What are all the factors which influence plant and crop growth?

The principal factors that influence plant and crop growth are both **Abiotic & Biotic influences**

Abiotic influences are the external elements which cannot be influenced including sun, rainwater, temperature, humidity, light, soil type, wind, humidity and air – extremes can lead to stress such as drought, heat, nutrient deficiencies, rot, etc.

- The sun provides the light needed by plant to manufacture its food
- Air contains essential gasses (nitrogen, oxygen, carbon dioxide etc.). Helps in transpiration and respiration in plant
- Water helps by plant dissolves nutrients and uptake
- Temperature speeds up or slows down the rate of activities in plant
- Wind influences the rate of air movement around the plant
- Humidity (the amount of water particles in the atmosphere) helps regulate atmospheric condition of plant

Biotic influences can be controlled and managed and include the plant itself, insects, worms, weeds, microbes, man, animals, and nutrients – extremes can lead to diseases, damage to plant parts, death, slow or deformed growth

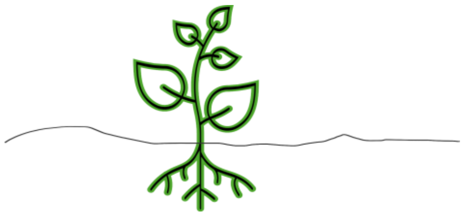
Soil nutrients are essential for plant growth. They are needed in varying quantities by plant

- Soil water is critical for nutrients transport, photosynthesis, cooling effect etc
- Air (oxygen) the root of plant respires to be able to take up nutrients needed by plant
- Soil pH is the degree of acidity or alkalinity of the soil. This affects the availability of nutrients to plant
- Organic matter helps soil structure and enrich soil with nutrients
- Beneficial microorganisms help in nutrients availability for easy plant intake

Micromix Plant Health is therefore focused on the **Biotic influences** and the supply of foliar fertilisers, macronutrients, micronutrients and biostimulants.

Plants are made up of:- Shoots (above ground)

& Roots (below ground)



Both the Shoots and the Roots can be affected by the biotic influences requiring a range of different products for farmers & growers to maximise their outcomes.

The effect of any **biostimulant** will be determined by its composition, however, all biostimulants have the same mode of action, i.e. stimulating biological process in plant.

For shoot growth, a biostimulant based on protein composition (peptides, amino acid, and protein hydrolysates) this can influence hormonal activities (concentration of plant growth hormone) in the shoot region leading to shoot cell elongation (growth).

Similarly, such biostimulants can also stimulate carbon, nitrogen (the main constituent elements responsible plant growth and quality) and metabolism (activities).

Also, indirectly, biostimulants will help in nutrient uptake by plant, to help shoot growth.

Biostimulants

Biostimulants, are a relatively recent addition to agriculture and horticulture, they are biological produces used to enhance plant response to various stressors, to promote nutrient uptake, and stimulate plant growth.

They are usually non-nutritive, meaning they don't supply nutrients directly, but instead trigger natural processes that improve nutrient efficiency and resistance to stressors in the plant.

Biostimulants are typically derived from various organic materials, such as plant extracts, beneficial microorganisms, seaweed extracts, and humic and fulvic acids. They are hailed for their ability to enhance plant vigour, yield, quality, and post-harvest shelf life.

Fertilisers

Fertilisers have been widely used for much longer in Agriculture. They are substances added to soil or plants to provide one or more essential nutrients necessary for the plant's growth. Fertilisers directly improve the nutrient content of the soil, primarily nitrogen, phosphorus, and potassium, along with the other essential elements required by the plant, macronutrients and micronutrients.

Fertilisers can be mineral or organic in origin, with mineral fertilisers being more widely used due to their cost-effectiveness and nutrient concentration. They are vital in preventing nutrient deficiencies in plants, promoting growth, and enhancing crop yield and quality.

Key Differences and Similarities

The primary difference between biostimulants and fertilisers lies in their functionality and mode of action. Fertilisers directly supply plants with essential nutrients, promoting plant growth and correcting nutrient deficiencies in the soil. In contrast, biostimulants stimulate the plant's innate abilities to absorb nutrients, manage stress, and grow, without providing nutrients directly.

Despite these differences, biostimulants and fertilisers also share common ground. Both are designed to optimise plant growth and enhance crop yield and quality. They can be used in conjunction and often complement each other in an integrated approach to plant care and nutrition. While fertilisers nourish the plants with required nutrients, biostimulants help plants use these nutrients more effectively.

What are Biostimulants, why do we use them, and how do they work?

The need to advance crop production through maximisation of crop's innate potentials has intensified the use of biostimulant in agriculture and horticulture.

The word biostimulant is a coinage of two words- 'bio' and 'stimulant'. Bio means life associated with living organisms, and stimulant is any substance capable of enhancing activity of a thing

Similarly, the need for a promising and environmental- friendly innovations that will enhance flowering, plant growth, fruit set, crop productivity, and nutrient use efficiency (NUE), and improve plants tolerance against a wide range of abiotic stressors necessitates the use of biostimulants

Biostimulant is any material which contains substance(s) (natural or synthetic) and/or micro- organism other than fertiliser which, when applied to plants, seeds or soils will stimulate natural plant processes to enhance nutrient uptake, nutrient use efficiency, tolerance to abiotic stress, and/or crop quality, independently of its nutrient content

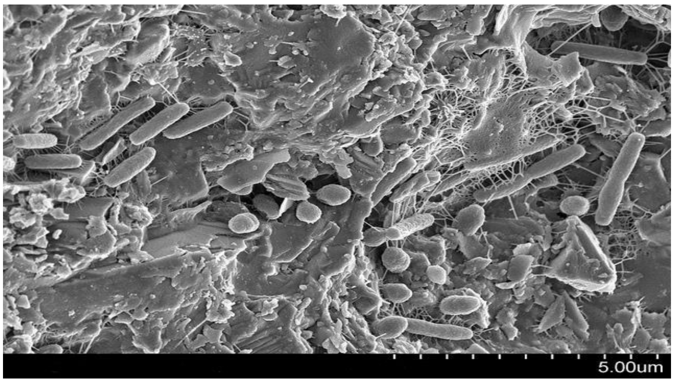
As highlighted prior, Biostimulants are broadly classified into two categories:

Microbial and Non-microbial Biostimulants

Microbial biostimulants have been shown to enhance plant growth (through direct and indirect mechanism), help with nutrient availability and uptake, improving soil condition, helping plants tolerate abiotic stress, and enhancing overall crop quality attributes.

Beneficial Fungi

Beneficial Bacteria



Humic substances (fulvic acid (centre), humic acid (left) and humim) are products of decomposition of plants and animal residues through the activities of soil microorganisms to form a more stable and complex particles that hold and is capable of attracting many essential plant nutrients which are in forms readily available for plant use either through soil or leaf surface applications, incorporation into fertiliser or irrigation water (fertigation) umic substances (fulvic acid, humic acid and humim) are products of decomposition of plants and animal residues through the activities of soil microorganisms

Amino acid (right) products (including protein peptides and hydrolysates) are products derived from animal, plant and microbial protein through natural (enzymatic) or chemical breaking down (hydrolysis) of protein complexes into peptides and free amino acids which modulate nitrogen uptake and assimilation in plants

Seaweeds are marine plants known as macro-algae which by virtue of their habitat (seas and oceans) possess beneficial compounds/substances

Plant extract (botanicals). Certain plants possess some active compounds (metabolites) known as allelochemical which when extracted and concentrated are good sources of plant biostimulants.

