on the top silvery like pin pricks are to be seen;
3. The red Spider Mite is only the red color when coming out of hibernation or going into hibernation
4. The wide use of fungicides to control Powdery mildew appears to encourage spider mites
5. Sulphur burners, control on both Powdery mildew and spider mite
6. Red Spider Mite is one of the main causes of problems found during phytosanitary inspections in export markets.
7. Most countries have an equally strong disliking of imported mites
8. So, Red Spider Mites must be eliminated on the nursery if the flowers are intended for export

B. Trips

- This small insect pest buries itself into new tissue in the growing points
- The insect complete the life cycle in the plant and the soil.
- difficult to control b/s of quick lifecycle and resistance to almost all pesticides used

C. Whitefly

- It is not a very common problem in roses
- attack the very young leaves and weaken plants
- It is a small white furry insect easily recognized once known
- Both the Tobacco Whitefly and Greenhouse Whitefly,
- once established are very difficult to control
- Therefore, immediate action once seen is required

D. Leaf roller

- Easy to find but by that time the leaf is damaged
- more common in temperate countries than it is in tropical areas
- Controlled by general insecticides which are widely available in the temperate countries

E. Aphids

- A common problem everywhere increasing all the time and going on to different species of rose.
- feed on stems, leaves and flowers.
- easily be detected from the cast skins and black sooty fungus that grows on the honeydew.
- Whilst in the beginning, they are relatively easy to control.
- But, later, they will be getting harder due to the build-up of resistance to the aphidicide range of products by some of the varieties.

CHAPTER 5
THE USE OF PLANT GROWTH REGULATORS IN FLORICULTURE

Growth regulating substances in plants are called *hormones*. Hormones are organic chemicals that act and interact to affect the growth rate. Prominent hormones are:

- *Auxins* (Greek word meaning to increase), accelerate growth by stimulating cell enlargement.
- *Gibberellins,* stimulate growth in stem and leaf by cell elongation. Also, stimulate premature flowering, growth of young fruits, and breaking of dormancy.
- *Cytokinins,* stimulate cell division. Work along with auxins (will not work without auxins present).
- *Inhibitors* (abscisic acid), inhibit seed germination, stem elongation, and hasten ripening of fruit (ethylene gas).

The auxins and gibberellins promote cell enlargement and the cytokinins stimulate cell division

Growth hormones are organic chemicals principally produced by actively growing plant tissue such as shoot tips and young leaves. They move throughout the plant and may be found in many plant parts.

These chemicals react with one another in a very complex system in the plat. In some cases one concentration or amount of a hormone stimulates growth and a different concentration or amount restricts growth.

5.1. Apical Dominance

A good example of regulating growth in plants is seen in the dominance of the terminal bud or shoot. Where *apical dominance* exists, the terminal bud secretes chemicals that inhibit or prevent the growth of axillary buds on the same shoot. Axillary buds are found in the axil or angle between a leaf and the stem. This causes the plant to grow tall and not send out side branches. Once the plant reaches flowering age and the terminal bud becomes a flower bud, the chemicals are not longer secreted. At

this time, the plant starts sending out side branches. It appears that this is a genetic program directing the plant to grow above competing plants in its early years. Once height and access to sunlight are secured, the plant spreads over its competitors. Pinching out the terminal leaf bud of the shoot nullifies the effect on axillary buds, and branching occurs sooner than the plant would have branched if left alone. This method is a commonly used by nurseries to encourage early branching of shrubs and the production of more compact plants.

For years, humans have bee developing methods other than pruning to control the growth rate, size, and shape of plants. Some major achievements include the discovery of:

- Chemical and natural stimulants that cause plants to grow taller or faster.
- Chemical retardants that cause plants to grow slower or cease growing at a certain point.
- Hormones that cause cuttings to root faster.
- Dwarfing rootstock for tree fruits.

5.2. Growth Stimulants

Applications of certain chemicals enable plants to grow taller. The most common chemical of this type is gibberellic acid (GA). It causes the stems of plants to stretch out. The *nodes*, the joints at which buds, leaves, and branches grow out from the stem, are farther apart. Notice how much longer the stems that hold the bossom buds are on the treated plant. Gibberellins also occur naturally in plants.

5.3. Growth Retardants

At times may grow too tall and open to be pleasing to customers. In these cases, chemicals are used to retard the growth of the plants, causing them to be shorter and more compact. Not only are these plants more attractive, but also the shorter stems are better able to support the followers, thereby reducing the need for staking or typing. Today, chemical *retardants* (chemicals *retard* or slow down growth) are used commercially as a normal part of the growing process of many plants.

One of the newest uses of plant growth retardants (PRG) is the application of a chemical to retard lawn grass growth. If applied at first “greenup.” After the first mowing of grass in the spring, a

chemical called “Limit” is absorbed by the roots and restricts grass growth for six to eight weeks. Another material called “Embark” is leaf-absorbed and also restricts grass growth.

A new plant growth retardant called sumagic reduces the height of plants by inhibiting the natural production of the plant hormone gibberellic acid. Gibberellic acid causes stems to elongate or lengthen. This chemical is taken up by the leaves, stem, and roots and moves through the plant to the growing point where it inhibits the production of gibberellic acid.

Plant retardants are also being used in the landscape to control growth on shrubbery and hedges. One application of the PGR Atrimmic after pruning or some regrowth is claimed to last the entire season on plants that have only one flush of growth, thus reducing or eliminating the need to prune. Plants that have a continuous growth habit would need a treatment again in eight weeks.

Atrimmic is a systemic (a material that penetrates the plant, enters the plant sap, and moves through the plant) that works by blocking the plant hormones that stimulate growth. Applied as a foliar spray it is absorbed by the leaves and moves to the shoot tips where it temporarily stops shoot growth.

5.4. Rooting Hormones

When propagating plants from cuttings, it is important that a large percentage of the plants root and that they root as quickly as possible. Some plants root very easily from cuttings without any chemical treatment. Geranium, azalea, and many soft, succulent houseplants require only a moist, well-aerated medium and high humidity to root. Many plants must have some assistance if any or very many of the cuttings are to root successfully.

Why is there a difference in ease of rooting? Early researchers discovered that some plants have more natural root-promoting chemicals than others. Indoleacetic acid (IAA) is a natural plant hormone that causes roots to form on plants stems. It is found in various plants in differing amounts.

Plants also root more easily or with more difficulty at different stages of maturity, which affects the hardness of the wood. Some root best when the wood is soft, others when it is almost hard.

The development of chemical rooting hormones made it possible to root certain plant cuttings that were considered impossible to root before. These chemicals also shortened the length of time required to root cuttings.

The chemical most commonly used for rooting cuttings is indolebutyric acid (IBA). Naphthaleneacetic acid (NAA) and alpha-naphthaleneacetic acid are also widely used. Indoleacetic acid, the first naturally occurring plant hormone to be used, is rarely, if ever, used today. It is generally not as effective as indolebutyric acid or naphthaleneacetic acid.

Rooting hormones are either mixed with talc and used as powders or dissolved in liquid and used as a wet dip. Some of the new liquid dips give better rooting percentages than do the powders. The strength of the active chemical varies from 0.1 percent to 0.8 percent, although concentrations as great as 2 percent of IBA have been used on certain evergreens such as camellias and yews. Whatever their concentration, all rooting hormones should contain a fungicide (a chemical that kills fungi) such as captan to prevent rotting of the cutting. Captan also seems to help promote faster rooting.

5.5. Plant Biostimulants

Biostimulants are natural products. They are organic, meaning from living organisms, and work to both stimulate soil microbial activity and improve soil cation exchange capacity, stimulate plant growth, and promote disease resistance. Humic acid, a product of humus or rotting organic matter, is an example of a soil microbial stimulant.

Root growth biostimulants improve water and nutrient uptake by the roots and also increase the number of fibrous roots. High levels of these growth stimulants are found in kelp seaweed. Fresh kelp is most effective and has been found to greatly increase growth and yields of plants. Processing such as drying, freezing, boiling, and chemical treatment decreases the stimulating effect. There is a product on the market that is processed to retain the stimulating effect of kelp.

