Classification of agricultural plants

PLANT TAXONOMY

Plant taxonomy is the science that finds describes, classifies, identifies and names plant. It is thus one of the main branches of taxonomy. Systematics deals with the scientific study of interrelationship, taxonomy, identification, nomenclature, classification, diversity and differences between crops. Taxonomy is one aspect of systematics that is concerned with the study of principles, procedures, rules, regulations and it is the bases of classification. In taxonomic studies the group of any rank is termed as taxon.

Plant taxonomy has two aims:

a) Identify all kinds of plants; this requires making a complete inventory of all plants. In scientific work it is essential to apply names with precision because the validity of research depends on correct identification of materials involved.

b) To arrange the kind of plant in a scheme of classification that will show their true relationship.

To be able to achieve this, the taxonomist must utilize the methods and resources of all the major fields of botanical investigation.

- the morphologist gives him an understanding of form and structure.
- The physiologist can point out the requirements for the existence of physiological species that appear identical but differ in their requirement
- The ecologist can furnish information about the relationship between plants and environment, about how environment may affect form and structure and how the effective action of the environment determine which plants will survive.
- The geneticist and cytologist contribute information concerning inheritance and reproduction as well as chromosome and morphology.
- Biochemistry is used effectively to solve taxonomic riddles.

The nomenclature of plants are sometimes changed. E.g. *Eupatorium odoratum* to *Chromolaena odorata*; *Voandzeia subterranean* to *Vigna subterranean.* Such changes are based on new information that will enable the taxonomist to name and classify plants according to acceptable rules of plant nomenclature.

The science of taxonomy is a synthesis of four interested fields:

1.) Systematic botany: includes genetics and cytology as well as other techniques applicable to the fields

2.) Taxonomic system: includes taxonomic concepts of plant group, or texa; concepts of evolutionary sequence of characteristics; classification and arrangement of texa, description of texa or photography.

3.) Nomenclature: a method of naming plants based on international rules. This permits only a single valid scientific name for each kind of plant; the discarded name is known as synonym.

4.) Documentation: preservation of living or fossil flora in a museum or habarium, including type, specimen and illustration.

C.) Plant Classification: This is the process of ordering plants into groups which are arranged in hierarchy. Each group termed taxon (plural taxa) contains items or objects with close resemblance which may be neutral or artificial. The first classification of plants were based on their economic uses, e.g. cereals, medicinal plants, oil yielding plants etc. or on gross structural resemblances e.g. herbs, shrubs, trees, climbers etc. Agronomic classification: Cereal or grain crops e.g. wheat, rice, maize, oat, sorghum, millet etc., Legumes for seeds (Pulses): e.g. peanut, fieldbean, fieldpea, pigeon pea, cowpea, soybean etc., Forage crops: e.g. grasses, legumes, crucifers etc. Root crops: e.g. sugarbeet, mangel, carrot, turnip, sweetpotato, cassava, yam., Fibre crops: e.g. cotton, kenaf etc. Tuber crops: e.g. potato, yam, etc. Sugar crops: e.g. sugarbeet, sugarcane etc. Vegetable crops: e.g. potato, sweetpotato, carrot, tunip etc.

An ideal system of classification should indicate the actual genetic relationship and also be within a reasonable limit of convenience for practical purpose.

PLANT CLASSIFICATION

Kingdom

Division

Class

Order

Family

Tribe

Genus- Plural: Genera

Species

Varieties, races, lines

All natural classification has a sound scientific basis while artificial classification is based on conveniences. In botany the following are hierarchical classes in descending order. The different hierarchies end with certain recommending letters thus: class-ae; order- ales; family-aceae; subfamily-eae.

From the hierarchical arrangement, there is a relationship between the groups and the division according to the differences between them. Varieties are important for agricultural purposes.

For example, yam has a specific (species) name and a generic name. The classification of of yam according to its hierarchical inter-relationship is as follow:

Species- rotundata

Genus or Generic name-Dioscorea

Tribe- Dioscoreaceae

Family- Dioscoreaceae

Order- Dioscoreales

Class- Dicotyledoneae

Division- Spermatophyta

Kindom- planta

Keys: A key provides several choices of characteristics by which one can identify a plant.