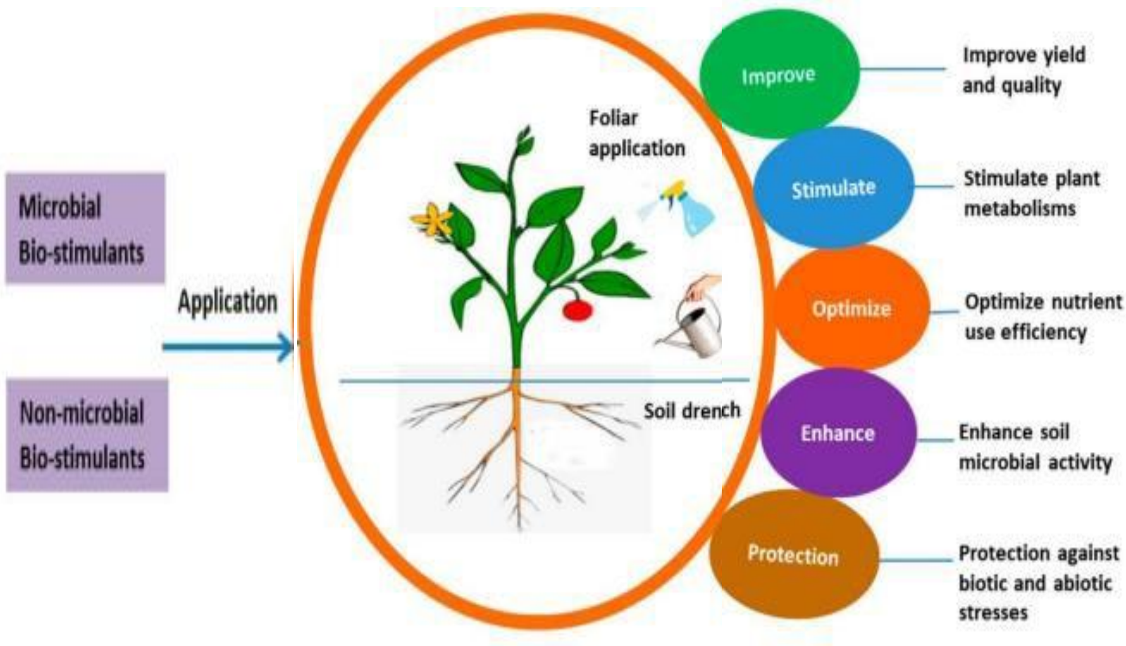
How do Biostimulants work?

Stimulate Agronomic and physiological process: germination, seedlings and plant growth as well as crop productivity are processes in plant that have been reported to have been enhanced by biostimulants application

Stimulate biotic stresses tolerance: Unfavourable environmental and soil conditions in particular drought, salinity, and extreme temperature are responsible for 70% of yield gap dictated by global climatic changes

Improve nutrient use efficiency: Increasing nutrient use efficiency in particular N and P is fundamental for both economic and environmental reasons

Enhance produce quality: modification of metabolic processes in plant ensures crop overall qualities

