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Characteristics of nano DAP (Diammonium Phosphate) designed for seed treatment and foliar spray applications

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Abstract
This study investigated the essential characteristics of nano DAP (Diammonium Phosphate) designed for seed treatment and foliar spray applications. The Indian Farmers Fertilizer cooperative limited nano DAP (Diammonium Phosphate) sample was sent to Deprtment of SAIF-DST centre, shivaji university, Kolhapur for analysis of particle size, PDI, KCPS and zeta potential. The particle size analysis revealed an average size of 293.9 nm, indicating the formation of nanoparticles approximately three times more than particle size of nano DAP (Diammonium Phosphate) by IFFCO (Indian Farmers Fertilizer cooperative limited) findings. The Poly-dispersity Index (PdI) scale, ranging at 0.860, suggested that the particles becomes too polydispersed across all samples, positioning them above the range value. The Count rate of IFFCO (Indian Farmers Fertilizer cooperative limited) nano DAP was 3.5 which was below the range of normal count rate, which indicated that less number of nanoparticle detected by instrument. Furthermore, zeta potential value of (-12.1 mV), signifying a negative charge on the nano DAP (Diammonium Phosphate) particles in aqueous suspension. This negative zeta potential contributed to enhanced stability, highlighting the potential for improved longevity and efficacy in agriculture. The findings collectively suggested that the developed nano DAP formulation held promise as a stable and less effective solution for seed treatment, offering lacks of benefits in crop yield and overall agricultural productivity.

Keywords: Characterization, nano DAP, polydispersity index, kilo count per second and Malvern zeta sizer ZS-90

Introduction
The intricate relationship between soil health and the well-being of both animals and humans is undeniably rooted in agriculture, where the vitality of crops directly influences food production. Essential nutrients to plant metabolism are such as nitrogen (N), phosphorus (P), potassium (K), sulphur (S), and micronutrients like zinc (Zn), copper (Cu), iron (Fe), boron (B), and manganese (Mn) (Singh M.V. 2009) [15]. Disturbingly, deficiencies in these nutrients have been observed in soils worldwide, including in India, as a consequence of intensive agriculture practices. The escalating demand for food to sustain a growing global population has led to an overreliance on chemical fertilizers, particularly nitrogen, exacerbating nutrient deficiencies in soils. The cultivation of high-yielding crops and cultivars, coupled with increased cropping intensity and the application of high-analysis fertilizers, has created a challenging scenario for sustaining high crop yields. In response to these challenges, nanofertilizers have emerged as a promising solution to enhance crop growth and yield. Applying nanofertilizers through foliar and seed treatments give advantages such as direct nutrient absorption through leaves, rapid uptake, and utilization by plants. This targeted approach improves nutrient delivery efficiency, minimizing losses through leaching or volatilization. Seed treatment with nanofertilizers promotes early-stage nutrient availability, contributing to improved seedling vigor. The nanoscale particles in these fertilizers enhance nutrient solubility and bioavailability, leading to increased nutrient uptake by plants (Yadav, A., 2023) [17].

Material and Method
The sample of experimental product IFFCO nano DAP was use in this study, it was send to department of SAIF-DST centre for analysis of particle size, polydispersive index, kilo count per second and zeta potential by using Malvern zeta sizer ZS-90. Dynamic light scattering

(Malvern Zetasizer, Nano ZS 90) was used to check particle size (nm), polydispersive index (PDI) and count rate (Kcps) following the standard operating procedure at 25 °C. It is a laser diffraction method with a Multiple Scattering Technique which was used to determine the particle size distribution of the nanoparticles. In order to find out the particle size and particle size distribution from the synthesized IFFCO nano DAP liquid solution. Surface charge of synthesized IFFCO nano DAP liquid solution was measured following standard operating procedure using Zeta Sizer, ZS-90 instrument. Zeta potential measurement specifies the electro kinetic potential of a colloidal system (Garcia *et al*., 1997) [5].

Results and Discussion

Testing of IFFCO nano DAP liquid solution by Malvern zeta sizer ZS-90

Data presented in table 1 indicated that IFFCO nano DAP liquid solution showed particle size of 293.9 nm, which was three times more than particle size of IFFCO nano DAP claimed by IFFCO. The Poly-dispersity (PdI) Index scale was 0.860 indicates that value above normal range and the particles remain in disperse form in samples. It can be develop adverse result on crop because the particle size of IFFCO nano DAP more than 100 nm (Hasnidawani *et al*., 2016) [6], and did not fullfil the nutrient content as well as nano characterization findings by IFFCO.

