Ecological factors affecting growth of horticultural plants

It includes both climatical and soil factors i.e above and under ground factors , respectively.

Climatical factors include temperature , light , moisture and wind meanwhile soil factors include texture , acidity , salinity , fertility , moisture and pollution .

I- Climatical factors

A- Effect of temperature:

Temperature is one of the most important determinants in plant adaptability and crops may be divided into :-

1- Tropical , 2- subtropical , 3- temperate 4- cold zones .

Each plant need special range of temperature within which it can grow and plants will be stunted or even died when grow out of this range which include:-

Minimum temperature :- lower than this temperature plants will stop grow or die .

Optimum temperature:- at which plants grow at its highest rate and all the bio or physiological processes of the plant take place at its highest and equalized rate within each other .

Maximum temperature :- higher than this temp plants will stop grow, wilted and die due to higher respiration and transpiration , as well as enzymatic activity . The suitable temp degree for plant growth differ according to various growth stage from seed germination , vegetative growth , flowering , fruiting and the formation of storage organs.

Effect of low temperature:-

1- **Frost** : it happened as result of lowering temp degrees up to 0c or some little below. Burning of the new terminal buds as well as flowers , small or large fruits . The bad effects of frost can be obviously observed on tropical plants but in a lower degree on subtropical and temperate trees and is known as ***"chilling".*** The frost that happened during spring season in Egypt is very dangerous , specially for fruit trees and it is known as***" Radiant frost "*** which take place by quite wind and clear sky that encourage the heat loss from the soil to the air and this can intensively happen during Feb. . and March when the wind speed at the evening become low and the sky is clear at this time the farmer must expect the following of frost .

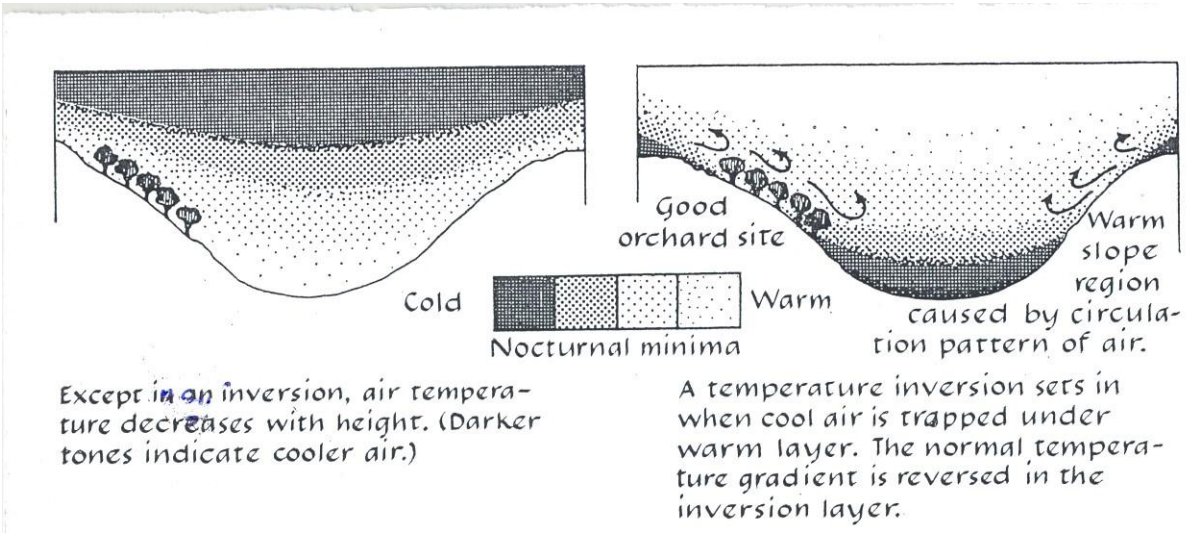

Fig. 12-3. *Schematic representation of the origin of a thermal belt as a result of a temperature inversion on a hillside.*

2- **Freezing** : it happened as a result of lowering temp degrees largely below zero 0c and it is rarely happened under Egyptian conditions .
Injuries differ from burning small branches to the death of tree trunks. The death of plant due to very low temperatures is the result of the formation of ice cristals which destroyed the plant tissues and or to the chemical variation of the dissolved proteins in the protoplasm which lead to protein and colloids coogolation .

