2021/10/19

قسم علوم الحياة — المرحلة الثالثة

الفصل الدراسي الاول

للعام 2021 / 2022

فسلجة النبات

Plant Physiology

المحاضرة : -1-

م. المادة : د. جواد

Lec. 1

قسم علوم الحياة
مرحلة النبات
المرحلة الثالثة

1st Semester
2020/2021

Bio. Sci. Dept
Plant Physiology
3rd stage

2020/2021 الفصل الدراسي الاول للعام الدراسي

يشمل هذا الكورس التالي

* محاضرات نظرية (9 الى 10 محاضرة)
* تقرير علمي مختصر بأحد مواضيع مادة النبات باللغتين الانكليزية والعربية (لايتجاوز 3 صفحات A4)
* يسلم كل طالب بعنوان التقرير لاحقاً آخر موعد 2021/12/1

الامتحانات الشهرية

1- الامتحان الشهري الاول يشمل اربعة المحاضرات الاولى
2- الامتحان الشهري الثاني يشمل خمسة المحاضرات الاولى

تحدد مواعيد تلك الامتحانات لاحقاً

الامتحانات الاسبوعية Quizes

تشمل واجب او اثنين . تحدد مواعيدها لاحقاً

الواجبات Homeworks

حلول اربعة تمارين تقدم في موعد محدد من قبل كل طالب . ملاحظة: تشمل تلك التمارين المحاضرات الاربعة الاولى

اصناف درجة الصف الفصل : درجة الصف 40/10

* الجزء النظري 25 ((22 + 3 غيابات))
* الجزء العملي 15

المجموع 40

اصناف درجة الامتحان النظري

* النظري 50
* العملي 10
* المجموع 60

Lec. 1

Plant Physiology

تعتمد المصادر العلمية لهذه المادة (فسلجة النبات) المصادر التالية

أولاً: المصادر الأجنبية

1- Donahue, R.L., R.W. Miller, and J.C. Shickluna. 1977. An Introduction to Soil and Plant Growth. 4th ed. Prentice-Hall, Inc., Englewood Cliffs, N.J., USA

2- Jain, V.K. 2009. Fundamental of Plant Physiology. Ram Nagar, New Delhi, India.

3- Kaufman, P.B. etal. 1989. Plants: Their Biology and Importance - Harper and Row, Pub, N.Y., USA

4- Salisbury, F.B., and C.W. Ross. 1985. Plant Physiology. Wadsworth Pub. Com., Inc., Belmont, Cali, USA

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ثانياً: المصادر العربية

١- سكري، فيصل عبد القادر وآخرون ١٩٨٩ - فسيولوجيا النبات. جامعة بغداد - وزارة التعليم العالي والبحث العلمي

٢- محمد، عبد العظيم كاظم، وكريم صالح ١٩٩٠. الحسابات الفسيولوجية النباتية - جامعة صلاح الدين - وزارة التعليم العالي والبحث العلمي.

٣- مصطفى، عبد العزيز وآخرون ١٩٧٩. النبات العام - الطبعة الرابعة مكتبة الأنجلو المصرية - مصر.

د. جواد كاظم
مادة

علم سلالة وراثة

المرحلة الثالثة

المحاضرة 1

قسم علوم الحياة

تشمل المحاضرة الاولى التالي

* تعريف واقسام علم السلالة الوراثية
* وظائف مكونات الخلية والجزيئات البايولوجية الاساسية

* علاقة علم السلالة مع العلوم الاخرى
* خصائص الماء والصفات المائية

* الظواهر السلجية

* انتشار السوائل والغازات
* الازموزية * التشرب * البلزمة

اسئلة عامة

Lec. 1

Plant Physiology :

Plant physiology is science concerning the functions of living things (systems).
Physiology derivates from "Ancient Greek":
Physis is meaning "nature, origin"
and Logia, means "The study of".
Plant physiology is studying all functions of cells, parts and organs in living systems.

Plant Cell :

Functions and Roles of plant cell :

Part	Function (s)
* Nucleus	Contains genetic materials (Chromosomes, Nucleic acids)
* Cell memberane	Movement of substances
* Mitochondria	Energy houses
* Ribosomes	Synethesis Proteins
* Cell wall	Strengthens the cell
* Chloroplasts	Absorption light energy for Photosynthesis

Lec. 1

Plant physiology

Essential Biomolecules :

Macromolecule : A molecule having molecular weight ranging from few thousands to many millions.

Micromolecule	Atomic Chemical Composition	Example	Macro-molecules
* Amino acids	C, H, N, O, (S)	Alanine, Tryptophane	Protein
* Carbohydrates	C, H, O	Glucose, fructose Ribose	Starch, Chitin, Pectin
* Glycerol, fatty acids	C, H, O, (N, P)	Glycerides, Palmitic, Stearic, Linolenic acids	Lipids (waxes) Fats, oils
* Purines	C, H, O, N	Adenine, Guanine	
* Pyrimidines	C, H, O, N	Cytosine, Uracil, Thymine	
* Nucleosides	C, H, O, N	Adenosine, Guanosine Cytidine, Uridine, Thymidine	Nitrogenous Bases + Saccharides (Ribose)
Nucleotides	C, H, O, N, P	Adenylic acid for example [Nitrogenous bases + Sugar (ribose) + phosphoric acid	DNA, RNA
Nucleotids	C, H, O, N, P	ATP ADP AMP	Adenosine tri = di = mono = phosphates

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Plant Physiology

Plant physiology can be divided into three divisons as follow:

1. Metabolism Physiology → deals with
   - Photosynthesis
   - Respiration
   - Water Absorption
   - Mineral Abs.
   - Transport and Paritions of assimilates
2. Integrating Physiology deals with
   - Plant growth Physiology
   - Floral and Reproductive Physiology
   - Senescence Physiology
3. Stress Physiology: It is concerning of
   - Water stress
   - Salinity stress
   - Ecological stress
     - Abiotic [CO_2, O_2, ... light, Climate, R.H, soil, Wind, Location]

Plant Physiology is related to Many Sciences as:

- Plant Anatomy
- Plant Biochemistry
- photochemistry
- Plant Taxonomy
- Cytology
- Molecular Biology
- Cytochemistry
- Plant Nutrition
- Plant Ecology
- Biophysics - Biotechnology
- Biostatistic and others

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Plant physiology

Historic Era of Plant Physiology

① Ancient Era :

* Fernel, a French physician introduced the term "physiology" in 1525.
* Carlus Linnaeus (1707-1778) who ushered in a new era of plant taxonomy

② Modern History

* Schleiden and Schwan ((cell Theory))

Transpiration :

Sayre (stomata mechanism)
Steward (=)

Water and Nutrient Absorption

* Dixon and Jolly ((cohesion - Tension Theory))
* Hoagland ((Nutrient solutions, Hydroponics))
* Jenny ((contact Theory))
* Hales ((Root pressure))

Respiration :

* Buchner (Fermentation)
* Embden - Myerhof - Parnas (EMP) ((Glycolysis))
* Kreb ((citric acid cycle))
* Warburg ((Respiration rate))

Enzymes and Plant Hormones

* Michales and Menton ((Enzyme kinetics))
* Sachs (plant growth Hormones
* Kogl, Haogen and Smith ((plant Hormones))
* Sumner ((Enzyme))

Photosynthesis :

* Calvin ((cycle, C_3 plants cycle))
* Slack and Hatch ((C_4 plants cycle))
* Einstein ((Photochemical Reactions))

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Plant physiology

Water and Water Relations:

Table 1. Physiochemical properties of water

Property	Value
Melting point	273.15° K (Kelvin) ((0° C))
Boiling point	373.15° K (=) ((100° C))
Density	0.999 g/ml at 273.15° K (0° C) 1.000 g/ml at 277.15° K (4° C)
Molar heat of fusion	6.00 K Joule/mol. (($KJ\ mol^{-1}$))
Drelectric constant	78.54 (dimensionless) at 298.15° K ((25° C))
Viscasity	0.01 Poise at 293.15° K (20° C)
Surface tension	72.75 dyne/cm at 293.15 K (20° C)
Diffusion Coefficient	2.4×10^{-9} m^2/sec 2.4×10^{-5} cm^2/sec } at 298.15° K ((25° C))

Water :

Water is considered of 65 to 95% of plant composition - Sometimes reached it upto more 95% of special plants and fruits. The percentage of water content is approximately 10% in plant seeds

Water compose by two hydrogen (H) atoms and one oxygen (O) atom (See Fig.1). The distance between O and H atoms is approximately 1.05 A° ((Angstrom (A) = 0.1nm)) = 0.105 nanometer (nm) → nm = 10^{-9} m. under acidic conditions (Low pH), meanwhile the value is 0.85 A° (= 0.085 nm) under alkaline conditions.

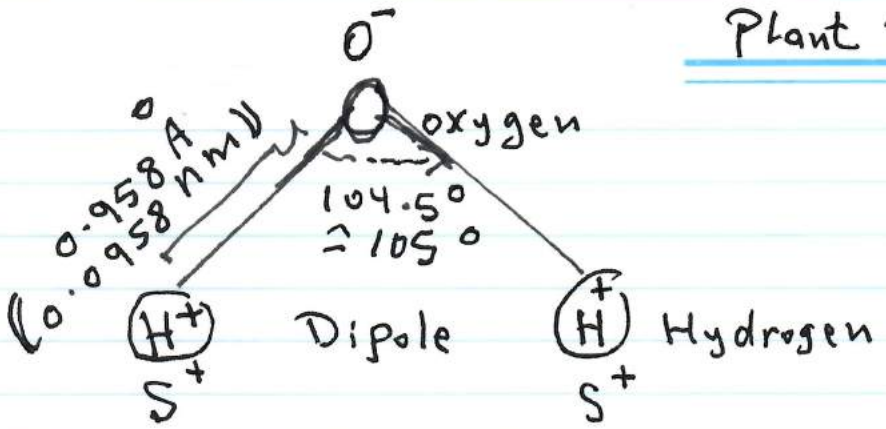


Fig.1. Water composition

Water Bonds and Its Criteria:

(1) covalent bonds (Its energy equal to 110 Kcal/mole)
(2) Hydrogen bonds (Its ≈ ≈ ≈ 4.5-10 ≈)

(3) Water Dipolar
This criterion very important as solvent and its roles in diffusion, osmosis and imbition.

(4) Heat of fusion (80 cal./g ≈ ? KJ/mole)

(5) Because of water density at 4°C ((277.15° K)) is 1 g/ml (1g/c.c.) causing raises the ice on water surfaces (Rivers, Seas, oceans), this phenomonian is very important for organisms life.

Water Structure Molecules:

Two theories of water structure molecules are explained as:

(1)- Distorted Theory جزيئات الماء غير منتظمة
نتيجة لتواجد الهيدروجين المتحركة بدرجة كبيرة

② . Flickering Theory (clustered Theory)
جزيئات الماء مرتبطة عنقودية مؤقتاً بعضها

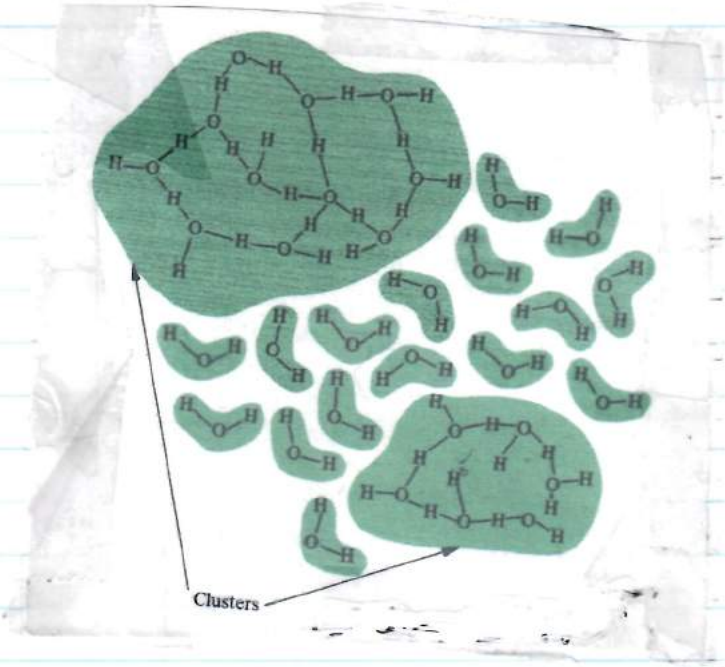


Fig. 2 -
Flickering Theory

Diffusion

In diffusion solutes (solvents) (gas, liquid , and solid) more freely from an area of higher concentration (Higher kinetic energy) to an area of lower concentration (Lower kinetic energy), which eventually results in equal distribution of solute (liquid) within two areas. The diffusion force is known as diffusion Pressure .

The rate of diffusion increases if,

① the diffusion pressure gradient is steeper
② the temperature is increased
③ the density of the diffusing particles is lesser
④ the medium through which diffusion occurs is less concentrated.

Liquid Diffusion:

The phenomenion of liquid diffusion depends on Fick's law as follow:

$$\text{Rate of diffusion} = \frac{dn}{dt} \propto -A \frac{dc}{dx}$$

$$\frac{dn}{dt} = -DA \frac{dc}{dx}$$

whereas, D is the diffusion coefficient

The units of D are cm^2/sec $(cm^2 sec^{-1})$, m^2/sec $(m^2 s^{-1})$. The negative sign indicates that the diffusion proceeds from higher to lower concentration - This means that the concentration gradient is negative in the diffusion direction.

Diffusion of Gases:

Gases have known as lowest matter state to resiste molecules diffusion. This mechanism is due to large distance occurs between gas molecules as compared to the liquid and solid forms of the water Fig. 3.

Graham's law consider the relation between diffusion rate and gas density according to the following:

$$\frac{R_{g1}}{R_{g2}} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$

whereas R_{g1} = Diff. rate of gas 1

R_{g2} = Diff. rate of gas 2.

M_1 = Molecular wt. of the first gas

and M_2: = = . = second gas

Also can be Graham's Law is written by:

$$\frac{Rg_1}{Rg_2} = \frac{\sqrt{D(g_2)}}{\sqrt{D(g_1}}$$

Example: Calculate rate of hydrogen(H) diffusion as compared to neon(Ne) diffusion, if you know the following

D(H) = 0.071 g/ml (g/c.c) (= g/cm^3)
D(Ne) = 1.20 =

Solution: $\frac{RH_2}{R\,Ne} = \frac{\sqrt{D\,Ne}}{\sqrt{D\,H}} = \frac{\sqrt{1.20}}{\sqrt{0.071}} = \underline{4.1}$ folds

Hydron gas is diffused 4.1 folds as compare with Neon gas. A.W = 1.007 H
A.W = 20.18 Ne

or $R = \frac{RH}{RNe} = \frac{\sqrt{20.15}}{\sqrt{1}} = \frac{\sqrt{20.18}}{\sqrt{1}} \cong \underline{4.6}$

Factors Affecting upon Gases Diffusion:

(1) Gas Density (2) Temperature يزداد الانتشار بزيادة درجات الحرارة
(3) Medium of dispersion
تنتشر جزيئات الغاز بصورة اسرع كلما كانت الوسط الذي تنتشر فيه اقل تركيزاً

(4) Diffusion pressure Gradient يتحدد بضغط الانتشار
(5) size of gas particle
(6) Type of electric charge
(7) Number of electric charges.