Use of biostimulants can greatly reduce the need for fertilizers, especially nitrogen. This not only saves the grower money, but also reduces water pollution from excess nitrogen run-off or percolation into ground or stream water.

Methanol (a form of alcohol) used in small amounts appears to speed up plant growth. In tests by Dr. Andrew A. Benson (University of California) methanol (Methyl alcohol) increased plant yield by 36-100 percent. A 10-30 percent solution of methanol was used.

The alcohol seems to work by blocking photorespiration. Plants use the water for growth rather than transpiring it into the air. This material works best on plants grown in full summer sun. Water use was reduced by as much as 50 percent from some plants. This product is already on the market. Other plants stimulants such as triacontanol and DCPTA are being studied as possible growth regulators.

CHAPTER 6 and SEVEN 7

BASICS OF LANDSCAPE DESIGNING

6.1 Definition of landscaping

Different authorities have offered different meanings,
Landscaping is a method of grading soil
Landscaping is exterior decoration
Landscaping is oil painting of the countryside.
Landscaping may be defined as the use of plants outdoor to fulfill aesthetic and functional purpose. To one landscaping may mean a couple of fruit trees or just plants on the property. To another person, plants in landscaping must not only be selected but also strategically arranged.

Definition of landscaping according to Hannebaum (1999).
Landscaping is the arrangement of space and features on a **property** so that they are at the same time both functional for the needs of that property and pleasing to view.

The needs of the property: land itself, building on the land, or the owner of the land
The features of the property: original appearance or those added later may range from plants, retaining walls, fences, garden pool, and outdoor lights.

- Pleasing to view is the pin point of the definition which means aesthetic value

- *Beauty is in the eye of the beholder*
- No landscape is going to please all who view it.
- Those who owned the property have the interest on the beauty of the property and must be pleased.

The key goal of landscaping design may be summed up in to two: functional and aesthetic.

5.2. Goals of landscaping

To fulfill aesthetic & functional purposes, landscaping may be specifically used to accomplish the following:

1. Enhance the aesthetic appeal of an area. To make more attractive and nurturing to human sprit home and business environments can be beautified through landscaping.
2. Enhance the neighborhood & increase property value. Home with beautiful garden have higher property value on the real estate market. Landscaping can transform a simple structure into an attractive one.
3. Blend concretes and architectural creations into the natural scenery. Plants can be used to introduce life to an area.
4. Provide privacy by shielding the general public from selected areas such as backyards of homes, and utility substations
5. Control vehicular and pedestrian traffic. Pavements indicate where people should walk. Trees, flower beds and other features can be used to discourage people from making undesirable shortcuts along lawns.
6. Hide unsightly conditions of an area.
7. Create recreational grounds to provide places for relaxation and community interaction.
8. Modify environmental factors. Trees can be planted to serve as wind break and to provide shade.
9. Improve and conserve natural resource by reducing soil erosion.
10. Provide therapeutic relief. Enjoying landscape is relaxing.
11. Provide hobby activities for home owners. Caring plants, watering, etc make the owner busy.
12. Reduce noise and environmental pollution. Plants in landscape can be used to absorb noise.

6.3Categories of landscaping

The categories of landscaping do not have fixed boundaries, but may overlap. Knowing the category is helpful in identifying what is required in planning a landscape design. The general principles of landscaping are applied in each case to achieve the best results by integrating functions and aesthetics.

A. **Residential landscaping**:- Residential or home landscaping is geared towards individual home owner and neighborhood needs.

B. **Public landscaping**:- Cities designed to look beautiful by blending architectural design with an effective visually pleasing landscape design. It can be in a form of trees planted along streets and flowers planted in the median or on street corners. It may take the form of recreational park, where a piece of land is developed for residents to rest during their free time. Eg. City squares, city parks, cemeteries and other sacred areas.

C. **Commercial landscaping**:- Commercial landscaping has a public element, since businesses are open to the general public. Commercial places often have large lots of parking. Commercial landscaping is found in places such as shopping malls, hotels, banks and restaurants.

D. **Specialty landscaping**:- is found in places such as zoological gardens and botanical gardens. Botanical gardens are designed to exhibit a large variety of plant types. The design has strong educational component in which plant species are labeled with their common and botanical names. Zoological gardens adopt landscape designs that area functional with respect to the need of the animal on display.

6.4 Landscape Design

Landscape design: is the artificial modification of the terrain, which is driven from the desire to impose order and harmony upon the natural world.

Landscaping combines elements of art and science to create a functional and aesthetically pleasing. One of the initial purposes of landscape design is to blend man's technology (house or building) into

the natural surroundings. To work toward a desirable landscape design, the landscape horticulturist must have a working knowledge of art elements and design principles.

Landscape Design

- The landscape design of a garden is a skillful and artistic arrangement of plants and may be considered as the first step in an effort to beautify an area. It must be remembered that a haphazard collection of plants in a given space will not make a good design. An understanding of horticulture as well as knowledge of ornamentals and planting materials, though essential, is not sufficient to design a given landscape or garden. It also requires a thorough understanding of the aesthetic values of nature and the landscape designer should possess artistic taste.
- A landscape or garden designer should familiar with the growth of various ornamental trees, shrubs annuals and other types of plants in order to properly allocate suitable places and spaces for them when laying-out (designing) the area (i.e. the landscape or garden). He should evolve a design which gives the maximum pleasing effect and try to include utility.

6.4.1 Types of Landscape Design

A. Formal (symmetrical or regular) landscape design

- This is usually considered to be the style of the western countries
- As the name implies, this style is entirely formal and is calculated to afford harmonies and contrast in color and a balanced whole.

  Features:
- One half of the design is equal to the other in shape of flower beds and types of plants
- Methodical symmetry and attention is given to minute details. In other words, the plant is symmetrical and there is no flexibility
- Usually includes design forms or shapes such straight lines regular squares rectangles circles or ovals
- Features or focal points like fountains, water pools, arches, pergolas, trellis, statues etc, are added to create strong visual impact
- This design easily harmonizes with massive buildings with large frontages
- Usually characterized by having some sort of enclosure

B. Informal (freestyle) landscape design

- Far east & Asian countries
- In this design, the plan is asymmetrical and therefore flexible
- It is more natural, with irregular flower beds, pathways or roads
- Here, plants are by and large allowed to grow to their natural form without frequent or strict trimming and pruning.
- This type of design combines the effects of the natural and formal styles of landscaping, which is favored by many.
- It is popularly called artistic and picturesque because it is capable of adapting to different situations to suit a variety of interests and needs. It is, therefore, the most popular of the three styles of landscape or garden designing.
- This is considered the basis of the gardens of the Far East. Southeast and Southern Asian countries. The concept of this type of design is known to have originated in any of those countries.

C. Naturalistic landscape design

- Through this natural or landscape style design, a landscape designer normally aims to imitate or simulate nature in the garden. By so doing, he strives to produce a rural effect
- In fact, this type of design is more suitable when the area is large enough and the scenery and vegetation cover spectacular. Hence, in large urban areas where such natural advantages are not available, this is hardly possible to achieve in its true sense, unless otherwise planned and preserved prior or with the establishment of the town itself

6.4.2 Factors in Landscape Designing

It is obvious that there cannot be any fixed landscape or garden design suited to all landscapes/places and no two designs can be identical. Landscape planning thus affords immense possibilities for evolving a variety of designs. However, the principles employed in landscape design and management are nearly the same whether in a home-garden, school garden or a public park

A landscape designer should be prepared before installation of the landscape. Planning and design are both an art and science. The environment must be thoroughly understood including land topography, soil and climate. The required materials must be selected properly and located to achieve the desired purpose.

❖ The major factors that should be considered in landscape design are

1. The taste and judgment of the owner or the occupant
2. The size of the building
3. Land topography
4. The source of water supply
5. The availability of labor
6. The cost to be incurred
7. The ability and interest of the owner or occupant to maintain it diligently and consistently.