The deletorious effects of low temperatures on plants may be differ due to :-

1- Plant species and varieties : Deciduous plants are more resistant than the ever greens , meanwhile some varieties are more susceptible than others.
2- The time of frost : the injury of low temp is more effective when it is happened at the beginning of the growth season that it may kill the new leaves and flowers premordia .
3- Growth condition and trees age : the ability of woody plants to withstand low temp. Of winter is dependant on the ability of the protoplasin to make compounds known as "hydrophilic colloids " which have a large surface in proportion to their size and can absorb large quantities of water on these surfaces.

This water is called "bound water "and can not be frozen at the usual subfreezing temperature ,Strong,elder and well be fertilized trees are more resistant to frost than small ,younger and bad fertilized trees .

4- Degree and duration of low temp : Injury due to immaturity of the tissues may be severe or mild , depending on the duration of low temperature, the time and rate of temperature fall and the rate of throwing if freezing does occur .

Injuries due to high temp followed by low temp :

Unseasonably high temp during late winter and early spring followed by very low temp .(frosts or freezes) are frequently injurious for early blooming fruit trees . This high temp promote the absorption of water , cell division in buds and the opening of flowers and consequently these trees loose hardiness and are subjected to considerable damage .

Protection from cold injury :

1- Careful selection of kinds , rootstocks and varieties adapted to the particular site .It is advisable to grow plants under protected cultivation.
2- The use of windbreaks and cover crops between trees .
3- Joung sensitive trees can be protected by hilling up the soil around the trunk and wrapping the trunk and main limbs with straw or other materials .
4- Irrigation plants during the nights expected to be subjected to frosts.
5- The use of orchard heaters and wind machines for mixing warm air at higher elevation with that the heavier cool air near the earth surface .
6- Spraying plants with any of the following chemical compounds which may increase its cold tolerance such as cycocyl (CCC) , abscisic acid (ABA), benzyl adenine (BA) and others.

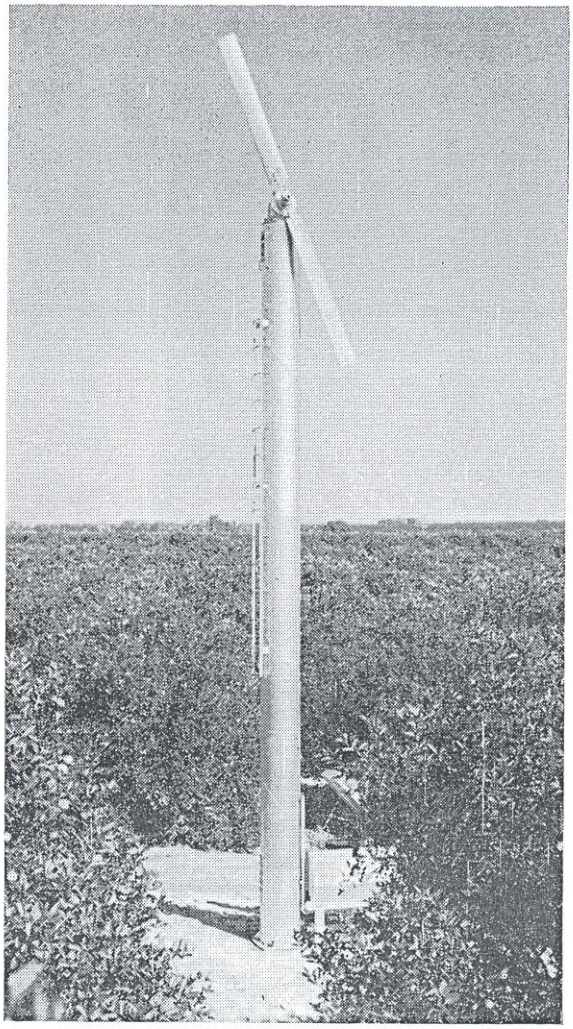

Fig. 12-4. *Wind machines protect citrus from frost by mixing the warmer upper air that exists under conditions of temperature inversion.*