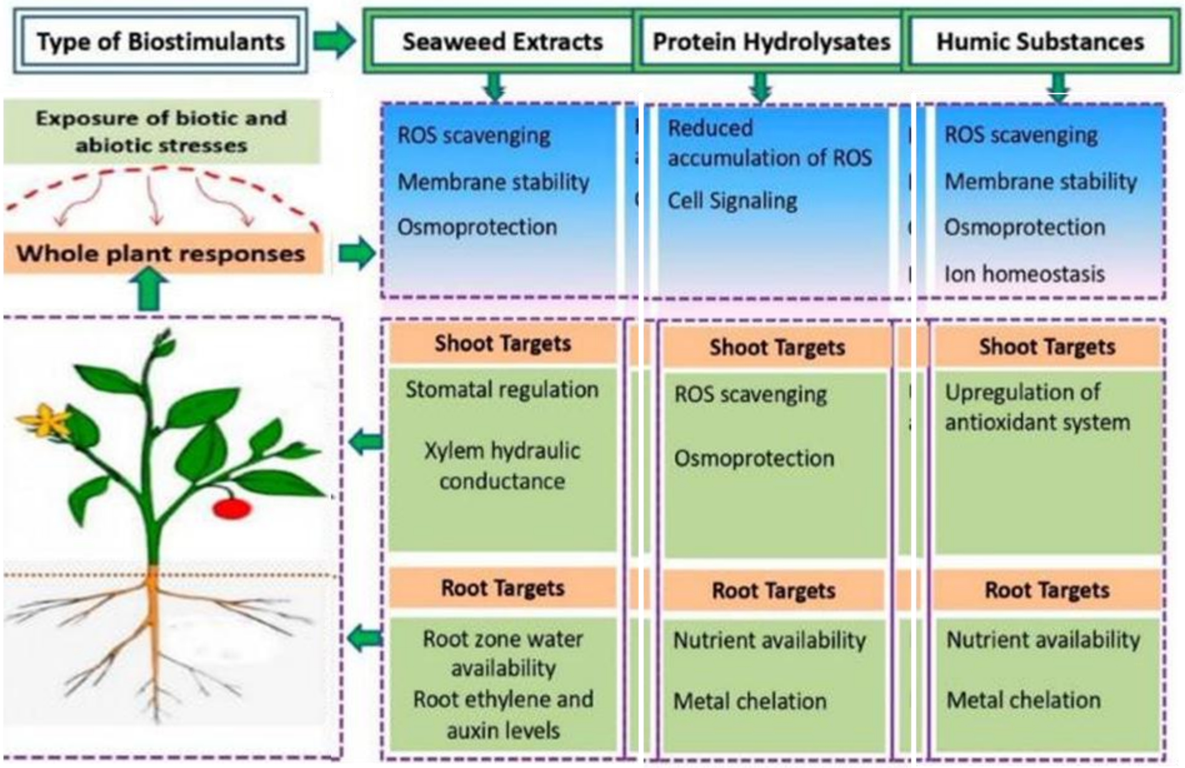


Rajput et al., 2019

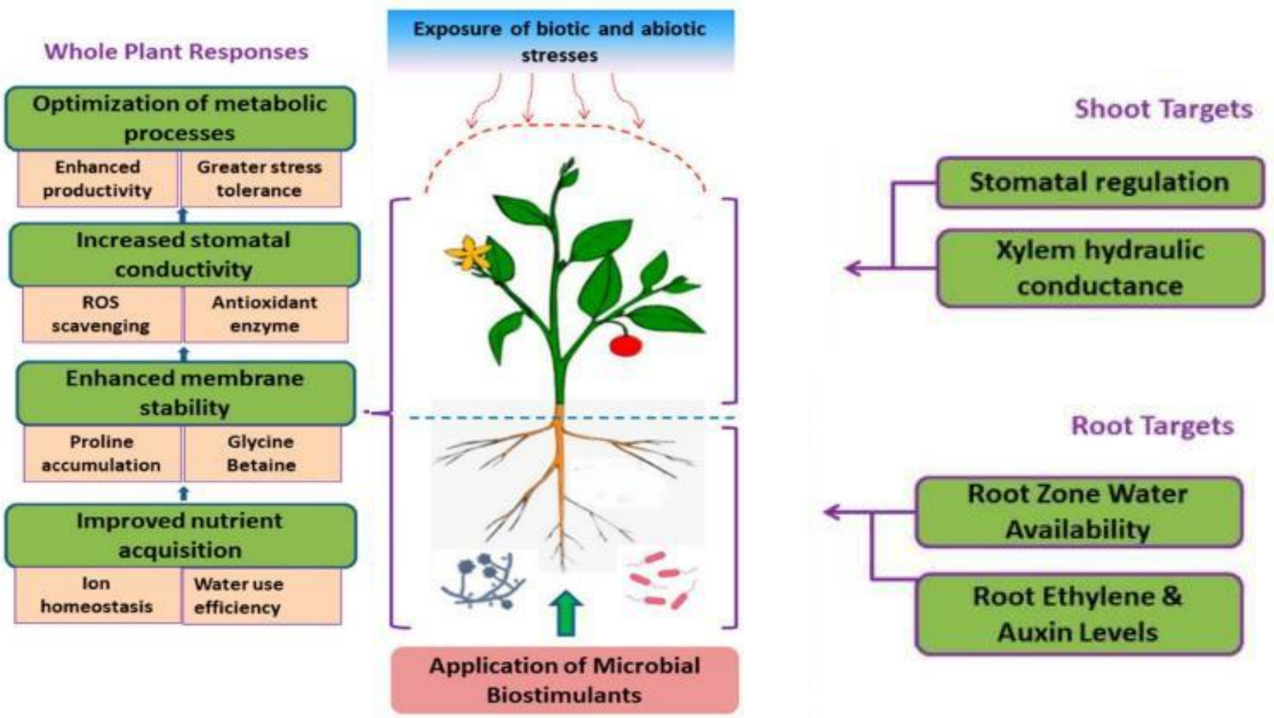
Bio-stimulatory mechanisms targeted by non-microbial biostimulants upon interaction with plants and their growing environment

(Pozo et al., 2015: Dubey et al., 2020)

Bio-stimulatory mechanisms targeted by microbial biostimulants upon interaction with plants and their growing environment