6.4.3 Basic rules of landscape design

A good designer:

- Analyzes the features and space of a given property
- Study the needs of the property and its owner
- Add some features
- Subtract others and
- Ultimately causes the property to function properly while enhancing its appearance

➢ Fulfilling all is not an easy task

➢ The basic rules by which landscape design can be simplified are:

A. Provide for the basic environmental needs of the property

- Among the most important tasks of landscaping is to make a property more comfortable by providing shade, wind protection, and screening.
- Studying the sun and the wind pattern of the property is the first task in any landscape design.
- Simultaneously, the desirable and undesirable views must be analyzed.
- A good knowledge of the area is crucial in making the determination.

- The direction of the prevailing wind along with the path of the sun which changes during the year must be known.
- Shade trees must be positioned to block the sun during the hottest time of the year and allow the penetration of sun rays during winter time.
- A quick diagram of the property that shows the prevailing patterns, the good view to be left open, and those that require screening must be drawn.
- Other notation can also be taken on the diagram: for example proper measurements, customer request, and any reminder about the adjoining properties
- The notes provide valuable information especially if the landscaping design completed away from the property.
- It is also advisable to take photographs (camera or video) so that particular building features will not be forgotten.

B. Accent only the good features of the property; deaccentuate the bad features

Every piece of property has its good features and its bad features. Look first for the good features.

C. Don't bend the rules of nature

- Even the best landscape designer cannot make water run up hill, creating a natural looking forest, or change the climate in an area.
- The rues of nature are largely unbending.
- A designer who undermines and goes against the rules of nature will be forced to deal with problems later.

D. Landscaping with the surrounding area in mind

- Anything that greatly differs from its surrounding will standout.
- Using materials that are endogenous to an area enhance a landscape.
- Trees and shrubs grown well in the area can be selected for landscaping.

E. Don't suggest anything without a reason

- Every part of a landscape design should have a distinct purpose that could be practical as well as environmental consideration to satisfy the interest of the owner.
- Designing landscape without a clear purpose results in overlapping and poorly functioning property.

F. Design landscaping with today in mind but with an eye to the future

- Although over planting is undesirable, under planting is just as bad.
- Try to establish quick maturing landscape without over planting by spacing plants of the same variety closer together and separating those of different varieties to their maturing spacing.
- It is wrong to think that landscape or at least some part of it as being permanent.
- The landscaper and the customer must know that the landscape needs renovation from time to time as we repaint and redecorate our houses periodically.

G. Design landscape for those most concerned with the property

- In designing a landscape, the interest of the owner must be taken in to consideration rather than the desire of the designer.
- This does not mean that the designer should do an inferior landscape design just to suit the poor taste of the customer.
- The landscape should endeavor to find out about the style of landscaping that the customer likes best and provide a well-done plan for that style.

6.5 The Basic in Landscaping Design

6.5.1. Elements of landscape design

Beauty is influenced by culture, traditions, personal experience; the elements that create beauty can be learned. The landscape designer uses plants as the primary objects in creating a design. Plant species have certain beautiful and desirable characteristics or features that influence how they can be used in a landscape. However, the presence of more than one feature in a place will affect their interrelation and interconnection. Choice of features can either enhance or diminish the overall appeal of the display. Hence, to make appropriate choice one should needs to understand the nature of the feature. Elements of art include but are not limited to color, line, form, texture and scale. These elements are never independent of each other, but we will discuss their individual natures before considering the interactions.

A. Color

- Color is the visual sensation produced by different wavelengths of light VIBGYOR. It may be described in terms of hue (VIBGYOR), value (light Vs darkness) and intensity or chroma (its

saturation or brilliance). The choice and combination of colors is a fundamental talent of a landscape designer.

- People respond differently to color. Color and combination of colors affect the feeling and moods of people significantly.

Types of colors

A. Primary colors are red, blue and yellow.
B. Secondary colors: they are combinations of two primary colors. Eg. Orange, green and violet

- For example, yellow and red are combined to yield orange.

C. Tertiary colors are the fusion of one primary and one secondary color. These colors would be between primary and secondary colors.

- Colors can be used to visually change distance perspective. Colors like red, orange, yellow and white are described as warm colors and advance an object or area toward the viewer. These colors and tints placed near the foundation of a house would make the house appear closer to the street.
- Cool colors and deep shades like blue, green and black tend to recede (move away) in a landscape composition and can be used to make the house appear farther from the street.
- Choice and arrangement of color in landscape are critical consideration to overall visual appeal. When color is used for this purpose, consideration must be given to year-round color not just to seasonal color.

B. Line is related to eye movement or flow.

- Line is one dimensional effect produced by arranging three-dimensional objects in a certain fashion.
- The effect of line is accomplished through the arrangement of objects. The concept and creation of line depends upon the purpose of the design and existing patterns.

- In the overall landscape, line is inferred by bed arrangement and the way these beds fit or flow together (Figure 2).

- Line is also created vertically by changes in plant height and the height of tree and shrub canopies. Line in a small area such as an entrance or privacy garden is created by branching habits of plants, arrangement of leaves and/or sequence of plant materials.

Figure 2.

- Straight lines tend to be forceful, structural and stable and direct the observer's eye to a point faster than curved lines. Curved or free-flowing lines are sometimes described as smooth, graceful or gentle and create a relaxing, progressive, moving and natural feeling. Arrangement of landscape objects in a line can be used to direct viewers to the focal point.

C. Form is a three dimensional attribute.

- Form and line are closely related. Line is considered usually in terms of the outline or edge of objects, whereas form is more encompassing. The three

- The concept of form is related also to the three dimensional shape of the plant canopy.
- Form can be discussed in terms of individual plant growth habits or as the planting arrangement in a landscape.
- Plant forms include upright, columnar, pyramidal, vertical oval, round, horizontal oval, vase, weeping, layered etc.
- Form is basically the shape and structure of a plant or mass of plants. Structures also have form and should be considered as such when designing the area around them.

D. Texture describes the surface quality of an object that can be seen or felt.

- Surfaces in the landscape includes buildings, walks, patios, groundcovers and plants.
- The texture of plants differs as the relationships between the leaves, twigs and branches differ

- Coarse, medium or fine could be used to describe texture but so could smooth, rough, glossy or dull.

E. Scale refers to the size of an object or objects in relation to the surroundings.

- Size refers to definite measurements while scale describes the size relationship between adjacent objects.
- The size of plantings and buildings compared on the human scale must be considered (Figure 5).

Figure 5.

6.5.2.Principles of landscape design

There are eight basic principles that guide the landscape designer or architect in planning landscaping. Regardless of the category of landscaping, the observance of the basic principles of design is necessary. These are unity, balance, transition, focalization, proportion, rhythm, repetition and simplicity. All these principles interact to yield the intended design. Landscape design involves the arrangement of different objects to accomplish the purpose of the landscape. Since these objects may vary in color, form, and texture the quality of the results of the arrangement depends on creativity and successful application of the basic principles of design

1. Simplicity: goes hand-in-hand with repetition and can be achieved by elimination of unnecessary detail. Too much variety or detail creates confusion of perception. Simplicity is the reduction of a design to its simplest, functional form, which avoids unnecessary cost and maintenance.

2. Balance: in design refers to the equilibrium or equality of visual attraction (Figure 6

- Symmetrical balance is achieved when one side of the design is a mirror image of the other side.

There is a distinct dividing line between the two sides. Equal lines, forms, textures or colors are on

each side of a symmetrical design.

Figure 6.

- Asymmetrical balance uses different forms, colors and textures to obtain balance of visual attraction.
- These opposing compositions on either side of the central axis create equal attraction.
- The landscape designer must skillfully manipulate the design elements to create asymmetrical balance.
- The central axis must be predetermined and then developed by the elements of art and other principles of design.

3. Transition is a gradual change.

- The transition can be obtained by the arrangement of objects with varying textures, forms, or sizes in a logical sequential order.
- For example, coarse to medium to fine textures, round to oval to linear structural forms, or cylindrical to globular to prostrate plants. An unlimited number of schemes exist by combining elements of various size, form, texture and color to create transition (Figure 7).
- Remember, transition refers to the 3-dimensional perspective of composition, not just the flat or facial view.

Figure 7.