The beneficial effect of low temperature :

Deciduous trees require low temperature during winter in order to produce high quality and quantity yields . The growth of many plants begin quickly then it continued slowly to reach an extent of stopping growth ,in this case the plant is "Dormant " As this state continued even the failed ecological factors are recovered the plant enter in " Rest period " and this appear in decedious trees .

In subtropical regions having warm winters ,chilling requirements of some trees cannot be met and deciduous fruits such as apple and peach grow not at all or if

they survive behave in an erratic mannar . The more tropical the climate ,the slower they leaf out and flower in the spring and the more irregular foliation and flowering and a consequent reduction in yield .

The differences between rest period and dormancy :-
Rest period can be recognized as follows :-

1- It appears yearly during autumn and winter in buds of deciduous trees .
2- It happens due to interior physiological factors which are governed with inherited factors .
3- It can be continued even the plants are subjected to suitable ecological conditions for growth .
4- A certain amount of cold is nessary to break the rest period of both vegetative and flower buds of deciduous trees in temperate climate .

Dormancy can be recognized as follows :-

1- It happens in both evergreen and deciduous plants in any time of the year .
2- It occurs due to unsuitable one or more of the ecological factors .
3- Occasionally , it may be occur to special internal factors as apical dominance.
4- Subjecting trees to low temperature for long time may prolong the dormancy period.

Effect of high temperature:

High temp is necessary for the beginning of growth , physiological activity of all plant processes . It is evident that to some extent, increasing temp degrees increased plant growth after that it decreased gradually until it stoped ultimately at 50 c for most plants .
When temp rises above the optimum day temp range increased transpiration takes place : This helps in lowering leaf temperature thus avoiding injury to the protoplasm . If high temp is coupled with low relative humidity , transpiration rates becomes so high , more than the amount of water , that the root system can absorb. Such disturbance of the water balance in the plant as a result of excessive water loss through transpiration leeds to sunburn of the plant organs due to direct sunlight and the wilting of vegetative and floral parts , Furthermore , the shoots may die as well as the deformation and shedding of flowers and fruits at different stages of development. Also , the size , color , yield and fruit quality are inferior .

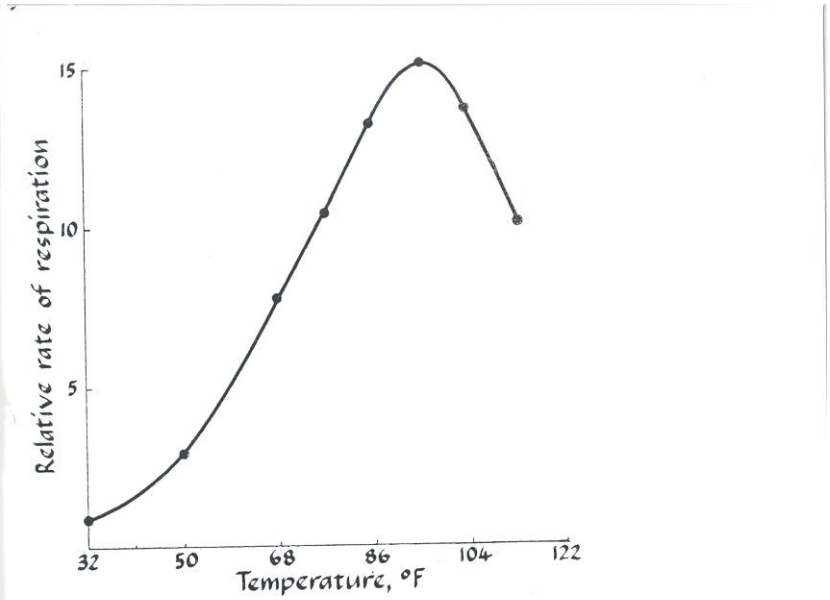

Fig. 4-2. *The relationship between the respiration rate of germinating pea seedlings and temperature.*