Below is the list of some plant families and their local name

FAMILY	LOCAL EXAMPLES
Agavaceae	Sisal hemp
Alliaceae	*Allium cepa*, Onion
Amaranthaceae	Amaranthus sp. Greens
Anacardiaceae	*Mangifera indica*, Mango
Araceae	Colocasia, cocoyam
Bromelaliaceae	Anana – pineapple
Caricaceae	*Carica papaya* – Pawpaw
Convolvulaceae	Sweet potato
Dioscoreaceae	yams (Dioscorea sp.)
Poaceae	Maize, rice
Fabaceae (Leguminoseae)	Cowpea
Malvaceae	Cotton, Okra
Rubiaceae	Coffee
Rutaceae	Citrus (Citrus sp.)
Solanaceae	Tobacco

NOMENCLATURE

1. As the number of plants known to man increased, it became apparent that some form of generally acceptable set of principles had to be adopted in naming them to avoid confusion botanists adopted rules known as the international code of Professional.

2. Nomenclature may be defined as the system of naming plants, animals or other objects. In botanical nomenclature, the names given to plants are either Latin names or Latinized names taken from other languages.

Botanical Nomenclature: these rules deals with the use and application of scientific names.

Binomial Nomenclature:

The Binomial system of nomenclature was started by Carolous Linnaeus (1753). In this system, the plants are given 2 names. One name is given to the genus, called generic name. The other is given to the species, the specific name. A plant therefore is underlined when printed. For example the scientific name for Yam is Diosscorea spp. underlined when written and *Dioscorea spp* italized in printed form. Based on the International code, there can only be one group of plants in the genus Dioscorea. Within each genus there can only be one group of plants in the genus Dioscorea. Within each genus there can only be one valid specific epithet esculentus, but the same specific epithet way apply to plants of different genus e.g Manihot esculentus., Abelmoscus esculentus etc.

The following terminologies are generally employed in plant taxonomy.

GENERIC NAME:- This is always a noun and it is always written with a capital initial letter. It may be desciptive or the aboniginal name of plants or a name in honour of a person such as Jeffersonia sp after Thomus Jefferson or Linnea sp. For Linnaeus.

SPECIFIC NAME:- This may be any of the following;

(a) An adjective agreeing with the generic name in gender, and usually indicating a distinguishing characteristic of the species or sometimes referring to a locality where the species was first discovered e.g. *Ulmus americana*, *Pennisetum americana* etc.

(b) A noun such as it occurs when the species is named in honour of one or more persons e.g *Carex davissi* after Mr Davis, *Gilia piersonae* after Miss Pierson. Note the ending letters in the two names.

The names of taxa superior to genus, such as orders families and subdivision of such groups are also formed in accordance with generally accepted principles.

ORDER:- Is the major taxa immediately superior to the family. We form the name of the order by adding ales to the stem of an included generic name e.g Poales for Poa for the order including grasses.

FAMILY:- A family consists of a group of related genera. We form its name, except for a few that antedate the standardized system, by adding aceae to the stem of an included generic name e.g Rosaceae for Rosa etc. A few family have long been designated by nauns that predate this system e.g

Family name	**Old name**	**New name**
Grass	Gramineae	Poaceae
Mustard	Cruciferae	Brassicaceae
Pea	Leguminouseae	Fabaceae
Sunflower	Compositeae	Asteraceae

SUB-FAMILY:- A major subdivision of a family and is sometimes used when the size of the family justifies it and when the included genera may be naturally so grouped. We form the name by adding oideae to the stem of an included generic name e.g Festucoideae, for Festuca and Panicoideae for panicum.

TRIBE:- Is a subdivision of a family, subordinate to the subfamily when the taxon is employed. We form the name by adding eae to the stem of an included generic name, e.g Festuceae from Festuca, for the Fescue tribe of the grass family.