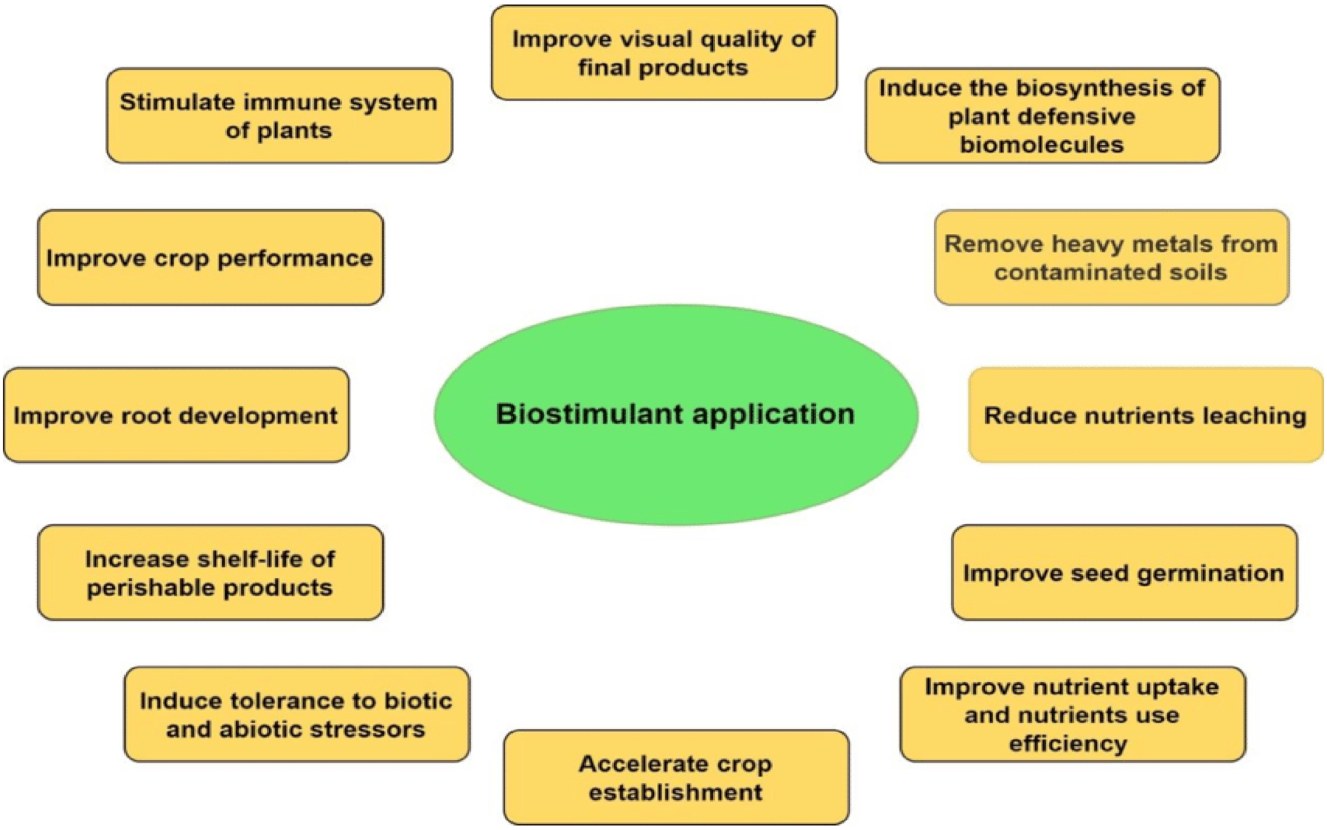


Overall Benefits of Biostimulants



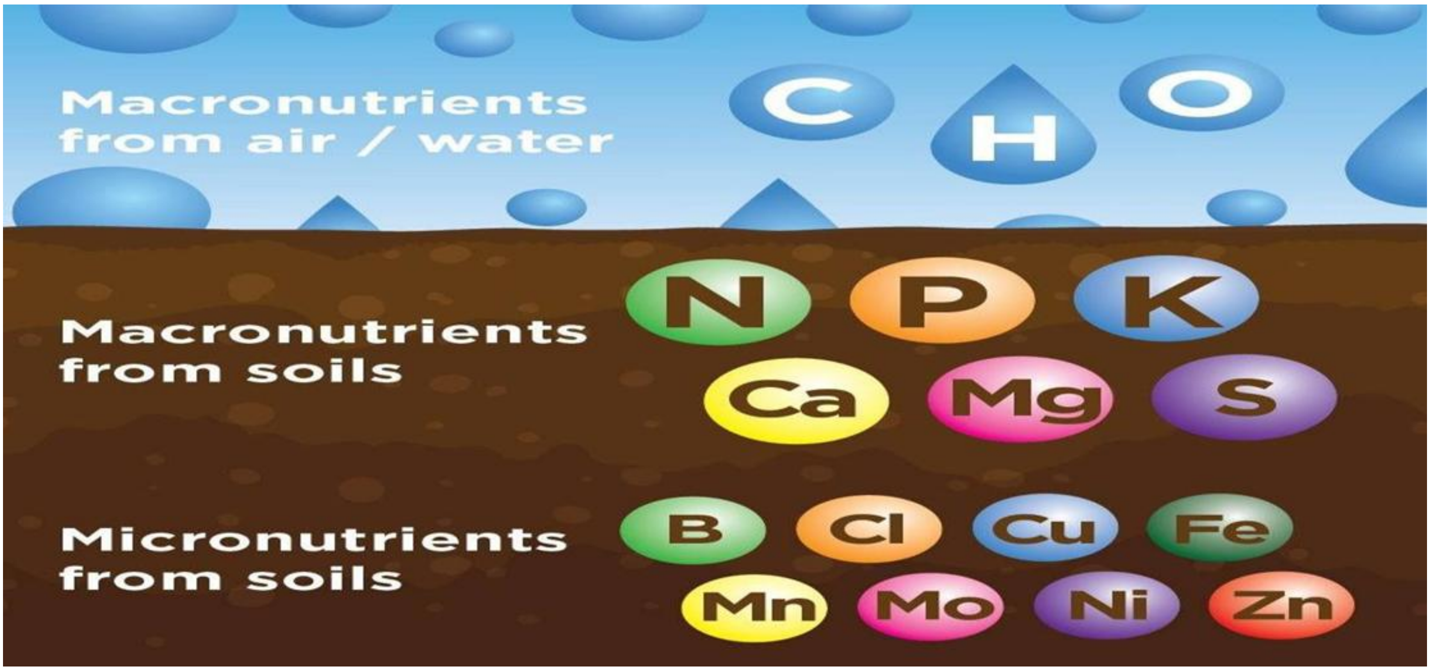
Md. Nasir and Jean, 2021

Overall Benefits of Biostimulants



Foliar Application

Plants require 16 nutrients for their growth and development. Three of these, carbon, hydrogen and oxygen, are obtained from the atmosphere and from soil water



The other 13 elements are nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, boron, copper, manganese, molybdenum, zinc, or chlorine

If these 13 elements are deficient, they must be applied for the plants' use either through the soil or through the foliage of the plants. When applied to the foliage they are known as foliar sprays

Soil nutrients are the most limiting resources for plants despite their abundance in soil because most nutrients, though present in the soil, but are not available in forms useable by plants.

Soil fertility is measured by the forms in which they are available for plant use and certain conditions however in the soil such as pH, immobility, leaching, volatilization and depletion can influence the availability of nutrients in the soil

Elements that are mobile (N, P, Cl, Mn, S) in the soil are easily leached away from the root zone of the plant

Most micronutrients however are locked in compounds that are not accessible by plant roots

Volatilization occurs when elements vapourised from the soil e.g. nitrogen leaves the soil through ammonia volatilization

Mobility of Nutrients

Nutrient	Plant-Available Form(s)	Soil Mobility
Nitrogen	NO_3^- NH_4^+	Mobile Immobile
Phosphorus	HPO_4^{2-}, $H_2PO_4^-$	Immobile
Potassium	**K^+**	**Somewhat mobile**
Sulfur	SO_4^-	Mobile
Calcium	Ca^{2+}	Somewhat mobile
Magnesium	Mg^{2+}	Immobile
Boron	H_3BO_3, BO_3^-	Very Mobile
Chlorine	Cl^-	Mobile
Copper	Cu^{2+}	Immobile
Iron	Fe^{2+}, Fe^{3+}	Immobile
Manganese	Mn^{2+}	Mobile
Molybdenum	MoO_4^-	Somewhat Mobile
Zinc	Zn^{2+}	Immobile

The plant roots are designed to take up nutrients in the soil in ionic forms (i.e. solution).

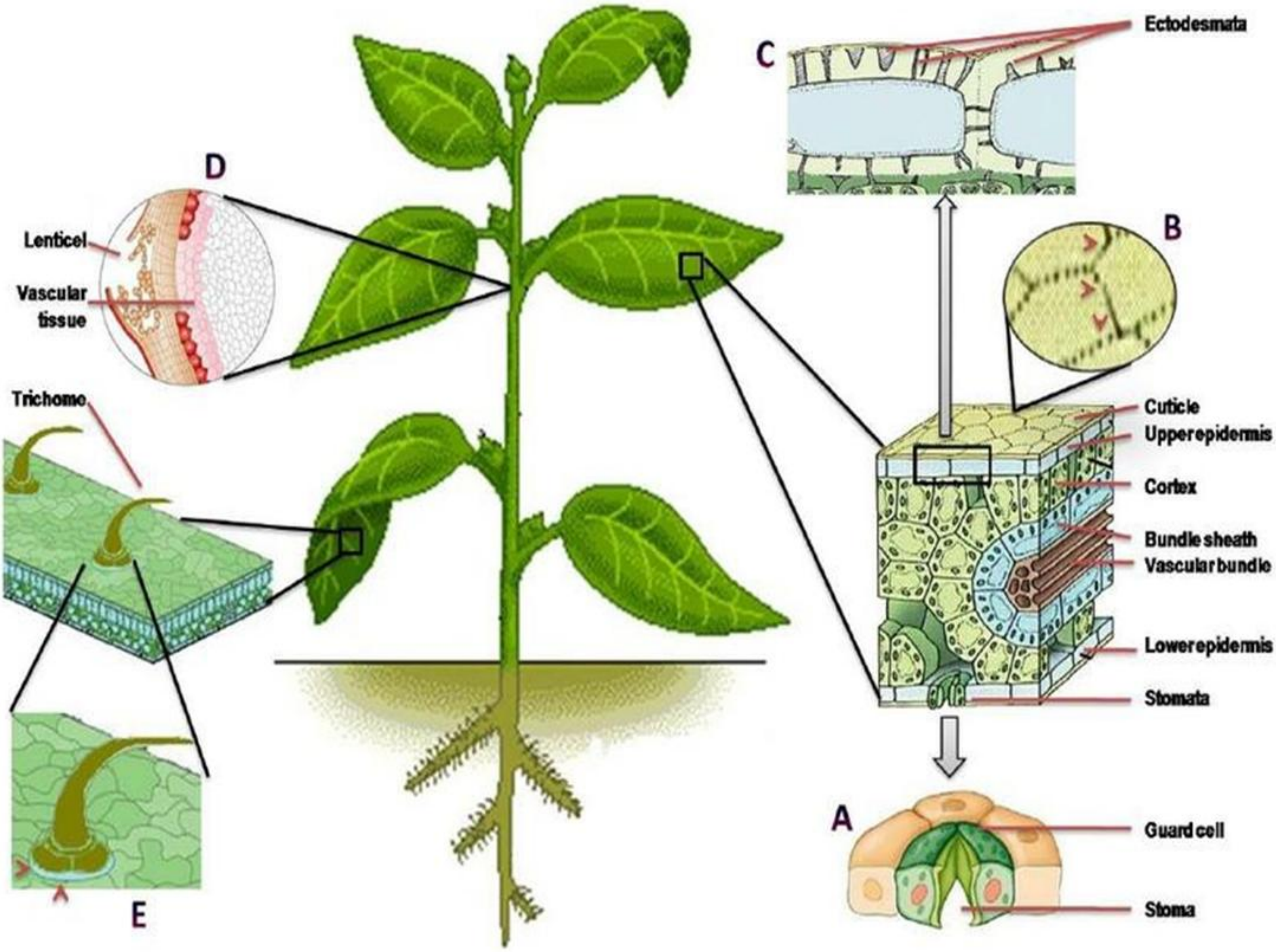
Processes like mineralization and decomposition help nutrients to be available in such forms for easy plant uptake soil macro and micro-organisms.