Plant Physiology

Osmosis

Osmosis process is diffusion of water through a semi-permeable membrane into another aqueous compartment with more concentration solution.

The diffusion of solvent molecules into the solution through semipermeable membrane is called as osmosis ((Sometimes called as osmotic diffusion)).

If a living plant cells or tissues is placed in water or hypotonic solution ((whose osmotic pressure is lower than that cell sap)) water enters into the cell sap by osmosis. This process is called as endosmosis.

Osmotic pressure can be calculated by Vant Hoff Equation

$$\Pi = \alpha C R T$$

Whereas α (or i) Type of ionization

- Π = osmotic pressure
  - C = Concentration in mole/L ((Molarity))
  - R = gas Constant
    - $R = 0.082 \frac{\text{Liter} \cdot \text{atm.}}{\text{mole deg.}}$
- T = absolute temperature
  - $T = 273 + {}^{o}C$

Units of osmotic pressure

Atm. = 1.013 bar

Atmosphere (جو ضغطي)

MPa = 9.87 atm.

bar = 0.987 atm.

MPa → Mega Pacal (10^6 Pascal)

MPa = 10 bar

Lec. 1

Plant physiology

Osmosis Process Mechanism

Plant cell process is selectively permeable memberanes especially plasmic memberane and vacuole meberane whereas those memberanes have important role in water absorption.

Vacuole contains water solution of mang substances ((such as salts, sugars, organic acids)).

The cytoplasm is surrounded by selective memberane called Plasma memberane or Ectoplast. The vacuole is surrounded by selective memberane is named Vacuolar memberane or Tonoplast

((Tonoplast limits for solutes transport))

Cell wall:

Cell wall is strengthen and flexible. It is permitted to pass the water and soluble materials through it and also gases.

Note:-

Osmotic pressure of the solution can be termed as osmotic potential.
The osmotic potential of pure water is equal Zero

Meanwhile the water solutions with soluble salts have negative (−) osmotic potential.

Plant Physiology

Lenticel

A structure consisting of loosely packed cork cells in the periderms of the stem of many wood plants that is thought to facilitate gas exchange between the atmosphere and internal tissues.

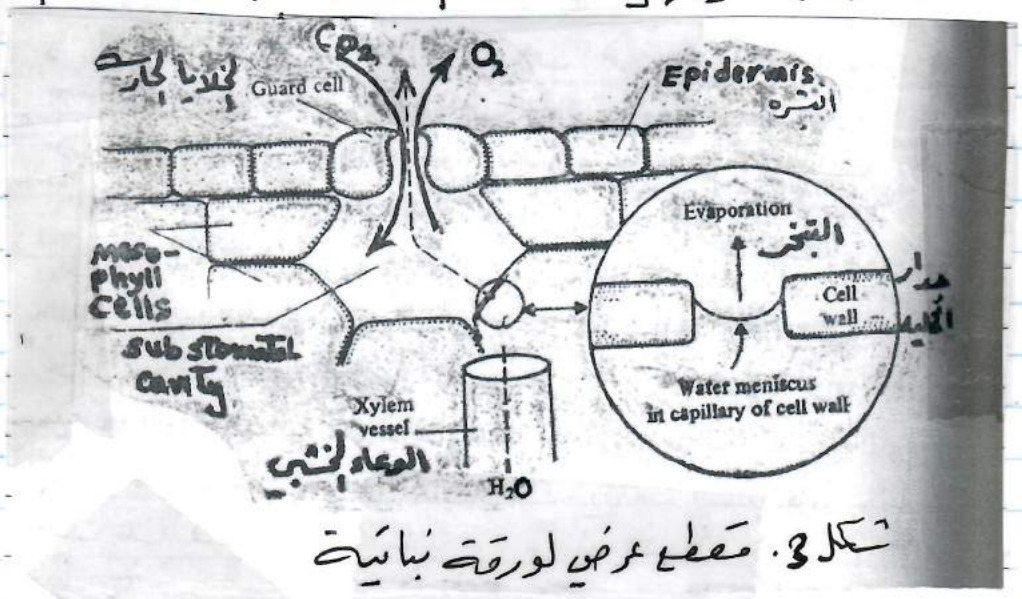
Hydathods

A water secreting pores along the edges and at the tip of leaves of many plants

plasmolysis:

Shrinkage of the cytoplasm away from the cell wall due to excess water loss when a cell is placed in a solution containing a higher effective solute concentration than that of the cell.

The plasmolysis is classifed into:
1 - permanent plasmolysis 2. Incipient plasmolysis
2



شكل 3. مقطع عرضي لورقة نباتية

Fig. 3 - Cross Section of Plant leaf

Lec.1

Plant Physiology

Imbibition: is process by which a porous material absorb a liquid (water) and swells as a result of the adsorption of the liquid to the internal surfaces of the materials,

Imbibition pressure (I.P) is similar to osmotic pressure (O.P) equation as follow

$$DPD = I.P - T.P$$

whereas:

I.P = Imbibition prossure . I.P sometime is replaced by the term matric potential (ψ_m)

DPD = Diffusion pressure deficit تفاضل الضغط الانتشاري

T.P = Turgor pressure

In particular case when TP (turgor pressure) doesnt occur,

DPD = I.P

Factors affecting imbibition rate are

1- Temperature
2- Osmotic pressure
3- Type of hydrophilic colloids presence in both living and dead cells.

امثلة حساب الضغط الازموزي للمحاليل

Example 1 :

Calculate osmotic pressure of KCl solution containing (0.746 g per 100 ml.) at 25°c by atm., bar, and MPa units ((Note: M.W = 74.6))

Solution :

$$0.746 \times \frac{1000}{100} = 7.46 \text{ g/Liter}$$

$$\text{Molarity} = M = \frac{\text{wt.}}{\text{M.W of KCl}} = \frac{7.46}{74.6} = 0.1 \text{ M}$$

$$O.P = \pi = \alpha c R T$$

$KCl \rightleftarrows K^+ + Cl^-$

α = No. of ion
c = conc. (M)
R = gas Constant = 0.082
T = 273 + °C = Kelvin
T = 273 + 25 = 298

$$\pi = 2 \times 0.1 \times 0.082 \times 298$$
$$= 4.89 \text{ atm.}$$
$$= 4.95 \text{ bar}$$
$$= 0.50 \text{ MPa}$$

1 atm. = 1.013 bar
$\frac{\text{bar}}{1.013} = \text{atm.}$

MPa = 9.87 atm.
$\frac{\text{atm}}{9.87} = \text{MPa}$

MPa = 10 bar
$\frac{\text{bar}}{10} = \text{MPa}$

Example 2 :

Count osmotic pressure of sucrose ((M.W = 342)) solution containing (1.71 g sucrose / 50 ml.) at 20° C, by atm, bar, MPa.

Solution:

Conc. of sucrose

$$1.71 \times \frac{1000}{50} = 34.2 \text{ g/L}$$

$$\text{Molarity} = M = \frac{wt}{M.W} = \frac{34.2}{342} = 0.1 \text{ M}$$

Sucrose is non-ionized compounds

$\alpha = 1$ $\quad$ $T = 273 + 20 = 293$ Kelvin

$$OP = \Pi = \alpha cRT$$

$$= 1 \times 0.1 \times 0.082 \times 293 = 2.40 \text{ atm}$$

$$= 2.43 \text{ bar}$$

$$= 0.24 \text{ MPa}$$

Gas Diffusion Rate

Example:

Calculate the diffusion rate of hydrogen gas ($D = 0.071$ g/c-c) as compared with:

1- O_2 ($D = 1.14$ g/c-c)
2- Ne ($D = 1.20$ g/c-c)
3- Xe ($D = 3.06$ g/c-c)

Solution

$$1- \quad \frac{RH}{RO_2} = \frac{\sqrt{D\,O_2}}{\sqrt{D\,H_2}} = \sqrt{\frac{DO_2}{DH_2}} = \sqrt{\frac{1.14}{0.071}} = 4.0 \text{ folds}$$

$$2- \quad \frac{RH}{RNe} = \frac{\sqrt{D\,Ne}}{\sqrt{D\,H}} = \sqrt{\frac{D\,Ne}{D\,H}} = \sqrt{\frac{1.20}{.071}} = 4.1 \text{ folds}$$

$$3- \quad \frac{RH}{RXe} = \frac{\sqrt{D\,Xe}}{\sqrt{D\,H}} = \sqrt{\frac{DXe}{DH}} = \sqrt{\frac{3.06}{0.071}} = 6.6$$

Lec.1

Conclusion الاستنتاج / تكملة لإجابة المثال

Diffusion rate of H gas is increasing (or is more faster) by 4.0, 4.1, and 6.6 folds (عدد مرات) as compared with O_2, Ne, Xe gases, respectively

Homework-1 (H-1) واجب بيتي

على كل طالب يقدم اجوبة المثال السؤال ويقدمها لاحقاً
Calculate the diffusion rate of oxygen (O_2) gas ($D = 1.14$ g/c.c) as compared with:

1- H ($D = 0.071$ g/c.c)
2- Xe ($D = 3.06$ g/c.c
3- CO_2 ($D = 1.977$ g/c.c)

Corrected Answers: [[0.25, 1.64, and 1.32 fold]]

د. عود
2024/10/26

Q6: Define the following in Brief

Ectoplasts , hydathods , MPa , exosmosis , $\frac{II}{}$, DPD

واجب بيتي (H-2) Homework-2

كل طالب يقدم اجابة الاسئلة التالية ويقدمها في وقت محدد لاحقاً

(1)- Calculate the osmotic potential (by atm, bar, and MPa units) of 9.532 gram of $MgCl_2$ in liter of water (M.W = 95.32) at 25°C.

(2)- Count the osmotic pressure of 4.995% of $CaCl_2$ solution ((M.W = 111.0)) at 20°C by MPa and atm. units.

(3)- Calculate the diffusion rate of hydrogen gas (D = 0.071 g/c.c) as compared with Xenon (Xe) gas (D = 3.06 g/c.c).

د. هوار
الجامعة
26/10/2021

Lec. 1

Plant Physiology

Universal Questions

Q1 : ① - The biomicromolecules are
1- 2- 3- 4- 5- 6-

② - Metabolism physiology is diveded into 1- 2- 3- 4- 5-

③ - Significance (Advantageous) of osmosis phenomenae are 1- 2- 3-

④ What are basic differenas between osmosis and diffusion (four only).

⑤ Write the diffusion laws of liquids and gases

⑥ What is the unit of diffusion coefficient ?

Q2) Put the word True or False

① - The energy of water covalent bond is 481.2 KJ/mole

② - The energy of water hydrogen bond is 25 Kcal/mole

③ - Vacuolar memberane is named Tonoplast

④ - The water surface tension of water is 62-8 dyne/cm at 293.15 Kelvin

⑤ - Ectoplast memberane is less limiting passed soluble materials

Lec. 1

Plant Physiology

Q3: Select the correct answer:

(1)- Liquid diffusion Law is established by ?

a) Graham b) Plank c) Newton d) Fick

(2)- Diffusion rate of H gas (D = 0.071 g/c.c) is more than oxygen gas (D = 1.14 g/c.c) by

a) 4.0 b) 3.2 c) 3.0 d) 2.5

(3)- Solute potential is called

a) pressure b) matric c) osmotic d) gravitational

(4)- Osmotic pressure (Mega pascal, MP) of solution containing 5.85 g NaCl per liter (MW = 58.5) at 20°C is,

a) 1.0 b) 10.0 c) 0.50 d) 0.25

(5)- Mitochondria is called as

a) energy b) energy houses c) ATP synthesis d) all of them

(6)- Carbohydrates are composed by

a) C, H, O, N b) C, H, N, P c) C, H, O, N, P d) C, H, O

(7)- Nucleotides are composed by

a) C, H, O, b) C, H, O, N, P c) C, H, O, N d) all of them

8- Stress Physiology is concerning of

a) Salinity b) senescence c) photosynthesis d) none of them

Lec-1

Plant Physiology

Q4: Fill the Following blanks

1- Phytosynthesis process is part of Plant _____ division

2- Senescence physiology is type of _____ physiology

3- _____ is viscosity unit

4- Water contains two _____ bonds such as _____ , _____ .

5- _____ is value of water heat fusion.

6- less size of gas particle is caused an increase _____ diffusion

Q5: Matching: ~~select the correct answer for Column A from column B.~~

Column A	Column B
1- Cell wall	a- 0.082
2- Nucleosides	b- α CRT
3- Amino acids	c- C, H, O, N, P
4- Water surface tension at 20°C	d- Protein
5- Π	e- 92.75 dyne/cm
6- R gas constant	f- 0.092
7- plasma membrane	g- Tonoplast
8- Vacular membrane	h- Ectoplast
9- Nucleotides	i- 0.082
	m- Strenythen the cell
	n- 72.75 dyne/cm
	J- osmotic pressure
	K- Osmotic potential
	L- C, H, O, N

2021/10/26

المرحلة الثالثة

قسم علوم الحياة

الفصل الدراسي الاول

للعام 2021/2022

فسلجة النبات

Plant Physiology

المحاضرة: 2

م. المادة: د. جواد

Lec. 2

3rd Stage

Plant Physiology

Transpiration

Transpiration process is the loss of water by evaporation from plant. It differ from the general process of evaporation, because the water vapor does not evaporate from a free surface but must pass through the epidermis with its cuticle or throughout the stomata.

Transpiration can be divided into

① **Stomatal Transpiration ((ST)):**
This process is loss of water throughout stomata. This kind form about 90 to 95% of the total transpiration.

② **Cuticular Transpiration ((CT)):**
This process deals with loss water vapor from epidermis surface in cuticle layer throughout the cracks particularly when the rate of stomatal transpiration decreased. This kind of the transpiration form about 5-10% of the total transpiration.

③ **Lenticular Transpiration ((LT)).**
LT is consisted loss water from the lenticels which are distributed in cork cells of tree stem. This type of transpiration is increased in autumn when the leaves fall down. LT is form about less than 1% of the total transpiration.

Generally, some physiologist pointed out that transpiration process is not useful. In contrast, many scientists showed that process is very important to the plant system.

Lec. 2

3rd stage — Plant Physiology

Transpiration Advantages:

1. Gase exchange
2. Cooling the plant parts especially leaf.
3. Enhancing the growth and development of plant.
4. Contributing of mineral transport from soil solution to the root system and other plant parts.

Table ①: water content lossing through the transpiration of various plants

Kind of Plant	Amount of Transpiration	Kind of plant	Amount of Transpiration
Cotton	5 ton / 4200 m^2 / day	Tomato	136 kg / plant / Season
Sunflower	15 ton = =		
Corn	12 = = =	Apple	36 kg / tree / day

Transpiration Coefficient ("TC")

TC defines the amount of water in liter or (grams) that plant is lossed it through transpiration process for synethzing one gram (or 1 kg) of dry matter (DW.)

$$TC = \frac{T}{Dw}$$

whereas: (T) = Transpiration (cm^3, g, kg ...)

(DW) = Dry weight (g, kg ...)

