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Farmers' perception towards benefits and challenges of nano fertilizers: Evidence from Raipur district, Chhattisgarh, India

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Abstract

Nano-fertilizers, particularly the Indian Farmers Fertiliser Cooperative's (IFFCO) Nano Urea and Nano DAP, have been promoted across India as an efficiency-enhancing alternative to conventional granular fertilizers. While the agronomic performance of these formulations has been documented in field-trial literature, the extent to which adopting farmers themselves perceive these products to be beneficial, and the operational constraints they continue to encounter, remains comparatively under-examined at the block level. This paper analyses the perception of 51 Nano-fertilizer-adopting farmers (31 from Abhanpur block and 20 from Dharsiwa block) of Raipur district, Chhattisgarh, towards the benefits and challenges of using Nano Urea and Nano DAP, using a structured interview schedule and a 5-point Likert Scale Matrix. Weighted Mean Scores (WMS) were computed for five benefit statements and six constraint statements. Farmers reported near-maximal agreement on ease of handling and transportation (WMS 5.00), eco-friendly nature and low run-off risk (WMS 5.00), and improvement in crop quality (WMS 4.88), with a comparatively lower though still positive score for ease of foliar spraying application (WMS 4.00). Lack of technical knowledge regarding Nano-technology emerged as the sole constraint rated at a medium level; all other operational constraints were rated low by the entire sample. All respondents expressed an intention to repurchase and to recommend the product to fellow farmers. The findings indicate that sustained institutional training, rather than further product-level intervention, is the more binding lever for consolidating adoption in the study area.

Keywords: Nano Urea; Nano DAP; farmer perception; Likert scale; Weighted Mean Score; Chhattisgarh

Introduction

A substantial share of the nitrogen applied through conventional prilled urea is lost through volatilisation, leaching and run-off rather than being taken up by the crop, imposing both an economic and an environmental cost (Kakade *et al.*, 2025; Yadav *et al.*, 2023) ^[3, 7]. In response, the Indian Farmers Fertiliser Cooperative (IFFCO) developed Nano Urea, a liquid nanoparticle-based formulation, and extended the platform to phosphatic nutrition through Nano DAP (Kumar *et al.*, 2023) ^[4]. Multi-location field demonstrations have reported yield parity or improvement under partial substitution of conventional fertilizer with these Nano formulations (Kumar *et al.*, 2023; Ghule *et al.*, 2025) ^[4, 2].

Nano fertilizers in India have diffused principally through Primary Agricultural Credit Societies (PACS) rather than open retail markets, an institutionally mediated pathway consistent with the classical diffusion-of-innovation framework, in which adoption depends on a technology's compatibility with existing practice and the strength of the

cooperative and peer networks through which farmers learn about it (Rogers, 2003) ^[6]. Existing literature has concentrated heavily on agronomic and economic performance under trial conditions, with comparatively little attention paid to how already-adopting farmers perceive the benefits and constraints of these products under normal field conditions (Kakade *et al.*, 2025; Yadav *et al.*, 2023; Ghule *et al.*, 2025) ^[3, 7, 2]. This gap matters because a technology can perform well agronomically while still facing an addressable perceptual or operational constraint that limits full-scale, unassisted adoption once initial subsidised demonstrations end.

From a policy standpoint, the perception dimension is not a secondary consideration to agronomic performance but a determinant of whether documented agronomic gains translate into sustained, unassisted farm-level use once initial subsidised demonstrations and cooperative push end. A farmer who finds a foliar-spray regimen difficult to execute correctly, or who remains unsure why a 500 ml liquid bottle is agronomically equivalent to a much larger bag of granular fertilizer, may under-apply, mis-time, or eventually abandon

the input irrespective of its measured field performance under trial conditions.

This paper isolates one objective of a larger farm-level investigation conducted in Raipur district, Chhattisgarh namely, to analyse the perception of farmers towards the benefits and challenges of using Nano fertilizers in the study area. It reports Weighted Mean Scores derived from a 5-point Likert Scale Matrix administered to 51 adopting farmers, and discusses the pattern of results against the wider literature on Nano-fertilizer performance and diffusion.

2. Methodology

2.1 Study Area

The study was conducted in Raipur district of Chhattisgarh, located in the fertile Chhattisgarh Plains agro-climatic zone. Raipur was purposively selected on account of its strong cooperative network and high market penetration of IFFCO's Nano Urea and Nano DAP through Primary Agricultural Credit Societies (PACS), field demonstrations, and extension programmes. Within the district, Abhanpur and Dharsiwa blocks were purposively selected on the basis of their relatively higher sales, consumption, and market performance of Nano fertilizers.

