05.

Forms of nutrients in soil and their functions in plants

Learning objective :

To know the functions of each nutrient in plant

Primary or major nutrients: are those nutrients required relatively in large quantities by the plants for its growth and development. Ex: N, P and K.

Secondary nutrients: are those nutrients which are required by plants in moderate amounts and given secondary importance in its supply and management.

Ex: Ca, Mg and S.

Micronutrients: The nutrients which are utilized by plants in relatively smaller quantities for their growth and development, but these are equally important & essential to plants as macronutrients.

Ex: Fe, Mn, Zn, Cu, B, Mo, Cl and Ni.

Plant Nutrients

Sixteen elements are considered essential for plants. They are grouped based on their relative abundance in plants.

Many non-essential elements are also found in plants that account for over 60 elements. Al is absorbed when soil solution is rich in Al ions. When plant materials is burned, the remaining plant ash contains all the essential and non-essential elements except C, H, O, N, S. Macro nutrients are absorbed in 30-100 times in proportion to that of micronutrients.

Essential Nutrients

Non-mineral Nutrients	Macronutrients		Micronutrients	
	Primary	Secondary	By all plants	Some

C	N	Ca	Fe	B	Na
H	P	Mg	Mn	Cl	Co
O	K	S	Zn	Mo	Va
			Cu		Ni
					Si

Chemical nature

Metals	K, Ca, Mg, Fe, Mn, Zn, Cu,
Non-metals	C, H, O, N, P, S, Cl

The plant content of mineral elements is affected by many factors and their concentration in crops varies considerably.

Nutrient		Relative concentration (Times)	Concentration (%)
Primary	N, K	400-1000	1-1.5
	P	30	0.1-0.3
Secondary	Ca, Mg	100-200	0.2-0.5
	S	30	0.1
Micro	Fe, Mn, B	1-2	0.002-0.01
	Others	<1	<0.002

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Plant Nutrients

Concentration, Mobility, forms, functions

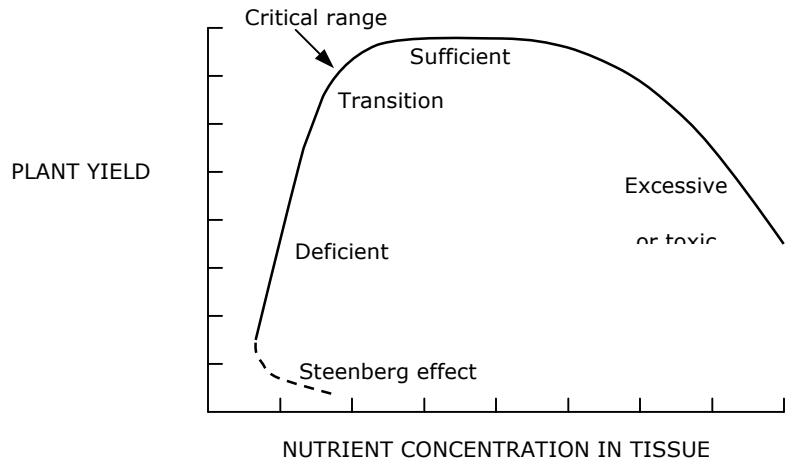
A mineral element is considered essential to plant growth and development if the element is involved in plant metabolic functions and the plant cannot complete its life cycle without the element. Terms commonly used to describe level of nutrients in plants are

Deficient

When the concentration of an essential element is low enough to limit yield severely and distinct deficiency symptoms are visible then that element is said to be deficient. Extreme deficiencies can result in plant death. With moderate or slight deficiencies, symptoms may not be visible, but yields will still be reduced.

Critical range

The nutrient concentration in the plant below which a yield response to added nutrient occurs. Critical level or ranges vary among plants and nutrients but occur somewhere in the transition between nutrient deficiency and sufficiency.



Sufficient

Concentration range in which added nutrients will not increase yield but can increase nutrient concentration. The term luxury consumption is used to describe nutrient absorption by the plant that does not influence yield.

Excessive or toxic

When the concentration of essential or other elements is high enough to reduce plant growth and yield then it is said to be toxic. Excessive nutrient concentration can cause an imbalance in other essential nutrients, which also can reduce yield

Forms of nutrients for Plant absorption	
N	NH_4^+, NO_3^-, organic N
P	$H_2PO_4^-$ (Primary) and HPO_4^{2-} (Secondary) Orthophosphates
K	K^+
Ca	Ca^{++}
Mg	Mg^{++}
S	SO_3^- (Sulphite) and SO_4^-
Fe	Fe^{++} (Ferrous), Fe^{+++} (Ferric)
Mn	Mn^{++} (Manganous) and Mn^{+++} (Manganic)
Zn	Zn^{++}
Cu	Cu^+ (Cuprous) and Cu^{++} (Cupric)
B	BO_3^- and other forms
Mo	MoO_4^{--} (Molybdate)
Cl	Cl^-

Concentration and plants yield

Yield is severely affected when a nutrient is deficient. When deficiency is corrected, growth increases more rapidly. Under severe deficiency, rapid increase in growth with added nutrient can cause a small decrease in nutrient concentration due to dilution effect. This is called the **Steenberg effect**

Luxury consumption

Nutrient sufficiency occurs over a wide concentration range, wherein yield is unaffected. Increase in nutrient concentration above the critical range indicates that the plant is absorbing nutrient above that needed for maximum yield. This **luxury consumption** is common in most plants. Elements absorbed in excessive quantities

can reduce plant yield directly through toxicity or indirectly by reducing concentration of other nutrient below critical ranges.

