

Efficient use of Fertilizer in Tea

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Soils of the mid-country region

Mid country Wet zone

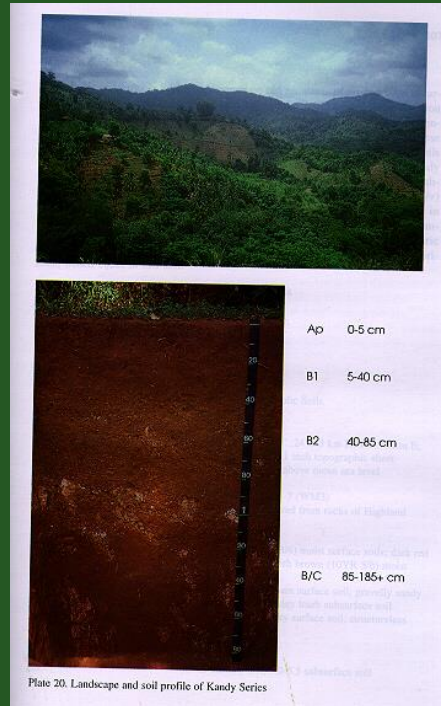
Kandy

Matale

Galigamuwa

Akurana

Ukuwela

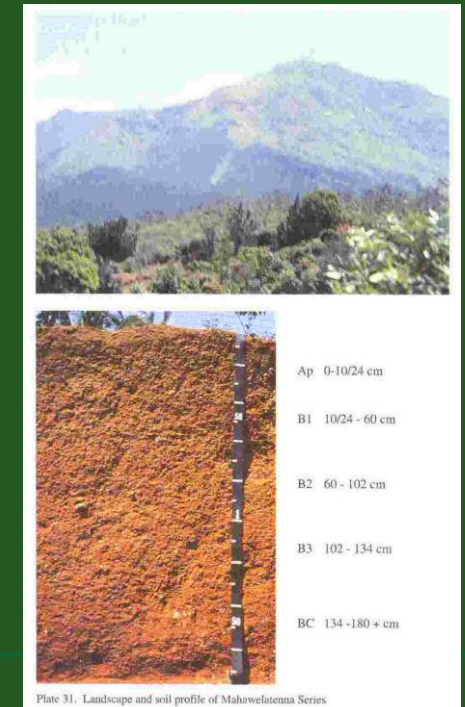


Mid country Intermediate zone

Ragala

Rikillagaskada

Hunnasgiriya



Fertility status of mid country soils ????

Plant Nutrients

Macro Nutrients

Carbon (C)	Used in exceptionally large quantities
Hydrogen (H)	
Oxygen (O)	
Nitrogen (N) Urea, SA	Used in large quantities
Phosphorous (P) DAP, ERP	
Potassium (K) SOP, MOP	

Secondary Nutrients

Calcium (Ca) Dolomite	Used in moderate quantities
Magnesium (Mg) Dolomite, Kieserite	
Sulphur (S) Kieserite, SA	

Yield kg/ha	N removal	N Applied	P ₂ O ₅ removal	P ₂ O ₅ applied	K ₂ O removal	K ₂ O applied
2000	128	270	32	35	67	100 -140

Plant Nutrients

Micro Nutrients	
Zinc (Zn) Zinc sulphate	Used in small quantities
Boron (B) Borax, Boric acid	
Manganese (Mn) Manganese sulphate	
Copper (Cu) Soil supplement	
Iron (Fe) Soil supplement	

What are Fertilizers?

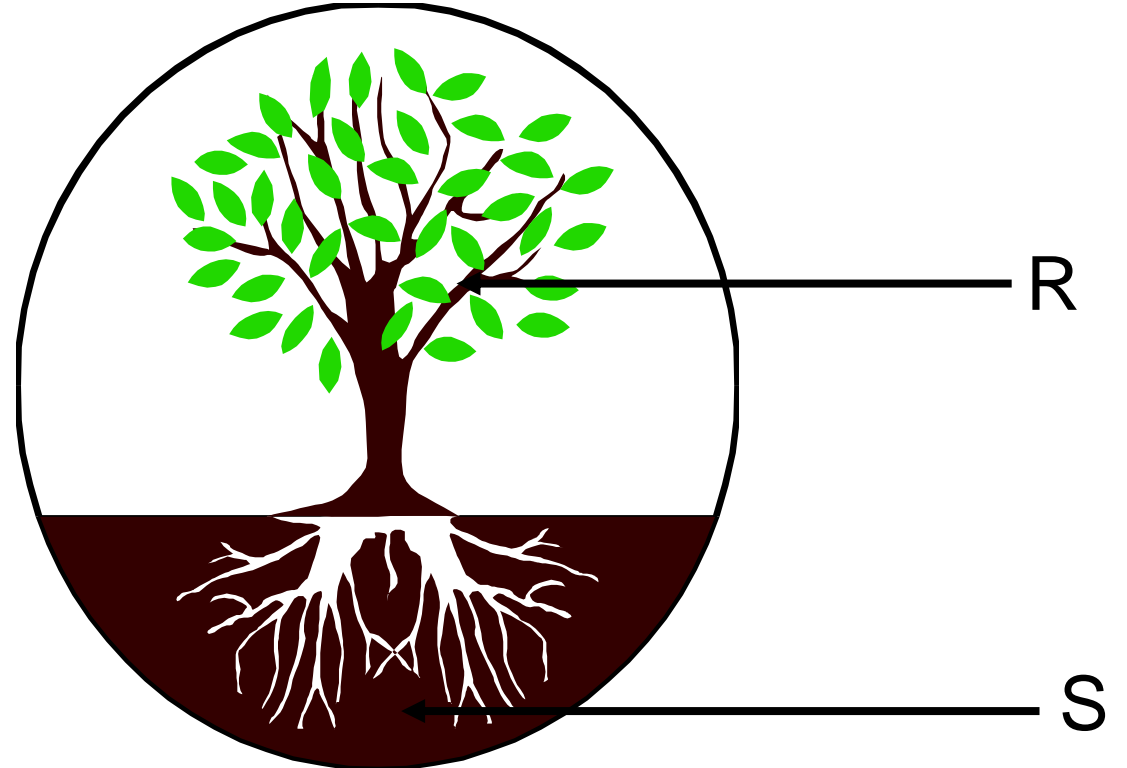
- ❖ Fertilizers are additional substances supplied to the crops to increase their productivity.
- ❖ These fertilizers contain essential nutrients required by the plants, including nitrogen, potassium, and phosphorus.
- ❖ They also enhance the water retention capacity of the soil and increase its fertility.