Table (2). Transpiration rate for some plants

Plant	TC.	Plant	TC.
Corn	349	Barley	527
sygerbeet	443	Pobatoes	575
Wheat	491	Clover	698
		Flax	783

Example: Suppose the total transpiration of Kind plant equal 300 kg water, and plant dry weight is 0.5 kg, calculate the transpiration coefficient (TC)?

$$TC = \frac{T}{Dw} = \frac{300}{0.5} = 600$$

Relative Transpiration (RT)

RT is described the portion of water loss by transpiration from plant surface to the weight of evaporated water from free equal surface area.

$$RT = \frac{WP}{Wa}$$

Whereas: WP = wt. of water is subjected to transpiration per time for 100 cm^2 (leaf area)

Wa = wt. of water subject to evaporation from free surface / time / 100 cm^2

Transpiration Rate (TR):

The amount of water losses through transpiration in time unit and leaf area unit or weight unit from all plant body.

$$TR = \frac{T}{A \times t}$$

whereas: (T) = The amount of water is lost by transpiration (g, cm^3, liter)

(A) = leaf area or total dry wt. of the plant (cm^2 or g.)

(t) = Time (h, day, week, ---)

The relation between transpiration speed with hydraulic conductivity and leaf water potential

$$\psi leaf = \frac{TS}{H}$$

where
$\psi leaf$ = leaf water potential
TS = Transpiration speed (liter / hour)
H = Water hydraulic conductivity (liter / hour) or (atm., bar. MPa)

Example:

TS (Transpiration speed) = 1.0 liter/h

Soil water potential $\psi m = -0.5$ atm. ضغط جوي
Π = osmotic pressure of soil solution $\doteq 1.5$ atm.

H = water hydraulic conductivity
= - 0.2 liter / atm. h. (لتر / ضغط جوي . ساعة)

$\psi \Pi$ الجهد الأزموزي = الضغط الأزموزي Π = -1.5 atm. ضغط جوي

$\psi soil$ = ماء التربة = $\psi m + \psi \Pi$ الجهد الأزموزي للتربة + الجهد المائي

$= -0.5 + (-1.5) = -2$ atm.

$\psi leaf$ الجهد المائي للورقة = $\frac{TS}{H} = \frac{1.0}{-0.2} = -5$ atm.

$\psi Total$ الجهد المائي الكلي = $\psi leaf + \psi soil = -5 + (-2)$
$= -7.0$ atm.

ψ_{Total} (MPa) $= \frac{-7.0}{9.87} = -0.71$ MP

$\psi \rightarrow$ PSi

الجهد الكلي المكافئ
تحويل الجهد

Measurement of Transpiration:

(1) Laboratory Measurements:

(a) - Measurement of water vapor by cobalt chloride paper (uses saturated cobalt chloride $CoCl_2$) with 3% concentration

(b) - Potometers

(2) Field measurements:

(a) - potted plant method ((Applied in greenhouse and in the field in some cases))

(b) Lysimeters ((Expensive method))

(c) Detch a leaf

(3) using Mathemticals Modles for calculating transpiration rate (TR).

Factors Affecting Transpiration Rate

((Exo Factors العوامل الخارجية))

1- Temperature
2- Relative Humidity
3- Wind velocity
4- Light intensity
5- Carbon dioxide Concentration (CO_2 conc.))

Factors Affecting Transpiration Rate
((Endo Factors العوامل الداخلية المؤثرة))

① Stomatal pores:
Stomatal pores consider the most factor that affect TR. TR is commonly decreased with decreasing pore size of stomata ((As shown in Figure as below))

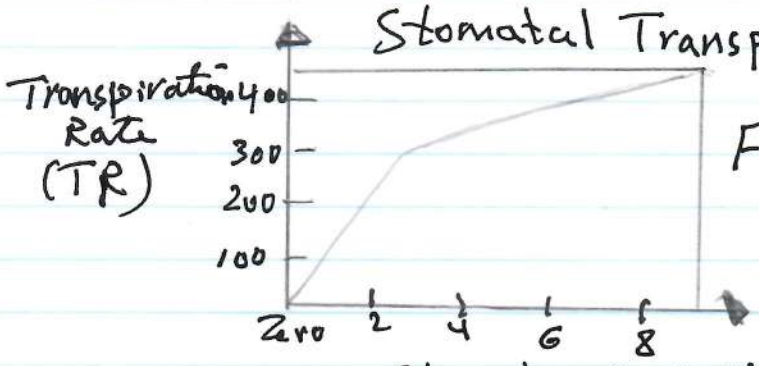


Fig.1. Relation between pore size and TR (معدل النتح)

② water content of plant cell subjects to transpiration

③ Many plant modification affects plant transpiration such as:
- (a)- Deeper pores under epidermis
- (b)- Increases of cutin layers on epidermis cell wall
- (c)- Decreases in plant surface exposure to the transpiration

④ leaf structure
⑤ leaf composition
⑥ leaf surface area

⑦ Proportion root system to vegetative system.

قسم علوم الحياة

2021/11/2

المرحلة الثالثة

الفصل الدراسي الأول

للعام

2021 / 2022

فسلجة النبات

Plant Physiology

المحاضرة : 3

م. المادة : د. جواد

التاريخ / / ٢٠١ الموضوع :

Water Balance in Plant System :

Plant water content is affected by two factors as follows: ① water absorption from soil system ② water loss by transpiration

The water balance in plant system depends on the two factors. If the balance is disturbed due to high rate of transpiration as compared with water absorption causing plant witing or vice versa.

Fig 2. illustrate the relation between the transpiration and water absorption by sunflower plant at sunny hot day in summer season.

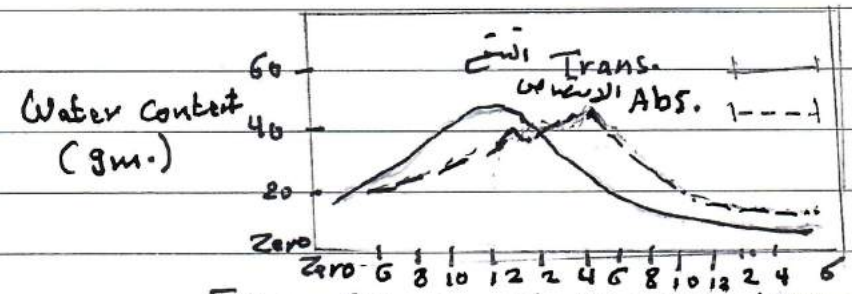
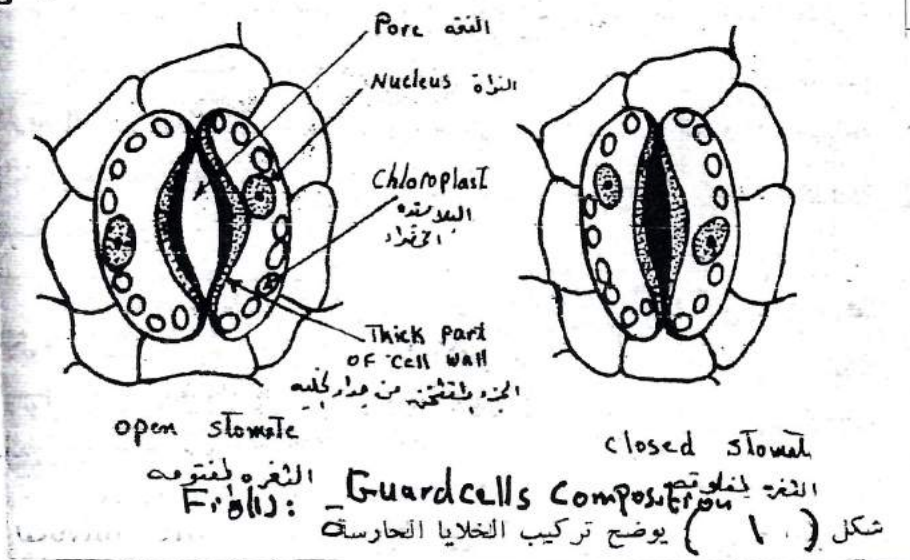


Fig 2: Average the transpiration and Absorption

Mechanism and Composition of Stomata

leaves epidermis are containing pores that its known as stomata. Stomata are limited by two specialized two cells known guard cells. These cells control the opening and closing the stomata (Fig). Fig. 3 illustrate the composition of guard cells



Fig(3): Guardcells Composition شكل (٣) يوضح تركيب الخلايا الحارسة

Class

The width (broaden) of the stomata at opening stage is approximately ranged from 3 to 12 μ (micro $= 10^{-6}$ m), and rate of its length ranged between to 10 upto 40 μ (micron).

Leaf surface contains 6000 to 300,000 pores/cm^2 (equal 60 – 3000 pores/mm^2). The numbers and distribution of stomata depend on kind of plant. The stomata are is counted as 1 – 2 % of leaf area.

Field crops are contained about 6000 to 180,000 pores/cm^2, meanwhile the trees contained 30,000 upto 10^6 pores/cm^2 (= 300 to 10^4 pores/mm^2).

Stomata Distribution:

Stomata are commonly distributed into three patterns:

1. On the upper leaf surface, names as Epistomatous.
2. On the lower leaf surface, names as Hypostomatous
3. On the both leaf surface which is called as Amphistomatous.

The Mechanism of Stomata Work:

The closing and opening stomata depend on the swelling and shrinking the guard cells. Some mechanisms and Theories are created and discovered for explaining the stomatal work. These are consisted of the following:

(1) Carbohydrate Mechanism

Opening the stomata depends on increases of carbohydrates content as a resulted of photosynthesis process, that process causes increasing water absorption. According to this phenomenon, the size of guard cells are increased, and its worked on opening the stomata during day hours. This mechanism has many disadvantages:

a) Dose not give clear explaination for stomata opening after sunset (غيب شمس)

b) Does'nt give clear explaination before sunrise (شروق شمس)

c) Carbohydrate content in guard cells is not enough for creating adequate osmotic potential for opening the stomata.

(2) Sayre Theory:

This theory deals with the transformation of starch into simple sugars. In general, the stomata opening are increased the pH value (pH $\geq$ 7.0) and it closure as decreases in pH value (pH $<$ 7.0). In day hours, CO_2 content is decreased because of it consuming (Reduced) by photosynthesis process. This process is enhanced the pH which its causing opening of the stomata.

Under dark conditions, CO_2 content is increased because of absence photosynthesis which its resulted in formation H_2CO_3. Carbonic acid causing decreases of pH value.

Two equations are explained this theory under day and dark conditions.

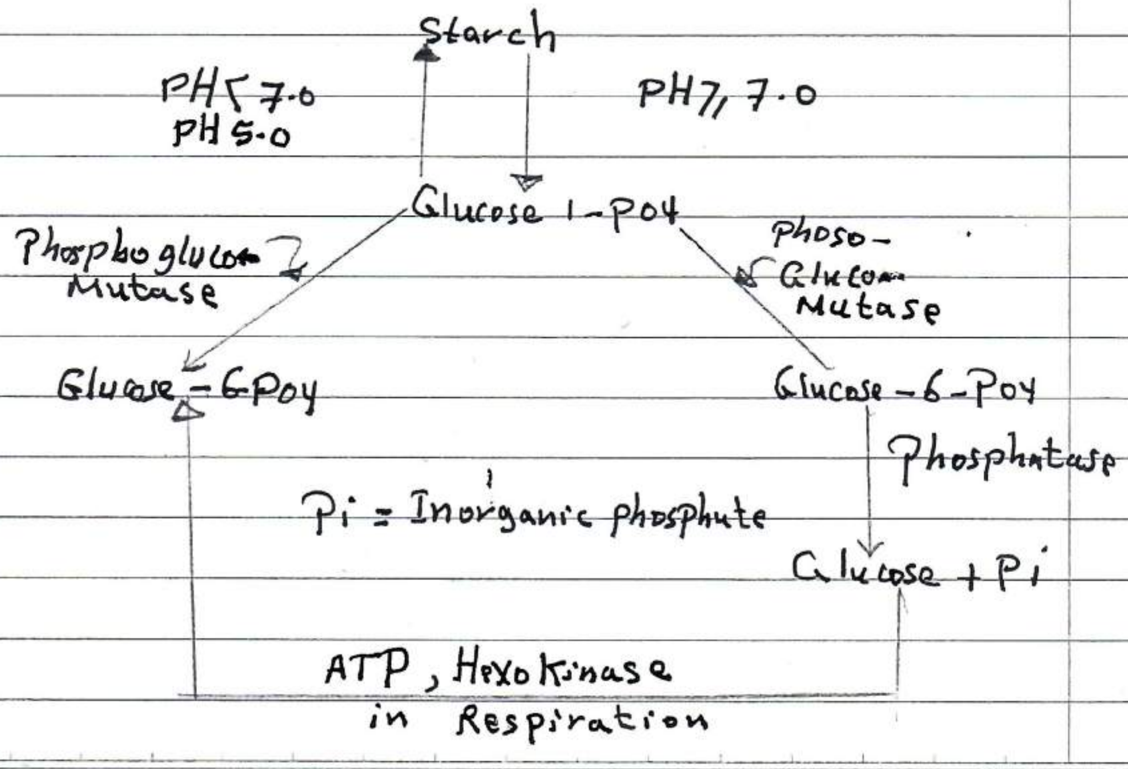
Starch + Pi ⟶ PH ⩾ 7 ⟶ Glucose 1-PO_4
under Day hours.

Glucose 1-PO_4 ⟶ PH ⩽ 7 (≅ pH = 5) ⟶ starch + Pi (unde darkness)
whereas : Pi = inorganic phosphate.

Sayre Theory opposes أي عن (الاعتراضات) الموجهة لنظرية سام

1. Dosent adquetly explain the opening and closure the stomata
2. Inorganic phosphate has important role in establishment osmotic potential that is equal to glucose function.

Steward (1964) had developed sayre theory according to the below scheme



Steward explained the modification of osmotic potential as a result of glucose hydrolyzed had more effective than starch. The Sayre and steward theories didn't explaination the speed of opening and closure of the stomata before sunrise and sunset.

Thind Theory: Metabolism Theory: نظرية الرابعة

This theory is more acceptance because of its adquatly explained the process more than other theories. This theory combins between K^+ (ions) in building up the osmotic potential and pH, and the abscisic role in controlling this process (Opening and closure the stomata).

Due to this theory, more studies were conducted under Laboratory basis confirming the follow:

* Opening the stomata events is happen before sunrise and its closure at sunset
* Accompany with this process (opening the stomata) build on osmotic potential
* Decrease of CO_2 resulted in of photosynthesis in guard cells.
* Accumulation of K^+ caused opening the stomata
* Accompany with accumulation of K^+ increases in pH because of starch hydrolyzed and formation of organic acids (for example, malic acid). Malic acid hydrolyzed into H^+ (Proton) and malate radical.
* Under light, and CO_2 decreasing causes of accumulation K^+ and stomata opening.
* Occurrance abscisic acid in higher concentration in guard

Class

cells resulted in closure the stomata and impediment K ions (K^+) accumulation.

How Control opening and Closure of the stomata:

Many scientists believe that two factor are principaly controled and adjustment these mechanisms. They are:

(1) Decreases CO_2 concentration of stomata causes flowing K^+ to the guard cells and establish higher osmotic potential which its causing increases of turgor pressure in these cells. This mechanism resulted in stomata opening and CO_2 reduction because of photosynthesis.

(2) Exposure plant to dryness is caused the water outflow from guard cells resulting in closing the stomata.

Guttation

Guttation process is secreted of liquid from Hydathodes, along the edge and tip of a leaf. This phenomenon is happened in grasses because of water flowing up as a resulted by root pressure and doesnt occur the transpiration in first hours of the moring before sunrise. In this case is not true that guttation drops are dew drops. The guttation drops are containing a little of soluble materials as a example: Sugars, amino acids, mineral salts, meanwhile those materials form precipatos location upon leaf edges.