Functions of nutrients in plants:

Nutrient		Functions
Major nutrients		
Nitrogen		Basic component of proteins and chlorophyll (the pigment that gives plants their green colour). Plays an essential role in plant growth. Also feeds microorganisms in the soil
Phosphorus		Plays an important role in root growth and promotes the establishment of young plants, flowering, fruiting and ripening, photosynthesis, respiration and overall plant growth.
Potassium		Moves through the plant. Promotes the movement of sugars, turgor and stem rigidity. Also increases the plant's overall resistance to cold, diseases, insect pests, etc. Promotes the formation of flower buds, the hardening-off of woody plants and fruiting.
Secondary nutrients		
Calcium		Plays a vital role in plant structure, because it is part of cell walls and holds them together. Promotes the development of the root system and the ripening of fruit and seeds. Found in the growing parts of plants (apex and buds).
Magnesium		An important part of chlorophyll. Helps fruit ripen and seeds germinate. Reinforces cell walls and promotes the absorption of phosphorous, nitrogen and sulphur by plants
Sulphur		A component of several proteins, enzymes and vitamins. Contributes to chlorophyll production. Helps plants absorb potassium, calcium and magnesium.
Micronutrients		

Iron		Essential to chlorophyll production. Also contributes to the formation of some enzymes and amino acids.
Boron		Essential to overall plant health and tissue growth. Promotes the formation of fruit and the absorption of water.
Manganese		Promotes seed germination and speeds plant maturity. Plays an important role in photosynthesis by contributing to chlorophyll production. Essential for nitrogen assimilation and protein formation.
Molybdenum		Essential for nitrogen assimilation by plants and nitrogen fixation by bacteria. This means that it is needed for the production of nitrogen-based proteins.
Chlorine		Stimulates photosynthesis.
Copper		Activates various enzymes. Also plays a role in chlorophyll production
Zinc		Plays an important role in the synthesis of proteins, enzymes and growth hormones.
Nickel		Key component of selected enzymes involved in N metabolism and biological N fixation.
Beneficial elements		
Silicon		Strengthens cell walls, energy transfer & drought resistance Reduces water loss & prevents fungal infection.
Cobalt		Essential in N fixation
Sodium		Na replaces K in certain functions in halophytes plants For C4 plants having dicarboxylic photosynthetic pathway
Vanadium		Essential for green algae

Forms of elements in Mineral soil

Macro elements are available in (1) Solid (2) Cations (3) Cations in soil solution

Nutrients	Mineral / solid	Cations	Soil solution as ions
N	Organic compounds and Amino acids	NH_4^+	NH_4^+, NO_2^-, NO_3^-
P	Organic compounds, nucleic acid and inorganic compounds. Ca, Fe, Al, PO_4's	-	$H_2PO_4^-$, HPO_4^-
K	Feldspar, mica, silicate clays	K^+	K^+
Ca	Feldspar, hornblende, lime stone	Ca^{2+}	Ca^{2+}
Mg	Mica, Hornblende, lime stone	Mg^{2+}	Mg^{2+}
S	Organic sources – protein, amino acids inorganic sources – Gypsum, pyrites .	- -	HSO_4^-, SO_3^{2-} SO_4^{2-}

Forms of nutrient element absorbed by plants

Nutrient element	Forms absorbed
C	Mainly through leaves - CO_2
H	HOH (Hydrogen from H_2O) – H^+
O	CO_2 mainly through leaves – O_4^{2-}, OH^-, CO_3^{2-}
N	NH_4^+, NO_3
K	K^+
Ca	Ca^{2+}
Mg	Mg^{2+}
S	SO_4^{2-}
Fe	Fe^{2+} (Ferrous), Fe^{3+} (ferric)
Mn	Mn^{2+} (Manganous), Mn^{4+} (Manganic)

Zn	Zn^{2+}
Cu	Cu^{+} (cuprous), Cu^{2+} (Cupric)
Co	CO^{2+}
Na	Na^{+}
Si	$Si(OH)_4$
Cl	Cl^{-}
B	H_3BO_3 (Boric acid) $H_2BO_3^{-}$ (Borate)
Mo	MoO_4^{2-}

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http://edis.ifas.ufl.edu/hs1191

Questions to ponder

1)How will you differentiate between N and K deficiencies of corn visually?

2) What is luxury consumption?

3)Which element is absorbed both in anionic and cationic forms?

4) Which element is specifically involved in nitrate reduction in plants?

5)Name the nutrients whos deficiencies are first exhibited in the apical region of the growing plant?