Why we need to fertilize our tea soil

The amount of plant nutrients to be given as fertilizer (F) = The amount required to make up the difference between the nutrient required by the crop (R) and that supplied natively by the soil medium (S)

$$F = R - S$$



Overall process is complex.

The quantity of the nutrient that can be supplied by the soil natively should be estimated

Volatilization L_V

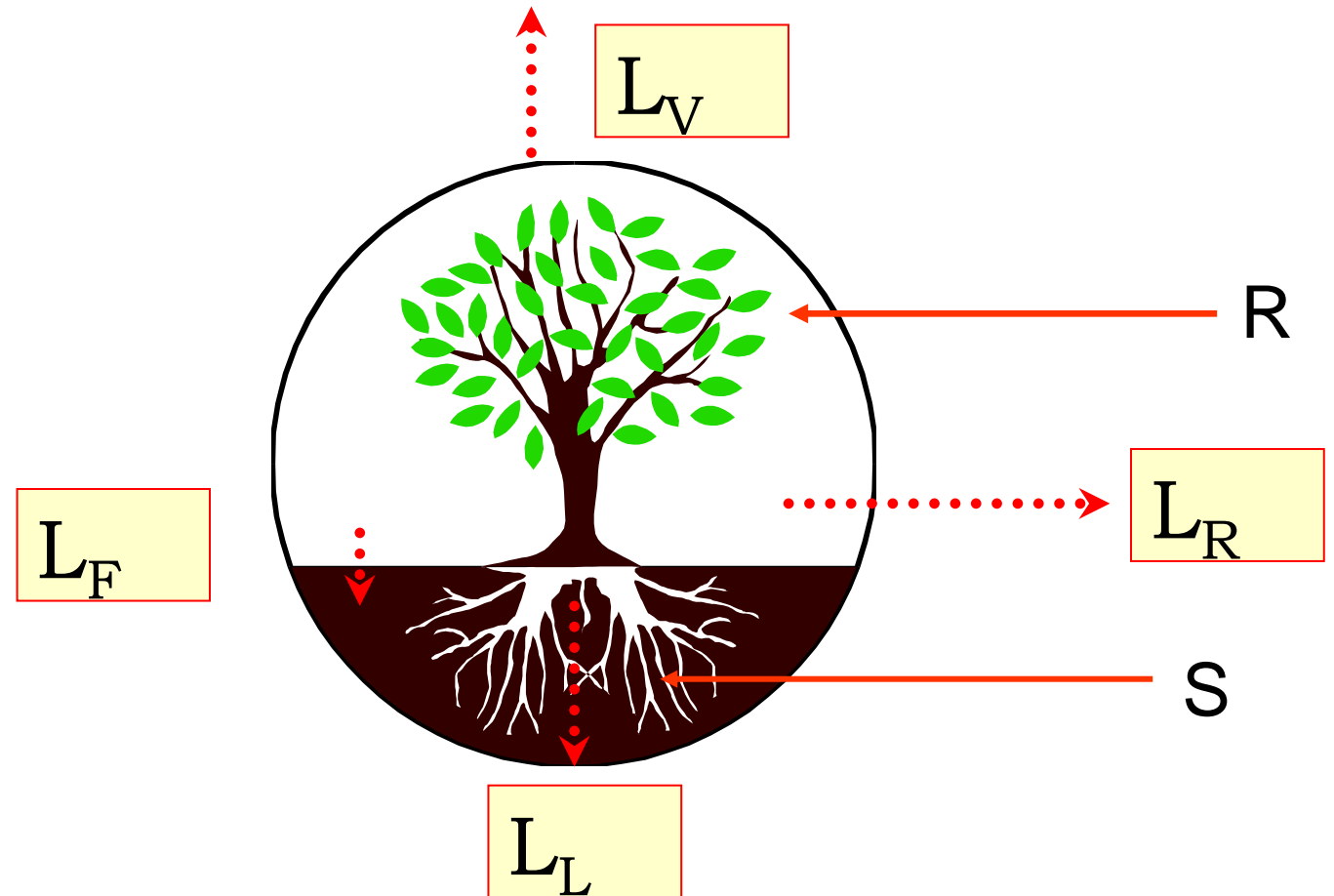
Run off L_R

Leaching L_L

Fixation L_F

Total losses = $\sum(L)$

$F = R + \sum(L) - S$



To increase the efficiency of fertilizer use, we need to attend to minimize these losses

