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Effect of nano urea on growth, yield, and nutrient efficiency in potato (*Solanum tuberosum* L.): A review

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Abstract

Potato (*Solanum tuberosum* L.) is a nitrogen-intensive crop, traditionally reliant on conventional urea fertilizers that often result in low nitrogen use efficiency (NUE) and significant environmental losses. Nano urea, a foliar-applied nanotechnology-based fertilizer, offers a promising alternative by enhancing nutrient uptake and minimizing nitrogen wastage. Recent field trials in West Bengal and Haryana have demonstrated that integrating nano urea with reduced doses of conventional nitrogen and micronutrients, such as zinc sulfate (ZnSO₄), significantly enhances vegetative growth, chlorophyll content, and tuber yield. Treatments involving nano urea recorded improved physiological traits and higher NUE, up to 15.30% compared to full recommended doses of traditional fertilizers. Its nanoscale formulation (30-50 nm) facilitates efficient foliar absorption and targeted nitrogen delivery, aligning well with sustainable nutrient management practices. Economically, nano urea reduces input costs while enhancing productivity, making it a viable option for resource-efficient farming. However, challenges such as limited farmer awareness and the need for region-specific application protocols remain. Overall, nano urea represents a forward-looking innovation in nitrogen management for potato cultivation, contributing to improved yield, economic viability, and environmental sustainability.

Keywords: Nano urea, potato, nitrogen use efficiency, foliar, sustainable, tuber yield, nanotechnology

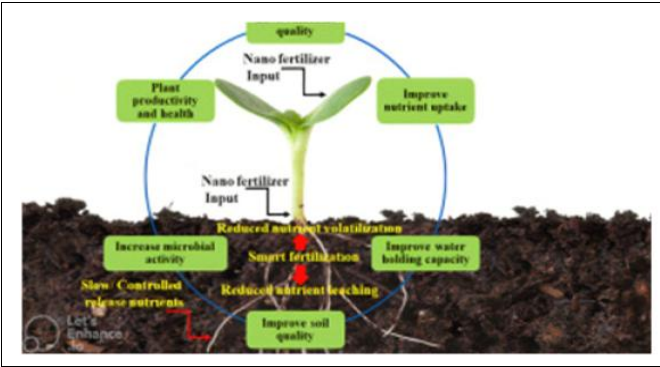
Introduction

Potatoes are one of the world's most important food crops, yet their high nitrogen demand and sensitivity to nitrogen management pose significant challenges for growers. Traditionally, farmers have relied on conventional urea fertilizers to meet this need, but these often prove inefficient, with less than 40% of the applied nitrogen actually utilized by the plant, with the remainder lost to the environment, leading to pollution and financial waste (Singh, Kumar and Sharma, 2022) ^[31]. To address this issue, a novel solution known as nano urea has been developed using advanced nanotechnology. Produced by the Indian Farmers Fertilizer Cooperative (IFFCO), nano urea is packaged in a compact 500 ml bottle containing 4% nitrogen. Its key innovation lies in its ultra-small particle size, ranging from 30 to 50 nanometers, which allows the fertilizer to be sprayed directly onto the leaves. This enables more efficient nutrient absorption, minimizes nitrogen loss, and supports environmentally sustainable farming practices (Suthar, Desai and Desai, 2023) ^[34]. As a result, nano urea offers a more innovative, cleaner approach to crop nutrition, helping farmers improve productivity while protecting natural resources.

Table 1: Nano Urea vs Conventional Urea - Growth Parameters (Rani *et al.*, 2024) ^[27]

Parameter	Conventional Urea	Nano Urea (Foliar)
Plant Height (cm)	45.2	52.6
Leaf Area Index	3.1	4.2
Chlorophyll Content	2.8 mg/g FW	3.6 mg/g FW
Dry Matter (%)	18.5	21.3