- It is possible to use the transition to extend visual dimensions beyond actual dimensions.
- For example, radical lines in the private area of the landscape can be used to enframe and/or focalize a lake scene.
- The transition of plant materials along these lines can make the scene become a part of the landscape (Figure 8).
- The transition from taller to shorter plants with textural changes from coarse to fine along focal lines emphasizes the beauty of a lake scene.
- Transition from shorter to taller plants and from fine to coarse textures would enframe the scene and make it appear closer, like a painting on a wall.
- Generally, transition assists in the gradual movement of a viewer's eye to the design and within it.

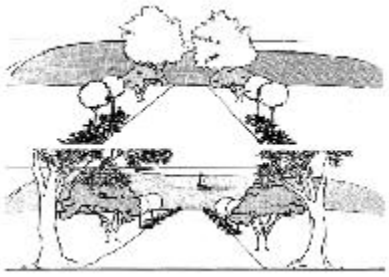

Figure 8.

4. Proportion refers to the size of parts of the design in relation to each other and to the design as a whole. It helps to keep all elements of the landscape in the correct size relationship without towering over the building when fully grown.

- One large towering oak may compliment an office building but would probably dwarf a single-story residence (Figure 9).

Figure 9.

- The desired size relationships of components in a design should pose little problem for the designer who considers this principle routinely in systematic thought processes.

5. Focalization: the principle of focalization of interest recognizes that the viewer's eye wants to see only one feature as being most important within any given view. All other elements complement that important feature (focal point) but do not complete it for attention.

Straight radial lines as in create a strong focalization when compared to curved lines.

- The viewer's eye is quickly forced along straight lines to a focal point.
- Curved lines are stronger when curved toward each other than when curved outward. Indirect focalization is created by lines curved in the same direction.
- Focalization can be adjusted by plant materials along the lines to create symmetrical or asymmetrical focalization.
- Asymmetrical focalization is indirect while symmetrical focalization is more direct, creating stronger focalization.

Figure 10.

6. Repetition refers to the repeated use of features like plants with identical shape, line, form, texture and/or color.

- Too much repetition creates monotony but when used effectively can lead to rhythm, focalization or emphasis.
- Unity can be achieved better by no other means than repetition.
- Think of repetition as not having too much variety in the design which creates a cluttered or busy appearance.

7. Rhythm is achieved when the elements of a design create a feeling of motion which leads the viewer's eye through or even beyond the designed area. This principle is responsible for the sense of continuity among different areas of the landscape. To avoid a disjointed display and create sense of flow or continuity, the different sections of the landscape should be linked, such as by the use of beds of appropriate plants. This linkage create movement in the design. Tools like color schemes, line and form can be repeated to attain rhythm in landscape design.

8. **Unity** is obtained by the effective use of components in a design to express a main idea through consistent style. Unity is the master principle of landscape design. Unity creates the flow among proportion, balance, rhythm and simplicity. The landscape design will complement the surroundings and creates an aesthetic appealing that is pleasing and beautiful.

- Unity means that all parts of the composition or landscape go together; they fit. A natural feeling evolves when each activity area belongs to and blends with the entire landscape.
- Everything selected for a landscape must complement the central scheme and must, above all, serve some functional purpose.

6.5.3. Steps in developing a landscape design

- The plan for the landscape designer should follow a sequence such as the one presented here:

1. Develop a plot plan

- It is difficult to visualize certain aspects of design without putting it to scale on paper.
- The designer should think with drawings or sketches and make the mistakes on paper not on the landscape site.

- The plot plan should consist of
    1) Accurate house placement on the lot,
    2) The accurate lot and house dimensions with window and door placement and
    3) existing driveways and/or walks.

2. Conduct a site analysis

- A complete survey of the customer's property is essential.
- The plot plan will assist you in organizing the information from the site analysis
- A thorough site analysis can save you time and money.
- Existing vegetation, natural factors and features, views, noise levels, utility placement, easements/setback lines and primary architectural features of the house should be noted.

A. Existing plants should be examined.

- Tree condition and placement should be recorded.
- Shrubs, groundcovers and grasses should also be examined as to their condition and potential use.

B. Natural factors and features of a landscape include house orientation, land form, soil conditions, rainfall distribution, seasonal wind pattern and micro-climatic conditions.

- House orientation affects the exposure of various portions of the house to the sun (Figure 11).

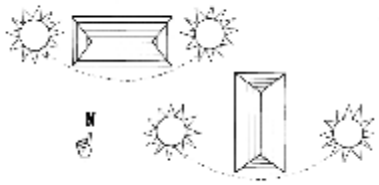

Figure 11.

C. Landform refers to slope or land elevation changes.

It determines surface water drainage patterns

It is essential knowledge for the landscape horticulturalists in developing functional and aesthetically pleasing landscapes.

- Soil characteristics will determine selection and placement of plants.
- Soil pH, nutrient and water holding capacity and drainage should be considered

D. Views should be identified that are to be preserved or accented.

- Likewise, less desirable views must be considered so screening can be planned
- Views and activities 30 feet (9 m) or so from the property line must be surveyed
- During the site analysis, views should be observed from inside the house to outside and from outside to inside the house (Figure 13).
- Observe the neighbors' property from positions on the customer's lot and view the customer's property from the neighbors' lots if possible.
- The house should also be observed at multiple angles from the street.
- Pictures from an instant camera can be helpful in reminding the designer of specific views when sitting back at the drawing table.

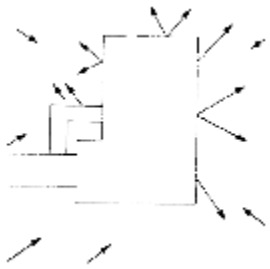

Figure 13.

D. ***Architectural*** style of the house is of primary importance.

- Specific details of interest must be identified during the site analysis.
- Things like the height of windows the height of house corners from the ground and overhang widths should be considered.

3. Assess Family Needs

- A landscape should be an outdoor extension of indoor living areas.
- It should be functional and provide space for family activities.

- Before the designer can create such an environment, knowledge of certain family characteristics is essential.

4. Locate Activity Areas

- Once the family needs have been determined, areas for these activities must be located on the property.
- Their placement should be considered in terms of the house plan and in relation to other activities in and adjacent to the property.
- These activity areas could include a public area, entrance, living area, quiet zone, service and work area, or vegetable or cut-flower garden plot.
- These areas should be defined on the plot plan or maybe on a piece of tracing paper laid over the plot plan.
- Actually, sketch the outline of these areas

Two major considerations for the placement of areas must be emphasized.

1) Place outdoor areas in relation to indoor activity areas. The outdoor living or entertaining area should be an extension of the family or living room in the house. The service area and work area may be an extension of the laundry room, kitchen or garage.

2) Arrange areas relative to the activities in each and activities on adjoining property. For example, do not position the children's play area beside the quiet zone.

5. Plant selection and placement

- Plant selection is the last step in the design process.
- Up until this point, plant form, texture, color and size have been visualized, but now a name must be assigned to each plant.
- Plants are selected on the basis of climatic adaptability to the microclimate of the location, plant architecture and availability.
- No matter how well a plant meets the physical characteristics for a location, if it is not adaptable to the conditions there, it will fail.
- These microclimate conditions include sun intensity and duration, soil conditions, rainfall, air circulation and temperature.
- Plant architecture consists of form, size, texture and color.

- Plant form is classified as columnar, upright, spreading, broad spreading and prostrate.
- Plants should be selected on the basis of their mature size or a size at which they can be maintained easily.
- Texture is referred to as fine, medium or coarse. It is determined by branching habit, leaf size and shape, leaf arrangement, leaf color and leaf surface texture (dull or glossy).
- Plant color is determined by the foliage, flowers and/or fruits. Knowledge of a plant's seasonal color variations is essential.
- Landscape designers must also be aware of insect and disease problems for plants they expect to include in a plan.
- Desirable plants are those resistant to or tolerant of pests like mites, scale, nematodes, borers, root rots, powdery mildew, wilts, galls, blights, and leaf spots
- Plants in some locations must be tolerant of human abuse, air pollution and animals.