Lec 2,3 Plant physiology

Universal Questions

Q1: Put the word True or False

1) The stomatal transpiration form 60-65% of total transpiration
2) Lenticular transpiration form less than 1% of total transpiration
3) Transpiration rate of Flax is more than barley.
4) Relative transpiration equal wa/WP
5) leaf surface contains 60 to 3000 pores/mm^2

Q2:

1- Transpiration process can be divided into 1-2-3-

2- Transpiration advantages are 1-2-3-4-

3- Endo factors affected transpiration are 1-2-3-4-5-

4- Types of stomata distribution are 1-2-3

5- what are the mechanisms of stomata work?

Q3: Define the following:

Epistomatous, Relative transpiration. transpiration rate, Sayre

Q4: Write the scheme of Steward for explaining stomata mechanism work

Lec. 2,3

Bio-Sci. Dept

Plant Physiology

Homeworks – 2

Q1 : Select the correct items for column-1 from column-2.

Column-1	Column-2
1- Cuticular transpiration	a- 90-95 %
2- Transpiration coefficient	b- Corn
3- Transpiration rate of wheat less than	c- 3-12 Micron
	d- 3-12 mm
4- Stomat width	e- wp/wa
5- Hypostomatous	f- upper leaf surface
6- Steward developed	g- T/Dw
7 Higher abscisic acid Concentration	h- Flax
	i- Sayer's Theory
8- Osmotic pressure of 0-1 M CaCl2 at 20°C	j- lower leaf surface
9- Osmotic pressure of 0.1 M sucrose at 20°C	k- 5-10 %
10- Maximum transpiration occur at	l- closure stomata
	m- 8.21 atm.
	n- 0.73 MPa
	o- Midday (12 o'clock)
q- 4-8 atm.	p- 2-4 atm.

Q2 : Calculate total leaf water potential by units : atm., MPa if you know the following :

TS = 3-0 liter/hour ψ_m = -2-0 atm.

π = OP of soil solution equal to 1-5 atm.

H = Water hydraulic conductivity equal – 0-2 liter / atm-h

د. جواد طاهر

أستاذ

2020/12/23

قسم علوم الحياة

المرحلة الثالثة
2021/11/9

الفصل الدراسي الأول

للعام 2021 / 2022

فسلجة النبات

Plant Physiology

المحاضرة: 4

م. المادة: د. جواد

التاريخ / / ٢٠١ الموضوع :

Absorption and Transport of Water:

Water absorption by plants are performed in different mechanisms (ways) as follow:

1. Absorption by root system. (Almost the water absorb by this mechanism).
2. Water absorption by vegetative system.
3. Water absorption by all plant parts especially by aquatic plants.

Root water Absorption

The most plants get all their watersby root system by:

1. Root hairs region 2. Growing apex region
3. Elenogation Zone 4. Secondary or lateral root Zone

Water is principally absorbed from root hairs Zone and epidermis because of:

1. Root hair cells have thin walls that containing Pectins matter.
2. It have succulent large vacoule volume, and its osmotic potential ($\psi\pi$) is more negatively 3. Covering it a gel surfaces as colloidal materials that its capable to adsorb by soil particles.
4. Higher water permeability beeanuse it doesn't contain suberin and cutin materials
5. It have large surface area which it forms 90% of root surface area 6. It have most capability to contact soil particles by 20 folds at least.

Class

Lec: 4

التاريخ / / ٢٠١ الموضوع :

for example, rye annual plant has 1-4 billion root hairs with large surface area which is about 640 m^2, meanwhile the root surface area is about 710 m^2 ($\frac{640}{710} \times 100 = 90\%$).

The actual reasons for decreasing water absorptivity at the other regions (growth apex region, and elongation zone) are due to the following:

1. Division and elongation of those regions.
2. Containing a compacted and compressed cells
3. have dense cytoplasm with high viscosity
4. Have little succulent vacoules.

The chemical and Anatomical Compositon of Root Hairs:

The chemical composition of root hairs is consisted of the celluluse materials. The anatomical pattern of root hairs from outside into inside is composed by 1. epidermis 2. Cortex 3. Endodermis 4. Cylindrical vascular (Xylem vessel). Note: Endodermis is protected by the casparian strip.

The water passes throughout thinner walls of root hairs to epidermis, cytoplasm, cortex, parenchyma cells, Xylem vessel, Pericycle cells, to leaves throughout stem by vessel Xylem. The water is transported in a column as mass form in xylem vessel to stem, to leaves. At final stage, water loss as water

Class

Vapor throughout the stomata system (Fig.1)

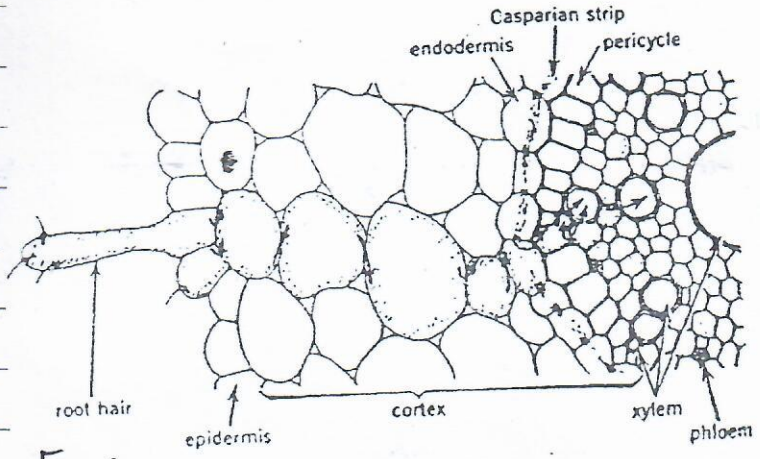


Fig. 1.

Water and other substances move into and within the plant root in a different three Ways. However, a combination of these three Pathways is responsible for transport of water across the root

① Apoplastic Pathway:
Water is movement through intercellular spaces and cells ((cell walls and intercellular spaces)).

② Transmembrane Pathway:
Water moves from cell to others by membrane transport ((by crossing the plasma membranes))

③ Symplastic Patway:
Water moves through plasmodesmata from cell to others ((through plasmodesmata))
note: Water is entered a cell by transmembrane and symplastic which are sometimes considered to be the same (Fig.2, Page 4)

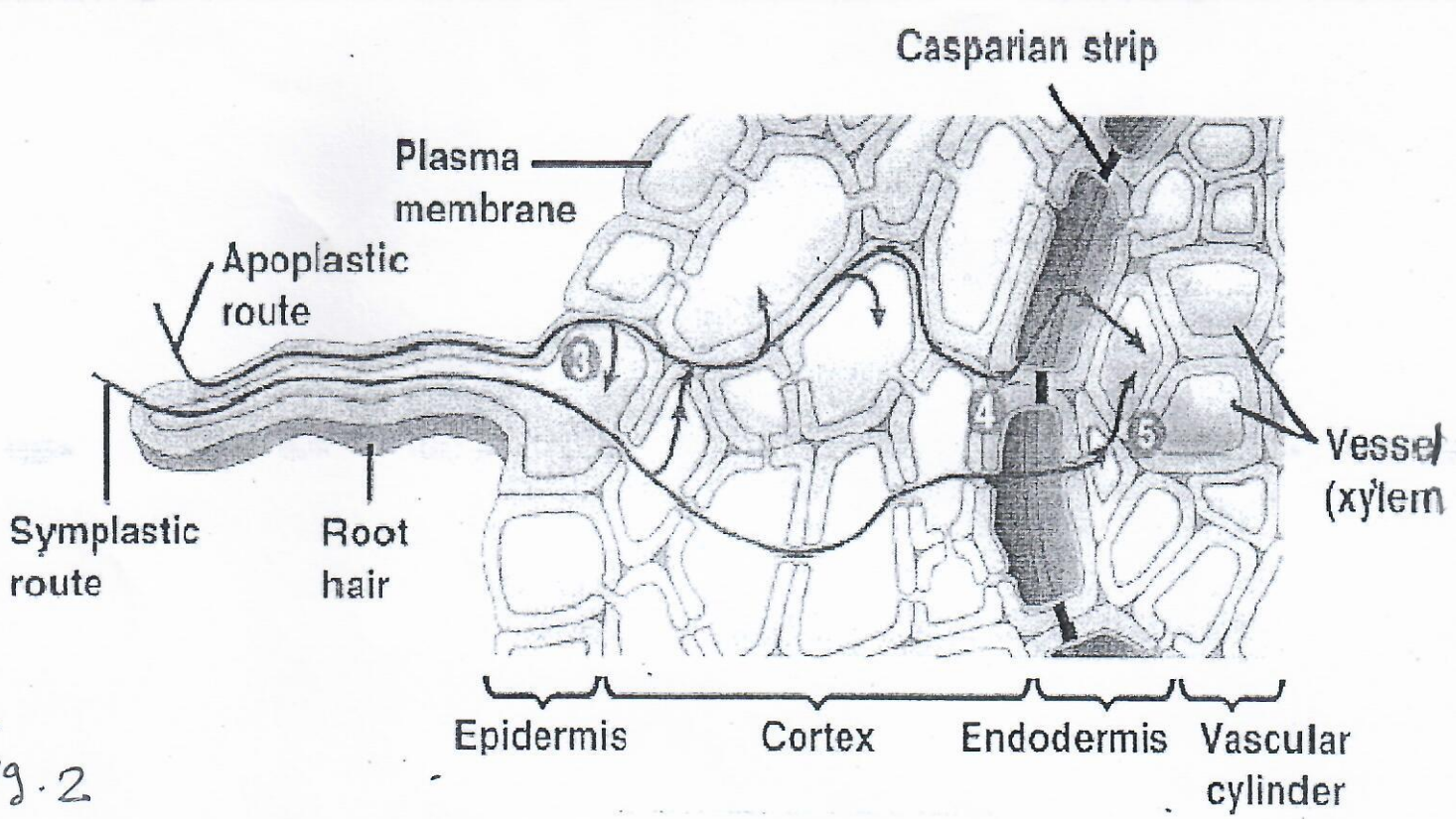


Fig. 2

Soil water

Water content in soils has an effect role on soil formation, erosion, and structure stability but the major concern is the availability of water for plant growth. Water serves many functions as (1) Constituent form 85 to 95% of protoplasm (2) essential for photosynthesis (3) Converse of starches to sugars (4) solvent (5) Moving nutrients through plant parts (5) Provides plant turgidity.

Soil is absorbed water from throughing rainfall and irrigation and is conserved as source for plants. At irrigation, water is under tension equally Zero ($\psi w = 0$). After irrigation schedule water moves by gravity force ((the gravity potential is named as ψg)).

Lec: 4

Soil / / التاريخ : الموضوع

Water classification

Different portions of water films (غشاء) in soils are held with many suctions. The most useful classification of water content relate water to plant growth and are labeled as follow:

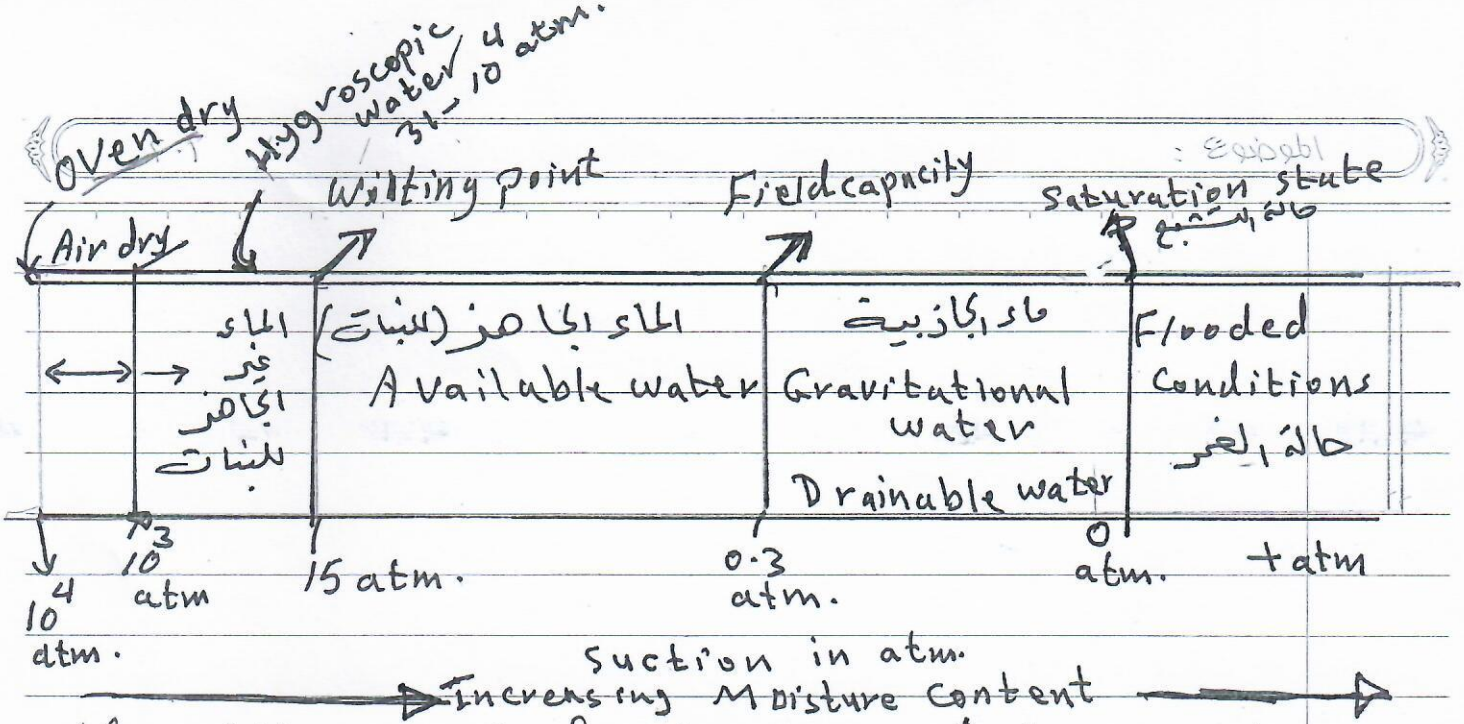
① Gravitational water is water held with tension of less than 0.3 atm ($\psi w = -0.3$ atm). This kind will drain freely by the gravity force. — fast enough

② Available water is the portion of stored soil water that can be absorbed by plant root. This kind is under tension 0.3 to 15 atm ($\psi w = -0.3$ to -15 atm) (Between field capacity and wilting point).

Field capacity is the percentage of soil moisture that is contained at 0.3 ($\frac{1}{3}$) atm (bar) ($\psi w = -0.33$ atm) suction and is a measure of the greatest amount of water that a soil will hold, or store.

For example, available water content in silty clay soil is equal 25% and the content of moisture at wilting point is 10%. The available water for plant is equally as $25 - 10 = 15\%$.

Fig. 3: Scheme of Water content in soil systems



ψw = Water potential is term dealing with forces that held soil water

$$\psi w = \psi M + \psi g + \psi p + \psi \pi$$

اكبر الماء الكلي
Total water potential

whereas: ψM = Matric potential
ψg = Gravitational potential
ψp = Pressure =
$\psi \pi$ = Osmotic =

ψp : Pressure potential of soil water belong to weight of water or air pressure on soil water. ψp is very limited, in many cases ψp = zero because soil doesnt reach high level beyond saturation state.