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Nano urea's ultra-small nitrogen particles allow it to pass through the leaf surface and into the plant's internal transport system, where the tissues absorb it directly. This will enable it to function with exceptional efficiency (IPCC, 2014) [10]. This targeted nutrient delivery minimizes nitrogen losses due to evaporation and leaching, enhances photosynthetic activity, and allows farmers to apply significantly less fertilizer without

compromising crop performance (Govindasamy *et al.*, 2023) [40]. Field trials on potato have shown clear improvements in plant growth, including taller plants, broader leaf coverage, richer green foliage due to elevated chlorophyll levels, and stronger root development (Dutta *et al.*, 2023) [6]. These physiological enhancements contribute to better nutrient uptake and overall plant vigour. Yield outcomes have been equally promising; studies conducted in West Bengal and Gujarat revealed that using only half the conventional nitrogen dose, along with full phosphorus and potassium and two foliar sprays of nano urea, increased potato yields by 15-20% compared to standard fertilizer practices. Among the tested treatments, T-7 emerged as the most effective, delivering the highest tuber count and proving more economical due to reduced input costs and improved productivity (Dutta *et al.* 2023) [6]. These findings underscore nano urea's dual advantage-environmental sustainability and economic viability-making it a compelling choice for modern potato cultivation.

Table 2: Summary of Field Trial Results

Location	Treatment Description	Tuber Yield (t/ha)	NUE (%)	Benefit-Cost Ratio	References
West Bengal	Nano Urea + 50% N + ZnSo ₄	32.5	73.48	2.8	Singh <i>et al.</i> , 2023 [48]
Gujarat	Nano Urea (2 Sprays) + Full P & K	30.2	68.90	2.5	Suthar <i>et al.</i> , 2023 [34]
Haryana	RDF (100% NPK)	26.0	58.20	1.9	Monika <i>et al.</i> , 2024 [47]

Nano urea is redefining how crops utilize nutrients by providing a more precise and efficient method for plants to absorb nitrogen. In contrast to traditional fertilizers, it releases nitrogen in accordance with the crop's growth stages, guaranteeing that the plant receives the necessary nutrients at the appropriate time. This not only reduces waste but also improves uptake, especially in nitrogen-deficient soils. Applying nano-urea at critical growth phases can significantly enhance nitrogen use efficiency (NUE), leading to improved crop performance and supporting more sustainable farming practices (Suthar, Desai, and Desai, 2023)

[34]. Beyond its agronomic benefits, nano-urea also offers notable environmental advantages (Tripathi *et al.*, 2020) [39]. It helps lower greenhouse gas emissions, minimizes chemical residues in the soil and encourages healthier microbial activity. By preventing salt accumulation and improving overall soil health, nano urea plays a vital role in climate-smart agriculture and precision nutrient management (Singh *et al.*, 2022) [31]. In essence, it's not just a fertilizer-it's a forward-thinking tool for building resilient, productive, and eco-friendly farming systems.