Importance of Fertilizers

Enhance plant growth development and yield

- ❖ Nitrogen in the fertilizers promotes plant growth, which is seen in the green color of the plants **THE MOST DEMANDING NUTRIENT FOR TEA**
- ❖ The potassium content present in the fertilizers strengthens the bush frame of the plants.
- ❖ The phosphorus present in the fertilizers helps in faster development of roots of plants.
- ❖ Fertilizers make plants more resistant to pests and disease attacks. Hence, necessity of agrochemicals are low, which results in healthier crops. Hence, fewer illnesses are present, giving the crops an aesthetic value.
- ❖ Fertilizers improve the water uptake and dynamics of the plants and soil due to strengthening and lengthening root depth.



Types of Fertilizers

❖ Nature of origin

Organic fertilizer

Inorganic fertilizer

❖ Nature of application

Ground Applied fertilizer

Foliar Applied fertilizer



Types of Fertilizers based on nature of origin

Organic Fertilizer

- ❖ Natural fertilizers derived from plants and animals.
- ❖ They boost the amount of organic matter in the soil, encourage microbial reproduction, and alter the physical and chemical composition of the soil.
- ❖ Supplies mixture of nutrients to the soil



Types of Fertilizers Cont.:

- **Inorganic Fertilizers**

- ❖ Chemical fertilizers generated by chemical techniques that contain nutrients for crop growth .
- ❖ The inorganic fertilizers contains known content/s of one or more nutrients
- ❖ **Straight/ Combined/ Mixtures**



Types of fertilizers based on nature of application

Ground Applied fertilizer

Broadcasting for dense mature tea fields



Band / ring application at the young stage of the tea plant



Foliar Applied fertilizer



Liquid fertilizer

Water soluble solid fertilizer

What do you think about efficiencies of each method ?

Ground Applied fertilizer
(30-50%)

Foliar Applied fertilizer
(70-85%)



Methods of Fertilizer Application & their Efficiencies

• Application of Solid Fertilizer

Broadcasting

- ❖ Spreading fertilizers uniformly all over the field
- ❖ Most common practice in tea



Advantages

- When the crops have a dense stand.
- When the plant roots absorb nutrients from the whole volume of soil.
- When soil fertility rich. (but for our soil ????)
- When using a large amount of material.

Disadvantages

- Not advantageous, it encourages weed growth all over the field.
- Most of the material remains on the soil surface and does not reach the root zone for uptake by plants.
- There is a more significant loss of fertilizer nutrients due to washing, run-off, volatilization.
- The recovery (extent of fertilizer used by plants) ranges between 25 to 45 percent or even less.

Methods of Fertilizer Application & their Efficiencies Cont.:

- **Application of Solid Fertilizer**

- Placement / band, ring application**

- ❖ Placement of fertilizers in soil at a specific place with reference to the position of the seed/ plant.



- Advantages:**

- Plants can use a maximum portion of the material.
- Losses through uptake by weeds, washing, run-off, volatilization could be eliminated to the greatest extent.

- Disadvantage:**

- Is not suitable for bulky manures.
- Labour intensive

Methods of Fertilizer Application & Efficiency Cont.:

• Application of Liquid Fertilizer

Foliar application

- ❖ The spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.
- ❖ Effective for the application of minor nutrients like **iron, copper, boron, zinc** and **manganese**.

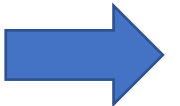


Advantages

- This method is preferred over other methods as it needs a minimal quantity of materials.
- The crop plants respond within 24 hours of application.
- Soil reaction, topography, and soil textures have no adverse effect on the soil's nutrient availability and fertility status.

Disadvantage

- Non-uniform spraying and improper concentration of the solution may lead to hazardous effects on the crop, and the entire plant population may get devastated.
- A high concentration of the solution may cause the burning of foliage.
- Can not fulfill plants' total nutrient requirement



Why.....??? Fertilizer Use Efficiency

- ❖ When a fertilizer is applied, all of its nutrients are not absorbed by the crop. Only a few fractions of the nutrients is utilized by the crop.
- ❖ Among inputs to the crop, fertilizer is a costly input thus, need to use efficiently.
- ❖ Fertilizer use efficiency is the output of any crop per unit of the nutrient applied under a specified set of soil and climatic conditions.