6. Minimal Maintenance Considerations.

- Maintenance cannot be avoided, but it can be minimized.
- Even the perfectly designed and installed landscape will fail if maintenance fails
- Complex designs usually require more maintenance.
- Simplicity can be achieved by avoiding unnecessary detail.
- Limit the number of plant species and create well-defined planted areas by not scattering plants throughout open areas.
- Design the appropriate size of maintained area and arrange plants in groups of like species to create a mass effect.
- Tree beds can eliminate trimming, reduce lawn mower damage to tree trunks and increase the speed of mowing

Avoid improper plant selection, spacing and installation that can cause maintenance headaches.

6.5. Parts of a Standard Landscape Garden

Section learning objectives

After studying this section, students are expected to be acquainted with:

- Common Road, paths and walk way in landscape or garden
- What a hedges, borders, edges, flower beds and topiary are?
- Landscape Embellishments
- Establishment and management

Content

3.9.1 Roads, paths and walks

3.9.2 Hedges, borders, edges, flower beds and topiary

3.9.2 Embellishments

A standard garden consists all or some of the following components

- Ω Circulations
- Ω Flower beds
- Ω Carpet beds
- Ω Hedges
- Ω Edges
- Ω Topiary
- Ω Garden embellishments
  - ☼ Water features
  - ☼ Statuary and sculptures
  - ☼ Garden seat
  - ☼ Musical enrichment
  - ☼ Lighting &
  - ☼ Other collected embellishments

6.6.1Roads, paths and walks

Refer books ???

6.5.1.1Hedges, borders, edges, flower beds and topiary

i. Hedges

Small planting of small trees, shrubs or conifers to act as a barrier (fence) where their branches are intertwining.

Use/purpose:

1. To keep trespassing animals away
2. Provide artistic background
3. Partitioning huge areas to small sectors
4. Hide unsightly
5. Wind break
6. as a natural filter against dust

Hedges could be any *height* & *width* depending on: spps type and functions.

⇒ Height depends mainly on functions. E.g. For fence: 1.5-3m

For edges: dwarf spps will be selected

⇒ Width depends on availability of area.

Considerations

1. Hedges should comprise of a single spp. Why?
2. Should withstand regular trimming
3. Should be strong, sturdy & preferably thorny. Why?
4. Adapted to various weather & soil conditions
5. Produce dense compact foliage
6. Long-lived evergreen
7. Require a minimum care & easily maintenance

Species of plants for hedges

1. Conifers: Are the most common. All spps are suitable (*Juniperous spps (Tid, Abbies spp, Cuperisus, Taxas baccata, Casuarina spp, Thuga plicate)*
2. Trees: *Illex aquifolium, Allos cordata*
3. Shrubs: *antana camara*, Bougainvillea, *Hibiscuss rosasinusis*

ii. Flower beds

- Flowers look better when grown together in flower beds.
- The style varies with style of garden
- The major garden styles: Formal, informal and free

The most important point in flower bed is *Simplicity*.

A. Flower in Formal garden style:

☼ Flower beds form major features of gardens

☼ Layout is more of geometrical fashion

☼ More of symmetrical (monotonous/calculated)

☼ Shape of the flowers may be oval, circular, square or rectangular.

☼ Usually placed along sides of drive ways, walk ways & edge of lawn

☼ Preferred by most designers (Easy to layout & Easy for maintenance activity)

B. Flower in Informal garden style:

- ☼ Flowers are given secondary importance.
- ☼ Grown along and/or in front of trees, or shrubs or hedges
- ☼ Without geometrical fashion (no calculation needed)
- ☼ Grown in their natural habit with no trimming or other practices

C. Flower in Free (modern) garden style: Combine both formal and informal effect. Geometrical fashion included. Planting *plan schemes* is important. Tallest should be planted at the rare back away from the walkway. **Why?**

iii. Edges:

- ♣ Materials used to demark the border of circulation routes, flower beds
- ♣ Could be: -artificial materials/mechanical or live plants

a. Artificial materials: Bricks, concrete blocks…

Disadv: expensive in cost (installation cost)

b. Live edging: can be:

Flowering plants: *labularia, gompherena, anthrhinium majus, tagetis erecta*

Foliage plants: *Iresine herbstii , althernathera vesicover, Pilea cadierei*

iv. **Carpet bed:** large areas (garden)close planting of plants like althernathera, verbana, iresine herbasti, echiveria to form a certain geometrical design or names altered in the form of carpet

v. Topiary:

Art of trimming or shaping of trees, shrubs or climbers in to various forms or shape

Specialist = **topiarist**

Shape can be:

Geometrical shape: oval, circular, square, rectangular

Other shapes: animals, birds

Can be made on patios, flower beds, …

Considerations:

- ⇒ Should be quick grow
- ⇒ Should be dense enough
- ⇒ Should withstand regular trimming N.B. Mostly conifers are suitable and common

6.5.2 Garden Embellishments

a. Water feature: Utility + enhancement

Can be: natural stream, artificial water feature, Fountain, Pond, Swimming pool….

Uses:

1. Add serenity to vision
2. If it is moving, provide pleasant listening & light
3. Creates special effect by mirroring surrounding environment
4. Alter the surrounding environment
5. Serves as setting of other landscape enriching items like Statues, water plants, ornamental fishes boulders…

N.B.: But fairly expensive.

b. Statuary and sculptures:

-as focal point

c. Garden seat: used for normal gathering even more than normal gathering

Materials: concrete, wood, plastic, metal…

Utility + add color, form, line texture… to the garden.


d Ornamental structures

Climbing plants can be grown on ornamental structures to create both beautiful and useful garden

Major structures:

- ☼ Pergolas
- ☼ Arbors
- ☼ arches

i. **Pergolas**: a frame work made of wooden posts or bars over w/c climbing plants are grown to form a covered walk in the garden.

Uses:

- ♣ means of unifying awkward spaces around a building
- ♣ Provide shady spots for outdoor recreation for sitting under
- ♣ As focal point

Construction:

- ⇒ Two rows of closely spaced poles are dug in to and positioned upright
- ⇒ The pairs of poles must be joined by horizontal bars
- ⇒ Cross bars/pieces must laid on the top of the structure
- ⇒ Decorated by creative climbers

Considerations:

- ✓ The upright should be strong and well secured in to the ground
- ✓ The cross pieces must be strong and support the weight of the plant.
- ✓ Height must be enough to allow people to walk underneath freely
- ✓ Width also must be sufficient

ii. Arbors: a place in a shade of trees or climbing plants made by trimming of tree branches or climbing/vine canes or wooden or metal frame work for people to seat under. Have various structures.

Uses:

- ☼ Serve as a shady sitting areas to make intimate garden room
- ☼ Focal point

iii. Arches: a curved structure forming passage or ornamental entrance. Easy to made.

Can be made from long length vine canes

Use:

- Ω Guide people to wards a garden room
- Ω Focal points

e. Musical enrichments:

Sound hear in garden:

a. Pleasant: should be enhanced. Depend on individuals preference

e.g. moving water sound, birds songs, instrumental music.

b.Overwhelming (unpleasant): e.g. traffic sound, factory noise

- Ω Should be screened by planting

f. lightings:

Embellishment + necessity

Uses:

1. Guide people through circulation routes safely
2. Provide security by discouraging trowlers
3. To create unusual & charming night time view to the outdoor at night
4. To create special effects during special occasions (Christmas, birth day).
5. Aid in creation of dramatic focal point at night.

Principles of lighting:

1. **"***Light should always be placed under or below the level. Should never be placed directly at direct people's eye contact or at windows."*
2. *"Correct amount of light should be provided."*

Light illumination:

- High: for circulations, drive ways
- Less: arbors by special shadow

CHAPTER 8

LAWN ESTABLISHMENT AND MAINTENANCE

Lawn is a very noticeable and important feature of any landscape. An elaborate, well-designed landscape will suffer appreciably if the lawn is poorly installed or poorly cared of. The establishment of a fine lawn is, therefore, essential to landscape development. After selecting the proper grass for a particular area, it is important to consider which method of lawn establishment is suitable; seeding, sodding, springing or plugging. Basically lawns are established for the following three reasons.