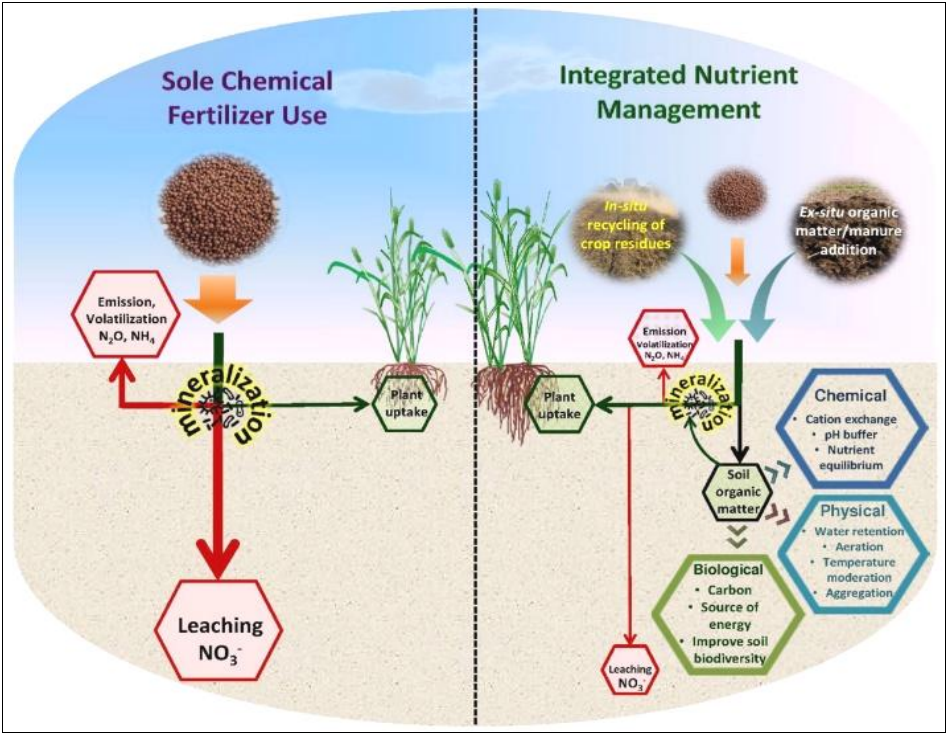


Fig 1: Integrated nutrient management

Nano Urea Production and Properties

Conventional urea must have its particle size reduced to less than 100 nm to be produced as nano urea. The fertilizer's solubility and reactivity are enhanced by the increase in surface area of the particles brought about by the reduction in particle size. It is a desirable option for sustainable agriculture due to its many qualities, including improved water solubility, increased fertilizer usage efficiency, and fewer environmental effects. It is typically produced using two methods: top-down and bottom-up. The top-down method involves chemically or mechanically reducing urea particles to the nanoscale. The bottom-up approach, on the other hand, involves chemically assembling urea molecules into nanoscale particles. Greater solubility compared to conventional urea, increased mobility in the soil, and improved plant absorption are just a few of the unique characteristics of the finished nano urea product. Additionally, compared to conventional urea, the nano urea particles release nitrogen more slowly, which reduces nutrient leaching and promotes more controlled nitrogen release (Kumar *et al.*, 2023)

[41].

Table 3: The main characteristics of the IFFCO Nano Urea (Jangir *et al.*, 2021) [12]

Characteristics	Nano Urea	Conventional Urea
Invention	2021	1823
Technology	Nanotechnology	Conventional method
Particle size	32 nm	1 mm
Use efficiency	85-90%	30-40%
Price	240/-	266.50/-
Storage	Very less area	Very high area
Pollution	No	Air, water and soil
Vaporization	No	Yes
Soil residual	No	Yes
Effect on soil	Enhance quality	Acidifies soil
Availability in the plant	Throughout the life cycle	3-4 days
Effect on crop maturity	Maturity on time	Early maturity
Intake medium	Direct through leaves	Through roots
Method of use	Spray	Top dressing

Table 4: Impact of Nano Urea on Tuber Crop Performance

Parameter	Observation	Details	References
Growth Parameter	Enhanced vegetative vigour, chlorophyll content and LAI	Due to improved nitrogen assimilation	Dey <i>et al.</i> , 2025 [5]
Yield Improvement	15-20% increase in tuber yield	Achieved via split foliar doses during critical growth stages	Al-juthery <i>et al.</i> , 2019 [50]
Nutrient Efficiency	Improved Nitrogen Use Efficiency (NUE)	Reduced leaching and volatilization; optimal at 2.5 ml/L during key stages	Masayya <i>et al.</i> , 2023 [51]
Soil Health	Maintains soil organic carbon and microbial activity	Promising long-term effects; more longitudinal studies needed	Yashaswini <i>et al.</i> , 2025 [52]
Economic Visibility	Higher benefit-cost ratio	Lower input costs and higher yields, better returns for resource-limited farms.	Kumar <i>et al.</i> , 2024 [53]

Growth Parameters

By facilitating better nitrogen absorption and utilization by plants, nano urea significantly increases vegetative growth. Improved nitrogen assimilation increases the leaf area index (LAI) and directly stimulates the production of chlorophyll, two key indicators of robust, healthy development. Nano urea has been demonstrated to dramatically increase plant height, LAI, and dry matter accumulation when administered at key developmental periods. In fact, Rani *et al.* (2024) [27] observed that wheat plants treated with nano urea displayed stronger vegetative vigour and higher LAI compared to those receiving conventional urea, pointing to better nitrogen uptake and utilization. Its ultra-small particle size enables rapid absorption and effective plant transport, thereby improving photosynthetic efficiency and increasing biomass production. As a result, it is not only a technological advancement but also a valuable tool for enhancing crop yield and quality.