Fertilizer use Efficiency

- **Recovery efficiency (RE)** = Increase in uptake per unit nutrient added
- usually expressed as %
- **Agonomic efficiency (AE)** = Crop yield increase per unit nutrient added
such as kg Made Tea /kg nutrient
 - Under specific set of soil and climatic conditions



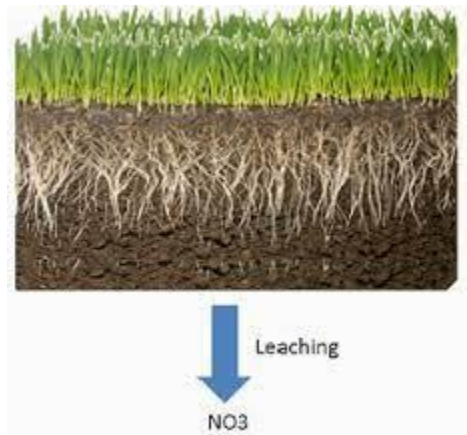
Fertilizer Use Efficiency Cont.:

- ❖ Fertilizers are considered as efficient when maximum yield is obtained with minimum possible amount of fertilizer application
- ❖ It is difficult to quantify the efficiency of a particular fertilizer since it depends on:
 1. Losses due to leaching
 2. Losses in gaseous form
 3. Immobilization by chemical precipitation, adsorption on exchange complex & microbial cells
 4. Chemical reactions between various components in fertilizers during mixing, before application to soil
 5. Physical properties of soil
 6. Chemical properties of soil
 7. Plant characteristics
 8. Fertilizer characteristics



1. Losses due to leaching

- ❖ Nitrate fertilizers are easily lost in leaching



- ❖ The extent of leaching is more in sandy soil than clayed soils.
- ❖ The loss is more in bare soil than cropped soil.

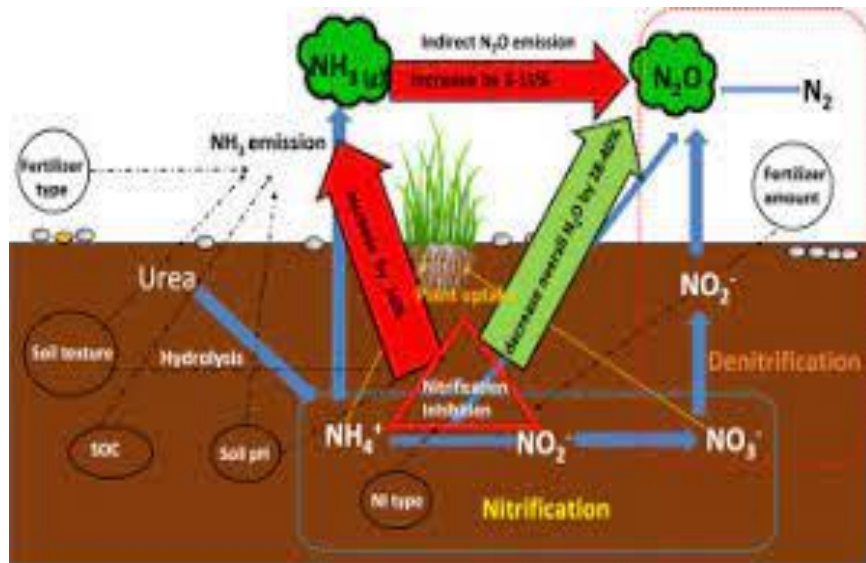
- ❖ The losses can be reduced to & extent by suitable method & timing of application
- ❖ Reduction of nitrification reduces NO_3 leaching
- ❖ In extreme acid soils or sandy acidic soils, ammonium fertilizers are lost because ammonium ions cannot easily replace the aluminum ions in exchange sites.

Nutrient Leaching losses from bare tea soils					
Treatment	K %	Mg%	$\text{NH}_4^+-\text{N}\%$	$\text{NO}_3^--\text{N}\%$	Total N%
U 834	20.8	5.2	8.2	10.0	18.2
T 1130	40.1		17.4	3.3	20.7
U 709	15.9		7.4	11.9	19.3
UT752	22.3		8.7	14.1	22.8
VPLC 880	6.6		7.3	14.2	21.5

(Liyanage *et al*, 2014)

2. Gaseous losses due to Volatilization

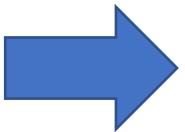
- ❖ The nitrogen compound present in the fertilizer are lost as gases under certain soil conditions.



- ❖ Types of gaseous losses
- ❖ Loss as ammonia NH_3 under high pH conditions
i.e. under alkaline conditions.
- 2. Loss as N_2 , N_2O , NO due to denitrification
- ❖ The above losses are determined by soil pH, fresh organic matter, moisture, temperature and type of microorganism present in soil.
- ❖ T 65, T 200 and T 750 mixtures having SA reduces NH_3 volatilization due to acidity formation

Treatment	Vol. losses NH_3 %
U 834	26.82
T 1130	1.34
U 709	26.94
UT752	26.07
VPLC 880	28.74