Soil microbes and soil worms through their activities, breakdown (mineralization) some of the nutrients complex compound to forms that are easily available for plants uptake

However, mineralized nutrients are not sufficient for plants due to the long process of mineralization and/or inadequacy, hence the need for soil amendments through soil fertilizer amendment.

Soil fertilizer application has its own challenges, such as losses through volatilization, leaching, runoff, immobilization, denitrification and environmental pollution.

Soil application of micronutrients and beneficial nutrients have not also been effective hence, the propriety of foliar fertilizer application effective through various points of entry of phosphorus and iron applied as foliar spray.



A: stomata, B: cuticular cracks, C: ectodesmata, D: lenticels, E: aqueous pore

Because soil fertilization is not efficient, foliar feeding is a technique of feeding plants by applying liquid fertilizer directly to the leaves. Plants are able to absorb essential elements through their leaves either by penetrating the cuticle or by entering through the stomata enabling it to absorb them in physiological processes and metabolism.

What are the advantages of foliar Nutrition?

Foliar Nutrition is the most efficient way to feed your crop. Foliar fertilization is not dependent on the soil and therefore offers a viable alternative

Foliar nutrition stimulates root development. A lot of respected literature has indicated that foliar nutrition improves root growth compared to traditional soil fertilizer and no fertilization.

It can compensate for the low activity of the roots, and the defective functioning of the roots as a result many soil factors can be compensated by foliar application

Foliar fertilization eliminates many common deficiencies. The CEC or cation exchange capacity of the leaves is just as strong as that of the root. In fact, both organs, leaf and root, have a similar absorption potential

Foliar nutrition will immediately solve a deficiency. Rapid intervention is a distinct advantage of foliar nutrition: the effect is much faster than that obtained by soil applications

Foliar fertilization increases the resistance of your plant. foliar applications with specific elements such as calcium, copper, silicon. These nutritional elements strengthen the plant.

Foliar nutrition improves the quality of your yield. Foliar fertilization ensures a more balanced nutritional elements that plant needs are available at the right time, independent of their variable and uncertain availability in the soil.

Foliar application is more time and cost efficient.

Essential Elements required for Plant Growth

These are the essential elements with their symbols.

Nitrogen (N)

Phosphorus (P)

Potassium (K)

Calcium (Ca)

Magnesium (Mg)

Sulphur (S)

Manganese (Mn)

Copper (Cu)

Boron (B)

Iron (Fe)

Chlorine (Cl)

Zinc (Zn)

Molybdenum (Mo)

Nickel (Ni)

Note: These active elements exist in their elemental forms given as the symbols against corresponding names. However, most of these actives do not exist in their elemental forms but in compounds. But for plant usage the forms they are available are shown below. They may however be written in this plant available forms or in elemental in the label composition.

For the values, they are the amount of a particular nutrient in grams in the entire composition

Nitrogen (NO_3, NH_4^+)

Phosphorus (P_2O_5)

Potassium (K_2O)

Calcium (CaO)

Magnesium (MgO)

Sulphur (SO_3)

Manganese (MnO)

Copper (CuO)

Boron (B)

Iron (Fe_2O_3)

Chlorine (Cl)

SC, SF, SL, SG, WP, G, MC, WSF are chemical terms use to describe various mixes of a particular composition/formulation for its safe and effective use.

Suspension concentrates (SC):

Soluble concentrate (SL):

Wettable Powder (WP)

Water-Dispersible Granule (WG)

Specific gravity (SG)

Water Soluble (WS)

Water-Soluble Granules (WSG)

Water-Soluble Liquid (WSL)

Wettable Powder (W)

A complexing agent is a chemical compound that can form complexes (through bonding) with metal ions, which alters their chemical behaviour.

A form of complexing agent are chelating agents. However, chelates have the ability to bind metal ions much more strongly and with a higher stable pH range. In agriculture, chelating agents are utilised in fertilizer formulations to protect nutrients from being tied up in the soil or by other nutrients.

Chelates work by putting a protective "claw" around the nutrient, allowing it to be brought into the plant without risk of tie-up. The common examples of chelating agent in fertilizer formulation are citric, humic and fulvic acids, ammoniated and EDTA.

EDTA stands for ethylenediaminetetraacetic acid is a synthetic compound that can chelate metal ions. They are particularly useful for chelating micronutrients, such as iron, zinc, copper, and manganese which help improve crop growth and overall crop quality and yields.

EDTA-chelated solutions can be soil or foliar applied and are designed for use in liquid fertilizers and suspensions. They are compatible with most fungicides, insecticides, and herbicides. Safe for in-furrow and foliar applications. Designed for use in all liquid fertilizers and suspensions and most commonly used with high orthophosphate products in various placements

Complexes and chelation

A chelating agent is a chemical compound that can form stable complexes, called chelates, with metal ions by coordinating with them through multiple sites. Chelating agents are often used in industrial processes, such as metal cleaning, water treatment and medical applications.

They are also used in fertiliser formulations to protect metals in alkaline solutions to prevent the metal ions precipitating out, or preventing unwanted reactions with other ingredients.

Chelating agents control metal ions by inhibiting the metal ion reactive sites and preventing them from entering their regular (often unwanted) reactions. Chelating substances that establish the most stable bonds with metal ions will be the most effective at preventing metal ion activity.

Chelating agents are chemical compounds with at least two functional groups that can engage with a metal ion to produce a ring structure known as a chelate ring. Metal chelates are chemical compounds formed by the interaction of a chelating agent with a metal ion.

These compounds change the chemical composition of the metal, increasing its overall stability and capacity to attach to other substances.

Typical chelates are Chlorophyll, a Magnesium complex which is found in all green plants and is responsible for photosynthesis. And Haemoglobin, which is an Iron complex and is responsible for the red colour of blood and is responsible for Oxygen transport to cells within the body .

Many chelates are available such as EDTA (Ethylene Diamine Tetra acetic Acid, EDDHA (Ethylene Diamine Hydroxy Phenyl Acetic acid) Citric acid, etc.