Yield Improvement

With production improvements of 15-20%, the application of nano urea via split foliar sprays has demonstrated remarkable benefits, particularly during critical stages such as tuber start and bulking. Better timing and availability of nitrogen when the crop needs it most are mainly responsible for this boost. Nano urea helps lessen nitrogen stress and promotes more robust growth by timing nutrient delivery with the times when the plant is most in need of them. Singh *et al.* (2025) [30] highlighted that foliar applications of nano-urea at concentrations of 2.5-4 ml/L during these critical phases significantly improved both grain and tuber yields, outperforming traditional nitrogen practices. The key to success lies in how well nano urea coordinates crop

development and nutrient supply, providing the plant with the best support at its most vulnerable growth stages. In addition to increasing output, this strategy represents a more intelligent and adaptable method of field nutrient management.

Nutrient Use Efficiency (NUE)

In terms of nutrient management, nano urea is revolutionizing the field by providing a more sustainable and intelligent method of increasing nitrogen usage efficiency (NUE). More of the applied nitrogen will genuinely benefit the crop if nitrogen losses from leaching and volatilization are kept to a minimum. Its foliar application, which delivers nutrients straight to the plants for rapid and efficient absorption, increases its effectiveness even more. According to Charjan *et al.* (2025) [4], nano urea treatments significantly outperformed traditional soil-applied urea, with NUE levels as high as 73.48%. In addition to improved yields and healthier crops, this is a big step in minimizing environmental damage and maximizing our agricultural resources.

Soil Health

Early research suggests a promising role for nano urea in promoting soil health. By better matching nitrogen release to crop needs, excesses that frequently upset soil ecosystems can be avoided (Jeyarajan *et al.* 2021; Kanno *et al.*, 2022)) [13, 14]. According to Singh *et al.* (2025) [30], this kinder method results in fewer nitrogen runoff and leaching factors, which may help microbial communities and indirectly maintain soil structure (Henning *et al.*, 2012) [8] Although long-term evidence is still being gathered, the potential is evident: using nano urea for sustainable nitrogen management could improve crop

performance and protect soil fertility for future growing seasons (Hunter *et al.*, 2017)^[9].

Economic Viability

By providing a more intelligent and efficient method of fertilizing, nano urea is revolutionizing the economics of farming Kiran *et al.* 2021^[15]. Without compromising yields, it helps farmers save a significant amount of money on inputs by lowering the amount of fertilizer needed. This is highly helpful in resource-constrained contexts where every penny counts. It was claimed that nano-urea treatments yielded results comparable to those of full-dose conventional urea at a substantially reduced cost (Rani *et al.*, 2024)^[27]. The greater benefit-cost ratio, which is driven by reduced costs and higher productivity, is the real victor. Because of this combination, nano urea is both inexpensive and effective (Ghormade *et al.*, 2011)^[7].

