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Introduction

Agricultural production to a marked degree in current scenario is dependent on relative supply of N nutrient to crop up to a certain level. Success of green revolution (1967) in India is largely attributed to enhanced N utilization by specially created high yielding varieties radically transforming the agricultural crop production which can be verified from the fact that

production of wheat and rice increased dramatically 4 and 11 times respectively from 1968 to 2017. Introduction of industrially manufactured nitrogenous fertilizers in agriculture not only assisted the country to achieve self sufficiency in food production but also marked the complete elimination of frequent recurrence of famines thus ensuring the sustainability of food security in coming future.

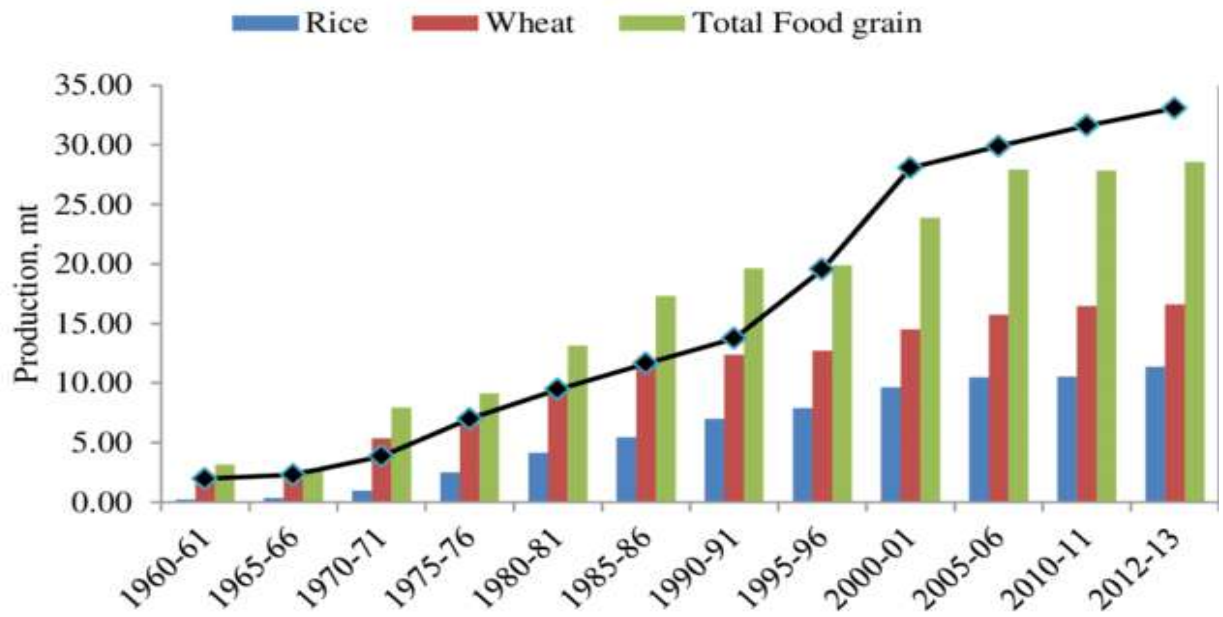

Fig1: Increase in production of staple food crops since 1960 in Punjab state (Lohan *et al.*, 2015)

Importance of Nitrogen

According to Food and Agriculture Organization of United Nations, fertilizer N directly influences the production of food crops to feed half of the global population. UN projections on growth of global population suggests it to be around 9.7 billion by 2050 feeding which is expected to be a huge challenge in the near future. Since arable land is a limited resource, the only way to meet food requirement of ever-increasing global population is to increase productivity of staple crops and fertilizer N will be a key factor in determining the fate of this approach. Nitrogen is also a key constituent of amino acids and protein structure, thus immensely affecting the nutritional value of food. Nitrogen is the most limiting plant nutrient in crop production.

Functions of N in Plant Growth

Nitrogen is basic constituent of life as it is an essential component of several compounds of physiological importance like amino acids, proteins, nucleic acids, porphyrins, flavins, purines, pyrimidines, enzymes, co-enzymes and alkaloids. N is an inseparable part of light

capturing pigment chlorophyll, thus have a direct role in photosynthesis which is most important biological process for sustaining life on earth. It is an essential constituent of deoxyribonucleic acid (DNA) thus involved in control and development of heredity processes. Nitrogen confers vigorous vegetative growth and also governs utilization of other elements especially potassium as robust vegetative growth increases root biomass consecutively expanding surface area of roots making them capable of drawing more nutrients from soil.

