Nutrient Dynamics in Degraded Soils

Any chemical element that is essential for plant growth and without which plants are unable to complete their lifecycle is known as nutrient. An element is considered essential if it is necessary for plant metabolism and for completion of plant lifecycle. Typically 17 elements are considered to meet this criteria and are divided into macro and micro nutrients. This division is based on their relative abundance in plant tissues rather than on their necessity for plant growth. However, degradation of soil results in loss of nutrients as well as their imbalance.

Nutrient Losses due to erosion

Essential plant nutrients such as nitrogen, phosphorous, potassium and calcium dominantly decline due to erosion. The eroded soil has three times more nutrients as compared to remaining soil surface Fertile soil estimated to have 1 to 6 kg of nitrogen contents, 1 to 3 kg of phosphorous contents and 2 to 30 kg of potassium contents whereas the left over soil having only 0.1 to 0.5 kg per ton of average nitrogen contents, To overcome these problems large quantities of fertilizers are being used. The cost of loss of basic soil nutrients is estimated to be about several billion dollars each year (Torah et al. 2004). If the surface of soil is about 300 nm deep the usage of commercial fertilizers and livestock manure replace the lost of nutrients but this practice is usually expensive for poor farmers and nations. Not only expensive these synthetic fertilizers also affect the human health and also result in soil, air and water pollution

Soil is a major source of nutrients needed by plants for growth. The three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Together they make up the trio known as NPK. Other important nutrients are calcium, magnesium and sulfur. Plants also need small quantities of iron, manganese, zinc, copper, boron and molybdenum, known as trace elements because only traces are needed by the plant.

The important characteristics of soil such as aeration, WHC, Nutrient holding capacity are affected by degradation of soil. Due to deficiency of oxygen roots activity becomes slow resulting in reduced water and nutrients uptake by plant roots. The absorption of water by plant roots proceeds more rapidly in well aerated soils compared to poor aerated soils. In poor aerated soils, concentration of oxygen reduces while that of carbon dioxide increases. Saturation of soil with water is the most common reason for aeration leading to poor root growth and poor nutrient uptake. Under poor aeration root activities are more affected due to lack of oxygen rather than excess of carbon dioxide.

Nutrients

Factors effecting salt absorption to plants

1) Plant Species

Plant species & varieties b/w species are greatly differ in their metabolism to take up different salt ion from same growth medium. It is not possible that if any 2 plant even of same species placed under identical condition will absorb salts in the same proportion/at the same total rate. The differential uptake of ions by plants is mainly attributed to difference in metabolic activities, root biomass & root activities, as well as root induced changes in rhizosphere.

2) Extent of Root System ∝ N.A

An extensive root system of a plant enable its roots to exploit greater volume of soil & plant nutrient as compare to shallow root system. root extension is also an important factor in absorption of nutrient particularly those which are not very mobile (P), whose uptake is generally reduced with reduction of root branching.

3) Metabolic Activities of plant tissues ∝ N.A

Accumulation of salts is usually closely related with growth & metabolism. Enlarging cells have higher accumulation as compare to mature or old cells which have lost their ability to enlarge. Moreover there is higher synthesis of new binding sites, carriers, and incorporation of inorganic ions in organic compounds in younger plant which ultimately enhances the ion uptake. However reduction in growth caused a significant reduction in above

* Osmotic Stress (within minutes/hours) {wilting due to less absorp.
* Salt ion toxicity (with in days) {effect on metabolic activities.
* Nutrient imbalance. Replaces K at absorption site.
* Oxidative stress & Disorder in metabolism due to Na (ROS prod.)

said activities - and ultimally the uptake of ions reduce. In simple words, the period of rapid vegetative growth is accomplained by rapid uptake of salts ion. Any treatment which reduces growth will cause decrease in corresponding ion uptake. when leaves grow old, ions & compounds which are present with in them will shift to enlarging new leaves, stem tips, young fruits & other rapidly growing stonctures. Thus there is gradients of salts conc. in plants related to level of metabolism & growth stage.

4) Internal Concentration of salts $\propto 1/N.A$

In principle as internal conc. of particular nutrient increases, its uptake rate decreases & vice versa. This decline in nutrient uptake with an increase in internal ion conc is due to decrease in conc gradient and low plant requirement of that particular nutrient.