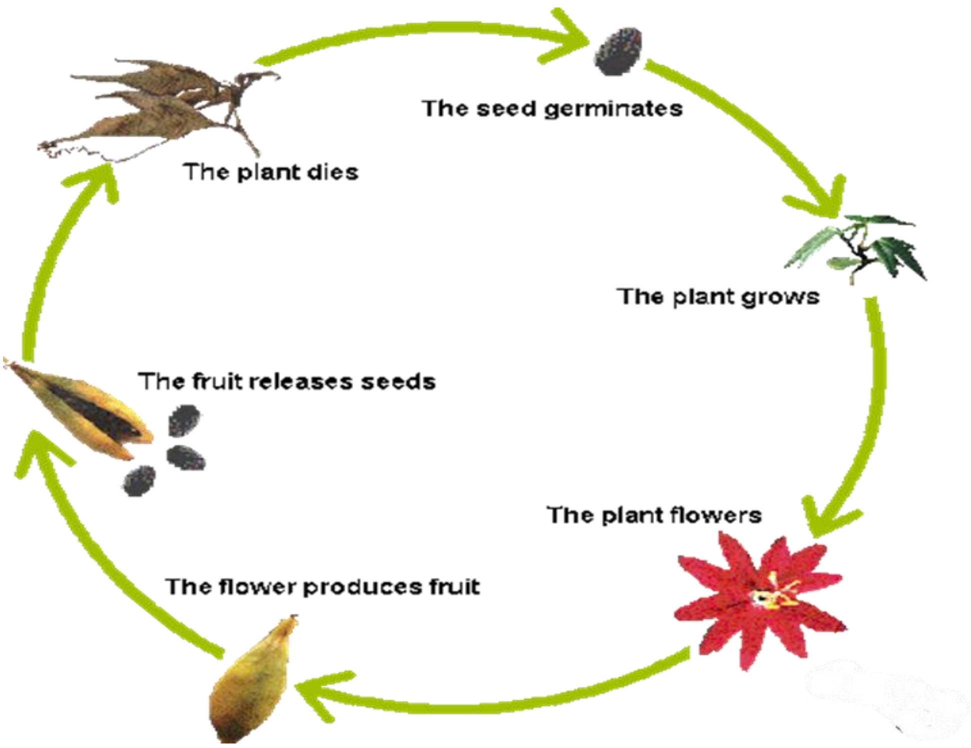
CROP GROWTH STAGES: FEATURES AND NUTRITION REQUIREMENTS

What are Growth Stages in Plant?

Plant growth stages refer to the sequential phases of development that a plant undergoes from germination to maturity, reproduction and senescence.

Crops express agronomic traits such as increase in size, dry matter accumulation and crop yield to indicate their growth

Crops can attain their specific stages of growth as a result of agricultural practices and effective management of the environmental resources.



Therefore, understanding the principal growth stages (GS) for agricultural and horticultural crops can assist with management decisions.

However, different crops express different features and nutritional needs at their different growth stages.

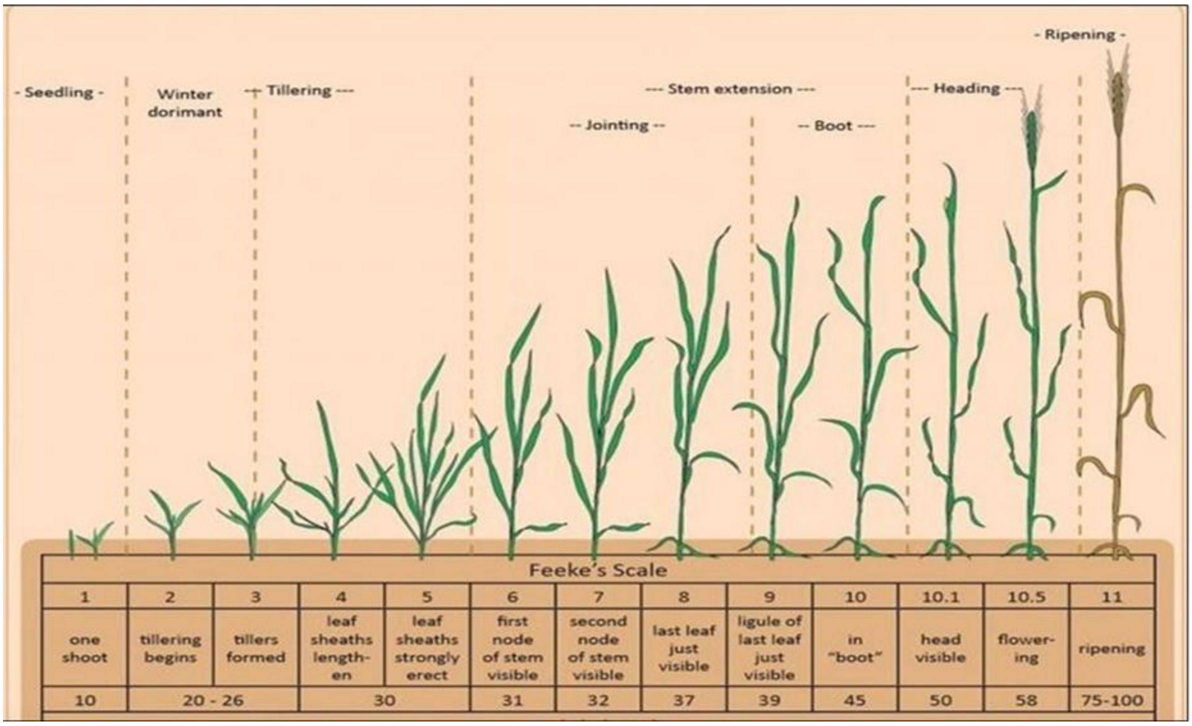
Growth stages in cereal can be broadly categorized into seedling, tillering, stem extension, heading and ripening.

Cereals (Wheat, Barley and Oats): Growth Stages and developmental Features

Development at each stage of growth is principally governed by temperature and day length.

The variety, sowing date, nutrition, crop protection and growth regulators play critical roles in development and growth

Varieties that are developed for early growth and tolerance will establish faster compared to their counterparts.



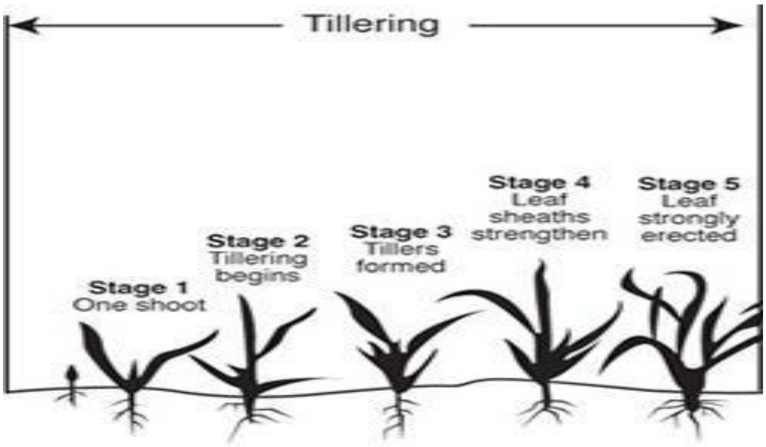
Sowing early or late can influence crop growth. Early sowing in some varieties ensures early establishment

Diseases and pest control protects crops and enhances crops' ability to express their respective growth stages potential.