Injuries due to high temperature:-

1- Loss of water content in plant tissues due to increase in water transpiration causing "***drought***" of plants.
2- Decrease of organic nutritional compounds in plant due to its consumption for respiration causing a condition of "***starvation***"
3- Accumulate of some poison compounds in the plant combined with the decrease in other beneficent due to the "***metabolic disturbances***" leading to the appearance of "***biochemicl lesions*** "
4- Decrease in enzymes and proteins in plants due to the increase in catabolism process in plants .

With continous subjecting plants to high temperatures , following direct injuries may happen:-

a- Variation in protein denaturation .
b- Lipid liquification
c- Loss of nucleic acids .
d- Finally , heavy injuries may be occured in all plant tissue and even in dry seeds leading to the death of plants .

Protection of plant from heat injury :-

Plants as well as juvenile trees can be protected by :-

1- Shading , especially for small plants .
2- Covering trunks and main limbs of old trees with a white lime wash or Bordeaux to help in decreasing heat absorption .
3- Using suitable training and pruning methods .
4- Narrowing spacing between plants or trees.
5- Growing small fruit plants like citrus under the shade of other tall trees such as date palm.
6- Using of windbreaks around the garden to avoid heat winds .
7- Using of sprinkler irrigation system to moist the atmosphere around plants.

B- Effect of light :-

The existence of higher plants is dependent upon photosynthesis.
In the absence of light , plants utilize the reserve foods for energy . If conditions are unfavorable for photosynthesis but favorable for respiration as with a low light intensity and high temperature, the plant may be use all of the stored food and die .

The application of fertilizers should be regulated in relation to light intensity .
In periods of low light intensity the carbohydrate supply is relatively low and large amount of nitrogen are wasteful and may even be injurious . However in bright weather frequent application of nitrogen are necessary for formation of amino acids and protein which will become an integral part of the cells of the newly developing growth .

The intensity of light is usually greater at higher altitudes than at sea level and cloudy weather , smoke and haze reduce light intensity .
If the light intensity is too low , the plants grow slowly and the stems are usually weak and soft and the leaves are likely to be poorly developed and thin .
If the light intensity is too high , a reduction in chlorophyll content may be occurred . It also raises the temperature and increases the loss of water from the foliage and a reduction in color in many flowers in summer may be attributed .
In order to discuss the role of light on plant growth following aspects may be taken in consideration :-

1- light intensity : It refers to the amount of light which the plants receive . The mostly used unit is " ***foot- candle***" which is the illumination at all points that are one foot from one candle power of light . During summer in Egypt , it reach 10000 foot – candle but it decreased to about 1000 during winter . Most plants cannot grow below 100-200 F.C ***compensation point*** "

at this light intensity ,plants will maintain themselves but will not grow . Foliage plants grown for decore are selected for their ability to maintain themselves at this level . For optimum appearance they must usually be replaced within the year unless more light is provided for growth. During the winter the light intensity available above plants in a green house is often between 300 and 1000 F.C . As a result of this low intensity and the short day length , plant growth in often severely limited .

2- Day length : it is the most obvious difference between climates . At equator line the day is close to twelve hours long throughout the year . At the polar regions the summer day length goes up to 24 hours . Consequently , long day plants cannot reproduce sexually in the tropics and they will remain vegetative indefinitely .

3- Quality of light : the visible part of the spectrum is most important to the growth of plants . The " ***ultraviolet*** "rays (the shortest wave length) are mostly screened from plants under glass unless a special type of glass is used which permits its passage . The " ***infrared*** " rays (the longest wave length) are the heat waves in light . they act to increase leaf temperature but are of no importance in photosynthesis . following table show the length of various rays of sun light .

