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Bio-inspired nano-nutrients : A key for sustainable agriculture

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Several organisms have been developed for production of nano-nutrients and nano-induced polysaccharide powder for agricultural use. An eco-friendly low cost protocol is now available for rapid synthesis of agriculturally important mono-disperse nano-nutrients like N, P, K, Mg, S, B, Fe, Mo, Zn by using microbial protein. The protein group which is responsible for nano-particle production and stability has been identified. In general, 32 kDa proteins is helping for breakdown of respective salts into Nano and 35 kDa protein is encapsulating the particle and preventing them from agglomeration resulted more stability.

The optimum concentration, size, shape of nano-nutrients required to be spread to plants and microorganisms for maximum benefit has been standardized. Nano-Zn and Fe helps in more stress tolerance, prevention of membrane damage and less carbon exudation by the crops. In general, 12-54% improvement of grain yield and 18-39% dry matter yield of 12 different crops (cauliflower, capsicum, castor, cluster bean, chick pea, maize, moth bean, mung bean, pearl millet, rice, tomato, wheat) was observed due to application of different nano-nutrients under three different soil groups, i.e. Aridisol, Inceptisol, Vertisol. The nutrient use efficiency (NUE) increased between 3 and 20 folds as compared to conventional fertilizers. There was 30% more nutrient mobilization in the rhizosphere of nano-treated plants. The beneficial enzyme (dehydrogenase, esterase, acid phosphatase, alkaline phosphatase, aryl sulphatase, nitrate reductase, cellulase, hemicellulase, lignase) activities in the rhizosphere increased between 18 and 283%. There was also 10-21 days advancement in crop maturity under nano-nutrient treated plants.

Nano-nutrients like Fe and Zn can induced 10 to 18 times more polysaccharide production by spraying on polysaccharide producing organisms. Methodology already developed for preparation of polysaccharide powder which has been identified as Xantham, Curdlan and Pollulan. The nano-induced polysaccharides have been found to be very effective in soil aggregation (33-83%), moisture retention (10-14%) and carbon build-up (3-5%) in arid soils. The nano based clay fabrications were developed and identified the bonding sits of nano-polysaccharides during soil aggregation. Nanofabrication of phosphorus was done on kaoline mineral receptacles for its use as advance nano-material including novel fertilizer.

No adverse effect was observed on seed germination, soluble protein content, soil microbial population, total RNA in plant tissue, body weight and consumption rate of nano-food to mice and nano particle concentration in seeds with the application of recommended doses of nano-nutrients and nano-induced polysaccharide powder. Bio-inspired nano nutrients and nano-fertilizers did not induced any adverse effects in rats even after feeding more than two and half times limit dose. No abnormal clinical signs, behavioural activity etc. were observed in animals which received nano treated test materials. Histopathological analysis for estimating toxicological effect showed no adverse effect on liver, kidney, spleen tissues due to intake of nano foods.

***Dr. J.C. TARAFDAR** did his M.Sc. and Ph.D. degrees in Soil Science and Agricultural Chemistry from Indian Agricultural Research Institute, New Delhi and Post Doctorate from Institute of Agricultural Chemistry, Germany as DAAD Fellow. He worked his carrier in the Agricultural Research Service of the ICAR as Scientist, Senior Scientist, Principal Scientist, National Fellow and Emeritus Scientist. He was a visiting scientist for two years in Germany after receiving most prestigious Alexander von Humboldt (AvH) fellowship. He also worked in USA on Nanotechnology. Dr. Tarafdar has made original and well recognized contribution mobilization of native phosphorus. He has developed an *in-vivo* filter paper technique for phosphatase estimation. His developed biological phosphorus (Bio-phos) fertilizer is now promoting by State Government of Rajasthan. **He is the first in the world successfully developed biosynthesized nano nutrients and nano induced polysaccharide powder for agricultural use.** He also developed a sequential P fractionation scheme and a rapid method for assessment of plant residue quality. Dr. Tarafdar has pioneered in finding out the origin of different phosphatase fractions and also developed a potential biological indicator. He has developed many new techniques now used in Soil Biology. The most notable are: Visual demonstration technique of germinating AM spore, Soil solarization technique for mass scale production of AM fungi, Freeze-drying technique to understand nutrient movement and Electrofoccusing technique to demonstrate the origin of enzymes. Dr. Tarafdar has travelled and lectured widely in many countries and published 353 research articles in national and international journals which include 35 book chapters and three books. **He has four patents and 73 new organisms in his credit.** In recognition of his professional contribution, Dr. Tarafdar received many awards most notable are Sukumar Basu Memorial Award, IMPHOS-FAI Award, Prof. S.K. Mukherjee Memorial Award, Prof R.S. Murthy Memorial Award, Bharat Jyoti Award, Glory of India Gold Medal, Prof. R.V. Tamhane Memorial Award, Dr. Kartik Oaron Memorial Award, Dr. N. S. Randhawa Memorial Award, ISSS Platinum Jubilee Commemoration Award. Dr. Tarafdar is a Fellow of the most prestigious Alexander von Humboldt (AvH) Germany and DAAD, Germany. He is also a fellow of National Academy of Agricultural Sciences, Indian Society of Soil Science, Indian Society of Salinity Research Scientists.