AUTHORITY:- This refers to the name of the person(s) written after the scientific name or taxon. The authors name may be written out, but more commonly it is indicated by a standardized abbreviation. For example *Poa pratensis* (Kentucky blue grass) was first named and described by Linnaeus, he became the authority for that name and it is written as Poa pratensis, L., *Erythronium grandifloruim* Pursh.; *Lomatuim montanum* C and R. When rank of a plant is changed or when a specie is transferred from one genus to another, the name of the original author is placed in parenteses and it is followed by e.g *Abelmoschus esculentus* (Moend) L., *Medicago zatira* (L) All., Feruca foeniculacea (Nutt.) C and R.

Summary of Taxa used in classification for *Poa pretenses*.

1. Kingdom	Plantae, plant kingdom
2. Division	Embryophyta, embryo plant
3. Subdivision	Phanaerogana – seed plants
4. Branch	Angiospermae
5. Class	Monocotyledoneae
6. Order	Poaceae - grass and sedges
7. Family	Poaceae – grass
8. Subfamily	Festucoideae
9. Tribe	Festuceae
10. Genus	Poa
11. Section	Protenses
12. Species	Poa pretenses

TYPE:- Type method is used by taxonomist to actieve stabilization of taxa from species and subdivisions.

The original plant on which the descriptive is based is deposited in a standard herbarium. When the original species is lost by accident, substitutes are provided and placed in the herbarium. The following are the terminologies for the type,

Method

HOLOTYPE: A particular specimen or element designated by the author which automatically fizes the application of this name.

LECTOTYPE: A specimen or element related by a competent worker from the original material studied by the author, to save as substitute for the holotype if the original material gets missing.

NEOTYPE:- A specimen selected to serve as substituete for the holotype when all material on which the name was based is missing.

ISOTYPE:- A specimen , other than the holotype, which duplicates the holotypes from the same collection, with the same locality, date and number as the holotype.

PARATYPE OR CO-TYPE:- Any specimen, other than the holotype, referred to in the original publication of the taxon.

SYNTYPE:- One of two or more specimen or elements used by the author of a taxon if no hologype was designated.

TOPOTYPE:- A specimen collected at the same locality as the halotype and therefore probably representing the same population.

CLASSIFICATION OF ANGIOSPERM- Flowering plants

The angiosperms belong to the branch – angiospermae and could be divided into 2 classes:- Monocotyledoneae and Dicotyledoneae.

MONOCOTYLEDONEAE: - This class consists of many subclasses and the important ones among them are;

1 Subclass Calyciferae – The agriculturally important order are :-

(a) Order Bromeliales:- This contain, the pineapple family Bromeliaceae which is mainly epiphytic,tropical and subtropical with densely clustered linear and usually spring toothed leaves.

(b) Order Zingiberates – This contain 2 important families;

Musaeae – which is banana and plantain and ginger.

Family – Zingiberaceae.

Subclass - Corolliferae – Agriculturally important orders are;

(a) Order – Liliales which contain lily family liliaceae which contains onion

(b) Order – Arales which contain Araceae family. Important crops from the family includes coconut palm – Cocos nucifera, date palm – Phoenix doctylifera; Royal palm- Roystonea regia; raffia palm – Raphia pedunculata etc.

3 Subclass Glumiflorae

This contains grasses and grass-like plants. Important order include.

(a) Order – poales – Annual or perennial, mostly grasslike herbs. Two families can be distinguished in this order: Cyperacea (sedges) and poaceae (grasses). Members of cyperaceae are mainly weeds. Poaceae is the most important plant family in the world and it contain all the cereals grains that serves as food for man and his animals. Table 4 shows common members of the family; Table 5 the forage crops:

Members of the Poaceae (grass family)	
Oats	*Avena sativa*
Barley-	*Hordeum vulgare*
Wheat	*Triticum aestivum*
Rice	*Oryza sativa*
Sugarcane	*Saccharum officinarum*
Sorghum	*Sorghum vulgare*
Maize	*Zea mays*

Millet	*Penisetum sp.*

Table 5

The forage crops	
Andropogon sp	gamba grass
Panicum maximum	guinea grass
Digitaria sp	crab grass
Cynodon sp	giant star grass etc

DICOTYLEDONEAE

This class contains many subclasses. Important ones among them include.