Generally, the term suction is equally numerically ψ (Potential). Almost situations water potential after 48 hours from irrigation is equal the following:

$$\psi w = \psi M + \psi \pi$$

Lec. 4:

التاريخ / / ٢٠١ الموضوع :

Water absorption by soil particle surface (solid phase) is resulted in the following:

1. Decreases in water molecules movement
2. Decreases in water free energy.
3. Heat releasing because of transforming water to lower level of energy.

Many water molecules layers (or films) are subjected to adsorption on soil particles surfaces due to adhesion forces. This kind of water is known as adhesion water, however has its lower movement and unavailable to plant uses.

Expression Methods for Energy status of Soil Water:

1. Negative potential ($-\psi$) (Suction) is the height of column of water its weighed equal to the demand tension.

2. PF. is the logarithm of the height of a column of water (in cm.)
   The normal range of PF in soils when plants have enough water to grow is from about PF 2-5 (wet) to PF 4.2 (wilting Point).
   PF 2-5 = 316 cm ≙ 0.3 atm =
   PF 4.2 = 15849 ≙ 15.3 atm.

3. Pressure units: Atmospher (atm.) Atm = 1.013 bar
   Bar = 0.987 atm.

4. Mega pascal (MPa), Mpa = 10^6 Pa
   Mpa = 9.87 atm.
   1 atm = 0.1013 Mpa.

(5) Pound per squar inch (PSi)

Atm. = 14.7 PSi PSi = 0.0680 atm.

(6) millibar = $\frac{1}{1000}$ bar .

Plant water content is depended upon many factors as follow :

(1) Soil available water content (2) Clay content (3) Type of clay (4) Soil texture (5) soil structure (6) Soil porosity (7) Organic matter. (8) Soil solution concentration (9) Soil air (10) Soil temperature.

Soil moisture Measurments :

(1) Gravimetric method

(2) Suction Methods : Consisting :
- Tensiometers
- Tension plate – Gypsum block
- Tension memberane

(3) Neutron scattering .

Capillary Phenomenon and Relation to Soil Water :

Capillary phenomenon is occurred in soil system and plant system. The example of this process is upward water movement in soil system by capillary tubes among soil pores . Capaillary proces is happened by two forces (1) Cohension force between water and solid phase of pores walls which water passed through it.

(2) water surface tension force. Water molecule

are subjected to attract on two sides of pore surfaces (or other porous material) in which the process is taking place. This adhesion forms a meniscus (curve) in which the water tends to rise up the side of the container. The pressure under the meniscus is lower than the atmosphere. This kind of phenomenon is causing in rise water upwardly (or upward movement).

The rising of water in capillary tubes is inverse proportional with radius of these tubes according to the following equation:

$$h = \frac{2T}{rdg}$$

Whereas: T = Surface Tension
r = radium
d = Water Density
g = gravity.

When all terms shown in above equation are substituted by the following:

$T = 72.8$ dyne/cm $g = 980.7$ cm/sec^2

$d = 1.00$ g/c.c (at 4°C), the equation form is

$$h = \frac{0.153}{r} \approx \frac{0.15}{r}$$

Whereas:

h = water height in capillary tube in (cm)

r = Radius of capillary tube (cm).

Capillary phenomenon is discussed in detailed for water absorption by plant system

Lect. 4

Objective Type Questions

Q1

(1)- The most plant get all their water by root system by 1- 2- 3- 4-

(2)- Water is primarily absorbed from root hairs regions because of 1-2-3-4-5-

(3)- The actual regions for decreasing water absorption by elongation zone are due to 1- 2- 3-

(4)- Anatomical pattern of root hairs is composed by 1- 2- 3- 4-

Q2: Put the word True or False

(1) Growth apex region have subject to high cell divisions

(2) Most Plants get their waters by lateral root zone

(3)- Root hairs have highor water permeability because it does contarn suberin.

(4) Apoplastic pathway, water is moved through intercellular spaces and cells

Q3: Define the following:
Root hair region, ψ_g, ψ_m, ψ_π, cutins.

Q4: Select the best (correct) answer of the following:

1- ψ_π is,
a) osmotic pressure b) matric potential
c) None of them d) osmotic potential

2- Root hairs have higher water permenbility because its containing,
a) pectins b) suberins c) cutins
d) all of them

3- Aquatic plants absorb water by
a) leaf b) stam c) all plant parts d) lentricel

4- Root hairs have large surface area which it form,
a) 90% b) 20% c) 50% d 60%
of root surface area.

Q5 Fill the following blanks

1- _____ is matric potential

2- _____ field capacity is under 0-3 atm tension

3- Available water to plants is under tension between _____

4- Oven dried soils are at _____ atm.

Q5 = Select the correct answer for Column-1 from Column-2

Column-1	Column-2
1- Pectins	a- Disaccharides
2- Suberins	b- poly saccharides
3- Root hairs region	c- less water absorption
4- Cutins	d- fat materials
5. ΨP	e- water potential
6- Endodermis protection	f- cortex
7- Elongation Zone	g- high water absorption
8- At irrigation, Water is under tension	h- 4-0 bar
9- At irrigation, Water is under potential	i- T = Zero
10- Plant available water under tension	j- Ψw = Zero
11- Water field capacity	k- 0.8 atm
12- wilting point	l- 5 atm.
	m- Casparian strips
	n- Compressed cells
	o- 0.3 — 15 atm
	p- waxy materials
	q- Pressure potential
	r- 0.3 atm
	s- 15atm.

2021 / 11 / 09

2021/11/16

قسم علوم الحياة

المرحلة الثالثة

الفصل الدراسي الاول

للعام

2021 / 2022

مادة النبات

Plant Physiology

الى طلبة: ج

أ. المادة: د. عمار

Water Absorption Mechanisms :

A number of mechanisms are known to be affected root absorption of water, over 90% of the total water absorption is absorbed by passively absorption mechanism.

Water absorption can be classified into :

(1) Passive absorption (2) Active absorption
(3) Root extension

Passive Absorption

Passive absorption process has high capabilit to absorb water from soil system to the limit at wilting point "ذبول دائم" ((water tension = 15 atm ($\psi w = -15$ atm).

Meanwhile, water active absorption doesn't extract (absorb) water in a limit of 2 atm. and more.

Active Absorption

In this process, the root cells play activ role in the absorption of water and metabolic energy which it released through respiration is consumed. Active absorption may be done by two kinds :

(1) Osmotic absorption for example, when water is absorbed from the soil system into plant system, through Xylem vessels of the roots according to the osmotic gradient

(2) Non - osmotic absorption, i.e, when water is absorbed against the osmotic gradient.

Lec. 5 Plant Physiology

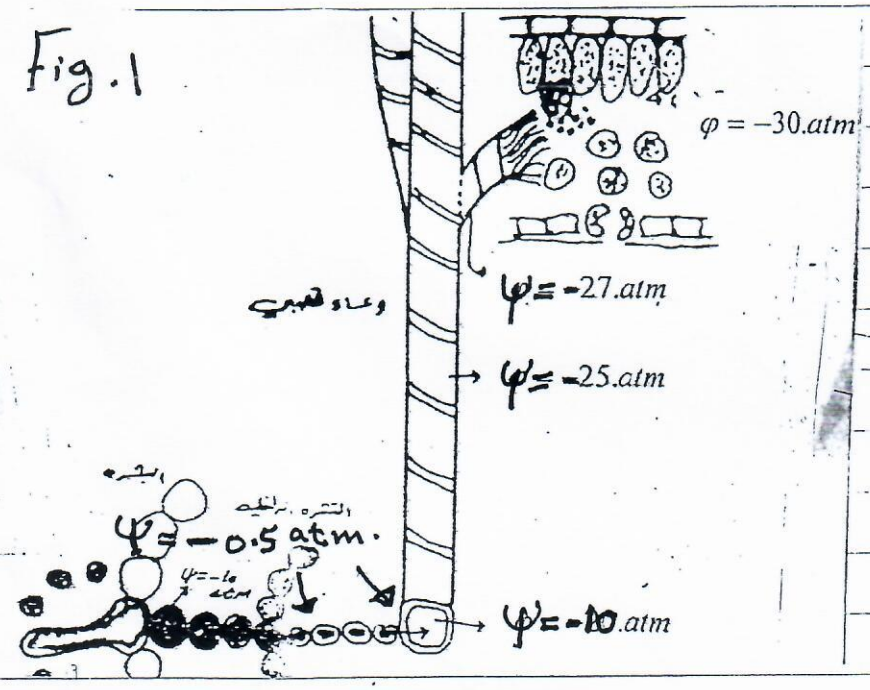
The kind of active absorption mechanism is occurred by root system due to :

① Matric potential « الجهد المتريكي »

The cells walls of root system are hydrophi colloids (غروي) (e.g., cellulose ...) and it have high ability to transport water from cell to other cells throughout root tissues by imbition (Matric) force (قوة التشرب).

② The active absorption of water can be done by osmosis (ψw of soil solution is less negatively) as compared with the root water potential (More negative value of ψw) (Fig. 1).

Fig. 1



Water upward Movement by plant transporting vessels is affected by the following:

① Root pressure

Some physiological phenomenonea due to the root pressure are: ① Bleeding ② Guttation

Lec : 5 Plant physiology

② Capillarity Criteria (capillarity) المعيار الشعري

The micro radius of xylem vessels and adhesion force of water with those vessels and adhesion force of water with those vessels are smallar than the cohesion force between water molecules.

The capallarity causes to upward water movement through plant system.

Two forces are occurred:

① upward (Lifting) force القوة الرافعة (قوة الصعود)

القوة الرافعة $L.F = T \cos\theta \; 2\pi r$

whereas, $2\pi r$ = Periphery of cylinder محيط الشكل الأسطواني

r = radius نصف القطر

T = surfnce tension of water (liquid) الشد السطحي

= 72.75 dyne/cm for water

θ = Adhesion angle زاوية التلاصق, $\cos\theta$ = جيب تمام الزاوية

② Downward force ((weight of liquid وزن عمود السائل

القوة النازلة $D.F = \pi r^2 h d g$

whereas π = constant percant النسبة الثابتة

πr^2 = Xylem Vessel Area مساحة وعاء الخشب

g = gravity = 980.7 cm/sec^2 الجاذبية

d = water (liquid) density كثافة الماء

= 0.9982 g/c.c (= g/ml)

at 20^0 C

h = water(liquid) hight (in cm) ارتفاع الماء

When water is upwardly moved, those two forces are to be equal according to:

$$T \cos\theta \; 2\pi r = \pi r^2 h d g$$

$$h = \frac{2T\cos\theta}{dgr}, \quad h = \frac{2 \times 72.75 \times 1}{980.7 \times 0.9982 \times r} = \frac{0.15}{r}$$

Plant Physiology

Example:

Calculate water height in a capillary tube with a radius (r) of (1) micron (μ).

Solution:

Micron = μm (Micrometer) = 10^{-6} m = 10^{-4} cm.

((مايكرون)) ((مايكرومتر)) (متر) ((سنتي))

$$\frac{1}{10000} = \frac{1}{10^4} \text{ cm} \quad , h = \frac{0.15}{0.0001} = 1500 \text{ cm} \text{ (سم)}$$

$= 15$ meter. ((متر))

Cohesion - Adhesion Theory:

This theory is expressed by many terms (or terminology) as following:

1. Theory of cohesive force — نظرية قوة التجاذب
2. Dixon and Jollys Theory — نظرية ديكسن وجوليس
3. Driving transpiration Theory — نظرية قوة النتح

Factors Affecting Water Absorption

(A) Soil Factors (or External Factors) (العوامل الخارجية) عوامل الترية

1. Plant available water content in soil system.
2. Osmotic pressure (osmotic potential) of soil solution.
3. Aeration
4. Temperature (soil temperature)
5. CO_2 Concentration
6. Soil air

(B) Plant Factors ((Endo factors))

1. Depth and distribution of root system.
2. Root water permenbility.
3. Root metabolic activity
4. Proportion between root system and vegetative system
5. Transpiration rates
6. Factors affect transpiration process and transpiration rate.

Water Absorption by Vegetative System

This type of absorption is done by water absurption as water vapor (Gas) form or as liquid form (سائل) (using sprinkler irrigation (عملية الري بالرش)) by aerial plant parts such as plant leaves.

This mechanism of water absorption is dependent on the following:

1. Water potential (ψw) of leaf.
2. Cuticle layer permeability
3. Climate factors ((e.g.: Temperature, Relative humidity, Pressure, wind speed, ... and other enviromental factors))
4. Plant factors such as leaf area, Stomata NO., Stomata size, leaf shape and others.

Lec-5

Plant Physiology

Example of calculating water height and radius of xylem vessels:

Example 1: If you know, radius of xylem vessel 2, 10, 50 micron (μ) - Calculate the water height in cm, and meter

solutions:

$$h = \frac{0.153}{r}$$

$$h = \frac{0.153}{2/10^4} \qquad h = \frac{0.153}{10/10^4} \qquad h = \frac{0.153}{50/10^4}$$

Answer:

765 cm — 7.65 meter

153 cm — 1.53 meter

30.6 cm — 0.306 meter

Example 2: If you know, Water height 153 cm in xylem vessels. Calculate the vessel radius in cm, mm, micron, micrometer

Solution

$$h = \frac{0.153}{r}$$

$$r = \frac{0.153}{h}$$

$$r = \frac{0.153}{153} = 1 \times 10^{-3} \text{ cm}$$

$$= 1 \times 10^{-2} \text{ mm}$$

$$= 10 \text{ micron}$$

$$= 10 \times 10^{-6} \text{ m}$$

$$= 1 \times 10^{-5} \text{ meter}$$

$$= 10 \text{ micrometer}$$

Universal Questions

Q1 : Put the word True or False

1. 98% of water passively absorption by plants
2. Root extension is type of water absorption
3. plants can be ability absorbed water from soil system at 16 atm.
4. Osmotic absorption is one kind of active water absorption

Q2 - Select the correct answer :

1. Which of the following parts of root is involved in water absorption
   a) root cap b) elongation zone
   c) root hair zone d) all of above

2. Main force behind passive absorption of water by roots is
   a) root pressure b) transpiral pull
   c) osmotic pressure d) none of them

3. First step in absorption of water by root hairs is
   a) imbibition b) simple diffusion
   c) osmotic diffusion d) none of the above -

Lec. 5

Plant Physiology

Q3 : Fill the following blanks :

① _____ are found in roots in endodermal cells

② Water holding capacity of the soil is much greater in _____ soil

③ The amount of water retained by the soil after the drainage of gravitational water is called _____ .

④ Plant available water is under specific tension occurred between _____, and _____ atm.

Q4 : Define the following :

* Passive absorption, ψ_g, ψ_m, PF, field capacity, apoplastic pathway

Q5 : Complete the following

① In general, water absorption by plants can be classified into 1-2-3-

② Active water absorption may be done by 1-2-

Plant Physiology

(3) Water upward movement by plant transporting is affected by
1- 2-

Homeworks - 5

Q 6:

Select the correct answers for Column-1 from Column-2.