Rays	Length of rays (Angstrom)
Ultra violet	3800
violet	3800-4300
blue	4300-4900
green	4900-5600
yellow	5600-6300
red	6300-7600
infrared	7600-20000

- Angestrom = 1/10 million from millimeter

Moreover , chlorophyll absorbs the red and blue portions of the spectrum , permitting the green light to go through. Thus chlorophyll appears green .

The intensity and quality of light reaching the plant varies with the season , latitude and the weather conditions affecting the water vapor in the atmosphere . Thus ,during winter , light often becomes a limiting factor in green house although heat is provided artificially . Light energy ,described in terms of particles called "photon or quanta " which is inversely proportionated to the wave length . The range in light intensity over the earth is enormous . Full sun is a billion times brighter than star light . Following are the intensity values in foot candles for :- star light 0.00001, moon light 0.02 , indoors near window 100, photosynthesis 1200 and direct sun light 10000 F.C .

Plants do not use all light sent from the sun as 10% will be reflected and 10% will be penetrate through leaves and 80% will be absorbed by the leaves . although , only about 1% of the light received by leaf is utilized in photosynthesis .

a- Light and seed germination :

Seeds of most plants do not need light to germinate except some plants like lettuce and celery as red and yellow rays of light are the most effective in promoting germination whereas violet and far red rays are actually harmful to germination. When light is not available at the germination stage of new harvested lettuce seeds (high temp), seeds do not germinate and it enter in secondary dormancy . For breaking such dormancy seeds must be soaked for 3 hours in water and then subjected for a little period to direct sun shine before planting .

b- Light and transpiration :-

Light not only affects stomatal movement , but increases the leaf temp and therefore , transpiration . Plants may lose water in a saturated atmosphere when the sun is shining on the leaves .

Raising humidity reduces transpiration. Shading plants from the sun is obviously a more effective way of preventing wilting than trying to keep the air humid .

c- Light and photosynthesis :

The main role of light in photosynthesis process is supplying plants with the energy required for the coupling of CO2 with water . Studies showed that increasing the rate of photosynthesis will be increased with increasing light intensity. Optimum intensity ranged between 2000 and 3000 F.C even many plants can grow in 500 F.C . According to light requirements plants can be divided into :

1- Sun plants : is saturated by about one third of sun light up to 5000 F.C shade may be harmful for them like roses, dalia , citrus , mango , tomato , cabbage …etc.
2- Shade plants : is saturated by about 1/10 of sun light up to 1000 F.C. Intensive sun shine may be harmful for them like asparagus ,croton ,defenbachia , Poteus and others. Using of various shading technology in nursyries may be useful for the protection of shade plants .

Increasing light period lead to the increase in the formed carbohydrates and consequently such amounts produced in 12 hours are relatively greater than those produced in 8 hours .

Plants stored carbohydrates in their organs i.e. roots like carrot , radish , turnip or in tubers like potato and in corms like taro require in their early stages of growth (vegetative) to long periods of light to produce large amounts of carbohydrates needed for the formation of large vegetative growth , meanwhile at later storage stages of growth it is preferable to be subjected to short light periods as the long dark periods encourage the transportation of carbohydrates from leaves to the storage organs.

The rate of photosynthesis process will be decreased as the concentration of sucrose in plant leaves reached its maximum level (about 25% in the cytoplasm).
At this stage the rate of photosynthesis is equal with the release of produced sugars either with its translocation to other plant parts or in respiration process .

d- Light and flowering :-

Effect of day length on flowering :

Flowering or vegetative growth of many plants is controlled by the daily period of exposure to light . This reaction of plants to length of day was first called " ***photoperiodism*** " by Garner and Allard (1920)

They succeeded to push soybean plant which usually flowers during autumn (***short day plant***) to flower in summer (***June and July***) after subjecting it to artificial short day conditions . Garner and Allard classified plants into three groups depending upon their relation to day length :-

1- Plants that flowered more quickly when the days were long than when they were short are called " ***long – day plants*** "more than 14 hours like spinach , beet ,potato , radish ,lettuce and others.
2- Plants that flowered more quickly when the days were short than when they were long are called " ***short – day plants*** "less than 10 hours like sweet potato , strawberry, artichoke and others.
3- Plants that were not affected by day length are known as "***Neutral***" kinds from 10-18 hours like tomato ,pepper , egyplant and others .