Sub-class- polypetalae – contain many orders. Such as:-

(a) Order paparales – contain many families such as Brassicaceae which contain mostly herbs with pungent watery juice. Members of the family include – Cabbage- Brassica oleracea, radish- Rapharues sativa; turnip – Brassica rapa.

(b) Order Rosaleles – herbs, shrubs or trees with simple or compound leaves. This is one of the largest order of flowering plant and it include families such as Rosaceae, saxifragaceae, Fabaceae etc. Fabaceae are herbs, shrubs or trees. It is usually divided into three sub families:- Mimosoideae, Ceasalpiniodeae and lotoideae. Among the three only Lotoideae subfamily contain food crops which include; pea- *Pisium sativum*, sweet peas – *Lathyrus odoratus,* soyabeans- Glycine sp. It also contains important species such as clover – Trofolium sp, alfalfa – *Medicago sativa.*

(c) Order geraniales: contains an important family- Rutaceae which contain aromatic trees or shrubs, important crop, include sweet orange – *Citrus sinensis,* Lemon- *Citrus limon*, grapefruit – *Citrus maxima*, citron- *Citrus medica.*

(d) Order Malvales – contain Tiliaceae and Malvaceae families. Tiliaceae contain corchorus, a popular vegetable. Crops such as cotton – Gossypium sp., okra – *Abelmoscus esculentus*, Rosette- *Hibiscus sabdarifa* etc.

(e) Order Sapindales – contains an important family such as Anacardiaceae which contain crops such as Anacardiaceae which contain crops such as cashew- *Anacarduim occidentale*, Mango – *Mangifera indica*.

(f) Order Euphorbiales – contains only one family Euphorbiaceae which are herbs, shrubs or trees often with milk juice. Important members of the family are; Rubber – *Hevea braziliensis*; Cassava- Manihot sp, Castor oil- *Ricinus communis*. The family also includes important ornamentals such as Euphorbia pulcherrima- poinsettia.

SUBCLASS – SYMPETALAE

(a) Order Scrphulariales – contain plant of various habitat but predominantly herbaceous. Important family include solanaceae which contain plants which are chiefly herbaceous, climbing and occasionally woody. Important crops in this family include; potato - Solanum luberosum, tomato – *Lycopersicon esculentum*, tobacco- *Nicotiana tubeccum*, peppers – *Capsicum frutescens* etc.

(b) Order Rubiales : Important family include Rubiaceae – mostly trees or shrubs e.g coffee- Coffea arabica.

(c) Order Cucurbitales – important family is cucurbitaceae and contain such vegetable crops as pumpkin- *Cucurbita pepo*, Water melon – *Citrulus lunatus*, Cucumber – *Cucumis sativus*, calabash – *Lagenaria sp.* etc.

ENZYMOLOGY

Enzymes- properties, compositions, Types, Mechanisms of action.

Enzymes are protein compounds that catalyse a specific reaction. Living cells contain thousands of different enzymes that accelerates or decelerates one kind of reaction without itself being changed. In some of these reactions, small organic molecules such as; acids, sugars, nucleotides and lipids are broken down to provide energy for the cell. In other reactions, small molecules are built into complex macromolecules, such as; proteins, DNA, RNA, and polysaccharides, or used to carry signals, or to control cell movement or gene expression. Sometimes the enzyme proteins have non proteins attachment called prosthetic group when bounded by covalent bond, e.g. metals like; Cu, Mg, and Fe, and co-enzyme or co-factors when bonded by loose hydrogen bond, e.g. Vitamins. The co-enzyme and prosthetic group may become attached to several different protein forming different enzymes. Enzymes exhibit enormous catalytic power, in some cases increasing reaction rates by a factor' of over 1014 (one hundred million). Enzymes dictate the pattern of chemical changes in a cell and without them life as we know it would be impossible.