Column-1	Column-2
1- Water upward force	a- CO_2 concentration
2- Water downward force	b- Transpiration rate
3- Water height in xylem vessel is equal	c- 10^{-6} m
4- gravity value	d- cuticle layer
5- $2\pi r$	e- area of cylinder
6- micron	f- 908.7 cm^2/sec
7- Exofactor affects water absorption	g- $\frac{0.183}{r}$
8- Endofactor affects water absorption	h- $\pi r^2 h d g$
9- Water absorption by vegetative systems	i- O_2 concentration

Lec. 5

Plant Physiology

Column-1

10- water height of water in xylems with 10 micron(μ) diameter is equal (in meter)

Column-2

j- 6-12 meter

k- root hairs

$l - \frac{0.153}{r}$

$m = \pi r^2 h d g$

$n - T \cos\theta\, 2\pi r$

$\theta\ \pi \cos\theta\, 2\pi r$

p periphery of cylinder

q - 306 cm (= 3.06 meter)

r - 980.7 cm/sec^2.

2) Calculate the water height in Xylem vessel with 20 micron (μ) in cm. and meter

3) Count the radius of xylem vessels if you know the height water in it as 1530 cm. by micron, mm., cm., and micrometer

2021/11/16

2021/11/23

قسم علوم الحياة المرحلة الثالثة

الفصل الدراسي الاول

للعام

2021 / 2022

فسلجة النبات

Plant Physiology

المحاضرة : 6

م. المادة : د. جواد

Nutrients Absorption and Mineral Nutrition

The adequate balance of mineral nutrition process has important work with plant growth factors (Genetics, Kind, family, location), enivromental factors (Temperature, pressure, water, R.H, wind ... etc.), and soil factors (porosity, clay, texture, OM ... etc) on growth, yield, and yield component of plants.

Nutrional element role in plant doesnt depend on its quantity only, but it depends on its physiological role and activity in plant systems, and availability.

Table 1: Elemental analysis of the stem, leaves, cob, and grain and others of graminy plants (such as corn, wheat and others)

Element Symbol	Element Name	% of total D.W	Element Symbol	Element Name	% of total D.W	Note
C	Carbon	43.57	Mg	Magnesium	0.18	D.W = Dry weight
O	Oxygen	44.43	Fe	Iron	0.08	
H	Hydrogen	6.24	Mn	Manganese	0.04	
N	Nitrogen	1.46	Si	Silicon	1.17	
S	Sulfur	0.17	Al	Aluminium	0.11	
P	Phosphorus	0.20	Cl	Chlorine	0.14	
Ca	Calcium	0.23	undetermined Nutrients			
K	Potassium	0.92	Mo, Cu, Zn, B		0.93	

Na, V, Co, Cl, Si, Al, Se ... are usually Considered as essential elements for special wild and field crops, and economical plants

التاريخ / / ٢٠١ الموضوع :

The concentrations of nutritional elements in plant system are dependent upon the following:

1. Nutrient availability index
2. Growth factors
3. Kind of plant
4. plant family
5. Physiological criteria of plants (root exchange capacity) 6. Fertilization (Kinds, schedule time, formulation, Methods)

Root Cation Exchange Capacity (RCEC)

plant roots exhibite a CEC which its ranging from 10 to 30 meq/100g in monocotyledonous plants (Grasses & wheat, Barley ...) , and it ranged between 40 upto 100 meq/100g in dicotyledenons plants (Legumes, ...)

The exchange propertries of roots are attributable mainly to carboxylic group (COOH). This mechanism is accounted for 70 to 90% of the exchange propertries of plant roots.

Table 2. Cation exchange of plant roots

plant	CEC, meq/100g dw
wheat	23
Corn	29
Beun	54
Soybean	60
Tomato	62

Mineral nutrients may be classified into:

1. Major nutrients (C, H, O, N, P, K)
2. Secondary nutrients (Ca, Mg, S)
3. Minor (trace) nutrients (Fe, Mn, Cu, Zn, B, Mo, Na, Si, Al, Cl)

Lect. 6

التاريخ / / ٢٠١

الموضوع :

Also, mineral nutrients may be classified to:

(1) Essential nutrients (16-18 Elements)
(2) Non-essential nutrients (3-6 Elements)

Nutrient Absorption:

Nutrient in soil systems is released from solid phase of soil (طور التربة الصلبة) to liquid phase (طور التربة السائل) by one of the following

(1) Ion Exchange تبادل الايون
(2) Dissolution الذوبان
(3) Chelation المعقد (الخلب)
(4) Soil Buffering capacity (SBC)

$$SBC = \frac{\Delta Q}{\Delta I} = \frac{\Delta \text{ Nutrient quantity}}{\Delta \text{ Nutrient intensity}} = \frac{\Delta \text{ كمية العنصر}}{\Delta \text{ شدة العنصر}}$$

Mechanism of Nutrients Absorption by Root system:

It is done by two mechanisms:

(1) Passive Absorption
(2) Active Absorption

Nutrient Movement to the Root System:

They are generally many ways in which nutrient ions in soil may reach the root system (Root surface)

(1) Root interception
(2) Massflow (3) Diffusion (4) Donnan Equilibrium
(5) Ion Exchange

Class

Lect. 6 Plant Phys. 3rd stage

التاريخ / / ٢٠١ اسم الموضوع :

Active uptake Mechanism Absorption

(1) Source of Energy

For calculation the amount of energy requires for inflow of 1mole of element inside plant against 10 folds of it Concentration in outer environment through a memberane

$$\overset{\circ}{G} \text{ (Energy)} = 2.303\ RT \log \frac{C_i \text{ (inside)}}{C_o \text{ (outside)}}$$

Example : $\overset{\circ}{G} = 2.303 \times 1.987 \times 293.15 \log \frac{10}{1}$

$= 1.34$ Kcal/mole

whereas : C_i = Ion Conc. inside the cell

C_o = Ion Conc. outside the cell

R = gas Constant = 1.987 cal./mole/ temperature (°K)

Note : ATP hydrolysis, produce 7.3-7.6 Kcal / mole (for each mole)

(2) Carrier Theory :

$$MOH + \underline{XH} \rightleftharpoons MX + H_2O$$

Carrier

Proteinous compounds

M = Mineral element.

(3) Ion Pump Theory

The factors affecting Ion Absorption by Active Absorption are (1) oxygen, temp., light, Inhibitors (2) Factors affecting on plant growth (3) Kind and Ion concentration in outer Area

Class

التاريخ / / ٢٠١ الموضوع :

Nutrient Absorption by leaves:

Many aquatic plants get all requirements mineral nutrients by leaves.

This kind of mechanisms is depended on ion permeability through leaves and kind of transporting in leaves by

(1) cuticle layer
(2) Stomatu (3) cuticle and stomata

Foliar fertilization can be used for treat nutrients defficiency especially minor (trace) nutrients such as: Fe, Mn, Cu, fe, Mo, B ...)

Table 3: Nutrient Content Requirement for all higher plants

Nutrient Symbol	Conc. mg/kg	Relative to at. No. of Mo	Nutrient	Conc mg/kg	Relative to Mo
Mo	0.1	1	S	1000	30×10^3
Cu	6.0	100	P	2000	60×10^3
Zn	20	300	Mg	2000	80×10^3
Mn	50	1000	Ca	5000	185×10^3
Fe	100	2000	K	10000	250×10^3
B	20	2000	N	15000	1000×10^3
Cl	100	3000	O	450×10^3	30×10^6
			C	450×10^3	35×10^6
			H	60×10^3	60×10^6

الموضوع : التاريخ / / ٢٠١

Table 4. Relative Significance of the Principal Ways in which plant Nutrient Ions Move from Soil to the Plant Roots

Nutrient عناصر	Atomic wt.	Nut. Symbol	Percentage supplied by		
			Root interception	Mass flow	Diffusion
Nitrogen	14.01	N	1.2	98.8	0
phosphorus	30.98	P	2.8	6.3	90.9
potassium	39.10	K	2-3	20.0	77.7
Calcium	40.08	Ca	28.6	71.4	0
Magnesium	24.32	Mg	13.0	87.0	0
Sulfur	32.07	S	5.0	95.0	0

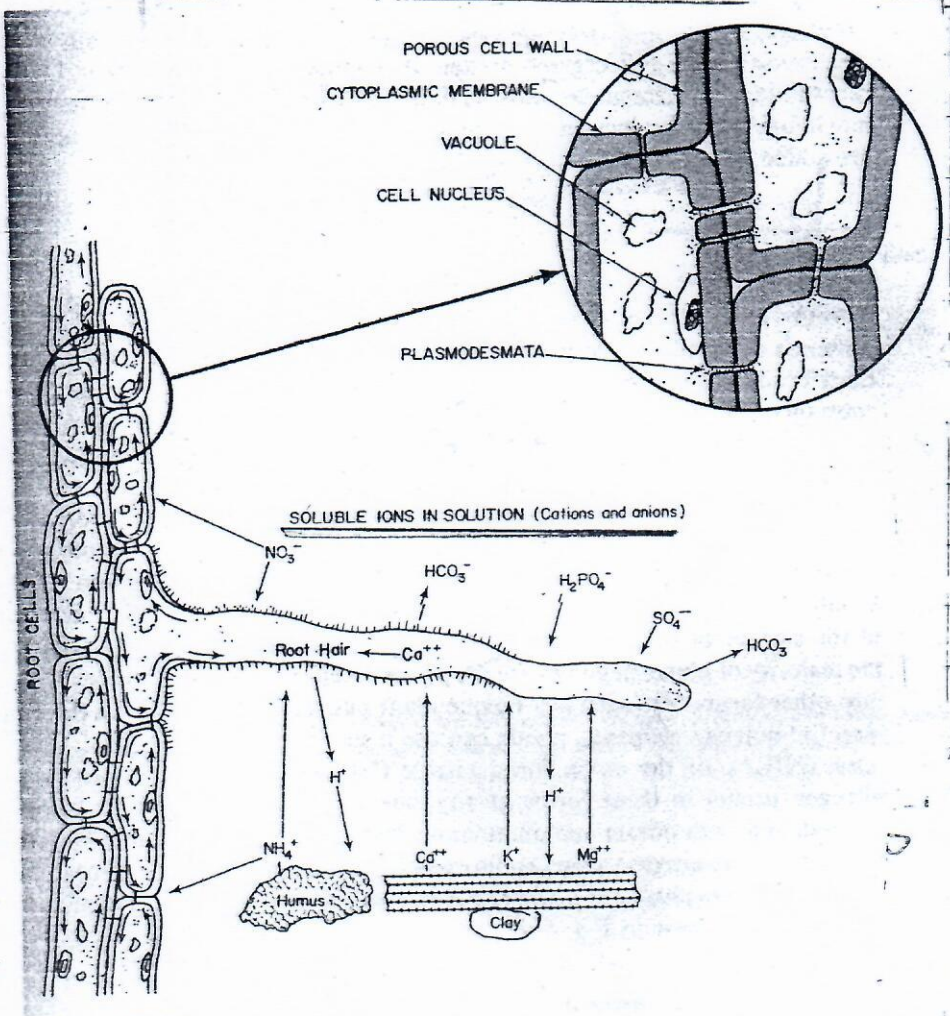


Fig 1:- Structure Composition of Root systems and Nutrients Absorption by Root Hairs

Lec. 6.

Plant Physiology

Universal Questions

Q1 : Complete the following :

(1) Enumerate the major elements that have high conconcentration in plant 1- 2 - 3 -

(2) Plant primary nutrients may be classified into 1-2-3-4-5-6-

(3) plant seeondary nutrienbs are 1-2-3-

(4) plant minor nutrients are 1-2-3-4-5- 6 -

Q2 : Put the word True or False

(1) Oxygen concentration in plant is 6-24%.

(2) Nitrogen Content in plant tissues is 1-46 %.

(3) Mg element is considered as major nutrient.

(4) Iron element is minor nutrient.

Q3 : choose the correct answer :

(1) Potassium is considered as,
a) minor b) major c) secondary
d) none of them

(2) Catrion root exchange of wheat is
a) less b) equal c) more d) none of them as compared with Soybean.

Cation

③ Higher root exchange capacity of the plant is

a) wheat b) corn c) tomato d) bean

④ The concentrations of nutritional elements in plant are dependent on,
a) CO_2 b) O_2 c) growth season d) kind of plant

Q4 : Fill the following blanks:

① _____ plant is lowest root cation exchange capacity

② _____ element is important for chlorophylls compostion.

③ _____ element is important for Hb (Haemoglobulin) composition.

④ _____ mechanism is type of nutrient movement from soil particle to the root system

Homework-6
Matching

Q5 :
Choose the correct answer for column-1 from column-2.

Column-1	column-2
1- Nutrient uptake by diffusion	Ca, Mg
2- Nutrient absorption not need it energy	root interception

Plant physiology

Column - 1	Column - 2
3- Most nutrients absorbed by mass flow	c- copper (Cu)
4- Lowest element content in plant	d- osmosis
5- Active uptake mechanism	e- 35×10^6
6- Ion pump theory	f- P, K
7- Hydrogen content in plant	g- soil application
8- Nutrient absorption by leaves is called	h- Mg
9- Major N uptake by	i- N, S, Mg
10- Major P uptake by	j- Carrier theory
11- Elements highly uptake by root interception	k- carbon
12- Chlorophylls consist of	l- Mo
	n- active absorption
	o- 60×10^6 folds as compared with Mo
u- mass flow	p- foliar absorption
v- Passive absorption	q- root interception
	r- diffusion
	s- Fe ion

2020/21

قسم علوم الحياة

المرحلة الثالثة

2021/12/7

الفصل الدراسي الأول

للعام

2021 / 2022

فسلجة النبات

Plant Physiology

المحاضرة 7

أ. الماحة: د. جواد

Lec. 7 Plant Physiology Bio. Sc. Dept
3rd stage

Photosynthesis

Introduction:

The sun is considered as thermal nuclear system

- Four hydrogen atoms is fusion (combined) in the sun for forming helium gas (He) according to the equation, below:

$$4H \xrightarrow{\text{Fusion}} {}^{4}_{2}He + 2\bar{e} + h\nu \text{ (energy)}$$

The mass of reactants = 4.0320
" " " Productants = 4.0038

The difference = 0.0282.