Internal conc. of Particular nu Demand

5) Internal Sugar Concentration $\propto N.A$ → Metabolic Ac

With increasing internal sugar conc ion uptake by plants increases mainly due to higher metabolic activities & higher demand of plants of particular nutrient.

metabolic activ

Fri. 13/05/16

6) H-ion Concentration

It influences nutrient absorption by plants indirectly through its effect on soil pH. most of the nutrients are available at pH range 6-6.5. Increase/decrease of pH from this range will adversely affect nutrient uptake by plants e.g P availability is max. at this pH range when pH rises above this range P is going to

react with Ca and becomes unavailable on the other hand when pH below this range P react with Mn and become unavailable.

7) Respiration & N.A

The main source of energy in non-photosynthetic cells & tissues including roots is respiration as respiration decreases plant growth will decrease that will affect the uptake of nutrients.

8) Aeration & N.A

Deficiency of O/excess of CO_2 is one of major factors that decreases the uptake of nutrient by plants due to its impacts on root growth, metabolic activities, microbial activities. However tolerance of to inadequate aeration varies widely among plant species. Rice plants can absorb sufficient amount of nutrient from flooded soils (Anaerobic) while Barley, wheat and other crops suffer from severe injury under anaerobic cond. and their capacity to absorb nutrient is significantly reduced.

9) Temprature & N.A (but in narrow range)

Salt ions absorption tend to be increase with increase in temperature with in narrow range Probably due to increase in metabolic activities, Bio-Chemical rex. with in plants while soil microbial activities with in soil. However above optimum temp salt absorption tend to be decrease due to adverse effect of temperature on root growth & microbial activities.

opens
closing of stom

Light Content ∝ N-A

10) ~~Soil moisture Content~~

Effect of light on opening & closing of stomata as well as on photosynthesis indirectly affects salts absorptn. Due to regular opening of stomata for photosynthesis, transpiration rate will increase which resulted in higher/increased absorption of H_2O & thus nutrients from the soil. Moreover process of photosynthesis releases energy which improves plants growth & hence nutrient absorption. In addition during photosynthesis O_2 is released which also have positive effect through increasing respiration & aeration

Adequate Movement

11) Soil moisture Content ∝ N-A

Adequate availability of moisture

Nutrient uptake by plants is max. at adequate soil moisture adequate availability of H_2O in soil not only enhances movement of salt ions from soil to plant roots but also increases root growth & activities as well as metabolic activities. It consequently results in higher uptake of salt ion by plants. moreover adequate moisture in soil improves microbial activity which have positive affect on nutrient availability to plants on the other hand if soil moisture is above the adequate limit, ~~soil aeration~~ root activities as well as metabolic functions with in plants & microbial activities in soil will negatively effected which causes reduced uptake of nutrient by plants.

R] Conc & Composition of particular nutrient in sol.

It is a well known factor that an increase in the conc of particular nutrient

increase in conc. of a nutrient ~~of~~ uptake due to conc. gr

in soil solution will favour the uptake of that nutrient. Moreover the form in which nutrient is present in soil solution also affect the availability & uptake of that nutrient by plants.

13) Interaction b/w Ions

Uptake of salt ion by plants is also affected by other ions in soil solution due to their competition for same binding sites and transport carriers e.g P & arsenate (Ar) are adsorbed on same binding sites in roots & translocated from roots to shoots by same transport carriers. If their is higher conc of Ar in soil solution that will affect uptake of P (Moreover, Ar) due to occupation of binding sites in roots & transport carriers by Ar. Moreover Ar will also displaces P from atp molecules & will adversly affect synthesis of energy with in plants it consequently affect the growth of plant & hence plant uptake of nutrient.

How soil moisture effect nutrient uptake?

In following ways.

a) Drying of soil ↓ Mobility of nutrient & availability
b) H_2O stress effect physiology & biochemistry of plants & hence lowering their ion req.
c) Reduced root growth under H_2O stress ↓ vol of soil that can be exploited by root.
d) Reduced microbial activities in soil.
e) Increased suberization of roots surfaces which ↓ root permiability & hence Ion uptake by plant

Soil Salinity & Plant growth:

Soil salinity is the most imp. env. factor.

* Diff. malfunction due to salinity.
  - ⇒ Cell membrane integrity.
    Na replaces Ca.
  - ⇒ Cell metabolical & Chemical activities affected.
  - ⇒ Reduces turgor.
  - ⇒ Reduces photosynthetic activities.
  - ⇒ Reduces leaves expansion by turgor effect.
  - ⇒ Reduces translocation of photosynthetic product.

major mechanisms involved in growth reduction under salt stress:-

i) Specific ion toxicity.