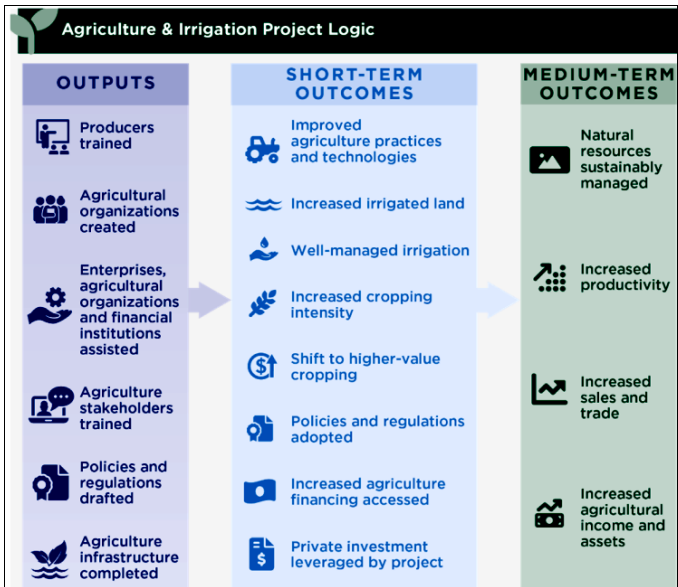


Fig 2: Agriculture and irrigation project logics

Crop-Specific physiological information

1. Photosynthetic Rate Enhancement

Due to its tailored nitrogen administration and rapid foliar absorption, nano urea significantly enhances photosynthetic efficiency. Better penetration through leaf cuticles and stomata is made possible by the nanoscale size (~20-30 nm), which improves nitrogen uptake and chlorophyll production (Nityamanjari *et al.*, 2018)^[22]. When nano urea was applied topically to *Arabidopsis thaliana*, the amount of chlorophyll rose by 0.5 mg g⁻¹ and the amounts of amino acids rose by 28.8 mg g⁻¹, which was directly related to higher photosynthesis (Dey *et al.*, 2025)^[49]. Utilizing nano fertilizer raises the proportion of dry matter, speeds up photosynthesis, and causes tubers to bulk up in potato (Hoque *et al.*, 2024)^[42]. The application of nanonutrients and biofertilizer raised the amount of chlorophyll in potatoes, which is vital for photosynthesis, leaf colour, and overall plant growth (Babaeian *et al.*, 2011)^[43]. In Chinese potatoes, canopy formation and the source strength for photosynthesis were positively impacted by availability at the target areas (Gopika *et al.*, 2024)^[44].

2. Stomatal Conductance

The high zeta potential of nano urea (-54.7 mV) makes it easier for stomata to absorb it, which enhances gas exchange and stomatal conductance. Increased transpiration efficiency and CO₂ assimilation result from this (Kottegoda *et al.*, 2017)^[16]. Maintaining nitrogen availability through a regulated release mechanism promotes stomatal function and lessens stress-induced closure (Dey *et al.*, 2025; Pooja *et al.*, 2023)^[5, 24].

3. Root Architecture Modulation

By encouraging lateral root growth and elongation, nano urea affects root shape. In root meristems, increased nitrogen availability promotes auxin production and cell division (Pandey *et al.*, 2024)^[23]. Research on maize and potatoes has revealed deeper rooting profiles and increased root biomass, which improve water and nutrient uptake (Nisha *et al.*, 2025)^[21].

Table: Root architecture modulation in potato crop

Parameter	Bulk Urea	Nano Urea	% Increase
Chlorophyll (mg g ⁻¹)	2.1	2.6	+23.8%
Photosynthetic Rate	12.5 μmol CO ₂ m ⁻² s ⁻¹	15.8 μmol CO ₂ m ⁻² s ⁻¹	+26.4%
Stomatal Conductance	0.32 mol H ₂ O m ⁻² s ⁻¹	0.41 mol H ₂ O m ⁻² s ⁻¹	+28.1%
Root Biomass (g plant ⁻¹)	3.8	5.1	+34.2%

Environmental impact assessment

1. Lifecycle Analysis: Nano Urea vs. Conventional Urea

A comparative lifecycle assessment (LCA) reveals that nano urea offers substantial environmental advantages over conventional urea across all phases of production, application, and post-application (Table). With an astounding efficiency of up to 85%, liquid nano urea significantly outperforms its

conventional counterpart, which operates at only 25-30% efficiency (Kumar *et al.*, 2019; Kumar *et al.*, 2022)^[45, 17]. Liquid nano urea offers an environmentally sustainable crop feeding option in addition to being economical. Its lower application needs compared to traditional urea improve crop nutrient efficiency while reducing air, water, and soil pollution (Iqbal, 2019; Kumar *et al.*, 2021)^[11, 46].

Table: Comparative assessment between conventional urea and nano urea.