The above mass unit is changed to energy as electromagnetic rays as light or heat according to the Einstein equation:

$E = mC^2$ whereas M = Mass
C = light velocity (cm/sec, m/sec)

Sun light component: H = 73.46% (≈ 3:1)
He = 24.85

Also sun atmosphere is containing other elements

Element	%	Element	%	Element	%
O_2	0.77	Ne	0.12	Mg	0.05
C	0.29	N	0.09	S	0.04
Fe	0.16	Si	0.07		

Lec. 7

The Nature of Light :

Light has waves (Newton) and particles (Einstein' theory) Criteria. Max Plank 1900 who confirmed that light energy called Photons or Quantums. Also Plank found the relation between light energy and length wave

$$E = h\frac{c}{\lambda} \rightarrow h\upsilon$$

whereas:

E : Quantum Energy

υ = Frequency التردد

h = plank's constants

$h = 6.626 \times 10^{-27}$ (erg . sec) ارج . ثانية

$h = 6.626 \times 10^{-3}$ (Joule . Sec) جول . ثانية

Frequency (υ) التردد $= \frac{c}{\lambda} = \frac{\text{light velocity}}{\text{wave length}}$ سرعة الضوء / طول الموجة

Calculation of Light Energy

Example :

* Calculate the energy of yellow-red light has wave length 650 nm ($= 6.5 \times 10^{-7}$ meter)

($nm = 10^{-9}$ m $= 650 \times 10^{-9}$ m $= 6.5 \times 10^{-7}$ m)

Solution

1. Calculate frequency coefficient (υ) according to the equation

$$\upsilon = \frac{c}{\lambda} = \frac{3 \times 10^{8} \text{ m/sec}}{6.5 \times 10^{-7}} = 4.6 \times 10^{14} \text{ sec}^{-1}$$

Energy $E = N h \nu$

whereas N = Avogadro's Number (No) $= 6.023 \times 10^{23}$ ثابت بلانك (جول . ثانية)

h = planck's const. $= 6.626 \times 10^{-34}$ Joule.sec

ν = Frequency $= 4.6 \times 10^{14}$

$$E = \frac{6.023 \times 10^{23} \text{ mole} \times 6.626 \times 10^{-34} \text{ Joule.sec} \times 4.6 \times 10^{14}}{4.184 \times 10^{3}}$$

$$= 9.539 \times 10^{-14} \frac{\text{KJ.sec}}{\text{mole}} \times 4.6 \times 10^{14} \frac{1}{\text{sec}} = \boxed{43.88 \text{ KJoule/mole}}$$

$$\frac{\text{Photon}}{\text{mole}} \times \frac{\text{Kcal.}}{\text{sec}} \times \text{sec} = \boxed{\text{Kcal/mole}}$$

وحدة الطاقة في جزيئات

Table 3: Energy of visible light

Wave length nm ($= 10^{-9}$ m)	Color	Energy Kcal/mole	KJoule/mole	ev** /mole
400 (390–422)	Violet	71.54	299.3	3.10
500 (422–492)	blue	57.23	239.5	2.48
600 (492–535	yellow	47.70	199.6	2.07
650 (535–586)	orange-red	44.03	184.2	1.91
700 (586–647)	Red	40.88	171.0	1.77
760	Infrared	37.65	157.5	1.63

** electro volt (ev) $= \frac{\text{Kcal/mole}}{23.06}$

Amount of Energy Recieved by Earth:

The earth plant is recieved about 258,100 calory / cm^2 / year. About 40% reflect from it due to clouds and atmospheric dust (الغبار الجوي), and 15% of that energy will transfer to heat energy in ozone layer (O_3 طبقة الأوزون). 45% of the energy will reach the earth surface which it is equal to 116,100 cal / cm^2 / year.

45% of this radiation will reach earth surface is visible light (45% infra-red rays, and 10% UV rays))

The total energy fixed by green plants is ranged between 0.05 to 0.1 % of the total radiation at earth surface which it is approximately equal 39 cal. / cm^2 only

The amounts of carbon is fixed by plants are equal 10.8×10^{10} ton / year ((= 10.8×10^{13} Kg / year))

Photosynthesis

The Photosynthesis is considered the most important process for all living organisms except anaerobic bacteria which it can fix CO_2 (carbon dioxide) with using hydrogen of the water (H_2O) as a source of protons.

Lec. 7 Photosynthesis

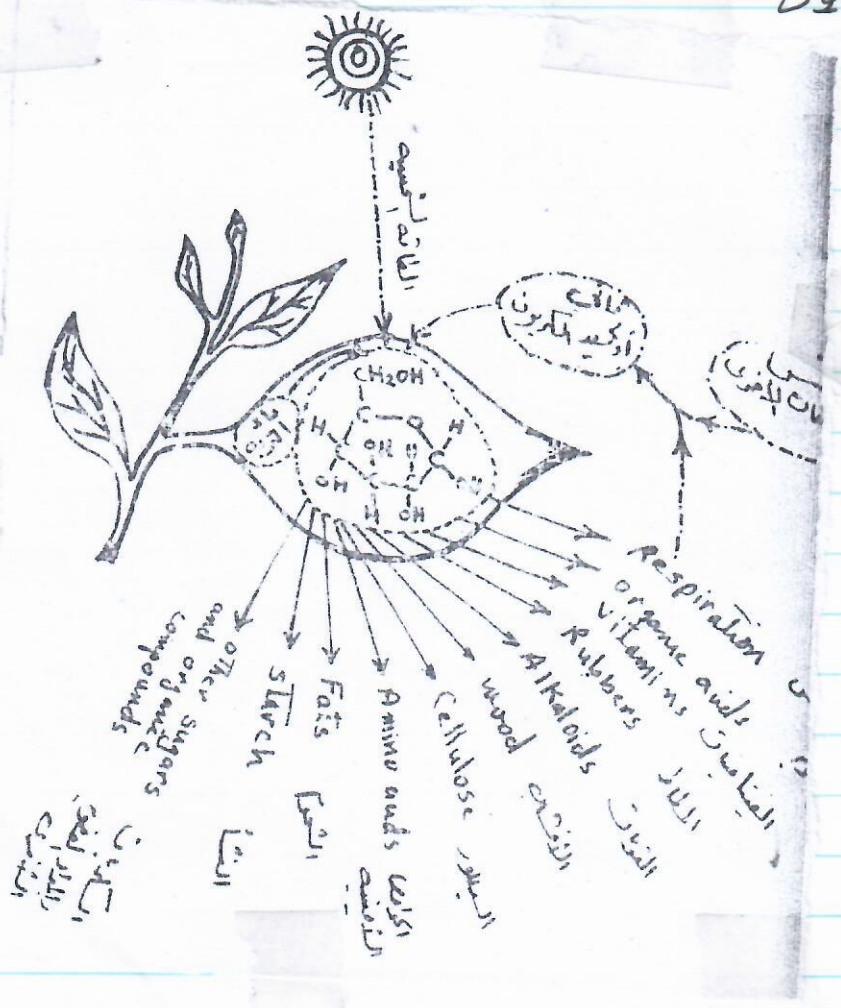
The import role of photosynthesis are:

[1]* one of important process and chemical reactions for all living organisms which source of a- food b- O_2 source c- energy

[2]* Fuel source: Example coal, Petorol, Natural gas

[3]* Industrial and economical products:
Example (schem 1)

Schreme 1: Importance of photosynthesis as food and source of energy and industerials technology



المواد اللازمة لعملية البناء الضوئي
Material requirement for photosynthesis

[1] light
[2] Energy
[3] Pigments
[4] Water
[5] CO_2
[6] Enzymes and Coenzymes
[7] Mineral salts
a- NO_3-N (N)
b- H_2PO_4 (P
c- Magnesium (Mg)
d- Iron (Fe)

History of Photosynthesis

* DeSaussur (1804) is the first scientist postulated the following photosynthetic equation:

$$n\,CO_2 + H_2O \longrightarrow (CH_2O)_n + O_2$$

* Van Niel (1930) pointed out the general equation for photosynthesis:

$$CO_2 + H_2O \xrightarrow[\text{Light}]{\text{Chlorophylls}} CH_2O + O_2$$

* Blackman (1905) illustrated that photosynthesis process consisted two processes:

1. Light reactions
2. Dark reactions

* Hill (1937) concluded the following facts according to his studies:

1. Photosynthesis is carried out in plastids
2. CO_2 [Carbon dioxide) is not necessary for light reactions

Photophosphorylation:

The process by which the plant can produce ATP [Adenosine Triphosphate] in the presence light and it happens in the plastids and through the light reactions. There are two types of photophosphorylation:

1. Non cyclic photophosphorylation
2. Cyclic photophosphorylation

Functions of light reactions:

1- Production of oxygen (O_2)
2- Formation of NADPH+H which is necessary for metabolic reactions including dark reactions
3- Formation of adenosine triphosphate (ATP) which is very necessary for metabolic reactions including dark reactions.

Methods of CO_2 Fixation

The plants can be divided into three groups:

1 C_3 Plants:

The plants with 3C atoms compounds as a primary initial CO_2 fixation (reduction) product such as:

Wheat, tomato, datepalm and others (Grasses). The C_3 compound is Phosphoglyceric acid (PGA) [Calvin cycle, Calvin, 1950, California University, USA

2- C_4 Plants:

The plants with 4C (carbon) atoms compound as a primary initial CO_2 reduction (fixation) product such as corn, sugarcane, and others. This compound is Oxaloacetate. This C4 (4 carbon atoms) is known by

Hatch and Slack, 1960, Biochemists, Australia.

CO_2 —(Reduction fixation)→ Phosphoenol Pyruvate ((PEP)) —(plants)→ oxaloacetate ($C_4H_4O_5$)

3. CAM ((Plants with crasulacean acid metabolism)).

This cycle called CAM since it was first investigated in plants of crassulaceae family which are commonly produced crassulacean acid. The plants of this group opening their stomata at night to fix (reduced) CO_2.

Source of oxygen Relased in Photosynthesis

Before 1930 it was thought that oxygen (O_2) released in photosynthesis process comes from CO_2. But idea that O_2 comes from water (H_2O) and not from CO_2 which is now well established was first given by Van Niel (1930 - 1931)

Van Niel observed that in certain photosynthetic bacteria such as green sulfur bacteria, oxygen is not released during photosynthesis. Such bactersa instead of utilizing water use H_2S and liberate sulfur (S)

$$6CO_2 + 12H_2S \xrightarrow[\text{Sulfur bacteria}]{\text{light photosynthetic}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

Green plant

$$6\,CO_2 + 12\,H_2O \xrightarrow[\text{chloroplasts}]{\text{light}}$$

$$C_6H_{12}O_6 + 6\,H_2O + 6\,O_2$$
sugar water oxygen

Ruben, Kamen and coworkers (1941) using a heavy isotope of oxygen [[O^{18}]] showed that if the photosynthesis took place in presence of H_2O^{18} and normal CO_2, the oxygen was found to be isotopically labelled

$$n\,CO_2 + 2\,H_2O^{18} \longrightarrow (CH_2O)_n + H_2O + O_2^{18}\uparrow$$

But if normal H_2O and CO_2^{18} were supplied, the O_2 released during photosynthesis did not contain the heavy isotope.

$$n\,CO_2^{18} + 2H_2O \longrightarrow [CH_2O^{18}]_n + H_2O + O_2\uparrow$$

$$6\,CO_2^{18} + 12\,H_2O \longrightarrow C_6H_{12}O_6^{18} + 6\,H_2O + 6\,O_2\uparrow$$

Lec. 7 Photosynthesis

Plant physiology

Universal Questions

Q1 : Put the word True or False :

1- Red light energy is more than orange red light energy

2- Violet energy is more energy than blue light beam

3- Wave length of yellow is range between 422 - 492 nM

4- Energy of yellow light is 199.6 KJ/mole

Q2 : Fill the following blanks

1- Energy of light is ~~equal~~ to _____ equation

2- Frequency of light is equal _____

3- _____ KJ/mole is the energy of blue light

4- Length of infra red is _____ and its energy _____ Kcal/mole

5- Energy of ~~violet~~ light is equal as compared with red light by _____ folds

Q3 : Select the correct answer :

1- The amount of carbon fixed by plants are equal (ton/year) as

a - 1.08×10^{10} b) 2.08×10^{10} c) 10.8×10^{10}

d) none of them

Plant Physiology

2- Total energy fixed by green plants is about,
a) 0.05 b) 0.05–0.1 d) 0.5 of total radiation

3- The total energy fixed by plant ($cal./cm^2$) is,
a) 13g b) 4g c) 2g d) 3g

4- Photosynthesis process is considered as process,
a) oxidation b) reduction c) CO_2 reduction
d) none of them.

Q4: Complete the following:

1- The important role of Phytosynthesis are 1-2-3-

2- Photosynthesis process is followed ——— division.

3- Nutrients required for photosynthesis are 1-2-3-4-.

4- Material required for photosynthesis are 1-2-3-4-5-6-

Homeworks

(x) Calculate the energy of red light has wave length 700 nm ((by kcal/mole, and kJoule/mole units)) ((Asw: 40.92, 171.2 kJ/mole))

(x) If you know: two lights wave length are 290 and 760 nm. Calcalate the energy of each of them, and compare between them

2021/12/14

قسم علوم الحياة

المرحلة الثالثة

الفصل الدراسي الاول

للعام

2022 / 2021

فسلجة النبات

Plant Physiology

المحاضرة 8

أ. المادة : د. جواد

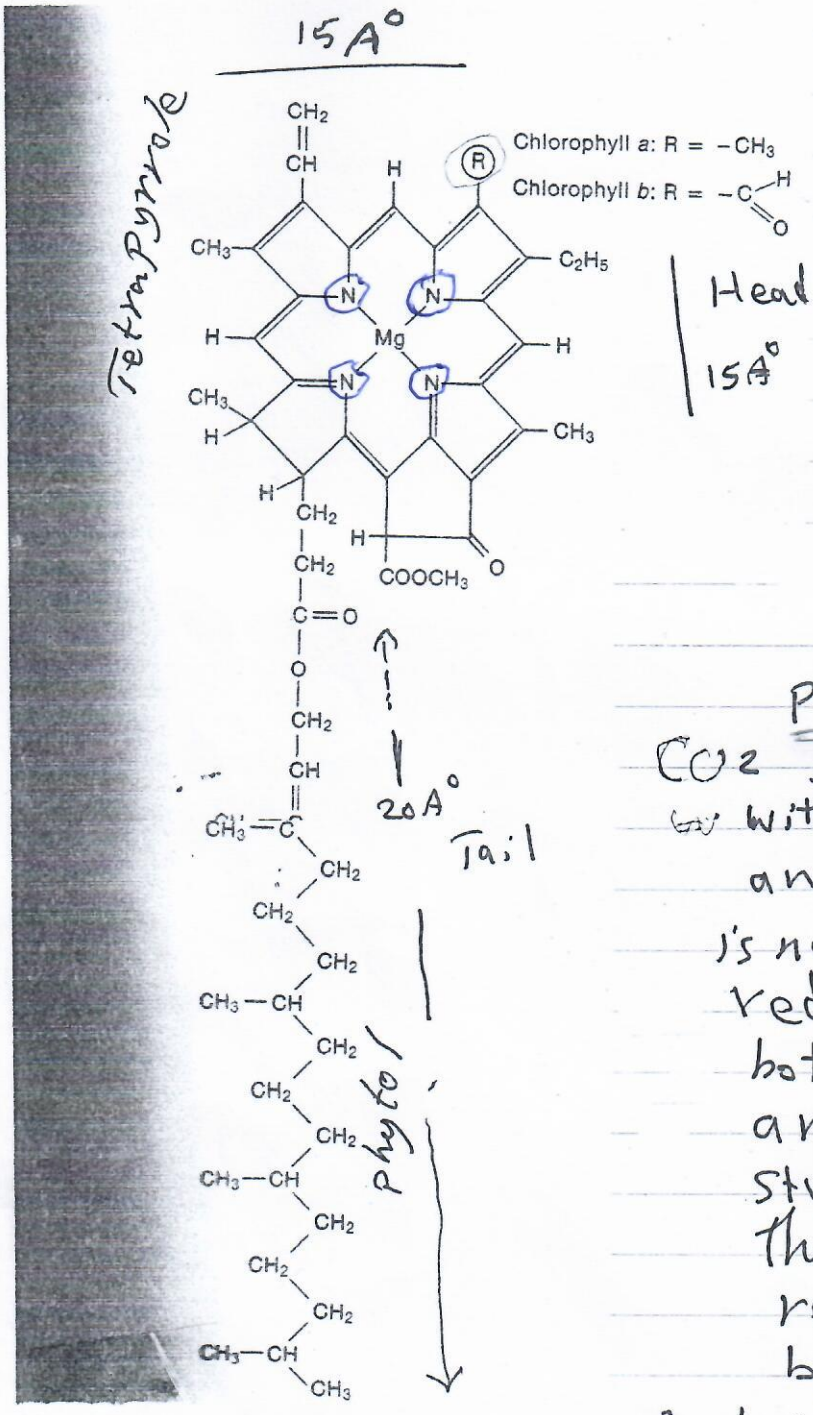
محاضرة 8 البناء

* تكملة البناء الضوئي
* الصبغة البنائية للكلوروفيلات a / b
* مسلكات اختزال CO_2
* الخصائص الكيمائية للكلوروفيلات a / b
* العوامل المؤثرة في عملية البناء الضوئي
  * العوامل الخارجية
  * العوامل الداخلية
* صبغات البناء الضوئي
* وحدات البناء الضوئي والأنظمة الضوئية Quantsome
* تركيب ومكونات البلاستيدات الخضراء
* عملية الشفرة
* دور واهمية تفاعلات الضوء
* الفروق بين الشفرة الضوئية الحلقية واللاحلقية
* الفروق الرئيسية بين C3 و C4 النباتات

Lect: 8

Fig 1. showing the chemical composition of Chl. a, and b.