Supplying crops with essential and beneficial nutrients will affect the performance of crop growth and development.

Stimulating innate ability of plant through the use biostimulant and growth hormone can enhance crop growth.

Cereals (Wheat, Barley and Oats): Growth Stages and nutrition requirements.



Establishment

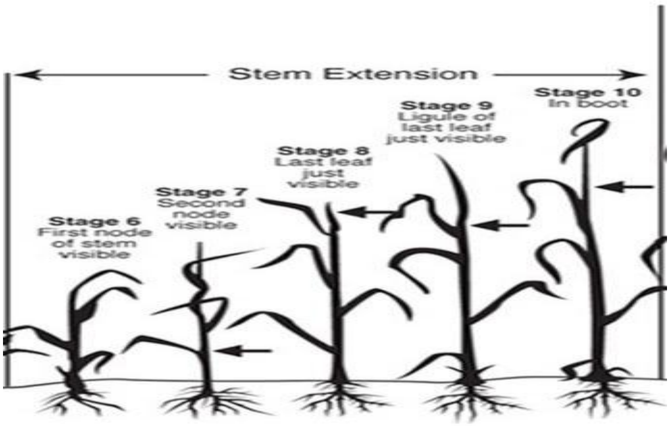
N- early rapid growth

P- early growth and root mass development

Tillering

N- increasing tiller number per plant.

Mn- photosynthetic proteins and enzymes.



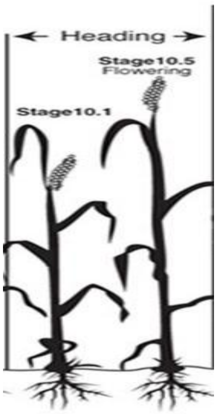
Stem Extension

N- large leaves and rapid growth

P- energy for growth and development. K- plant water regulation and structural integrity.

S- yield and quality improvements.

Mn- photosynthetic proteins and enzymes. Zn- enzyme reactions, nitrogen metabolism, and protein synthesis



Flag Leaf and Grain Filling

N- higher yields through green leaf duration, grain site survival, grain size and protein levels.

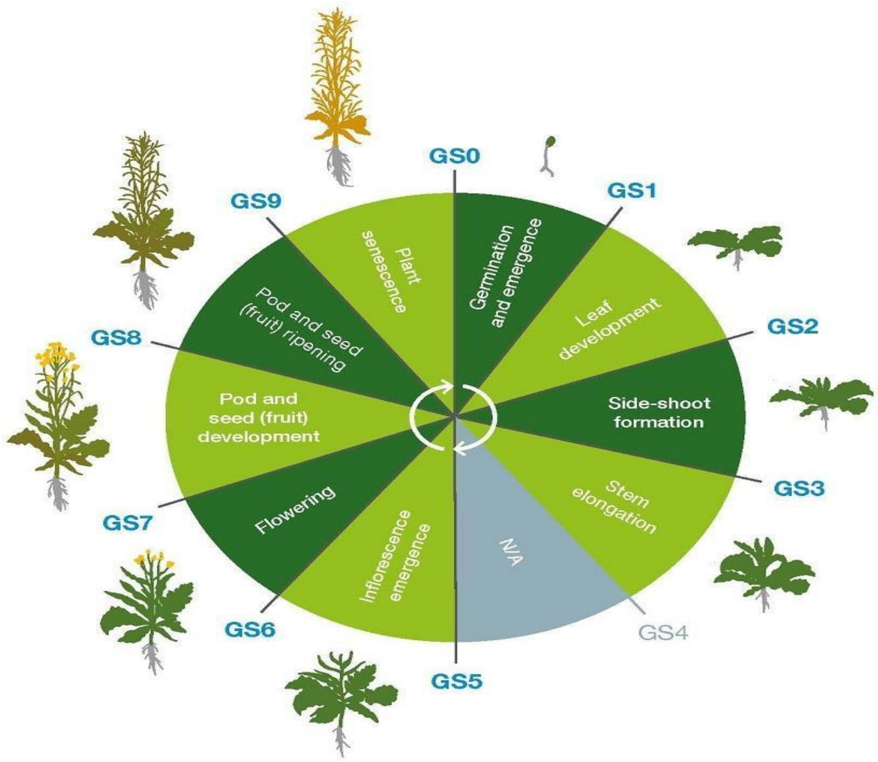
Mg- green leaf duration.

P- dry matter remobilisation for yield

improvements.

B- pollen viability

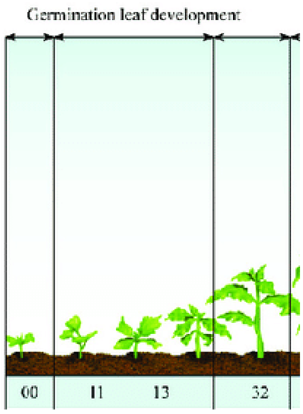
Oilseed Rape: Growth Stages and Developmental Features



Oilseed rape is an annual crop, meaning that it is planted and harvested within a single growing season

Growth stages in oilseed rape can be broadly categorized into germination, leaf development, stem elongation, flowering and ripening.

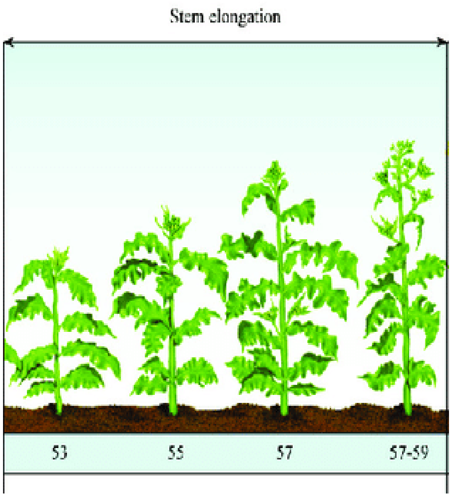
Oilseed Rape: Growth Stages and Nutrition Requirements



Emergence and Establishment

N- early rapid growth

P- early growth and root mass development



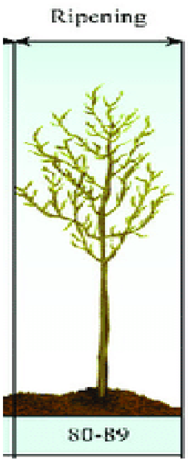
N- increasing tiller number per plant.

P- root mass development

K- lower cell sap freezing, good water regulation, Mn- photosynthetic proteins and enzymes

Sulphur and boron during flower development

Magnesium

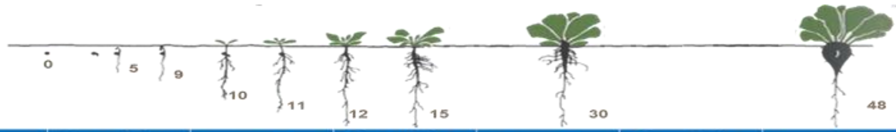


Nitrogen and magnesium are important to achieve this.