2.2 Sampling and Data Collection

A total of 51 Nano-fertilizer-adopting farmers were selected for the study 31 from Abhanpur block and 20 from Dharsiwa block all of whom used both conventional and Nano fertilizers in their farming practice. Fertilizer dealers and wholesalers were excluded to keep the focus strictly on farmer-level behaviour and perception. Primary data were collected through a structured interview schedule administered by personal interview during the agricultural year 2025-26. The schedule included a dedicated section recording farmers' agreement with statements on the perceived benefits of Nano fertilizers and the operational constraints they faced in using them.

2.3 Likert Scale and Weighted Mean Score

Farmers' perception was measured using a 5-point Likert Scale Matrix covering statements on ease of handling, eco-friendliness, crop quality, ease of application, and overall satisfaction (benefit statements), and on technical knowledge, dosage clarity, visible performance, wash-off risk, market availability, and equipment handling (constraint statements).

Responses were scored on a scale of 1 (Strongly Disagree) to 5 (Strongly Agree) for benefit statements, and analogously for constraint severity. The Weighted Mean Score (WMS) for each statement was computed as:

$$WMS = \Sigma (f_i \times X_i) / N$$

Where,

- f_i = frequency of respondents choosing a given score category,
- X_i = score (1-5) assigned to that category,
- N = total number of respondents (51).

Constraint statements were additionally classified into Low, Medium, or High categories based on the modal frequency response of the sample.

3. Results and Discussion

3.1 Socio-Economic Context of Respondents

The sample was composed predominantly of middle-aged farmers (70.59% in the 35- 55year bracket, average age 46.25 years) with a comparatively strong educational profile: 94.12% of respondents were literate, 58.82% had completed secondary-level education, and 21.57% held a graduate degree. The average operational landholding was 4.40 hectares, and 88.24% of the cultivated area was served by borewell or combined borewell-canal irrigation. This literate, assured-irrigation, moderate-to-large-landholding profile provides the backdrop against which the perception results below should be read; the findings should not be treated as necessarily representative of more resource-constrained or non-adopting farmers in the wider district.

3.2 Perceived Benefits of Nano Fertilizers

Table 1 presents the Weighted Mean Scores for the five benefit statements evaluated. Farmers registered the maximum possible score (WMS 5.00) on both ease of handling and transportation and on the perceived eco-friendly nature and low run-off risk of Nano formulations. Improvement in crop quality and grain weight was rated marginally lower at 4.88. The benefit least strongly endorsed, though still clearly positive, was ease of foliar spraying application, at a WMS of 4.00. Overall satisfaction was rated at 4.45.

Table 1: Weighted Mean Scores of Farmers' Perceived Benefits of Nano Fertilizers (n = 51)

S. No.	Perception Statement	Modal Response Category	Weighted Mean Score (WMS)
1	Ease of handling and transportation	Strongly Agree	5.00
2	Eco-friendly nature and low run-off risk	Strongly Agree	5.00
3	Improvement in crop quality and grain weight	Strongly Agree	4.88
4	Ease of foliar spraying application	Agree	4.00
5	Overall satisfaction with the product	Highly Satisfied	4.45

Source: Primary Data (2025-26)

The unanimous top scores on handling, transport, and perceived eco-friendliness are consistent with the physical and agronomic case made for Nano formulations in the wider literature: a 500 ml liquid bottle is markedly lighter and easier to store and carry than a bag of granular fertilizer, and nanoparticle-based nutrient delivery has been associated with reduced nitrogen losses relative to conventional urea (Kakade

et al., 2025; Kumar *et al.*, 2023)^[3, 4]. It should be noted that the WMS of 5.00 on eco-friendliness reflects farmers' perception rather than an independently measured environmental outcome in this study area.

The comparatively lower score on ease of foliar spraying is the most informative single result in the benefit set, signalling a genuine, if modest, transition cost associated with moving

from a familiar soil-broadcast application method to a foliar-spray regimen requiring correct dilution, spray timing, and equipment handling a transition also documented in adoption- behaviour research on Nano DAP elsewhere in India (Reddy & Rani, 2025) ^[5]. This suggests farmers are distinguishing between the product's intrinsic advantages and the behavioural adjustment required to use it correctly, a distinction relevant for extension design.

