



## **NANO-DAP: REDEFINING SUSTAINABLE NUTRIENT DELIVERY FOR FUTURE FARMING**

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Ensuring proper nutrient availability and mobility in soil towards plant system is crucial in enabling better crop yield and to ensure future food security. Recent practices performed from farmers in application of high dose of inorganic fertilizers like urea, DAP, MOP, ZnSO<sub>4</sub>, etc. for proper crop growth and development. Over a period of time, soil equilibrates with optimal level of nutrient, and overdose of application leads to losses without up taking from crop. To overcome such constrains and to ensure high nutrient use efficiency, and crop productivity especially in phosphorus, nano formulated liquid emulsion popularly known for "NanoDAP" which was formulated and released by Indian Farmers Fertiliser Cooperative Limited (IFFCO). This emulsion formulation significantly influences nutrient mobilisation inside cytoplasm, provide a better way for crop development through various physiological attributes.

This article highlights the significant effect of NanoDAP for effective nutrient uptake, increased biomass content, accelerated

photosynthetic efficiency and moreover nutrient use efficiency. Also techniques involved to determine the phosphorus use efficiency were also included at this article.

### **NanoDAP**

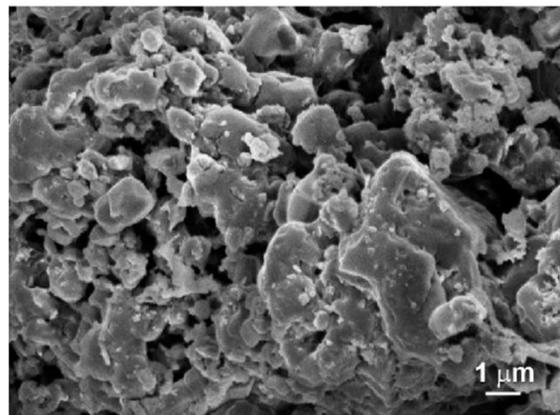
NanoDAP was more popular in agriculture domain since April, 2023. It was formulated and released to farmer usage for getting benefitted purpose in farming system. The delivery was notified under Fertilizer control order. This NanoDAP formulation is liquid oriented, nano-scaled emulsion, which holds nutrients including nitrogen (8%) and phosphorus (16%) in form of P<sub>2</sub>O<sub>5</sub>. This formulated nutrient will be applied to the crops in the form of spraying using knapsack sprayer holding 30litre capacity. It significantly elevates the nutrient absorption by directly entering into the leaf surface thereby quickly it can relocate into plant cell. The physiological entry process is pointed below.

1. Notable, the size of formulation is about < 100 nm. It will be easy to enter the layer of stomata since, the pores size is very much small in stomata, thus NanoDAP can effectively enter into it and passes cuticular pore region.
2. Then the physiological process involving endocytosis and diffusion will be taking place. Here the mesophyll cells were in stage to readily absorb the nano-scaled formulation.
3. Then translocation of nutrient (N&P) takes place seeking vascular system driven in region of phloem. This underscores effective mobilisation of nutrients into all the various parts of the plants within short span of time. These translocate nutrients reaches flowers, fruit, leaves, economic part, and root system which ignites crop growth and development and increased biomass ratio.
4. Thus it will directly attributing to target delivery cell without any loss in nutrients thereby enhancing its NUE.
5. Because nitrogen is an essential nutrient in plant system for synthesising protein molecule, mineralisation, cell functional, etc. In case of phosphorus, it is energy currency for ATP synthesis.

**Characterisation**

The NanoDAP formulation represent excellent stability with particle size ranging from 1-100 nm, poly-dispersive index accounts ranges between 0.2-0.5 depending on method, lowered radioactivity emission of 100-500 kcps, zeta potential (to know the charge on the surface) was found between -30mV to +30mV, and most importantly N and P level was found to be 8 and 16% respectively. In characterising its surface area observation through field emission scanning

electron microscope (FE-SEM), it was observed to be honeycomb like structure (Fig. 1).