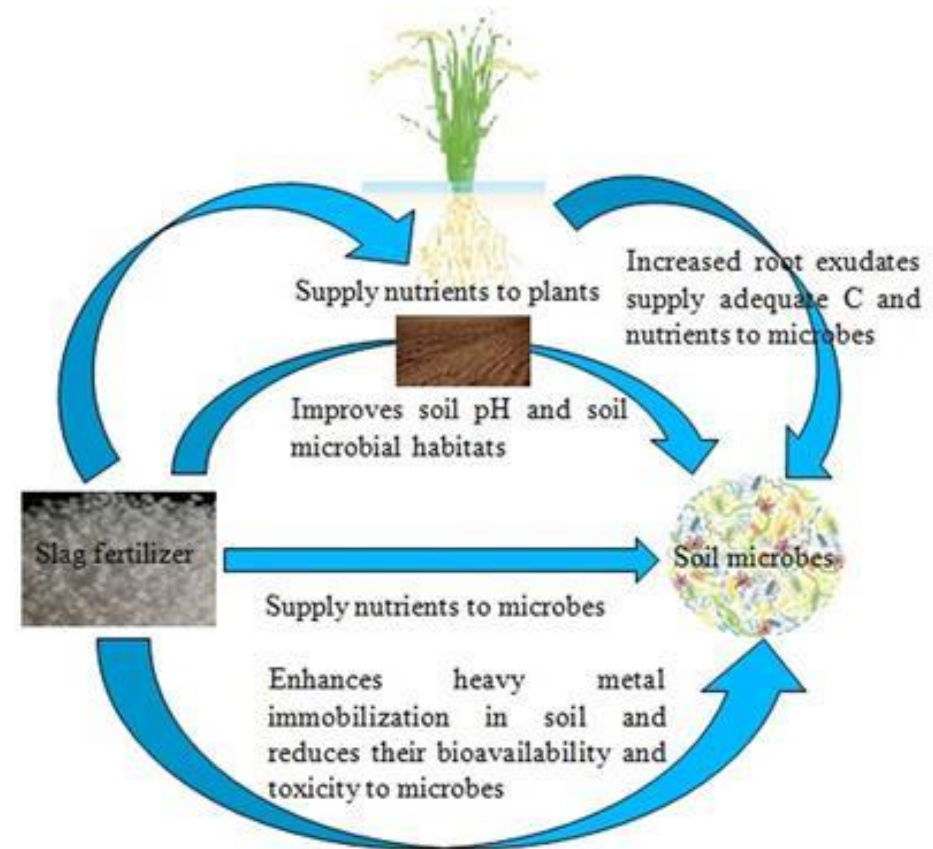
(Liyanage *et al*, 2014)



3. Immobilization of Fertilizer Nutrients

❖ Nutrient elements may be immobilized or fixed or converted into unavailable forms by one or more of the following three means:

1. Chemical immobilization
2. Physicochemical immobilization
3. Microbiological immobilization



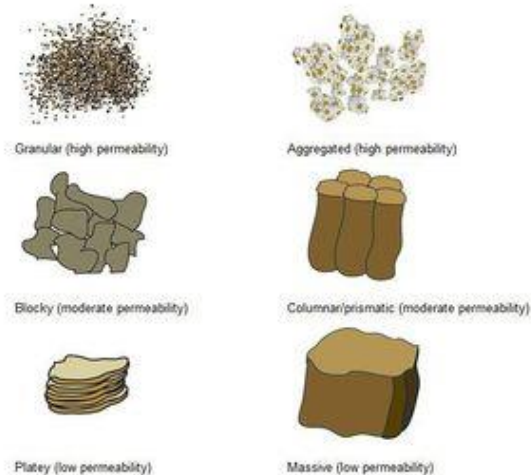
4. Interaction between different fertilizers

- ❖ Common practice to mix fertilizers containing different nutrient carriers , just prior to application.
- ❖ The efficiency of the following fertilizers will be lowered if mixed with the fertilizer or amendment noted against them.

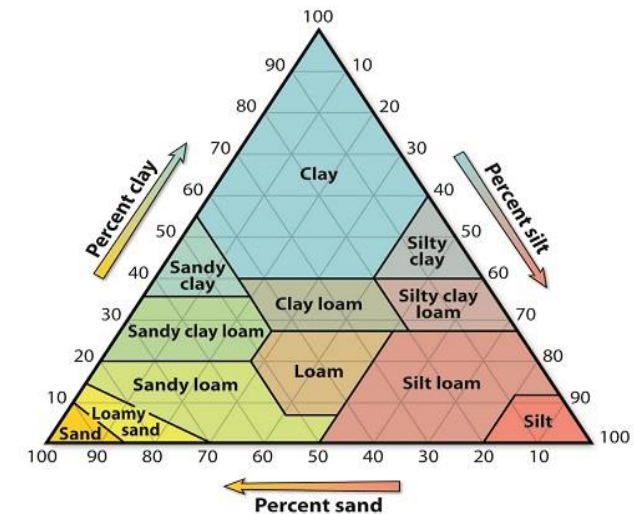
Eg. Dolomite with Urea containing fertilizers

5. Soil physical properties

- ❖ Soil compaction reduces the fertilizer efficiency.
- ❖ Soil temperature affects the fertilizer efficiency by changing solubility of fertilizers, concentration of solubilized fertilizer cation exchange and also ability of the plants to absorb and use of nutrients.
- ❖ Soil temperature is modified by common management practices like tillage, mulching and irrigation.



Soil Moisture



This is the textural triangle. If you know the percent clay (flat line) and percent sand or silt, you can draw lines into the triangle to figure out what textural category the soil belongs too.

