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New generation eco-friendly plant nutrients for sustainable agriculture

By: Rana P. Singh[1]*, Sanjeev Kumar[1], Manish Sainger[2], Anurag Kumar Singh[1]

For years together, the solo objective of fertilizer application to crop plants had been to provide nutrients to plants and in turn obtain enhanced or sustained optimal yield and hence the fertilizer producers and users had been and are being attempting to improve fertilizer use efficiency in terms of nutrient uptake and crop yield. It has been realized that the excessive use of inorganic fertilizers, which is the common agricultural practice of green revolution, is not a sustainable farming practice from either economic or ecological point of view.

Nitrogen is one of the major nutrients for the plant productivity. The inorganic forms of N i.e. nitrate, nitrite and ammonium are assimilated by the plants including bacteria into the primary amino acid, L- glutamic acid. Ammonium is the entry port for incorporation of inorganic N into the organic cycle. The primary sources of nutrient N are nitrate (in most of the arable soil), ammonium (mostly in anaerobic conditions) and biological fixation of di-nitrogen into ammonium (symbiotic and non-symbiotic). The nitrate gets reduce to nitrite in presence of the enzyme nitrate reductase (NR), which subsequently reduced to ammonium in presence of the enzyme nitrite reductase (NiR). Ammonium get assimilated into L- glutamine in presence of L- glutamine synthetase (GS) and subsequently produces L- glutamic acid by incorporation of amide nitrogen of the glutamine into 2-oxoglutarate which is catalyzed by L-glutamate synthase (Fd- GOGAT and NAD(P)H-GOGAT) . In this pathway one L- glutamic acid molecule is used to produced L- glutamine and subsequently two L- glutamate molecules are produced with a net benefit of one L- glutamate. This pathway was discovered in early 1970s in bacteria and subsequently in plants. Another enzyme, for which at least 14 isoforms have been reported, L- glutamate dehydrogenase (NADH-GDH and NAD-GDH), which occurs in almost all living organism has been reported to catalyze a direct amination and deamination of ammonium to and from L- glutamic acid. Being a reversible catalytic system GDH pathway of ammonium assimilation is considered as an alternative pathway which generally operates under the stresses when ammonium is available in excess amount. The assimilated N gets incorporated in proteins, nucleic acids and many other metabolites essential for the functioning of living organisms.

Nitrogen deficiency is one of the major yield limiting factors in plants especially in cereals, hence application of N- fertilizers are considered as an essential input to maintain high yield of the crops. Plants are responsive to the applied N which constitutes most of the vital macromolecules and metabolites related to its vegetative and reproductive growth and metabolism. The applied fertilizer N enhances crop productivity per unit area, as agricultural soil is deficient in N worldwide. The fertilizer application is thus considered essential to meet the requirements of the burgeoning population, particularly in the developing countries.

The losses of chemical fertilizers occur in many forms. Due to runoff and leaching it contaminate ground and surface water bodies which causes eutrophication and its environmental consequences. High levels of nitrate and phosphate etc. have been reported to be associated with the many kinds of toxicity to zooplanktons and aquatic animals and health hazards to cattle and ruminants and human being specially children. The nitrite may combine with organic pollutants and form nitrogenous xenobiotic compounds which affect nervous system, induces heart diseases and cause many types of cancers. The excessive use of N fertilizer are known to cause enhanced volatization of ammonia and emissions of NOx gases which are very potential threat to the global warming. Organic manures also emit methane in anaerobic conditions.

In most of the countries, applications of chemical fertilizers, pesticides, energy based tools and equipment and high water consumption for irrigation to gain high yield in plant agriculture have raised cost of production, on one hand, and have degraded soil, water and biosphere, on the other. Therefore, there is an urgent need to develop innovative procedures, tools, techniques, production, transportation, distribution and marketing systems, which are based on low input agriculture, sustained productivity and yield and sustainable resource management.

Organic manures e.g. cow-dung, compost, vermi-compost and farm yard manure (FYM) etc. have been recommended as an alternative to the chemical fertilizers in organic farming systems. However, these manures are slow acting and thus required to be applied in bulk to maintain high crop yield similar to that obtained by the application of chemical fertilizers. In recent years due to rapid urbanization and industrialization globally the populations of cattle and ruminants have decreased rapidly and thus the availability of organic manures in bulk is difficult. The practices to convert other organic wastes of