Sugar Beet: Growth Stages and Developmental Features

Sugar beet is a biennial crop. The first year is the vegetative phase (establishment and the main production). Year 2 is the reproductive phase (vernalization)

Growth stages in sugar beet can be broadly categorized into germination and establishment, canopy development, storage root growth and pre-harvest stage



Growth Stage	Description of stage	Growth Stage	Description of stage	Growth Stage	Description of stage	Growth Stage	Description of stage
Germination		Leaf Development (Youth stage)		Principal Growth Stage 3		Development of harvestable vegetative plant parts	
00	Dry Seed	10	First leaf visible (pinhead-size): cotyledons horizontally unfolded	31	Beginning of crop cover: leaves cover 10% of ground	49	Beet root has reached harvestable size
01	Beginning of imbibition: seeds begins to take up water	11	First pair of leaves visible, not yet unfolded (pea-size)	33	Leaves cover 30% of ground		
03	Seed imbition complete (pellet cracked)	12	2 leaves (first pair of leaves) unfolded	39	Beet root has reached harvestable size		
05	Radicle emerged from seed (pellet)	14	4 leaves (2nd pair of leaves) unfolded				
07	Shoot emerged from seed (pellet)	15	5 leaves unfolded				
09	Emergence: shoot emerges through soil surface	19	9 and more leaves unfolded				

Sugar Beet: Growth Stages and Nutrition Requirements

Germination

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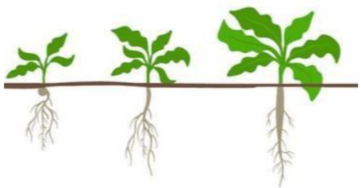
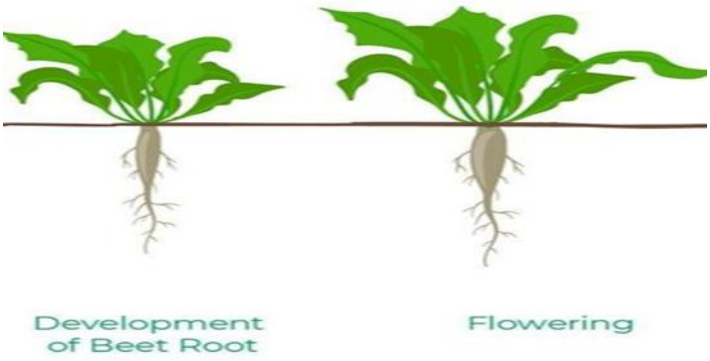


Leaf Development

Rosette Growth

Establishment

- Nitrogen for early rapid leaf expansion and growth.
- Phosphate to supply the energy for early growth and development, especially root mass.
- Manganese for its role in the structure of photosynthetic proteins and enzymes.
- Zinc for enzyme reactions, early growth and vigour



Canopy development

- Nitrogen for leaf development and size.
- Potassium for its role in canopy structure and nutrient movement around the plant.
- Manganese for its role in the structure of photosynthetic proteins and enzymes.
- Magnesium for its role in chlorophyll.

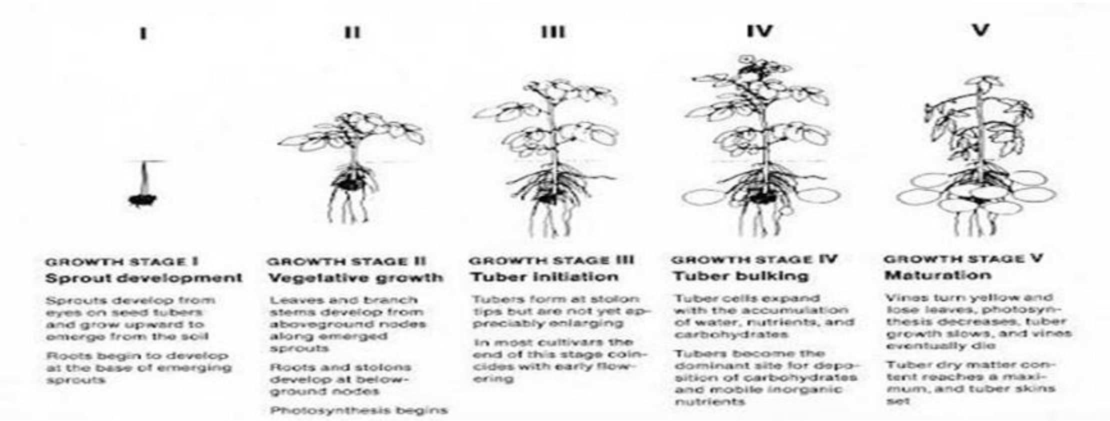
Canopy duration

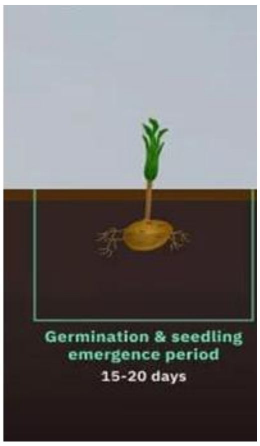
- Nitrogen for large leaves and their duration.
- Phosphate to supply the energy for growth and development.
- Potassium for plant water regulation and structural integrity.
- Sulphur for yield and quality improvements.
- Manganese for its role in the structure of photosynthetic proteins and enzymes.
- Magnesium for its role in chlorophyll quality.
- Boron for its role in root development.

Potato: Growth Stages and Developmental Features

Potato is a typical root crop with a special growth cycle pattern and underground tubers.

It has a relatively short life span of between 70 and 150 days from planting to maturity. Its developmental stages are often described in terms of tuber sprouting, vegetative development, tuber initiation, tuber bulking, and finally plant senescence.





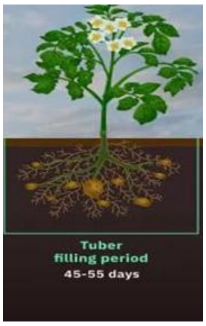
Post planting

N- split applications to reduce losses

P - enzymatic activity and growth

Hilling

- N- second split application
- C (+/- B) - cell division, good skin quality, internal rust spot reduction, stress tolerance – drought/heat.
- P- energy transfer and tuber set

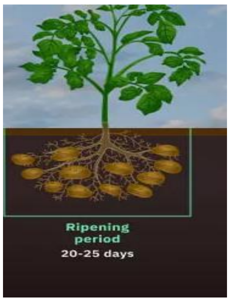


Tuber initiation

P- tuber set and energy transfer

Zn and Mn – helps cell division and photosynthesis

Ca (+/- B) – cell division, good skin quality, internal rust spot reduction, stress tolerance – drought/heat



Bulking

- N, P and Mg - maintain tuber growth
- Ca – improves skin finish and reduces disease, drought and heat stress impact

Source Material.

https://livefarmer.co.uk/understanding-the-key-differences-and-similarities-between-biostimulants-and-fertilisers/#:~:text=Fertilisers%20directly%20supply%20plants%20with,grow%2C%20without%20providing%20nutrients%20directly.

Other sources of further information.

https://ahdb.org.uk/biostimulants

https://www.cpm-magazine.co.uk/technical/biostimulants-breaking-down-biostimulants/

https://www.farmersguide.co.uk/arable/potatoes/can-a-biostimulant-improve-your-potato-crop/

https://www.britannica.com/topic/fertilizer