Origin of flowering stimulus :

Knott (1934) mentioned that spinach plants which normally require long days for flowering , was found to bloom when ***only " the leaves*** " were subjected to long – day treatment , meanwhile such long day treatment ***only*** on "***the growing tip*** " of the plant did not cause flowering .This indicates that the cause for the response to day length is coming from the leaves.

This leads to the assumption that one or more substances may be formed in leaves as a result of the interaction with photoperiod and were called "florigen"

and it must translocate from the leaves to the apical meristems and push the plant to flower . In this connection " Parker and Bortwick " reported that new young leaves from soybean were more responded to photoperiod effects than old leaves .

Critical light period :

It in the light period above which the plant will be responsed in a direction and below it it goes to other direction . Plants that require short days for flowering initiate and develop flowers under daily light below the critical light period and vegetate at exposures above it . The reverse is true for long-day plants .

What the plant measure the light or dark period ?

The response of plants to the effects of day length on flowering process confirmed that plants are able to measure the time, but it do not clear what time is that ? the time of light or that of darkness.

This question remained without answer till many experiments were made by "Borthwick , Bonner , and hamner " by which the long dark period (short day) was broken to two short day periods using subjecting the plants for few minutes to artificial light near the middle of the long dark period . This practice leads to inhibit flowering of short day plants which require long dark period and it continue vegetate . Contra experiment was made by which a short dark period for few minutes was entered in the middle of the long day period ,no differences were noticed regarding the response of plants to flower .

From the aforementioned results it is clear now that plants actually measure the dark period .

In this respect it is better to say short night or long night plants instead of saying long day or short day plants ,respectively .