A° = Angstrom
= 0.1 nm



Photosynthesis is consisted CO_2 fixation and accompany with it water photolysis and release O_2 (O_2 is not related to CO_2 reduction, because of both O_2 and CO_2 are oxidants)). Many studies were confirmed that O_2 is not related to CO_2 fixation by using heavy isotope ^{18}O.

CO_2 reduction process is required
1 - Source of photo energy
2 - Source of energy capture
3 - Energy storage ways.

Lec. 8 Photosynthesis

Photosynthesis Process Stages:

Generally photosynthesis is expressed by the following chemical equation:

$$6CO_2 + 6H_2O \xrightarrow[\text{chl.}]{\text{Sun energy}} C_6H_{12}O_6 + 6O_2$$

The following equation is expressed for photosynthesis efficiently

$$6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$$

Table is shown the photosynthesis pigments

Pigment	Chemical Composition	Molecular wt.(g).
Chlorophyll a	$C_{55}H_{72}O_5N_4Mg$	892.32
Chlorophyll b	$C_{55}H_{70}O_6N_4Mg$	906.32
Xanthophyll	$C_{40}H_{56}O_2$	568
Carotenoids	$C_{40}H_{56}$	536
Phycocyanins	-	-
Phycoerythrins	-	-

Chlorophyll b is more soluble by organic solvents than chl. a (is due to chl. b is contained CHO aldhyde group meanwhile chl. is contained CH_3 methyl group at pyrole cyclic NO.3 (Figure 1)

Factors Affecting photosynthesis:

A) External factors

① Light: The light is an essential factor for photosynthesis. It affects the rate of photosynthesis in three ways:

a - Light quality b - light intensity
c - duration of light period.

Photosynthesis

② Carbon dioxide (CO_2)

An increase in CO_2 concentration upto about 1% increases the rate of photosynthesis. But very concentration may prove toxic and the rate of photosynthesis will go down (decreases))

③ Temperature:

Usually, an increases in temperature from 10°C to about 40°C brings about an increase in the rate of the photosynthesis Q_{10} for photosynthesis is 2.

④ Water ⑤ oxygen

B) Internal Factors:

1) Chl. content 2) protoplasmic factors
3) Accumulation of the end products of photosynthesis 4) Anatomy of leaf
5) microstructure of chloroplasts.

Photosynthetic Pigments

Photosynthetic pigments are three types:

① Chlorophylls (a, b ... ...) ② Carotenoids ③ phycobilins

Functions of carotenoids are:

① protect chlorophylls against photooxidation under extensive light

② Absorption the light and then transfer it to chlorophylls pigments.

Photosynthesis

(3) Causes phototropism in plants

[[Phototropism ⟶ The growth of a plant or plant part toward light ((positive phototropism)) or away from light ((negative phototropism))]]

Emerson effect and Emerson Enhancement

Emerson and his associates found that the efficiency of photosynthesis is significantly decreased in plant exposed wave length of 680 nm. Also, they found that the efficiency of Photosynthesis is increased when plant exposed to short wave length and then followed by long wave length of the light. This phemomenon is called Emerson enhancement.

Photosynthetic Units of Pigment Systems

Photosynthetic units are called Quantosomes and each quantosome is composed by:

(1) Mn^{2+} (2 ions) (2) Cu^{2+} (1 ion)
(3) Fe^{2+} (12 ions) [[2 ions involve in synthesis Chl. a and b, and 10 ions involve in synthesis of cytochromes]].

(4) Forty six molecules of Quinone
(5) Forty eight = = caroten

(6) 150 - 250 molecules of Chl. a and chl. b

Lec. 8

Photosynthesis

Photosynthesis is consisted the chemical reactions as:

1. photo chemical reactions
2. Brochemical reactions

Also photosynthesis is consisted two kind of reactions at day periods (time) as

1. - Light reactions
2. - Dark reactions

photosynthesis is manily performed in chloroplasts (البلاستيدات الخضراء) which it is containing the chlorophylls and other pigments.

Chloroplastids form is as spherical, football shaped, disk shaped with diameter is ranged between 5 to 10 μm (10^{-6} m) (or micron) and a depth of 3 to 4 micron (μ). Plastids NO. are ranged between 50 to 200 per cel.

Plastids are containing the following:

1. - Thylakoids 2. Stroma 3. Grana.

Plastids are composed by proteins which it form as 6g% of dry wt. basis. 75% of total N (Nitrogen) in plant are mainly found in chloroplastids.

Stroma is containing DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid) molecules which it is formed about 0.03% of plastids dry weight (d.wt).

Lec-8

Photosynthesis

Two active pigment systems(PS) are located in Quantosome. They are PS 700 (PSI), and PS 680 (PS II) which present in a ratio of 1:200 molecules of Chlorophyll. These two PS are resonsible for receiving the light energy and utilize it in dissociation of water (H_2O) and liberate the electrons (e^-) that become ready to be received by the acceptors.

Components Located Between the Pigment Systems

(1) Plastoquinone
It is a cyclic compound responsible for receiving the electron after dissociation H_2O

(2) Cytochrome b (3) cytochrome f
(4) Plastocyanin

Photophosphorylation:

The process by which the plant produce ATP (Adenosine triphosphate) in the presence light and it happens in the plastids through the light reactions.

Functions of Light Reactions:

(1) Production of oxygen (O_2).
(2) Formation of $NADPH_2$ ($NADPH+H$) which is necessary for metabolic reactions including dark reactions.

(3) Formation of ATP which is necessary for metabolic reactions including dark reactions.

Electrons transfer and photophosphorylation

Photophosphorylation: synthesis of ATP (Adenosine triphosphate) from ADP (Adenosine di phosphate) and inorganic phosphate during the light reactions.

When photosystems I and II exposed to light, both are excited. Photosys. II starts dissociating H_2O (water) and liberating the electrons (e^-)

The $\bar{e}$ ⟶ captured by P680 (Sys II) ⟶ Q (e^- acceptor)

Reduced Q ⟶ B (Carrier) $\xrightarrow{e^-}$ (Carrier) plastoquinone ⟶ PS I (~~700~~ 700) ⟶ by Cytochrome and cytochrome f (Both located in PSI)

$\bar{e}$ $\xrightarrow[(Fe\text{-}S)]{\text{Ferredoxin}}$ Reduced ferrodoxin $\xrightarrow{\text{Reduced}}$ $\underset{\text{oxidized form}}{NADP^+}$ ⟶ $\underset{\text{Reduced form}}{NADPH}$

The $NADPH_2$ is used to fix (reduced) CO_2 in the dark reactions (Fig. 1)

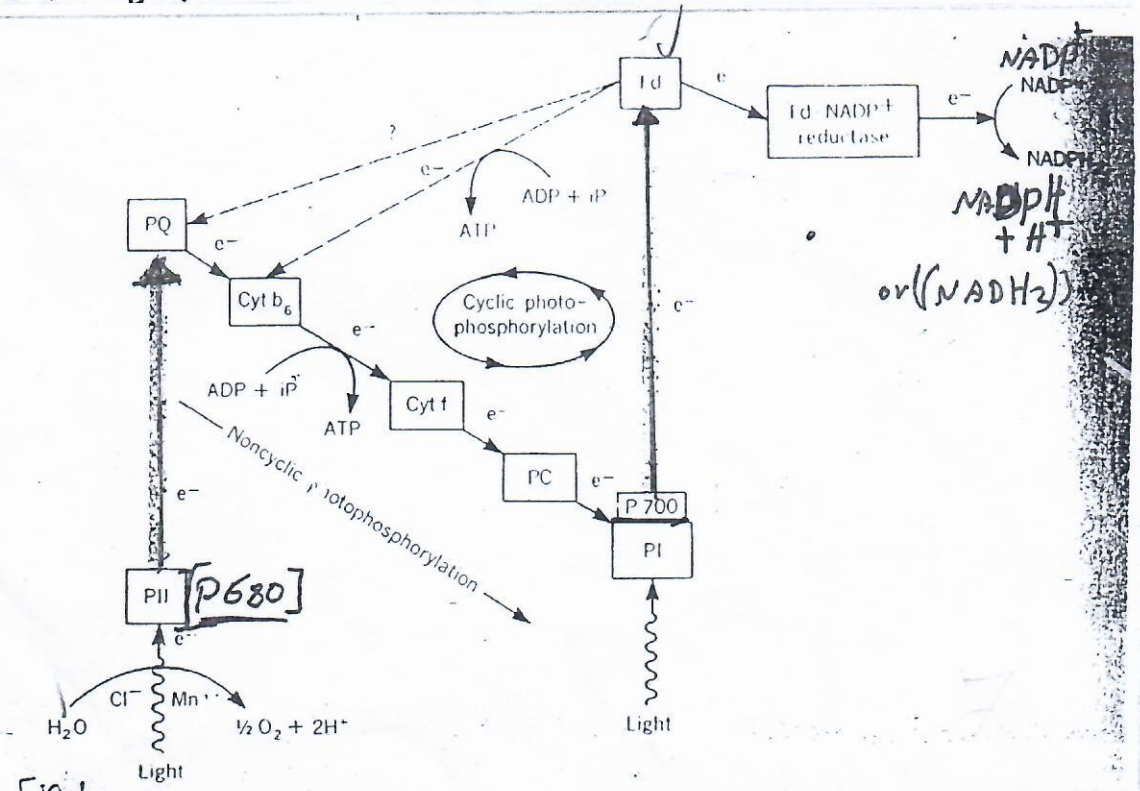


Fig-1. Schematic representation of photoelectron transport in the chloroplast. PII = pigment system II, PQ = plastoquinone, Cyt b_6 = cytochrome b_6, Cyt f = cytochrome f, PC = plastocyanin, PI = pigment system I, and Fd = ferredoxin. See discussion in text for further details.

Photophosphorylation Photosynthesis

Cyclic Electron Transport and photophosphorylation	Non-Cyclic Electron Transport and Photophosphorylation
1- Associated with pigment system I (P700)	1- Associated with both PSI (P700) and PSII (P680)
2- The electron expelled from chlorophyll molecule is cycled back	2- The é expelled from chlorophyll molecule is not cycled back
3- photolysis of water and evolution (release) of O_2 don't take place	3- Photolysis of water and release of O_2 take place
4- Phosphorylation take place at two places	4- Phosphorylation take place at one places
5- $NADP^+$ is not reduced	5- $NADP^+$ is reduced to $NADPH + H^+$

Differences Between C_3 and C_4 plants:

C_3 Plants	C_4 Plants
1- C_3 plants example: wheat, oats, cotton barley, rice, beans spinach, sunflower, etc.	C_4 plants example: Maize, Sorghum, Atriplex, etc.
2- Carbon pathway is C_3 (Calvin cycle) only Calvin Pathway	2- Carbon pathway is C_4, (Hatch-Slack Pathway

Lec. 8

Photosynthesis

Differences Between C_3 and C_4 plants

C_3 Plants	C_4 plants
3- First compound is Phosphoglyceric acid [[PGA]]	3- First compound is oxaloacetic acid [OAA]
4- Optimum temperature is from Low to High	4- Optimum temperature is High
5- Photorespiration occurs	5- No hotopespiration happend.
6- Photosynthetically less efficient	6- Photosynthetically more efficient
7- Carbonic anhydrase enzyme activity is highe	7- It is low
8- Optimum temperature growth is low to high	8- It is <u>low</u> only
9- Low effeciency of CO_2 fixation	9- High effeciency of CO_2 fixation
10- Low productivity as compared with C_4 plants	11- High productivity as compared with C_3 plants
11- The enzyme involved in CO_2 fixation is Ribulose diphosphate Carboxylase	11- The enzyme involved in CO_2 fixation is phosphoenolpyruvate Carboxalyse
12- PEP locates in cytoplasm	12- RuBP locates in chloroplasts.

Photosynthesis Lec. 8

Plant Physiology

Objective Type Questions

Q_1 : Select the correct answer:

1- photosynthesis is,
a- catabolic b) amphibolic b) anabolic d) none of them

2- In photosynthesis, light energy is converted into,
a) heat energy b) O_2 and hexose sugar c) chemical energy d) none of them

3- Most of the photosynthesis in world is carried out by a) marine algae
b) bacteria c) forests d) grass lands.

4- which of the following is not required for photosynthesis?
a) CO_2 and H_2O b) light c) green plants
d) none of them

Q_2 : Put the word True or False:

1- In photosynthesis, light energy is converted into heat energy.

2- Higher plants contain chl.a and chl.b.
3- Blue light has more energy per photon than UV (Ultraviolet))
4- Reaction center of pigment system I (PSI) is P-680
5- Plastoquinone is a component of electron transport chain in chloroplasts.

Q_3 : Fill the following blanks:

1- _____ reaction center of pigment System I.

Plant Physiology

2- _____ is a component of electron transport chain in chloroplasts

3- The process of phytosynthesis is a complacted _____ process.

4- Calvin cycle is also known as _____.

5- Oxygen gas comes from water and not from _____.

Q4- Define briefly of the following:

PSII, P700, calvin cycle, C4 pathway, plastoquinone

Q5: Count of the following:

1) The amount energy is released from light beam with 600 nm (nm = 10^{-9} meter) [[Kcal/mole ; KJ/mole]]
2) The energy of two light beams with 280 and 700 nm [[Kcal/mole ; KJ/mole]]
3) The weight of reactants component and products component in photosynthesis equation, if you know (Atomic wt. of C = 12, H = 1, O = 16)

Q6: Differentiate between:

1) PSI and PSII (write five only)
2) Chla and Chl.b (write six only)
3) C_3 and C_4 plants (write six only)

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Photosynthesis

Q7 : Define photosynthesis. Give the details of light reaction of photosynthesis

Q8 : Universal Questions:
1- What are C3 plants?
2- What are C4 plants?

Q9 = Choose the correct answer for column-1 from column-2:

Column-1	Column-2
* PS II	a - P700
* photosynthesis is	b - catabolic process
* UV energy is more than	c - blue energy
* light energy is converted to	d - heat energy
* Chl-a and chl-b	e - C3 plants
* Hatch and Slack	f - 0-3 %
* CO_2 concentration is	g - CO2
* Pigment system	h - P680
* Plastoquinone	i - anabolic process
* Soura of oxygen released from photosynthesis	j - red energy
* PS I	k - Chemical energy
* Light reactions	l - Plants
* CAM	m - C4 plants
* Required CO_2 reduction	n - 0-03 %
	o - quantosome
	p - electron carrier
	q - water
	r - plastocyanin
	s - O_2, NADPH $+H^+$, ATP

u - crassulacean acid metabolism
v - Source of photon energy
x - Source of chemical energy