Properties characteristics of Enzymes

a) Small amount of enzymes are needed to convert large amount of substrate into products.

b) Same substrate can be utilized by several enzymes. For instance, isomers, phosphoglucomutase and glucose – 6 – phosphate dehydrogenase act on glucose to produce fructose – 6- phosphate, glucose - 1- phosphate and 6- phosphoglucolactone respectively.

c) Enzymes work at narrow range of temperature. Optimum temp is 40^{o}c and could be destroyed at 60^{0}c.

d) They work at specific pH. Most function at around neutral pH (5-7). However, pepsin in stomach works at pH 2-3 and trypsin in duodenum works at pH 8.5.

e) Catalytic actions of enzymes may be specific. Hence an enzyme which catalyse one reaction may not catalyse another. For instance, invertase works on sucrose to produce glucose while zymase act on glucose and give carbondioxide and ethanol.

f) Enzymes are not destroyed by the reactions they catalysed and could be used again.

g) Enzymes could be poisoned by chemical compound like; mercury, chloride, silver chloride and hydrogen cyanide. This inactivate the enzymes, for example HCN blocks the enzymes involve in respiration.

Mechanism of Action (working) of Enzymes.

This can be explained by chemical hypothesis A B. Chemical energy needed could be in the form of heat (temperature) to activate passive A by bombarding A's molecules to activate it and later turned into B molecules. The energy that A molecule required to react and be converted into molecule B is the activation energy of reaction. Enzymes are believe to catalyse reaction by lowering the activation energy e.g. in

$2H_2O$ catalase $2H_2O + 2O_2$ the activation energy in the absence of catalase is

18,000cal mol. While in the presence of catalase, it is 6,400 cal mol. Lock and Key Hypotheses: the enzyme is believed to be the padlock and substrate the key.

substrate

enzyme Enzyme –substrate complex Products

Classification of Enzymes

Enzymes are generally of two types, they are : intracellular enzymes and extracellular enzymes. But specifically, enzymes can be classified as follows:

1 According to substrate they act upon, e.g Arginase that act on arginine, tyrosinase act on tyrosine, lipase acts on lipids while proteinase acts on protein and carbohydrases and maltase on carbohydrates and maltose respectively.

2 According to the type of reaction they catalyse. For example: hydrolyses (hydrolytic enzyme), oxidases (oxidation reduction enzymes), phosphorylases (phosphate adding and deleting enzymes).

In both cases above, the suffix-ase is added to the name of the substrate or reaction type.

SPECIFIC ENZYME TYPE

1 Hydrolyses (hydrolytic enzymes) they catalyse the addition of the elements of water to specific bond of substrate. RCO-OR' HOH RCOOH + R'OH

E.G, lipases, carbohydrates, proteases

2 oxidases, (oxidation- reduction enzymes). These catalyse the removal or addition of hydrogen, oxygen or electron from or to substrate, which is thereby oxidised or reduced in the process.

RH +HA R+ AH_2(removal of H_2)

RO $+_{1\backslash 2})O_2$ RO_2(addition of O_2)

R^{2+} R^{3+} +e e.g dehydrogenases and oxidases

3 Phosphoric; these catalyse the addition or removal of elements of phosphoric acids, e.g glucose + phosphate Hexokinase glucose – 1- phosphate

4 Carboxylase; these catalyse the removal or addition of CO_2 e.g, ribulose- 1,5 –diphosphate(5C) carboxydismutase Keto acid (6C)

5 Isomers: these catalyse the interconversion of aldose and ketose sugars e.g, Glucose – 6-phosphate Phosphoglucoisomerase fructose -6- phosphate

6 Lyase; these carry out breaking of double bonds e.g, lysozyme (found in tears, nasal mucus and egg) which dissolve certain airbone cocci (bacteria) by breaking the double bond of polysaccharides in their walls.

ESTIMATION OF RATES OF ENZYME ACTIVITIES

1 Use of turnover numbers; this is the number of moles of substrate converted per minute by 1 mole of enzyme. Succine dihydrogenase has turnover number of 1150 while carbonic anhydrase has turnover number 360,000,000.

2 Manometric; gases evolve as a result of enzyme activities are measured manometrically, e.g oxidase, carboxylase.

3 Spectrophotometric: uses the fact different quantities of product have different optical density at the same wavelength. The wavelength used depends on the enzyme type involved. E.g, for amylase, the wavelength is 490nm and for protease it is 700nm.