Table 1: Testing of IFFCO nano Diammonium Phosphate solution by malvern zeta sizer

Standards	Range	IFFCO Findings	IFFCO Observed values	Remarks
Particle size (nm)	1-100 nm	<100 nm	293.9 nm	Particle size approximately 3 times more than IFFCO claimed
Polydispersive index	0.2-0.5	-	0.860	The observed value above range value, Hence solution become too polydisperse
Radioactivity (Kilo Count Per Second)	100-500 kcps	-	3.5	Indicate a lower level of radioactivity or a reduced emission of radiation from the nanoparticles
Zeta potential (mV)	-30 mV – +30 mV	-	-12.1 mV	Sample becomes more stable
Nitrogen	-	8%	4%	Nitrogen content is found to be lower than the levels claimed by IFFCO, leading to a reduction in effectiveness by half
Phosphorus	-	16%	8.5%	Phosphorus content below the levels stated by IFFCO

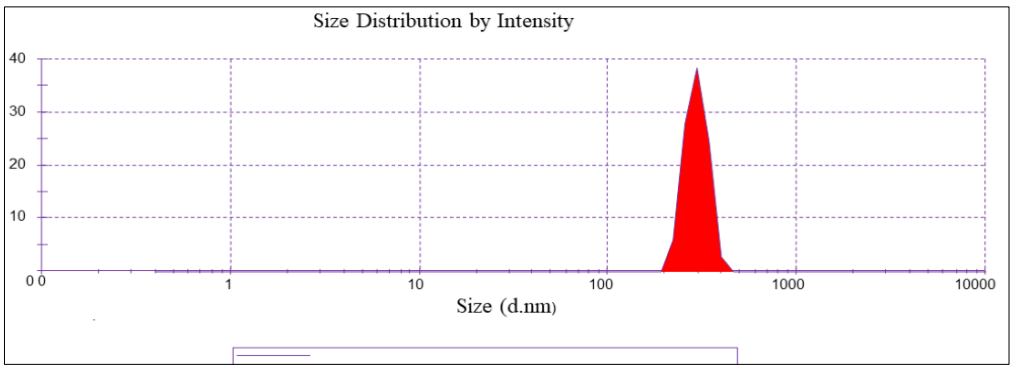

Fig 1: Particle size of IFFCO nano Diammonium Phosphate liquid solution

In fig 2, zeta potential indicated the magnitude of negative charge developed on surface of particle. The larger zeta potential values represent lower degree of aggregation that leads to higher degree of stability of nanoparticles and smaller z-averaged hydrodynamic diameter. At lower zeta values, the nanoparticles flocculate early and the stability in nano-suspension reduces. The common dividing line between unstable and stable suspensions is taken as +30 or -30 mV; particles having zeta potentials beyond these limits are generally considered as stable (Zak *et al*., 2011) [18]. Data presented in table 1 revealed that zeta potential value was found to be (-12.7 mV), which was in range between (-30 to +30 mV) revealing that nano DAP solution become stable.

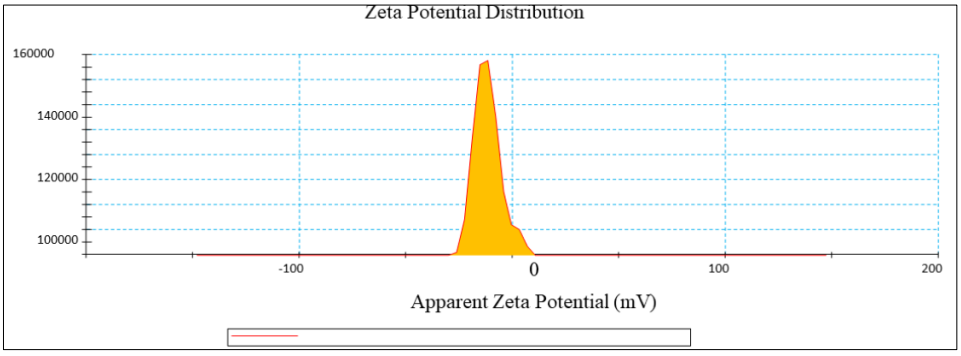

Fig 2: Zeta potential of IFFCO nano Diammonium Phosphate liquid solution

Data presented in table 1 indicated that IFFCO (Farmers Fertilizer cooperative limited) nano DAP contain 8% nitrogen and 16% phosphorus. However, when the fertilizer was analyzed, the actual content was found to be lower, with 4% nitrogen and 8.5% phosphorus. This discrepancy in nutrient content is significant because the plant receives only half of the expected nitrogen and phosphorus. Additionally, the larger particle size of the fertilizer can result in reduced surface area, limiting nutrient contact with soil exchange sites. As a consequence, the efficiency of the fertilizer decreases, and plants may not receive an adequate amount of nutrients for optimal growth.

Moreover, the absence of information about which stabilizing agents add in the nano DAP solution to maintain particle size over a long period of time because nano DAP solution form aggregates when exposed to air. This aggregation can lead to a decrease in zeta potential, causing the particles to disperse in the solution. This could impact the fertilizer's performance and raise questions about its ability to maintain particle size over time and showed adverse impact on crop performance.

Conclusion

It can be concluded that IFFCO (Farmers Fertilizer cooperative limited) nano DAP did not fulfill the nutrient content as well as nano characterization claimed by IFFCO.

Summary

IFFCO provided a sample of their experimental nano DAP (Diammonium Phosphate) product for analysis at the SAIF-DST center. Unfortunately, analysis of particle size, nutrient content, polydispersity index (PDI), and zeta potential revealed that the IFFCO product did not meet desired specifications reported by several research. These parameters fell short of benchmarks established by various research studies, potentially contributing to lower crop yields.

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Competing Interests

Authors have declared that no competing interests exist.

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