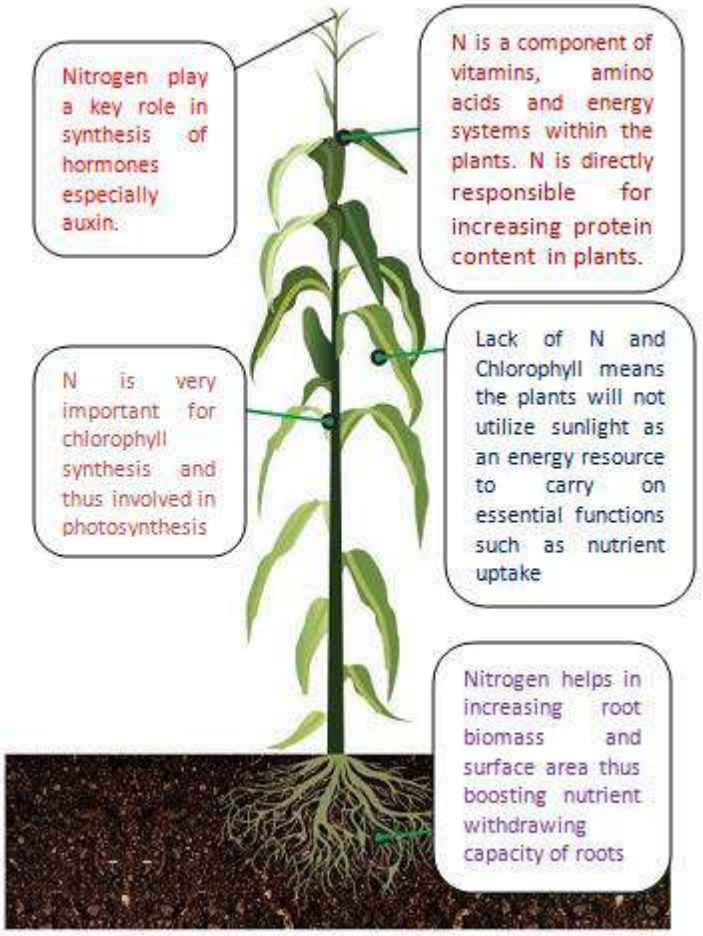

Fig 2: Functions of N in plants

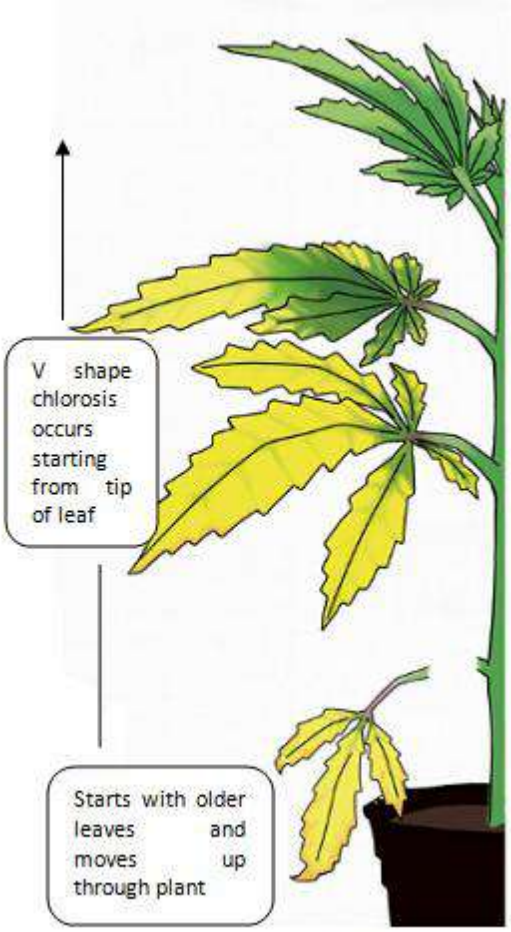

Fig 3: Deficiency Symptoms of N in plant

Deficiency Symptoms of N in Soils

Deficiency symptoms appear when concentration of N in plant tissues fall below 1%. Deficiency symptoms appear on older leaves first as V shape chlorosis due to high mobility of N in plants. N deficiency is also associated with stunted growth, low protein content, reduction in flowering and yield.