1. They add beauty to the landscape. A well managed lawman is very appealing and inviting.
2. They are used as a playing area for sports such as baseball, basketball, golf or for relaxation. Since sports are tough on lawns, it is important to select a lawn grass that can take wear.
3. They provide excellent cover to help control of soil erosion while allowing the movement of air and water to roots of trees and shrubs in the soil below.

8.1. Choosing grass species

Selection of the right variety of grass is a prerequisite to establish a good lawn. In choosing the grass to plant in a certain area the most important factors to consider are the soil and climatic conditions such as temperature of the area and availability of moisture.

There are two basic types of grass warm season grasses and cool season grasses:

Warm season grasses are Zoysia, Bermuda, St. Augustine, and centipede grass. These grasses grows well in hot weather but will not survive under cold winters.
Cool season grasses: Bluegrasses, tall fescues, creeping red fescue, chewings fescul, and ryegrasses. Bentgrasses are cool-season also, but they are intensely cultured grasses, more suitable for golf courses than lawns. These type of grasses are more difficult to maintain in hot weather and are generally more susceptible to the ravage of disease and insects.

The uses intended for a new lawn area will play a large role in the decision of which grass to select. Warm season grasses are considered stronger because most of them spread by stolons or rhizomes, or both some of the cool season grasses, such as the bluegrasses and bentgrasses, also have the capacity of spreading but at much slower rate. Most of the cool-season grasses prosper only under fairly high mowing while most of the warm season grasses respond to very short mowing. Most of the cool season grasses are propagated sexually, by seed most of the warm-season grasses are propagated a sexually, by means of sprigging, sodding, or plugging.

8.2 Soil Preparation

Regardless of the type of grass planted or the method of propagation used to establish that grass, soil propagation is essential prior to planting. Essentially the same preparation is needed for each type of planting, with minor differences soil preparation consists of cultivation, grading, firming for consistency, and texturizing.

Cultivation

Cultivation is done to loosen the soil, there by relieving compaction, to remove weed growth or other vegetation present on the surface, and to do subsequent soil preparation activities easily. Different soil types require different cultivation treatments. If the soil is uniform in makeup and compaction to a depth of 15 cm or more the cultivation should be as shallow as possible. Repacking to a consistent firmness can then be accomplished with more ease.

On the other hand, if there is a hardpan layer within the top 15 cm, the cultivation should be deep enough to loosen the hardpan so that adequate surface drainage can be established. Similarly if there are layers of different soil types within the top 15 cm cultivation should be through enough to homogenize the soil by mixing the different types together

The use of discs or rotary-tooth implements is advisable because they do not turn the soil over, so the soil on top at the beginning of the cultivation process remains on the top. Wet soil should never be cultivated; the soil must be allowed to dry out before being cultivated

Grading

Grading is a process by which the area smoothed, firmed, and arranged in the proper sequence of levels for adequate drainage of surface water. Lawn grasses will not grow in an area that is consistently water logged. Thus preparation of the soil must provide for the controlled runoff of excess surface water. Good drainage on a grassy surface requires a slop of at least 2%. Less slope allows slow drainage, but the lower the degree of slope, the less margin for error exists, and puddles of standing water are likely to occur during heavy rain or watering the grass in these puddle might decline or even die, because the saturated soil in the root zone doesn’t allow free oxygen movement.

-A lawn area needs to be smooth to produce a good stand of grass and facilitate mowing and play activities. Lawns can be graded by hand or by tractor. But the only area ordinarily graded by hand are those next to a structure or otherwise inaccessible to tractor drawn implements. Tractor drawn implements are much faster, more accurate in the establishment of a grade and equal firmness. Although hand grading seems less sophisticated than tractor grading in realty it is more difficult and more involved.

8.3. Method of lawn establishment

Lawns are started in one of the two ways

1. SEEDING

Mechanical tractor–operated seeders, hand-operated mechanical seeders, and broadcasting by hand are the three basic methods of starting a lawn by seeding. Each of these methods can be very successful if the following rules for seeding are followed

A. The seed must be evenly applied in the proper amount
B. The seed must be adequately covered by soil to the correct depth
C. The soil must be packed tightly against the seed, so soil and seed are in close contact all sides.

Regardless of the method of seeding, grass seed should normally be planted at a shallow depth, between 0.60 to 1.25 cm, for quicker germination and establishment. In hand seeding, to obtain uniform distribution, the seed is mixed with small amount of a carrier such as sand. The mixed material is divided into two equal parts; one part is sown in one direction, and the other part crosswise to the first sowing.

Covering the Seed

The seed is light covered of hand raking. Large seeds are covered with 0.60 to 0.90cm of soil and small sees with 0.30 to 0.60 cm of soil. It is important that all seed is covered by and in close contact with the soil.

Mulching

Mulching with a light covering of weed free straw, hay, or commercial pellitized fibers helps to hold moisture and prevent the seed from washing away during watering or rainfall. The much also helps to hide the seed from birds

Watering

The first watering given to the newly seeded area can contribute to the compacting of the seedbed. Through watering, applied heavily, will firm the seed bed further, resulting in a better stand of grass height mist watering can be applied thereafter, but the first watering should consist of heavy droplets to ensure tight contact between seeds and soil. Care must be taken to avoid erosion during heavy watering. For a good stand of healthy grass to result, the seedbed must receive the proper amount of moisture at the right time. Once the seed absorbs water, the germination process begins. If watering is interrupted the seed embryo dries out and the germination process will be interrupted. New seedlings must be kept moist until they are well established. A void saturating the soil since excessive moisture is favorable for the development of damping off.

Vegetative Planting

There are some grasses for which seed is not available, or the seed that is available does not produce plants that are true to type. These grasses must be planted by one of several vegetative methods, such as sodding, sprigging, or plugging.

1. Sodding

Sod consists of grass and grass root in a thin layer of soil that is removed from the area in strips. It is rolled and transported to the area to be sodded. Sod should not be cut more than 2.5 cm thick. Sod that is cut 2 cm thick will knit to the underlying soil faster than thick sod.

Soil preparation is done in similar fashion to that of a seed bed with cultivation, grading, and firming all necessary prerequisites to laying the sod. A sobbed must be fine texture than a seed bed because large clods prevent close contact between the sod and the ground below. Air spaces created by such a gap cause the root tips of the sod to dry out, and results in poor establishment.

-the sod will suffer less shock if the length of time between harvesting and installation is very short. Plenty of moisture must be available at the time of sod harvesting.

Fertilizer

A complete fertilizer with high phosphorus content is recommended for the use in establishing new lawns. Some companies manufacture a special fertilizer known as a controlled release (release over period of time) starter fertilizer that is high in phosphorus.

-Before applying fertilizer, the soil should be tested to determine the correct amount of fertilizer and lime to add. The results of soil tests sometimes indicate a need for the addition of lime to the soils. Lime reduces the acidity of the soil and encourage root development. If the soil pH is too high or alkaline, sulfur or iron sulfate may be used to lower the pH. Most lawn grasses grow best in a well limed soil with a pH level from 6 to 6.5. If the soil test calls for lime, add the recommended amount evenly over the entire soil surface. Work it into the ground 4 to 6 inches before seeding or sodding.

Placing sod

Rolling of sod is essential to conserve moisture for long period of time.

Sod is laid in strips, usually of equal length. To facilitate knitting of the sod, make sure that all portion of the soil on the soil are touching the ground beneath, Also adjacent pieces of sod must not overlap. Once sod is laid it must be rolled into close contact with soils to protect the drying of the root tips and to facilitate the penetration of the roots into the ground. If the sod shows a sign of wilting when it is laid, it should be watered lightly before rolling. After rolling, initial watering, must be done the entire thickness of the sod must be thoroughly saturated and the ground below must be saturated.

-Subsequent watering on a newly sodded area must be frequent Newly sodded areas should be mowed when the grass exceeds the recommended mowing height by 2.5 cm just as with newly germinated grass. Care should be exercised not to now the sod when the grass is wilted or when the lawn is soggy.

If the prepared sod bed is extremely dry and loose at the time the sod is laid, it may require a second rolling after receiving water frequently for a few days.

