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Utilisation of Nano-Urea Fertilizer in Major Cereal Crops

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Nitrogen is the most crucial nutrient in cereal crops, whereas urea is among the widely used nitrogen fertilizers. A considerable portion of the nitrogen applied is bound to be lost due to leaching, volatilization, runoff, etc. Nano-urea is now known as a new source of nitrogen providing the benefits of improved nitrogen efficiency due to nitrogen in a form of a mixture of nano particles.Use of nano-urea in major cereals like rice, wheat and maize has generated interest in Indian agriculture. The results of the field studies have been encouraging and indicated the positive influence of the combination of the application of nano-urea and the conventional nitrogen fertilizer but show varying results depending on the type of the crop, type of soil and climatic conditions as well as nitrogen rate and timing of application. According to the latest research of ICAR, although nano-urea may appear to deliver nitrogen efficiently to the plants, it cannot be assumed to be a complete replacement of the nitrogen applied to the soil.

Keywords: Nano-Urea, nitrogen-use efficiency, rice, wheat, maize, foliar fertilization, cereals.

Introduction

In India, cereal crops such as rice, wheat and maize are very important for food and nutritional security as they contribute considerably to the vegetative growth of these plants along with the formation of chlorophyll, tillering, leaf area development and grain production. In fact, nitrogen is one of the key inputs in this regard and, therefore, farmers often depend on nitrogen fertilizers, especially urea, to satisfy the needs of their crops. One of the great challenges is that nitrogen provided in the soil does not guarantee that it will be available for plants in full capacity. Depending on various conditions related to the soil/weather/irrigation and management, it is possible to lose nitrogen through volatilization, leaching, runoff and other ways. That is why increasing nitrogen use efficiency (NUE) is one of the key tasks of modern nutrient management. Nano-urea is introduced as a foliar nitrogen fertilizer that aims at satisfying the nitrogen needs of crops. Instead of providing all the nitrogen through the soil, foliar nano-urea is to be sprayed on the plant canopy at specific growth stages.

Figure 1: Foliar application of nano-urea in cereal crops.

Understanding Nano-Urea: The Concept

Nano-urea is non-solid nitrogen fertilizer created through advanced technology at a nano-scale. The key feature of it is that very small-sized particles can effectively deliver nitrogen through leaf spraying. However, one thing to keep in mind is that nano-urea should not be regarded as a substitute for conventional nitrogen fertilizers but rather as a complementary tool for nitrogen management. The effectiveness of nano-urea application depends on several factors including crop needs, crop growth stages, already existing nitrogen in the soil and environmental conditions.

Nano-Urea's Importance for Cereal Crops

Cereal crops have a great need for nitrogen as a result of their high nitrogen requirements. Nitrogen deficiency leads to pale green leaves, reduced tillering, lesser production of biomass and low yield of grain. Foliar fertilization provides an additional method for nutrient application during crop growth. This is why nano-urea can be considered especially effective in cases of urgent nitrogen needs at critical growth periods.

Advantages of its application consist of:

- supplementary nitrogen supply;
- improved nitrogen-use efficiency under suitable conditions;
- reduced dependence on excessive fertilizer application;
- compatibility with precision nutrient management;
- convenient foliar application;
- potential reduction in the quantity of conventional nitrogen fertilizer in selected situations.

Nevertheless, the advantages of using nanourea should be viewed in light of evidence that has been accumulated through research and not just on the assumption that the reaction will be the same in all cases.

Usage in rice production

Rice is considered to be one of the most significant cereal crops in India. There is also a significant need for nitrogen management since nitrogen available makes an impact on tillering, canopy, panicle formation, and grain production. At the ICAR-IARI experiment field site in New Delhi, an experiment was conducted using various combinations of conventional nitrogen and nanourea fertilizer under different irrigation conditions applied to basmati rice. It was established in that experiment that the use of 75 percent of the recommended dose of conventional nitrogen together with two applications of nanourea gave statistically equivalent results to the full recommended dose of nitrogen used in the experiment. However, the performance when the use of nitrogen was reduced to 50 percent of the recommended dose and two applications of nanourea were also included was poorer.A recent ICAR study in the northeastern hill region also reported that **75% recommended nitrogen + two nano-urea sprays** could produce rice performance comparable with 100% recommended nitrogen under the particular experimental conditions. These findings suggest that nano-urea may have value as part of an **integrated nitrogen-management programme**, but it should not automatically be used to eliminate most soil-applied nitrogen.

Use of Nano Urea in Wheat

Wheat needs adequate nitrogen supply throughout its lifecycle, especially at the stages of tillering and reproduction. Therefore, nano-urea as a foliar nitrogen source has been tested.

Studies were conducted in the year 2021-22 and 2022-23 by the Indian Council of Agricultural Research (ICAR)-IIndian Agricultural Research Institute (IARI) on various sources of nitrogen available for wheat. The results indicated that by applying 97.5 kg of nitrogen along with foliar spraying of nano urea, the result did not vary significantly from

that under application of 130 kg nitrogen. However, applying 65 kg of nitrogen with nano-urea was found to be poorer than that achieved under application of 130 kg of nitrogen/ha. Another study conducted by ICAR-IARI postulated that some combinations of reduced nitrogen with the use of nano-urea gave similar results in growth and yield as compared to the previous conventional nitrogen levels. Thus, in the case of wheat, it appears that nano-urea can be used as a supplement to soil-applied nitrogen under specific conditions when the total dose of nitrogen and the requirement of the crop are taken into account.