**Fig. 1. Nano-Di-ammonium Phosphate seen under FE-SEM(Reagan et al., 2021)**

**Usage and formulation adopted with regard to Nano-DAP**

Recent practices following adoption of both seed treatment practices as well as foliar application.

Sl. No	Method	Rate of application
1	Seed treatment	4-5 ml mixing of formulation per kg of seeds
2	Foliar spraying	2-4 ml/ litre of water especially tillering stage

Other methods are also followed like root drenching where the NanoDAP mixed water solution at the ratio of (1:3) at large volume were poured at the surface base of crop at nearing saturation level for increased uptake and quick recovery of nutrients. Moreover, integrating NanoDAP with other control agents for withholding soil borne pathogens were significantly improves crop productivity and less prone for soil borne infestation.

Highlighting this, Anmol et al. (2024) benefitted higher yield response from maize crop through integrative application of

(50% recommended dose of fertilizer + Nano DAP formulation + Nano Zn composite + Bioneema solution).

**Advantages**

1. Through the optimal dose of applying by foliar spray, the degradation of ecosystem as well as soil micro-organisms doesn't affect and it was environmentally stable, when compared to conventional fertilizer application.
2. High nutrient absorption: By enabling direct application towards foliar, it directly enters into sub-cuticular region, thereby promoting chlorophyll and photosynthetic efficiency via acceleration of RUBISCO enzyme activation in photo system II.
3. It allows the plant for quick recovery of nutrients even under stress situation
4. Reduces fertilizers cost to the farmers, since bags of conventional fertilizers are high in volume and cost. This formulation supports cost effective.
5. Most of the nutrient losses like volatilisation, immobilisation, and leaching loss can be avoided in such case of foliar application of NanoDAP (Sachin et al., 2025).
6. Due to its reduces particle size and enhanced specific surface area, it has high capability of entering into other tissues like seeds, for which it quickly increases seed vigour and health for germination.
7. The self-resiliency of promoting NanoDAP brings easy domestic production under India and better availing towards farming and scientific community, thereby reduces import cost

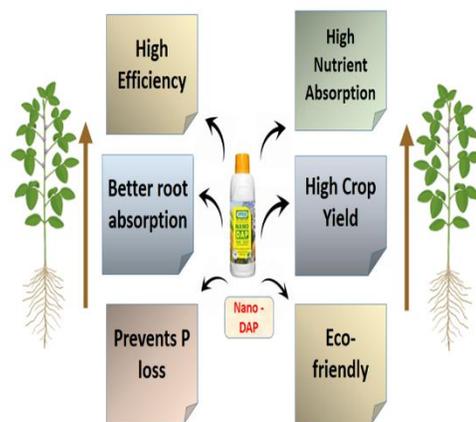
of conventional fertilizers from global scale.

8. Less labour can be involved at field level and cost of cultivation can be reduced seeking high B: C ratio.

**Disadvantages**

1. It was found there is no proper documentation in long term reliability on soil when applying with NanoDAP
2. Stability of formulation can be subjected to change under climatic and temperature fluctuation
3. Since it was cost effective, but it cannot be affordable for all farmers, especially small farmers (Veeramallu et al., 2024).
4. The sprayed nano particle may expose radiation effect towards human health while spraying in the field
5. Sometime, the sprayed formulation on the upper surface of the leaves were subjected to washing once heavy downpour happens. Proper timing and weather prediction is necessary before spraying.

The major advantages employing NanoDAP formulation in agriculture point of view was illustrated in Fig. 2.



**Fig. 2. Advantages of spraying NanoDAP formulation in crops**

### Techniques to Quantify Nutrient Use Efficiency among crops

The direct attributed measurement involving Agronomic Use efficiency (AUE), Apparent Recovery Efficiency (ARF), Physiological Efficiency (PE), Relative Agronomic Efficiency (RAF) and indirect measurement follows chlorophyll content, biomass and growth attributes, yield ratio, and more over percentage of yield obtain (Manish *et al.*, 2024).

**Technique:** Radio Isotope tracing technique can be enacted in determining phosphorus use efficiency in crops. It will be studied using P<sup>32</sup> tracer by labelling.

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