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N Status of Soils

N is considered as universally deficient nutrient owing to the negative effect of tropical and subtropical climatic conditions on accumulation of soil organic matter content. N content in soils is generally low as it is directly associated with organic matter content and generally ranges from 0.02% and 0.44% in soils whereas its concentration in Indian soils oscillates between 0.02- 0.13%.

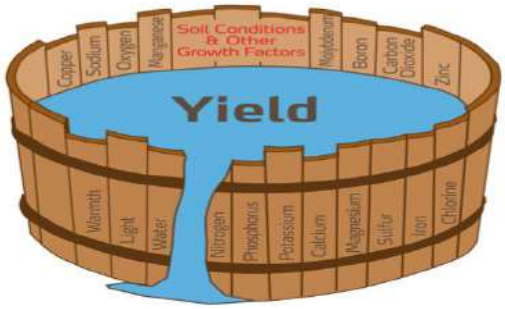


Fig 4: Tandon and Kimmo (1993) described Liebig's Law of Minimum through a barrel having staves of different heights with N stave being least high indicating its most limiting nature.

Fertilizer Sources of N

Crop are able to utilize maximum 50% of applied fertilizer N. Plants absorb N in the form of nitrate (NO_3) and ammonium (NH_4^+) ions. Commercial nitrogenous fertilizers are classified into Nitrate, Ammonical and Amide fertilizers. Nitrate fertilizers eg. sodium nitrate (16% N) and calcium nitrate (15.5% N) are highly mobile in soil, have basic residual nature and suitable for top dressing. Ammonical fertilizers are readily soluble in water and less prone to leaching, have acidic residual nature and are more susceptible to denitrification and volatilization losses. Amide fertilizers are both organic and inorganic in nature. Urea is the cheapest and commonly applied N fertilizer in India containing 46% N. Anhydrous ammonia is the most concentrated commercial fertilizer N (82% N). Calcium ammonium nitrate also called kisan khad is the most suitable nitrogenous fertilizer for vegetables. It is neutral in reaction and contains about 26% N.

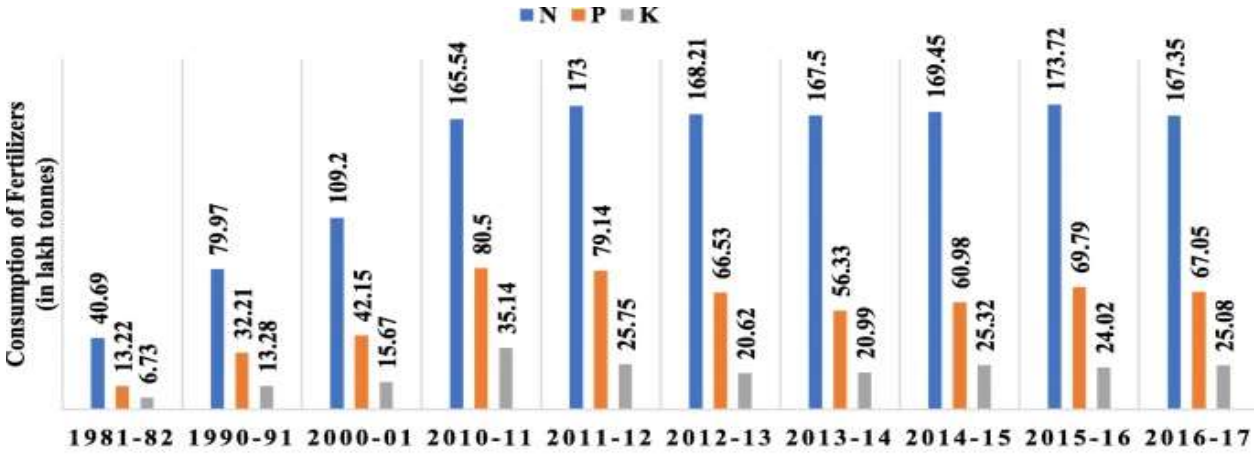


Fig 5: Increase in consumption of commercial fertilizers since 1980 (Nelson *et al.*, 2019)

N transformations in soil:

Nitrogen transformations consists of

1) Mineralization: Conversion of Organic form of N to inorganic form.

a) Aminization: conversion of proteins and polypeptides into amino acids or amines through enzymatic digestion by heterotrophic microbes.