Lifecycle Stage	Conventional Urea	Nano Urea
Production	High-energy-intensive Haber- Bosch process	Lower energy input due to nano-scale synthesis
Packaging & Transport	Bulkier, higher volume per hectare	Light weight, reduced packaging waste
Application Efficiency	~30-40% nitrogen use efficiency (NUE)	>80% NUE due to targeted foliar uptake
Leaching & Runoff	Significant nitrate leaching	Minimal leaching due to controlled release
Environmental Burden	High GHG emissions, eutrophication risk	Reduced emissions and lower ecological impact

By reducing nitrogen losses through volatilization and leaching, the foliar application of nano urea minimizes eutrophication and groundwater contamination (Nisha *et al.*, 2025)^[21].

2. Nanoparticle Behaviour in Soil Ecosystems & Ecotoxicology

Nano urea particles interact differently with soil matrices compared to bulk fertilizers:

Mobility and Retention: The higher surface area and reactivity of nanoparticles enhance adsorption to soil colloids, thereby decreasing movement outside the root zone (Mejías *et al.*, 2021)^[19].

Microbial Interactions: Research indicates that when treated at agronomic levels, nano urea does not substantially alter microbial biomass or enzymatic activity (Dey *et al.*, 2025; Sarwar *et al.*, 2018)^[5, 28].

Ecotoxicological Risk: Current formulations of nano urea are designed for low-dose, high-efficiency use, which mitigates

toxicity concerns, even though nanoparticles can be hazardous at high quantities (Mukherjee *et al.*, 2019)^[20]. To evaluate cumulative effects on soil fauna and microbial diversity, longer-term research is still required.

3. Carbon Footprint Reduction Estimates

Nano urea reduces greenhouse gas (GHG) emissions, which helps with climate-smart agriculture:

Production Emissions: Compared to conventional urea, nano urea synthesis emits around 40-60% less CO₂ per kilogram of nitrogen (Nisha *et al.*, 2025; Pramanik *et al.*, 2020)^[21, 25].

Application Emissions: Reduced volatilization of ammonia and nitrous oxide (N₂O) leads to ~30-50% lower field-level emissions. (Ghule *et al.* 2025)^[54].

Overall Impact: Depending on the crop and environment, switching to nano urea might lower the carbon footprint of nitrogen fertilization by as much as 0.5 to 1.2 tons CO₂-equivalent per hectare per year (Raliya *et al.*, 2017)^[26].

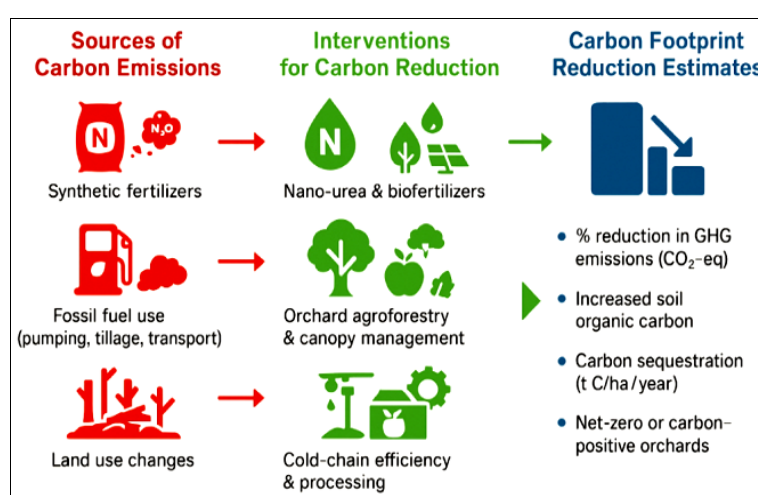


Fig 3: Greenhouse gas sources and sinks

Limitations & Research Gaps

Unquestionably, recent advancements in sustainable agriculture have enabled the effective application of certain nano- fertilizers to increase crop yields. Shubha *et al.*, 2021)^[29]. The agricultural industry greatly benefits from nano-fertilizers, as they increase productivity and enhance resistance to abiotic stress. Additionally, given the current climate change situation, there is considerable interest in enhancing the crop yield capacity due to the potential benefits of nanofertilizers. However, the intentional use of this technology in farming operations may have numerous unintended, irreversible consequences. Some of the limitations are:

Lack of Multi-Location Trials

Although nano urea has shown encouraging results in controlled settings, it has not been thoroughly evaluated in a variety of agroclimatic zones. The majority of research is region-specific, which restricts its applicability (Soundarya *et al.*, 2024).^[32] The creation of location-specific recommendations is hindered by the scarcity of multi-location trials, particularly for crops grown in diverse soil and climate conditions (Bisht *et al.* 2025)^[3]. Agronomic advice remains speculative and may not be suitable for heterogeneous farming systems in the absence of solid, multi-location data (Suman and Yadav, 2022)^[33].