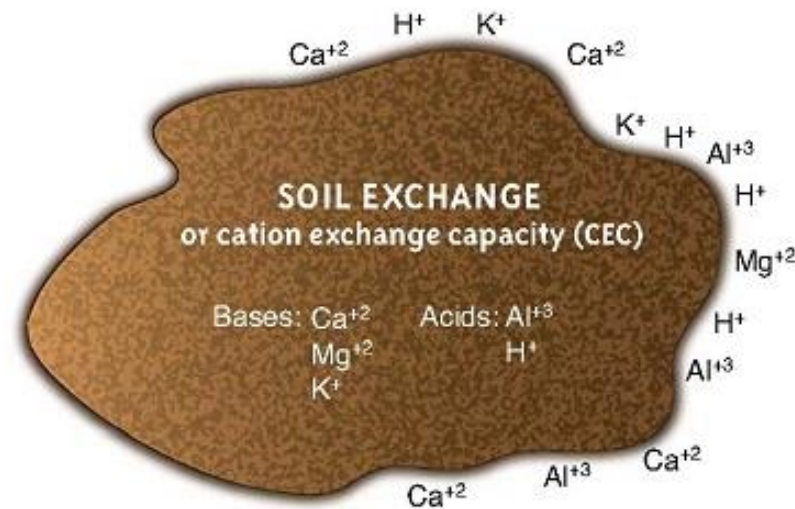
- ❖ One of the most singled out problem in agriculture is the lack and excess of moisture.
- ❖ Efficient water management is complementary to efficient fertilizer management.
- ❖ Maximum efficiency of fertilizers can be obtained only in the presence adequate soil moisture.

Maximum NH_4 and NO_3 uptake	19 -24 °C
Maximum P uptake	10 -35 °C
Maximum K uptake	24 -28 °C

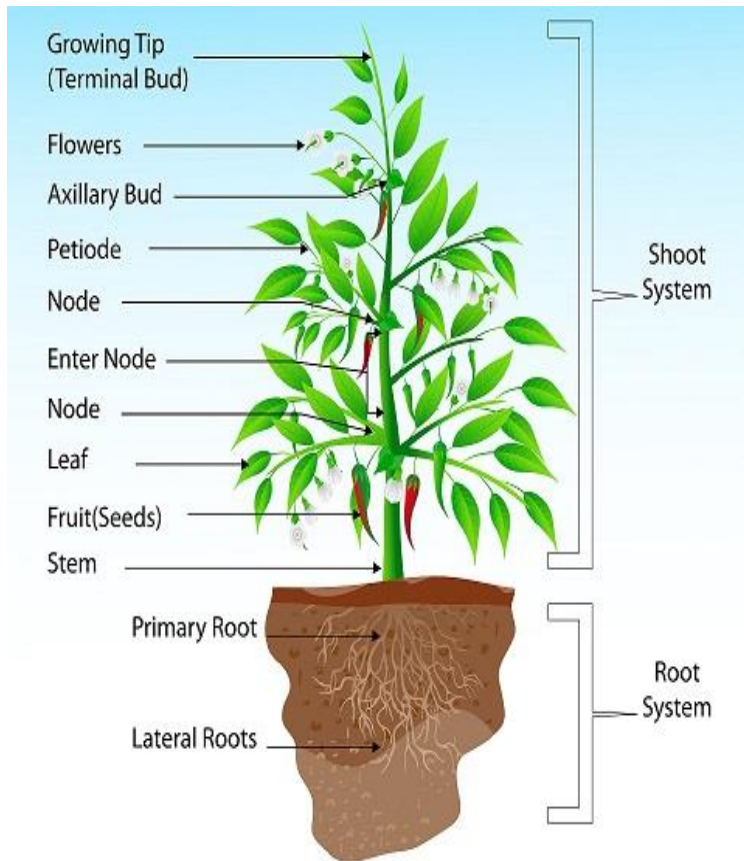
6. Soil chemical properties

- ❖ Plant nutrient availability depends on the prevailing pH of soil. →
- ❖ In strongly acidic and alkali soils the efficiency of the phosphatic fertilizer is low.
- ❖ In such situations, efficiency of fertilizers can be increased by correcting the soil condition, using suitable amendments.

Eg. Dolomite



7.Plant characteristics



- ❖ Different growth stages of the tea plant remove varied amount of plant nutrients from soil.
- ❖ At the nursery stage all nutrients are required in easily up taking/ available form.
- ❖ So that applied with 100% water soluble form (T65)
- ❖ Roots are the principal organs for nutrient uptake, the rooting pattern and habit have an important role on the nutrient removal.
- ❖ Depending on the age of the tea plant fertilizer type and composition varied
- ❖ Zn in reducing dormancy of the tea shoot growth

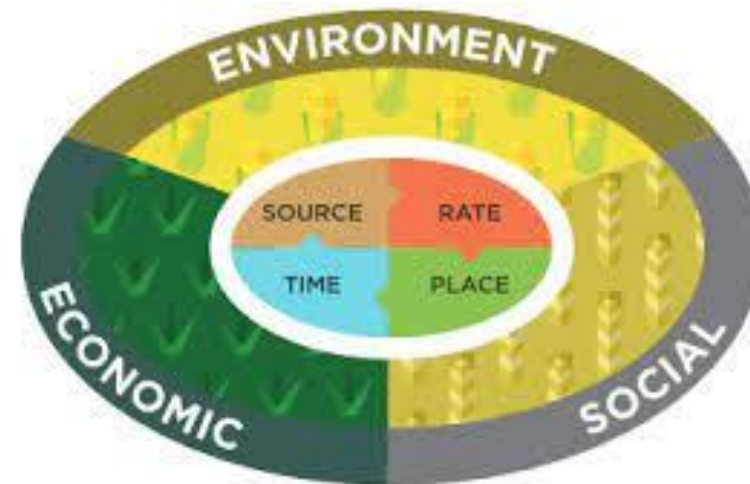
8. Fertilizer characteristics

- ❖ The mobility of the nutrients in the fertilizer, the type of fertilizer and the time and the mode of application decide the efficiency of fertilizer.
- ❖ The nitrogenous fertilizer are highly mobile and subjected both downward and sideward mobility.
- ❖ Phosphorous is highly immobile.
- ❖ Potassium is also mobile but compared to nitrogen its mobility is lower.
- ❖ Nitrogen and Potassium are more prone to leach from soil
- ❖ To get maximum efficiency N & K fertilizer should be applied in frequent split doses and phosphorous as basal dressing or near the root zone.