4 Colouration Method: works on the basis that the substrate and the product have different colour with dye. The disappearance of the colour with time is taken note of e.g. starch + iodine(blue black) Amylase maltose +iodine + E (iodine colour)

5 Chemical Estimation: this involve titration, chromatography and electrophoresis techniques. For instance, lipase are estimated by breaking lipids into fatty acids and glycerol using lipases and the liberated fatty acids quantities determined using titration with NaOH and Phenolphtalein as an indicator.

Enzyme Inhibitors

These are compounds that prevent, limit, or stop enzyme activities; they are divided into competitive inhibitors and non competitive inhibitors.

1. Competitive Inhibitors: have similar shape to the substrate and can fit into the active centre of enzymes. They lower enzyme activities e.g, the inhibition by malonic acid of the enzyme succinic

dehydrogenase that catalyse the conversion of succnic acid to fumaric acid. Competitive inhibition can be overcome by increasing the concentration of the substrate.

2. Non Competitive Inhibitor: either undergoes chemical reaction with the enzymes and thereby alter the configuration of the enzymes or form bond with enzymes substrate complex to form inactive compound. They normally stop the working of enzymes and effect cannot be overcome by increasing the concentration of the substrate. Examples are effects of poison, heavy metals (Hg, Au, Ag). Cyanide, and carbon.

COMMERCIAL USES OF ENZYME

A papain obtains from plants like pawpaawa leaves- protease is sold as meat tenderizer (Aldolfs). It breakdown protein into peptones and make the meat soft.

B Protein digesting subtilism(from Bacillus Subtillis) is incorporated into pre-soak laundry agent and detergent for cleaning purposes. It is effective in removing protein- containing stains (chocolate or coffee) from clothes etc.

C Synthetic amylase is used in beer laundry to break down starch substances into maltose.

D synthetic cellulose is used in the textile industry to breakdown clothes into pieces of yarns.

Plant-water relations

Water is the most abundant constituent of all physiologically active plant cells. Leaves, for example, have water contents which lie mostly within a range of 55–85% of their fresh weight. Other relatively succulent parts of plants contain approximately the same proportion of water, and even such largely nonliving tissues as wood may be 30–60% water on a fresh-weight basis. The smallest water contents in living parts of plants occur mostly in dormant structures, such as mature seeds and spores. The great bulk of the water in any plant constitutes a unit system. This water is not in a static condition. Rather it is part of a hydrodynamic system, which in terrestrial plants involves absorption of water from the soil, its translocation throughout the plant, and its loss to the environment, principally in the process known as transpiration.

Cellular water relations

The typical mature, vacuolate plant cell constitutes a tiny osmotic system, and this idea is central to any concept of cellular water dynamics. Although the cell walls of most living plant cells are quite freely permeable to water and solutes, the cytoplasmic layer that lines the cell wall is more permeable to some substances than to others.

If a plant cell in a flaccid condition—one in which the cell sap exerts no pressure against the encompassing cytoplasm and cell wall—is immersed in pure water, inward osmosis of water into the cell sap ensues. This gain of water results in the exertion of a turgor pressure against the protoplasm, which in turn is transmitted to the cell wall. This pressure also prevails throughout the mass of solution within the cell. If the cell wall is elastic, some expansion in the volume of the cell occurs as a result of this pressure, although in many kinds of cells this is relatively small.

If a turgid or partially turgid plant cell is immersed in a solution with a greater osmotic pressure than the cell sap, a gradual shrinkage in the volume of the cell ensues; the amount of shrinkage depends upon the kind of cell and its initial degree of turgidity. When the lower limit of cell wall elasticity is reached and there is continued loss of water from the cell sap, the protoplasmic layer begins to recede from the inner surface of the cell wall. Retreat of the protoplasm from the cell wall often continues until it has shrunk toward the center of the cell, the space between the protoplasm and the cell wall becoming occupied by the bathing solution. This phenomenon is called plasmolysis.