Usage in Corn

Corn is a crop that requires a considerable amount of nitrogen and hence responds to good nitrogen management practices. At ICAR-IARI, Hazaribagh, Jharkhand, a field experiment was conducted to evaluate nano-urea versus prilled urea under varying nitrogen-management practices during the kharif season of 2022–23. The results of the study indicated that maize yield obtained under 75% recommended nitrogen + two nano-urea applications was in line with the recommended fertilizer treatment thus indicating the possibility of lowering the use of traditional nitrogen in certain conditions. This finding is important in the maize-growing regions as it indicates that nano-urea can serve as an additional tool for integrated nitrogen management when used in conjunction with other nitrogen sources.

Comparison of Nano-Urea Use in Major Cereal Crops

Table 1: Research evidence on nano-urea utilisation in major cereals

Crop	Potential role of nano-urea	Research observation
Rice	Supplementary foliar N	75% RDN + 2 sprays performed similarly to 100% RDN in selected trials
Wheat	Supplementary N during crop growth	Some reduced-N + nano-urea treatments produced comparable yield
Maize	Complementary N source	75% RDN + 2 sprays showed comparable yield to recommended treatment in one ICAR-IARI study
Finger millet	Supplementary N	Response has been variable in trials
Rice–wheat system	Integrated N management	Response depends on location and nitrogen strategy

RDN means Recommended Dose of Nitrogen. Outcomes depend on the experiments conducted and cannot be viewed as general recommendations.

Correct Application Strategy

Nano-urea is used mainly in foliar spray rather than in conventional soil application of urea fertilizer. The timing of application is important because the crop's demand for nutrients changes with the crop growth stages.

Table 2: Important considerations for field application

Factor	Importance
Crop stage	Application should coincide with important crop nutrient-demand periods
Spray concentration	Follow the product label and locally recommended dose
Water quality	Suitable water should be used for spraying
Weather	Avoid spraying immediately before rainfall
Leaf coverage	Uniform canopy coverage is important
Conventional N	Do not reduce soil-applied N arbitrarily
Crop condition	Nutrient application should consider crop growth and deficiency
Compatibility	Tank mixing should be done only when compatibility is established

The ICAR's kharif advisory 2025 has suggested that for maize cultivation, nano-urea should be applied at 4 ml/L at various stages of growth and insists on nutrient management specific to individual crops.

Benefits of Nano-Urea

There is a possibility of enhanced efficiency of nitrogen utilization; through foliar application, nitrogen can reach the canopy and can also act as a supplement to soil-applied nitrogen.

Lower conventional nitrogen requirement in selected situations

Several recent field experiments indicate that partial replacement of conventional nitrogen may be possible under specific crop and environmental conditions.

Easy transport and application

Because it is a liquid formulation used at relatively small application volumes, transportation and handling can be convenient.

Integration with precision nutrient management

Nano-urea can be incorporated into approaches based on crop growth, leaf colour, soil testing and other indicators of nitrogen demand.

Limitations and Research Concerns

The performance of nano-urea is not uniform across all crops and locations. This is an important aspect for farmers and agronomy professionals. Government/ICAR communication summarising research from multiple institutions reported crop- and location-specific responses. In some experiments, replacing 50% of recommended nitrogen with two nano-urea sprays resulted in lower grain yields in rice and wheat. Other trials found positive responses when only 25% of recommended nitrogen was replaced. For example, the same ICAR assessment reported reductions in rice and wheat grain yield under a treatment consisting of 50% RDN plus two nano-urea sprays compared with 100% soil-applied RDN in a Punjab rice–wheat experiment. This evidence demonstrates why nano-urea should not be promoted as a blanket replacement for conventional nitrogen.

Intellections Related to Economics and Environment

Following the use of nano-urea by farmers to have their crops cultivated with lesser quantity of conventional nitrogen, the fertilizer requirement is expected to have reduced. Such enhancement will have positive bearing on the environment if the amount of nitrogen lost is actually reduced and also if there is improvement in the total nutrient management system. From the economic perspective, it is necessary to focus on the costs of the product, its yield, savings on conventional fertilizers during production and those of labor and application of nano-urea. Consequently, farmers should assess the advantages of nano-urea taking into consideration the crop yield, total amount of nitrogen applied, costs of fertilizers rather than peering just at the price of one bottle of nano-urea and one bag of urea.

Future Prospects

The future of nano-urea research should focus on:

- crop-specific recommendations;
- location-specific nitrogen management;
- long-term soil effects;
- nitrogen-use efficiency;
- grain quality and protein content;
- interaction with irrigation and weather;
- compatibility with precision nutrient management;
- economic analysis at farmer-field scale.

ICAR has initiated a five-year network project covering 14 centres, 10 major agro-ecological zones and 12 major crops to evaluate nano-urea in relation to crop productivity and nitrogen-use efficiency. Such long-term studies are important because short-duration experiments may not fully explain the agronomic and environmental consequences of repeated nano-fertilizer use.

Conclusion

Nano-urea represents an interesting development in modern nitrogen management. Research in rice, wheat and maize indicates that it can have a useful role when integrated with conventional nitrogen fertilizer and applied at appropriate crop stages. In selected experiments, partial reduction in conventional nitrogen has been possible without significant yield reduction. At the same time, current evidence shows that the response is crop-, location- and management-specific. For this reason, nano-urea shouldn't be viewed as a panacea for soil application of urea. Scientific nitrogen management should combine soil testing, recommended nitrogen doses, crop requirement, appropriate application timing and, where validated, foliar nano-urea. The most promising approach is therefore "integrated nitrogen management" rather than complete replacement of conventional nitrogen by nano-urea. Continued multi-location and long-term research will be essential for developing reliable recommendations for Indian cereal production.

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