These 8 factors should be duly addressed in order to increase the fertilizer use efficiency

5R Concept in Fertilizer Use Efficiency

1. **Right Type** of fertilizers with favorable chemical and physical properties
2. **Right Dose/ Rate** of fertilizers based on the nutrient supplying power of soils and crop need.
3. **Right Time** of fertilizers application (time of application should synchronize with the rapid crop uptake period and there should synchronize with the rapid crop uptake period and there should be only a minimum time for soil fertilizer application)
4. **Right Method** of application.
5. **Right cost** of application



List of mixed fertilizers recommended for tea

Right Fertilizer

- T65 MAP Mixture - Nursery mixture
- T65 DAP Mixture -Nursery mixture
- T200 Mixture -Immature tea
- T750 Mixture - Immature tea
- ST/UM 400 Mixture - Mature tea
- ST/LC 365 Mixture - Mature tea
- ST/UVA 435 Mixture - Mature tea
- VP/UM 910 Mixture - Mature tea
- VP/LC 880 Mixture - Mature tea
- VP/UVA 945 Mixture - Mature tea
- UT 752 Mixture - Mature tea
- U 709 - Mature tea
- U 834 Mixture – Mature tea
- T 1240 Mixture – Mature tea



ANNUAL REQUIREMENT OF NITROGEN

Right Fertilizer
Right Rate

Potential Yield (Kg made tea/ha/yr)	Nitrogen (kg N/ha/yr)
Less than 900	90
900-1300	140
1300-1500	160
1500-1700	180
1700-1900	200
1900-2000	220
2000-2500	270
2500-3000	320
3000-3500	360
Above 3500	400

Phosphorus, Potassium, Magnesium and Sulphur are based on soil test values



Methods/ Place of application

Generally 3 methods of application of fertilizers are in practice.

Broadcasting: Uniform distribution over the whole cropped field.

Placement: Application in bands or in pockets near the plants or plant rows.

Foliar application: Using low or high volume sprayers, the fertilizers are sprayed covering the plant

Time of application

Right Fertilizer
Right Rate
Right Place
Right Time

Apply when soil is moist

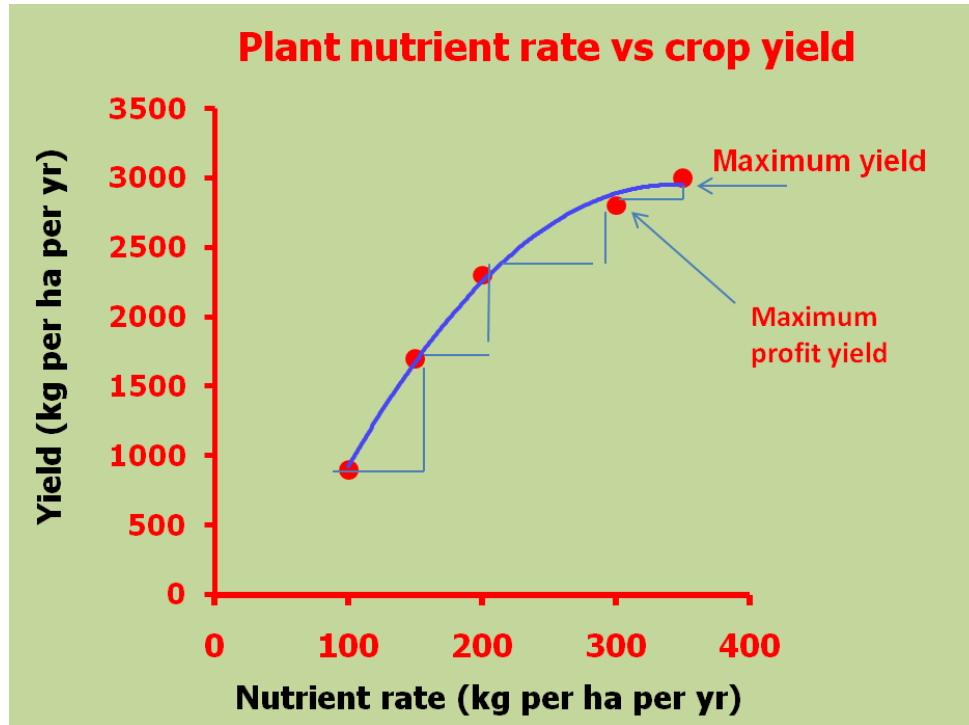
Avoid heavy rain and severe drought period

Fertilizer should be broadcast at least 6 weeks after / before dolomite application

Foliar fertilizers should be applied at early morning

Fertilizer response- Diminishing return

Right Fertilizer
Right Rate
Right Place
Right Time
Right Cost



Whether or not fertilizer use is profitable

The amount of profit or loss

The optimum dose

The rate of return (value of crop per rupee spent on fertilizer)