In some kinds of plant cells movement of water occurs principally by the process of imbibition rather than osmosis. The swelling of dry seeds when immersed in water is a familiar example of this process.

Stomatal mechanism

Various gases diffuse into and out of physiologically active plants. Those gases of greatest physiological significance are carbon dioxide, oxygen, and water vapor. The great bulk of the gaseous exchanges between a plant and its environment occurs through tiny pores in the epidermis that are called stomates.

Although stomates occur on many aerial parts of plants, they are most characteristic of, and occur in greatest abundance in, leaves.

Transpiration process

The term transpiration is used to designate the process whereby water vapor is lost from plants. Although basically an evaporation process, transpiration is complicated by other physical and physiological conditions prevailing in the plant. Whereas loss of water vapor can occur from any part of the plant which is exposed to the atmosphere, the great bulk of all transpiration occurs from the leaves. There are two kinds of foliar transpiration: (1) stomatal transpiration, in which water vapor loss occurs through the stomates, and (2) cuticular transpiration, which occurs directly from the outside surface of epidermal walls through the cuticle. In most species 90% or more of all foliar transpiration is of the stomatal type.

Transpiration is a necessary consequence of the relation of water to the anatomy of the plant, and especially to the anatomy of the leaves. Terrestrial green plants are dependent upon atmospheric carbon dioxide for their survival. In terrestrial vascular plants the principal carbon dioxide–absorbing surfaces are the moist mesophyll cells walls which bound the intercellular spaces in leaves. Ingress of carbon dioxide into these spaces occurs mostly by diffusion through open stomates. When the stomates are open, outward diffusion of water vapor unavoidably occurs, and such stomatal transpiration accounts for most of the water vapor loss from plants. Although transpiration is thus, in effect, an incidental phenomenon, it frequently has marked indirect effects on other physiological processes which occur in the plant because of its effects on the internal water relations of the plant.

Water translocation

In terrestrial rooted plants practically all of the water which enters a plant is absorbed from the soil by the roots. The water thus absorbed is translocated to all parts of the plant. The upward movement of water in plants occurs in the xylem, which, in the larger roots, trunks, and branches of trees and shrubs, is identical with the wood. In the trunks or larger branches of most kinds of trees, however, sap movement is restricted to a few of the outermost annual layers of wood..

Root pressure is generally considered to be one of the mechanisms of upward transport of water in plants. While it is undoubtedly true that root pressure does account for some upward movement of water in certain species of plants at some seasons, various considerations indicate that it can be only a secondary mechanism of water transport.

Upward translocation of water (actually a very dilute sap) is engendered by an increase in the negativity of water potential in the cells of apical organs of plants. Such increases in the negativity of water potentials occur most commonly in the mesophyll cells of leaves as a result of transpiration.

Water absorption

The successively smaller branches of the root system of any plant terminate ultimately in the root tips, of which there may be thousands and often millions on a single plant. Most absorption of water occurs in the root tip regions, and especially in the root hair zone. Older portions of most roots become covered with cutinized or suberized layers through which only very limited quantities of water can pass.

Whenever the water potential in the peripheral root cells is less than that of the soil water, movement of water from the soil into the root cells occurs. There is some evidence that, under conditions of marked internal water stress, the tension generated in the xylem ducts will be propagated across the root to the peripheral cells. If this occurs, water potentials of greater negativity could develop in peripheral root cells than would otherwise be possible. The absorption mechanism would operate in fundamentally the same way whether or not the water in the root cells passed into a state of tension. The process just described, often called passive absorption, accounts for most of the absorption of water by terrestrial plants.

The phenomenon of root pressure represents another mechanism of the absorption of water. This mechanism is localized in the roots and is often called active absorption. Water absorption of this type only occurs when the rate of transpiration is low and the soil is relatively moist. Although the xylem sap is a relatively dilute solution, its osmotic pressure is usually great enough to engender a more negative water potential than usually exists in the soil water when the soil is relatively moist. A gradient of water potentials can thus be established, increasing in negativity across the epidermis, cortex, and other root tissues, along which the water can move laterally from the soil to the xylem.