Limited Understanding of Nutrient Interactions

It remains unclear how nano urea interacts with other vital nutrients, particularly phosphorus (P) and potassium (K) (Trehan *et al.*, 2013)^[38]. Although nitrogen supply has improved, little is known about the synergistic or antagonistic effects with macro- and micronutrients (Swaminathan, 2011)^[35]. Nano urea lacks multi-nutrient support and cannot completely replace conventional fertilizers, which could result in nutritional imbalance if applied alone (Agriplanting 2024)^[1]. To prevent inadequacies or antagonistic reactions, integrated nutrient management systems need to take into account how well nano urea works with other fertilizers (Taheri and Abdollahzadeh, 2019)^[36].

Need for Standardized Protocols

Regarding the frequency, dosage, and time of nano urea foliar treatment, there is no widely recognized methodology. Farmers often rely on manufacturer instructions or trial-and-error methods, which may not be tailored to specific crops or regions. The necessity of agronomic standardization to maximize effectiveness and reduce misuse is emphasized by Bisht *et al.* (2025)^[3]. Standardized procedures would lessen performance variability in the field and guarantee consistent outcomes.

Insufficient Data on Residual Effects and Environmental Safety

Uncertainty surrounds the long-term environmental effects of nano urea, including its impact on ecological toxicity, groundwater contamination, and soil microbiology. Although nano urea lowers nitrogen discharge, little is known about how its nanoparticles behave in soil ecosystems (Tarafder, *et al.*, 2022)^[37].

As noted in many research studies, environmental safety uncertainty remains a significant concern (Agriplanting, 2024; Pandey, 2024)^[1, 23]. The sustainability qualities of nano urea require further ecological and toxicological research.

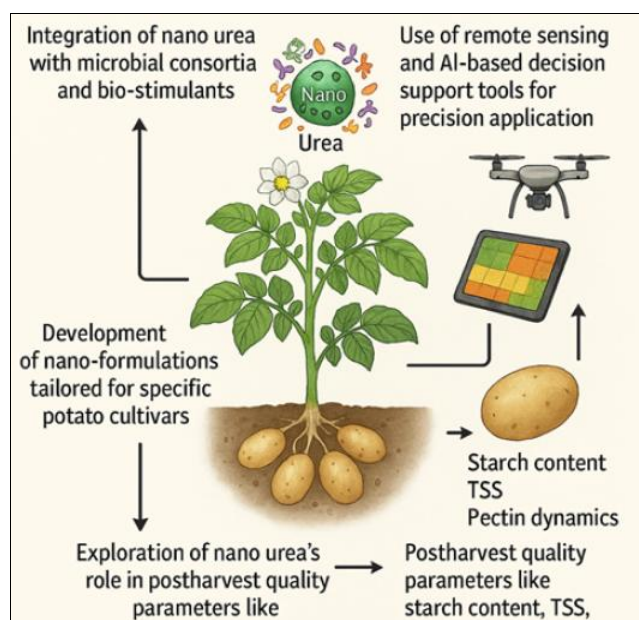


Fig 4: Future Directions of using nano technology in agriculture

Future Directions

Researchers need to explore how nano-urea interacts with other nano-nutrients, such as zinc and copper, and how it fits into precision farming technologies. Additionally, they should investigate the potential impact of nano-urea on post-harvest quality and storage. Some of the future trends in using nano fertilizers are highlighted in figure.