2. Sprigging

Sprigging also involves basically the same soil preparation as do seeding and sodding. Sprigging involves the removal of individual sections of rhizomes or stolons from sod. These sections must contain at least one or two nodes from which new roots and stems can grow. Both rhizomes and stolons are modified stems; stolons grow on the surface of the ground and rhizomes grow under the surface. Both produce new roots and stems when transplanted and maintained properly.

Sprigging is commonly accomplished by drawing a series of shallow trenches in the prepared ground into which the sprigs are placed. Then the sprigs are covered over by soil and packed. These trenches can be spaced as desired, the spacing dictating both the cost of the operation and the speed with which coverage can be completed. Sprigs can also be broadcasted over the area, then disced partially into the ground, or the covering soil can be top dressed over the sprigs after broadcasting. Discing results in poorer coverage of the sprigs than trenching, and top dressing costs more. All methods require rolling to secure the soil tightly against the sprigs.

Initially, sprigs require very frequent watering because they are small in size and thus dry out very quickly, and because they possess no roots until they generate them. The moisture level of a sprigged area must approximate that of a seeded area; that is, watering is required whenever the ground is dry enough to walk on.

Since sprigging leaves much bare ground between the sprigs, it is best to apply a pre emergent weed and grass control agent to limit the competition for water and nutrients. Fertilizing, although it can be done at the time the sprigs are planted, is best delayed until the sprigs root and begin to grow. Only at that time can the sprigs make use of the nutrients.

3. Plugging

Plugging is similar to sprigging in that the objective is to make the grass spread by means of rhizomes or stolons. It is basically a propagation method for warm-season grasses. Plugs are pieces

of sod that are transplanted so that they may spread laterally in all directions, eventually growing together to form a sod.

Plugs can be made by cutting pieces of sod into squares or circles or by using a plug-making tool, which takes round plugs from existing grass areas. Commonly, plugs are made in 2-in.-diameter circles or in 2 in. x 2 in. squares. A 2-in. plug is considered to be large enough to hold moisture for a substantial amount of time and yet small enough to make efficient use of the sod from which it is taken. The important measurement is the surface exposure around the edge of the plug, since it will grow outward in all directions. Although plugs are often cut in long strips, there is no advantage to this method unless the strips are being used to prevent erosion. Such "stripping" requires much more sod, but since the surface area exposed on the edges is not much greater, coverage does not occur any more quickly.

Plugs are commonly set in rows and spaced 6 to 18 in. apart. Naturally, the farther apart the plugs are set, the longer the time required for complete coverage. Doubling the space between each plug has the effect of quadrupling the amount of area that each plug must cover.

Grading practices are the same for an area to be plugged as for a seedbed or sodbed. Trenches are drawn across a prepared area, the plugs are set at the prescribed intervals, and soil is backfilled around the plugs and packed securely. Then the entire area is rolled with a heavy, smooth roller. The plugs should be set slightly lower than the grade around them, so the backfill can just overlap their edges. This prevents the plugs from "floating" out of the ground as they are watered. When plugging is done on a bare area, it is best to apply a pre emergent weed and grass control agent to limit competition, thus allowing the plugs to spread faster.

Because of a tendency for new plugs so "float," as mentioned earlier, it is wise to roll or otherwise pack a newly plugged area a week or two after the plugging operation, so if any floating has occurred the plugs can be pushed back down before they become securely rooted. In a newly plugged area, washouts occasionally should be filled with soil. Then, as the grass covers, the lawn will be smooth and even.

8.4. Lawn maintenance

After the lawn has been seeded or planted vegetatively Proper lawn maintenance care must be taken to keep it healthy.

8.4.1. Watering

Watering Lawns the Right Way

How much water does a lawn need? In general, cool-season grasses need about one to 1.5 inches of water per week is needed to maintain green color and active growth, and naturally slow down in growth and may go dormant in hot weather. Factors such as the soil, weather, and management practices all have a role in water needs of lawns. Here are a few general rules to follow:

- When is it time to water? The first few warm days of summer does not automatically mean to water lawns. In fact, allowing lawns to start to go under mild drought stress actually increases rooting. Watch for foot printing, or footprints remaining on the lawn after walking across it (instead of leaf blades bouncing back up). Grasses also tend to turn darker in color as they go under drought stress. Sampling the root zone soil could be another option.
- In general, water as infrequently as possible. Water thoroughly so moisture gets down to the depth of the roots. Exceptions to this general rule would be for newly seeded lawns where the surface needs to stay moist, newly sodded lawns that have not yet rooted into the soil of the site. Otherwise, avoid frequent watering that promotes shallower root systems and weeds (e.g., crabgrass).
- Given a choice, water early in the day when lawns are normally wet from dew. Avoid midday due to evaporation, and at night due to potential increased chances of some diseases.

- Spread the water uniformly across the lawn. Sprinklers vary in distribution patterns, and require spray overlap for uniform coverage. Placing coffee cans or similar straight-sided containers on the lawn can help measure water application rates. Avoid flooding areas, or

missing other spots. On heavy clay soils and slopes, watch for excessive runoff; it may be necessary to apply the water in two applications to assure it soaks in.

- To help conserve water use, mow higher, avoid excess nitrogen as warm weather approaches, limit traffic over the lawn, improve turf rooting, control thatch and soil compaction, and avoid pesticide use on drought stressed lawns.

8.4.2. Mowing

Importance of Proper Mowing

Although often overlooked, mowing has a major impact on lawn appearance and health. Follow a few simple guidelines to assure lawns are mowed properly:

- Don't make the common mistake of mowing too short. For most lawns **a mowing height between two and three inches** is suggested; with the upper range best for warm seasons. Lawns mowed at higher heights tend to have deeper roots, less weed problems, and look much better. Mowing too close invites problems such as weed invasions. Simply raising the mowing height can have a major impact on the quality of many home lawns. A mowing height of two inches would be fine when grasses are rapidly growing, but the height should be raised as growth slows, stress increases, and when the lawn is in the shade.
- Base mowing frequency on the rate your lawn is growing. **Do not remove more than one-third of the grass leaf in any one cutting.** Mowing on a regular basis as the lawn needs it is essential. Don't mow when the grass is wet.

- As long as the lawn is mowed on a regular basis and the clippings readily filter back down into the lawn, **clippings do not need to be collected**. Returned in this manner, clippings readily decompose (contain 75 - 80 percent water) and do not cause thatch. Clippings also recycle nutrients, in particular nitrogen, so less fertilizer is needed.

- Selecting a mower can involve a number of factors, many being personal preference. Regardless of the type of mower, **blades need to be kept sharp**.

- Mow in the direction that is safest. Periodically change directions if desired, although mowing the same direction each time should not be a problem on taller grass of home lawns.

8.4.3. Fertilizer and Lime

All new lawns should have fertilizer applied before seeding. Some also will need lime. Poor lawn establishment or complete failure often occurs because soil fertility is low and is not corrected. Soils with low in available phosphorus must receive corrective application of high phosphorus-containing fertilizer to assure satisfactory establishment of grasses.

The best way to determine fertilizer and lime needs for a particular lawn is to have samples of the soil tested. Apply fertilizer (and lime, if needed) to bring the soil fertility/nutrient level up to a desirable range. This fertilizer, if needed, is called a corrective application. Corrective fertilizer and lime should be tilled into the top 3 to 6 inches of the soil. **Do not apply lime without a soil test.** Too much lime is more detrimental than a lime deficiency.

Sound Fertilizing Practices

Fertilizing is an important lawn care practice, as it influences grass color, ability to recover from stress, and helps prevent weed invasions and disease. There are important factors to consider when fertilizing lawns, including **choosing the proper fertilizer, how much fertilizer to apply, and when to apply fertilizer**.

Nitrogen (N), phosphorus (P), and potassium (K) are the three major nutrients needed by lawns. Nitrogen is the nutrient required most, although too much nitrogen can cause excessive top growth, leading to assorted problems. Percent nitrogen (by weight) is always the first of three numbers on the fertilizer bag, followed by phosphorus and potassium. Recommended ratios of N-P-K for lawn fertilizers are 3:1:2 or 4:1:2.