Summary Tips for Better **Fertilizer Application** Efficiency:

Ground Application

- Apply fertilizer based on the soil test value to avoid unnecessary application
- Correct the soil pH
- Use skilled labour to make sure uniform distribution
- Avoid application at 10 am – 3 pm time in hot days
- Avoid windy and rainy weather
- Mix bags well before at the field just before application
- Select the right nutrient of fertilizer to be applied (SA for immature tea, urea for mature tea)
- Try to apply fertilizer when there is a demand by the plant
- Try incorporation of fertilizer with soil as much as possible at least at immature stages

Foliar Application

- Use of skilled labour to make sure uniform distribution
- Avoid application after 10 am
- Avoid windy and rainy weather
- Try to apply fertilizer when there is a demand by the plant
- When applying foliar , never mix with pesticides or any other antagonistic elements
- Try using synergistic fertilizers for foliar eg. Urea and CES
- Never exceed 5% concentration
- Foliar application under the leaves increase uptake
- Avoid the use of mist blowers and use Knapsack sprayers

Summary Tips for Better **Fertilizer Use** Efficiency Cont.:

- Improve soil Organic Matter content
- Adapt soil conservation measures
- Apply biochar or any other soil enhancing materials
- Correct the soil pH in order to maximize nutrient availability to uptake
- Maintain good ground cover to prevent wash off as well as volatilization
- Shade tree management
- Direct sunlight increase volatilization losses
- Proper weed control help in reducing wasting of fertilizers
- Use of biofertilizers help in reducing synthetic fertilizers
- Improve soil biological properties
- Restore degraded soil in terms of soil health/ quality



Thank You!

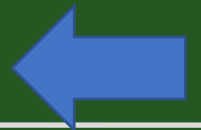


Optimum environmental conditions increasing efficiency in **foliar fertilization**

- Temperature - < 25°C better
- Sun Light – Too bright is not good
- Wind – No wind
- Humidity – Moderate
- Time – Before 10 a.m.

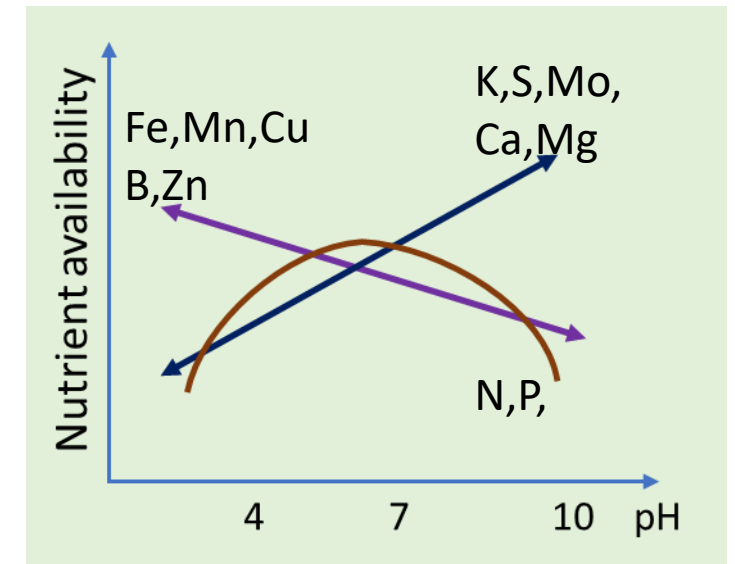
Optimum plant factors increasing efficiency in **foliar fertilization**

- Cuticle and wax on leaf
- Age of leaf
- No of stomata
- Leaf hairs
- Side of the leaf: Upper or Lower side
- Moisture on leaf
- Nutritional condition of the plant
- Cultivar



How the pH affect to increase fertilizer use efficiency

- Correction of pH increases the available nutrient content in the soil (pH 4.5 - 5.5)
- pH helps to retain nutrients in the soil reducing leaching and volatilizing losses
- Improving of pH increases the negative sites of the clay humas complex
- Thus, pH correction increase CEC thus increase nutrient retention capacity
- It also increase nutrient buffering capacity of soils too



How to minimize urea volatilization losses

1. Establish shade trees
2. Establish wind breaks
3. Form well spread of tea bushes to have good ground cover
4. Infilling vacancies
5. Mulching
6. Addition of compost and increase organic carbon in soil
7. Right time of fertilizer application



Nitrogen Deficiency Symptom



Apply 2 to 4% of urea, (8 to 16 kg urea) per ha in 400 l water, as when necessary)



- **Magnesium deficiency symptom**



- **N and/or Mg deficiency symptoms are commonly observed,**

Correction of Mg deficiency

When Mg deficiency symptoms are observed, Spray CES initially @ 48 kg per ha per year in 4 applⁿs, at 3 months intervals

Urea & CES can also be mixed together & applied as a single spray, when required. The quantity of urea & CES could be adjusted depending on the severity of deficiency symptoms. Total salt concentration in the spray solution should not exceed 5%

Test soil for Mg content, if it is below 60 ppm, apply Kieserite at the rate of 125 kg per ha per year, by mixing with mixtures or with urea in situ.



Mn Deficiency



If soil pH is above 5.5, apply 2% of Manganese Sulphate until symptoms disappear @ 3 to 4 times at monthly intervals

Withhold scheduled dolomite application

Thank You!