Integration with Microbial Consortia and Bio-Stimulants

A synergistic approach to nutrient management is provided by combining nano urea with biostimulants and microbial inoculants. While nano urea delivers nitrogen precisely, microbial consortia including *Azospirillum*, *Azotobacter*, and phosphate-solubilizing bacteria improve nutrient uptake. Hybrid maize treated with *Azophos* microbial inoculants and nano urea exhibited notable increases in grain production, cob length, and nitrogen utilization efficiency (Bhoopesh *et al.* 2024)^[2]. By encouraging rhizosphere connections and enzyme activity, this integration fosters sustainable intensification. These combinations may increase the resilience of soil health and lessen reliance on chemical fertilizers.

Tailored Nano-Formulations for Specific Potato Cultivars

By creating nano urea formulations tailored to individual cultivars, nutrition delivery might be optimized according to physiological and genetic characteristics. The kinetics of nitrogen uptake, canopy structure, and tuber bulking rates vary amongst potato cultivars. Personalized nano formulations that

are modified for carrier matrix, release rate, and particle size may improve yield and quality. In order to address crop-specific nutritional demands and environmental conditions, Lohar *et al.* (2023)^[18] emphasized the necessity of customized nano technologies. Precision nano-fertilization has the potential to decrease general recommendations and transform cultivar-specific agronomy.

Remote Sensing and AI-Based Decision Support Tools

Precision agriculture can be made possible by combining the use of nano urea with AI-driven platforms and remote sensing. Site-specific foliar spraying can be guided by real-time monitoring of crop nitrogen status using drones, satellite imaging, and spectral indices (e.g., NDVI). AI systems can forecast the optimal times, doses, and spatial variability for spraying. This strategy promotes climate-smart farming, reduces misuse, and improves NUE. Nano urea can be converted from a static input into a dynamic, responsive nutrient solution using digital agronomy techniques.

Postharvest Quality Enhancement

Emerging research suggests that postharvest characteristics, such as pectin dynamics, total soluble solids (TSS), and starch concentration, may be influenced by nano urea. Processing quality, shelf life, and tuber texture are all impacted by these characteristics. Nano urea may change cell wall metabolism and glucose partitioning by adjusting nitrogen availability during bulking and maturation. To measure these effects, however, focused research is required as there is a dearth of empirical evidence. Gaining insight into the biochemical effects of nano urea on post-harvest physiology may lead to new opportunities for quality improvement.

Conclusion

Precision agriculture and sustainable nutrient management have advanced significantly with the use of nano-urea in potato farming. Nano urea is a highly targeted and ecologically friendly substitute for traditional urea, which is prone to volatilization, leaching, and poor uptake. Its foliar spraying technique and incredibly small particle size allow for accurate nutrient delivery straight to the plant's metabolic regions, improving nitrogen uptake and utilization. This significantly reduces nitrogen losses to the environment while enhancing vegetative development, increasing chlorophyll content, and yielding a noticeable increase in tuber production.

By reducing chemical overload and runoff, such efficiency not only promotes climate-resilient farming methods but also improves soil health. In terms of economics, nano urea makes a strong argument because it lowers the cost of fertilizer inputs, requires less labour, and increases output, making it a good option for both large-scale commercial operations and smallholders with limited resources. Additionally, it opens up new possibilities for comprehensive crop nutrition strategies due to its compatibility with integrated nutrient management systems and possible interaction with other nano-formulated fertilizers. Although recent results from pilot field trials and controlled tests are encouraging, further extensive validation is necessary. They must be evaluated for consistency, scalability, and adaptability under actual farming conditions through long-term, multi-location studies in a variety of agro-climatic zones. Future studies should also examine how it interacts with soil microbes, how it improves postharvest quality attributes, including shelf life, texture, and nutritional content, and how it affects ecosystem services over time. Nano urea has the potential to

revolutionize nitrogen fertilization paradigms in potato farming if these aspects are fully investigated and taken care of. This would usher in a period of more intelligent, profitable, and sustainable agriculture that aligns with the demands of food security and global sustainability.

Author contributions

Conceived and designed the analysis, collected the data, contributed the data or analysis tool, performed the analysis, and wrote the paper.

Compliance with ethical standards

Conflict of Interest: The authors declare that they have no competing interests.

Ethical issues: None

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