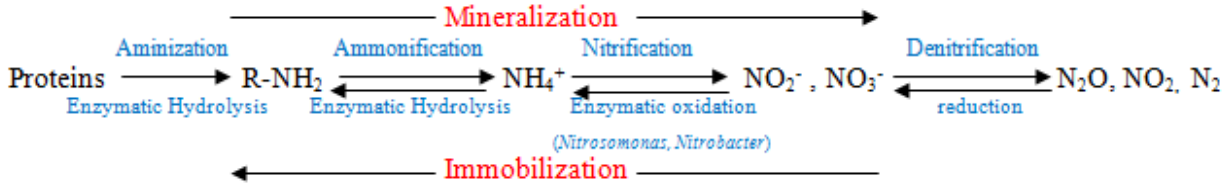
b) Ammonification: Conversion of amines/amino acids into ammonia through enzymatic hydrolysis carried out by microbes

c) Ammonia Volatilization: Conversion of ammonia-to-ammonia gas which then lost into atmosphere.

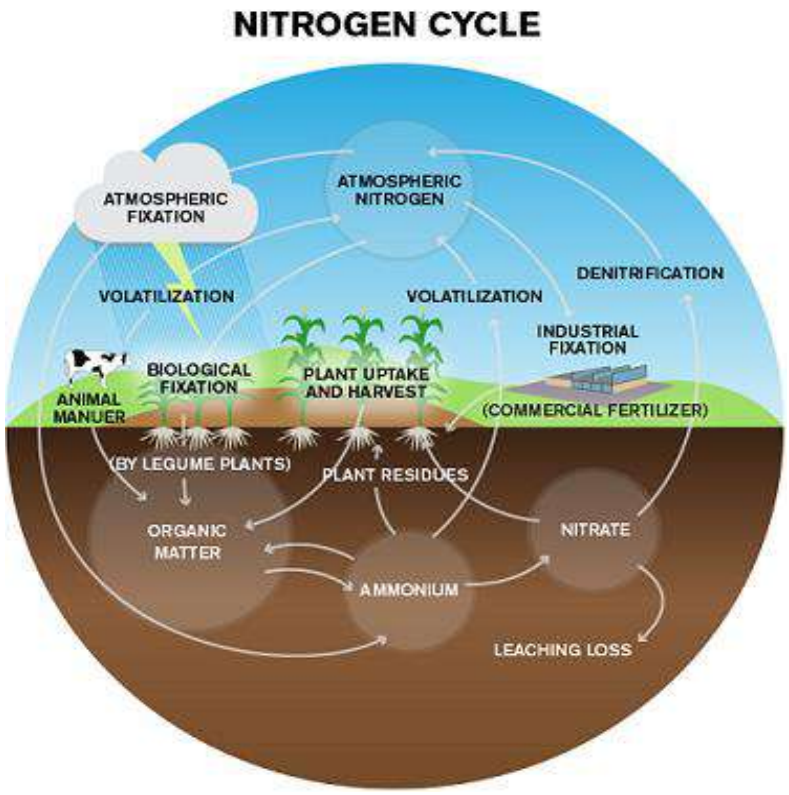
d) Nitrification: Enzymatic oxidation of ammonium into nitrite and nitrate ions by certain nitrifying bacteria (*Nitrosomonas, Nitrobacter*). The process requires a pH of 5.5 to 6.5 and an optimum temperature of 35˚C.

e) Denitrification: Conversion of nitrate into nitrogen dioxide, nitrous oxide and nitrogen gas.

2) Immobilization: Conversion of organic form of N to inorganic form



N transformations in soil



Methods and time of fertilizer application

Nitrogenous fertilizers are water soluble, thus suitable to be applied through broadcasting. It is recommended to apply total fertilizer dose in two to three splits to minimize leaching and denitrification losses. Band placement in anaerobic soils also prevents volatilization of urea. Urea mud ball application is recommended in fields in which draining facilities are limited.

Conclusion:

Nitrogen is the backbone of modern agriculture and it will continue to play a major role in agriculture sector in the coming years. An enhanced understanding of N dynamics in soil is critical for judicious use of expensive N fertilizers and simultaneously maintaining good soil health and harmony with environment. For increasing the efficiency of nitrogenous fertilizers beyond present level need more exploration in the field of fertilizer technologies like nanotechnology, resource conservation technologies like leaf colour chart (LCC) and other related disciplines. In future there is no alternative to N fertilizers to maintain present food crop productivity.

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