Another important factor in choosing nitrogen fertilizers is what kind of nitrogen is actually in the product. Nitrogen fertilizer may consist of fast-release or controlled-release nitrogen. For lawns,

fertilizers containing controlled-release nitrogen sources are suggested for most applications, primarily because they help assure uniform growth and do not readily burn grass.

8.4.4. Weed management

General Weed Management Concepts for Lawns

Identifying the weed and trying to determine why it has become a problem is the first step in dealing with lawn weeds. Some weeds are good indicators of underlying problems. For example, ground ivy (creeping Charlie) readily invades lawns in shade and with poor soil drainage, while knotweed is a plant able to survive in compacted soils. Crabgrass typically invades lawns that are mowed too short or watered too often. Clovers may be a sign of low fertility. Dandelions may adapt to a range of conditions. An assortment of weeds may indicate overall poor conditions for lawn grasses and/or poor management

After identifying the weeds present, step two for controlling weeds should be to review lawn care practices and make adjustments as needed to assure a good stand of grass. Sound lawn care practices should promote a healthy, vigorous turf able to prevent and compete with weed invasions. These practices include proper selection and establishment, fertilization, watering, mowing, thatch management, and related practices.

The third step is removal of existing weeds. Pulling by hand is one option; be sure to get as much of the root system as possible. There are a number of herbicides available for weed control, specific to the type of weed to be controlled.

Broadleaf Weeds

Dandelions, plantain, clover, and ground ivy (creeping Charlie) are among the common broadleaf weeds appearing in lawns. Selective **broadleaf weed herbicides (weed killers)** are available for use on lawns. Choices found in garden centers typically include 2,4-D (2,4- dichlorophenoxyacetic acid); mecoprop or MCPP (2-(2-methyl-4-chlorophenoxy) propionic acid); or dicamba (3,6-dichloro-o-anisic acid); with two and three-way combinations available (e.g., Trimec).

Common Broadleaf Weeds & Chemical Controls

1. 2,4-D (2,4-dichlorophenoxyacetic acid)
2. mecoprop or MCPP (2-(2-methyl-4-chlorophenoxy) propionic acid)
3. dicamba (3,6-dichloro-o-anisic acid)
4. Combination of all three (Trimec, Three-Way Lawn Weed Killer, etc.)

Broadleaf Weed	**1**	**2**	**3**	**4**
Dandelion	x	xx	x	x
Ground Ivy (Creeping Charlie)	..	xo	xx	x
White Clover	xo	x	x	x
Thistles	xx	xo	x	xo
Common & Buckhorn Plantain	x	..	..	x
Knotweed	..	xo	x	x

Key

x = usually provides adequate control; xo = may only provide partial control;

xx = multiple applications required; .. = information unavailable

Thoroughly read, understand, and follow all information on herbicide labels. Avoid windy days, as these materials can damage many landscape and garden plants if they drift (spray droplets land off the lawn). Also avoid hot days. It's best to have adequate soil moisture, but no rain for 24 hours after application. Don't mow for a few days before and after application. Consider spot treating weeds rather than broadcasting weed killer over the entire area. Use caution on newly seeded areas; wait four mowings before treating newly seeded lawns and 30 days before seeding areas treated with broadleaf herbicides. Read the label regarding potential tree damage when used on lawns growing over tree root zones.

Managing Grass Weeds in Lawns

Grass weeds in lawns are classified as either annual or perennial. Management options differ between the two classes, with annuals generally easier to control.

Crabgrass and other annual grass weeds are common problems in home lawns that can be treated through both chemical and non-chemical methods. A proper lawn care practice to encourage a dense stand of vigorous grass is the best way to prevent weeds from invading. For example, **mowing height** can have a big impact; lawns mowed higher (over two inches) tend to have less problems with annual grasses such as crabgrass. Close-mowed lawns tend to open up, allowing weeds like crabgrass to invade. Light, frequent **watering** also favors crabgrass. Crabgrass often invades areas seeded in late spring because of bare soil, frequent watering, and the onset of hot weather, which is ideal for its growth.

Herbicides (weed killers) are also available to manage annual weeds. Pre emergence herbicides prevent annual grass weeds such as crabgrass from emerging. **Timing of application** is important, as the weed killer should be applied to soil before the crabgrass emerges from the soil.

Perennial grassy weeds are considered to be the most difficult weed problems to deal with in lawns. Control options are limited because the weed species are similar to the lawn species. In fact, many perennial grassy weeds are not considered weeds, but are considered desirable grasses when growing by themselves under a different set of conditions.

For example, several common perennial grasses, when growing in Kentucky bluegrass lawns, are considered weeds because they differ greatly in leaf width, color, or growth habit. **Tall fescue** is more coarse and grows in distinctive clumps when it occurs with Kentucky bluegrass. **Creeping bentgrass**, a very desirable turf species for golf courses, becomes a weed in bluegrass lawns because it appears as patches of finer grass, usually lighter in color. **Zoysiagrass**, a warm season turf species, appears as patches of thick grass, dormant (straw- colored) for much of spring and fall in Kentucky bluegrass or other cool-season grass lawns.

Removing these weed patches by hand is one control option. It's important to get all of the plant, as many have underground or above ground stems (rhizomes or stolons). These stems enable these species to spread quite readily, so if broken or cut, they regrow.

Selective chemical control is not an option with most perennial grass species. Unlike selective herbicides used on annual grasses (e.g., crabgrass), nonselective herbicides used to control perennial weed grasses may also damage the lawn species. For this reason, spraying over the lawn is not suggested unless the problem is severe enough that all grasses need to be killed and the lawn

reestablished. **Using a nonselective herbicide**, such as *glyphosate,* patches of the undesirable species can be spot treated. After weeds and portions of lawn hit with spray die, reseed with desirable grass species.

8.4.5. Insect Pests

White Grub Problems in Lawns

White grubs are the most serious and destructive lawn insect pest. While not all lawns will get grubs and the extent of grub damage varies from year to year, there are some important points to consider concerning managing grubs in lawns. Grubs are white in color, with a characteristic "C" shape body when found in the soil feeding on lawn roots. Grubs are the larval stage of beetles.

Since grubs feed on the roots of lawn grasses, damage will appear as browning of the lawn. Consider that this also could be due to problems such as drought, poor soil, or diseases. However, grubs are easy to find by lifting sod in damaged areas and checking the root zone for the whitish grubs. Don't treat for grubs that don't exist!

Lawns showing damage from grubs may be treated with an insecticide. Insecticides available for homeowners include diazinon (25% EC [liquid] or 5% granular); trichlorfon (Dylox) (6.2% granular); bendiocarb (Intercept), halofenozide (GrubBGon, GrubEx), or imidacloprid (Merit, formerly GrubEx) for control of white grubs.

Ants and termites

Ants and termites are occasionally appear in large enough numbers in the lawn that control is needed. The ants may not be actually damaging the grass itself, but the tunneling into the soil may be creating problems. Termites feed on the grass and can damage the lawn significantly. In both cases the recommended pesticide should be applied.

8.4. 6. Lawn Diseases

Lawn Disease Development

There are several diseases which could potentially infect home lawns. The general environmental conditions occurring on the lawn, how the lawn is managed, and weather conditions all impact lawn disease development. Lawn diseases need favorable conditions to develop. The best defense against home lawn diseases is to maintain a healthy lawn through sound cultural practices, avoiding favorable conditions for disease. Disease outbreaks often occur when lawns are not managed properly or are under extreme stress, such as from poor soil conditions or perhaps weather conditions. The following table outlines disease requirements and how to manage lawns to reduce diseases.

Disease Requirements & Lawn Disease Management

Condition	**Management Practices to Avoid Disease**
Susceptible Grass Plant	Resistant Species/Varieties Use of Mixtures/Blends
Causal Agent(Fungi for most diseases)	Fungicides (temporary protection) Can Never Eliminate All Causal Agents
Proper Environment for Causal Agent to Develop	Proper Establishment and Proper Lawn Practices (e.g., watering and fertilizing)