3.3 Operational Constraints in Using Nano Fertilizers

Table 2: Operational Constraints Perceived by Farmers in Using Nano Fertilizers (n = 51)

S. No.	Constraint Statement	Constraint Level	Respondents Reporting (%)
1	Lack of technical knowledge regarding Nano- technology	Medium	100.00
2	Confusion in optimal dosage / mixing ratio	Low	100.00
3	Slow visible performance (lack of instant greenness)	Low	100.00
4	Risk of wash-off / need for re-application after rain	Low	100.00
5	Temporal unavailability in local village markets	Low	100.00
6	Technical difficulty in handling spraying equipment	Low	100.00

Source: Primary Data (2025-26)

Two points deserve discussion. First, the pattern in which a single constraint (technical knowledge) is rated meaningfully higher than the remaining five is the constraint-side counterpart of the benefit-side finding above: farmers discriminate between constraint dimensions rather than rating all items uniformly, lending confidence to the internal consistency of the scale. Second, that every other operational constraint including dosage confusion and equipment handling, the more mechanical corollaries of the same underlying knowledge gap was rated Low suggests the gap identified here is specifically about understanding Nano-technology as a product category rather than about the physical mechanics of spraying, which farmers appear to have mastered comparatively well.

This reading is reinforced by extension-exposure data: while all 51 farmers had attended at least one field demonstration, only 39.22% had received formal institutional training, with a marked imbalance between Dharsiwa (85.00% trained) and Abhanpur (9.68% trained). The concentration of the sole Medium-rated constraint around technical knowledge, set against this uneven training coverage, points to a specific and addressable institutional gap rather than a diffuse dissatisfaction with the product.

A methodological caveat is warranted: the uniformity of 100.00% responses on five of six constraint items, and on two of five benefit items, is a striking pattern in a sample of 51 independently interviewed farmers. Such uniformity is plausible in a population that received its product, training, and information through a single institutional channel (100% PACS- mediated awareness in this sample), which can produce genuinely homogeneous experiences while also compressing the discriminatory power of a Likert scale relative to a more heterogeneously sourced sample. This is flagged as a limitation of the design rather than presented as an unqualified finding of unanimous sentiment.

3.4 Adoption Behaviour and Future Intentions

All 51 respondents expressed an intention to purchase Nano fertilizers again in subsequent seasons and a willingness to recommend the product to fellow farmers. Read alongside the perception results above, this pattern is best interpreted as an

Table 2 presents the constraint dimensions evaluated. Lack of technical knowledge regarding Nano-technology was the only constraint statement classified as a Medium constraint, reported uniformly across the sample (100.00%). All five remaining constraint dimensions dosage/mixing confusion, slow visible performance, wash-off risk, temporal unavailability in local markets, and difficulty in handling spraying equipment were classified as Low constraints by the entire sample.

outcome of sustained institutional trust and engagement reinforced by universal field-demonstration attendance and frequent extension-officer contact rather than as evidence of unqualified product superiority in every dimension. The one consistently identified soft spot, technical knowledge, is precisely the dimension that institutional training, rather than further product reformulation, is positioned to address.

3.5 Reading Benefits and Constraints Together

Placed side by side, the benefit and constraint results describe a coherent picture of adoption in this sample. On the benefit side, the two dimensions rated at the ceiling of the scale handling/transport convenience and perceived eco-friendliness are precisely the attributes that require no new skill from the farmer. By contrast, the one benefit item that scored below the ceiling (ease of foliar spraying) and the one constraint item classified above the floor (technical knowledge of Nano-technology) both concern the same underlying competency: correctly understanding and executing an unfamiliar application method. This internal consistency across two independently scored sections of the same schedule is a more informative validation of the survey instrument than any single high or low score in isolation.

The practical implication is that the adoption challenge in Abhanpur and Dharsiwa blocks is narrower and more tractable than a generic “low awareness” or “high cost” narrative would suggest. Farmers in this sample already have full awareness, full adoption, assured institutional supply, and a favourable price perception (76.47% rating Nano fertilizers as reasonable and cost-effective). What remains is a comparatively narrow, well-defined technical-literacy gap concentrated in application technique and product rationale precisely the kind of gap that a short, well-designed, PACS- anchored training module is best placed to close.

4. Conclusion

Farmers adopting Nano Urea and Nano DAP in Abhanpur and Dharsiwa blocks of Raipur district report strongly favourable perceptions of the products' handling convenience, perceived environmental profile, and effect on crop quality, with a comparatively more moderate though still

positive perception of ease of foliar application. On the constraint side, a specific and addressable gap in technical knowledge of Nano-technology stands out against an otherwise uniformly low-constraint profile. Given that formal institutional training reached under 40% of the sample, and unevenly across the two blocks studied, the most direct policy lever available to consolidate the already-strong adoption and repurchase intentions documented here is an expansion of structured, PACS-anchored technical training, rather than further changes to the product itself or its distribution price, which farmers in this sample did not identify as a binding constraint.

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