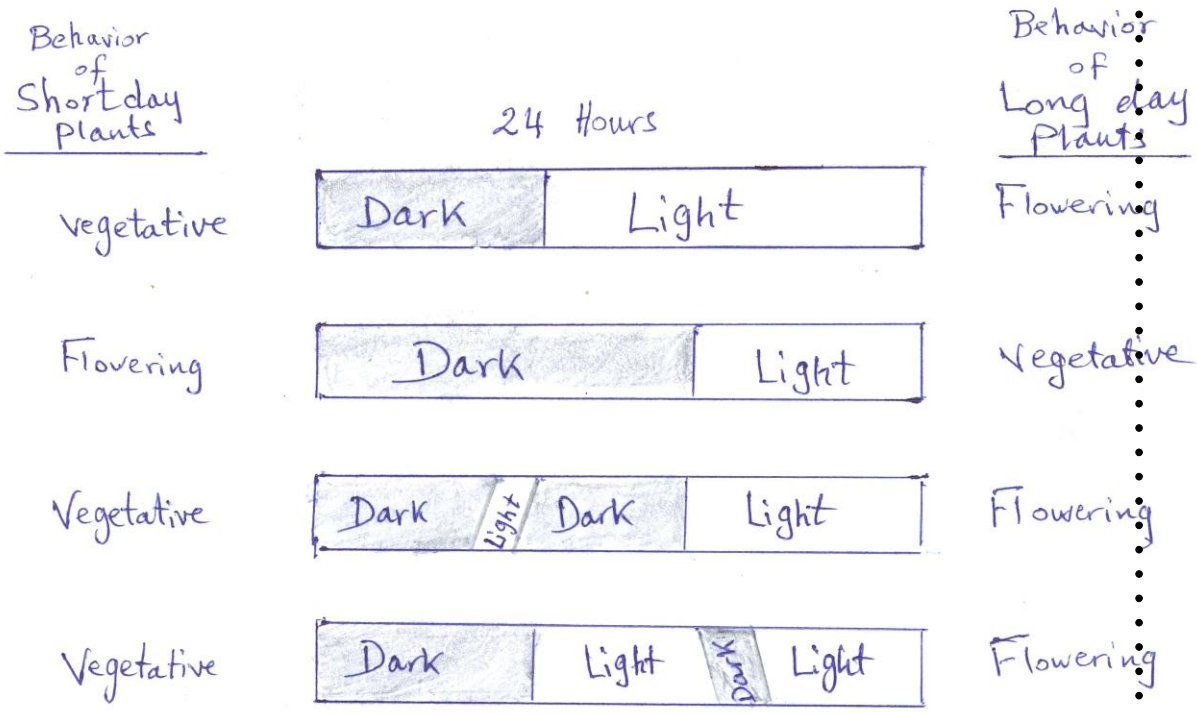

Fig. 5 : Behavior of short and Long day plants to day length.

Practical uses of light knowledges :

1- It is enough to expose short day plants daily to few minutes of artificial light during dark period instead of lengthening day light for many hours after the end of the day .
2- Using suitable methods of pruning and training to permit adequate light to the middle of trees .
3- Widen the distance between trees to prevent crowding of limbs and branches to allow the entrance of light between trees .
4- Washing leaves from adhering dirty or dusts to enhance the penetration of CO2 and light required for photosynthesis process.

5- Planting small plants in the tropics like coffee ,tea ,cacow and pineapple under large trees to protect them from high intensity sun light which may lead to the increase in leaf temperature and respiration and to the disturbance of C/N ratio (high C and low absorbed N) leading to deleterious effects on flowering .
6- Selecting varieties and species that are capable for growing in the district suitable for its requirements of light .

C- Effect of Moisture:

The amount of moisture in the air can be expressed as "Absolute or Relative" humidity .

Absolute humidity : it refers to the amount of water in the form of vapor in grams per cubic meter of air .

Relative humidity : is the percentage of amount of water vapor in grams per cubic meter of air to the amount of water – vapor of the same volume which is capable of absorbing till saturation at the same temperature .

Air moisture may be affected with many factors i.e. temperature, wind ,the distance to water resources , the hight from sea level and the water content of the soil . following items may taken in consideration :-

1- The high temperature increased air ability to absorb and carry water vapor and consequently the relative humidity will be decreased and vice versa with low temperature.
2- Warm dry winds decreased moisture content and increased then transpiration .
3- There is a great relationship between the abscission of flowers and small fruits due to blowing of warm dry winds , especially in citrus trees during " June drop "in Egypt as a result of high temperature and low humidity .
4- On the other hand increase humidity , especially in green houses promote the spread of various diseases such as fungus as molds , botrytis in grapes and cucurbits and rust in cowpea and others.
5- For the storage of leafy vegetables and root crops , the optimum relative humidity required is 90-95 % but for most fruits and vegetables 85-90 % in desired . Seeds are best stored at 4-8 % only .

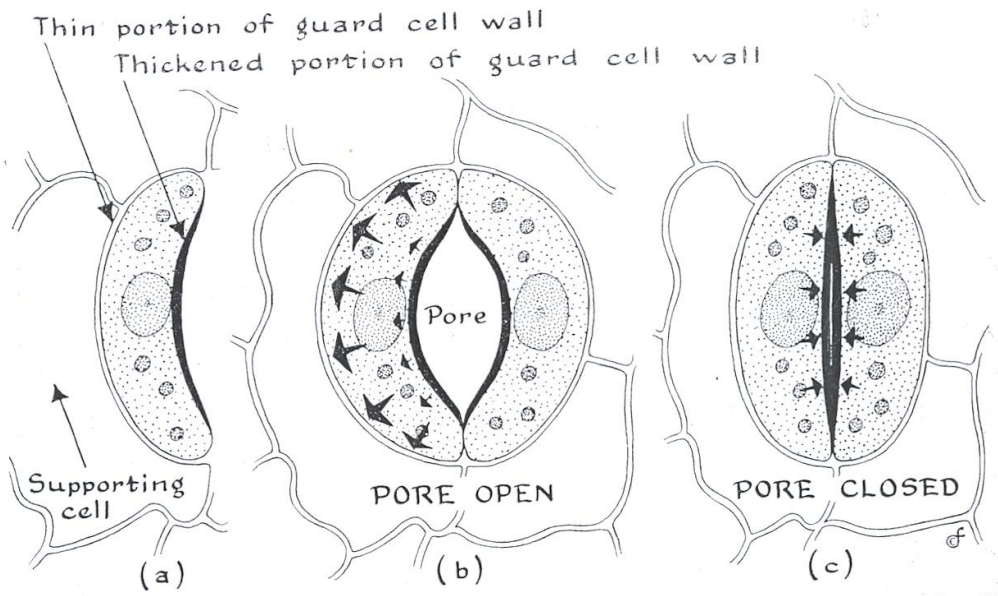

Fig. 9. *The stomata is an epidermal structure composed of two guard cells that form a pore. The guard cell wall abutting the pore is thicker than the other surfaces. This causes the pore to open when the guard cells become turgid.*

6- Walnut require high temperature with high humidity and we must take care if planting it around Nasser sea in Aswan as temperature will be covered but humidity do not meet the requirements of plants .
7- Dry date palm varieties succeed under dry disert conditions with 30-40 % relative humidity , meanwhile wet varities required 60%
8- Tea and coffee plants grow well in regions with heavy rain fall (50-75 inches yearly) and humidity saturated weather.
9- High relative humidity may increase biological control efficiency by using some special funguses in controlling insects.
10- Under Egyptian conditions in general average of R.H ranged from 44% in May to 61% in Nov. usually it increased in north and decreased in sud Egypt . through March it ranged 67% and 36% and in December it ranged 74% and 52% for Alex . and Aswan , respectively .

D- Effect of wind :

Wind and air movement results from the heating , cooling expansion and caused mainly by differences in temperature and rotation of the earth .

Movement of air masses with regard to their moisture content and temperature are of importance for plant growth and development .

Wind velocity , especially at critical periods such as flowering is of practical importance .

Loss of moisture from plants or soils and the spread of disease organisms ,seeds and pollen are also affected .

Erosion of soil through wind may have a direct bearing on agricultural utilization of given areas.

Wind damage to plants can be classified under two main kinds of injury :-

a- Mechanical injury : includes wounding ,cutting and dropping of leaves ,flowers and fruits and breaking of shoots , twigs and limbs.

b- Physiological injury : it result from the unbalance of water in the plant due to the increase in water transpiration of leaves which leads to more water absorption from the soil and if it is not adequate ,wilting of leaves and dropping flowers will occur . The physiological injury is more deleterious than mechanical injury . Moreover ,many side effects injuries are :-

1- Decreasing of pollination intensities due to the less of bees and other useful insects visiting flowers during strong winds .
2- Hinderness of pest control practices as spraying or fumigation of insecticides .
3- Helping translocation of various diseases and insects and the distribution of weed seeds from one place to another.
4- Wounding fruits which may be adopted to the infection of diseases due to blowing winds carrying sand grains .

However ,slow winds may induce some beneficial effects such as :-

1- It promote pollination process in spinach and other plants of nightshade family .
2- Diminishing the deleterious effects of frosts during cold nights due to the circulation of air around plants .

Control of wind injuries :

1- Selecting varieties and species that can withstand blowing strong winds .
2- Selecting rootstocks that are suitable for grafting and do not easily broken in strong winds .
3- Crowd planting of trees to minimize injuries of winds .
4- Using wind break trees around the garden one or two years before its construction in rows 100 meter from each other .

II -Soil factors