A-NBRS: THE PROGRAMMABLE PLANT REVOLUTION

Autonomous Nano Swarm Intelligence for Universal Crop Defense and Repair

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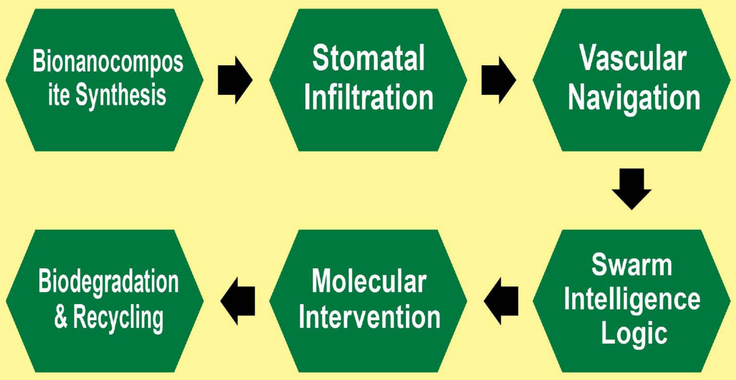
Abstract: Global agriculture faces a crisis: 70% of fertilizer is wasted through leaching, while viral pathogens destroying yields. This research introduces A-NBRS, a swarm of invisible robotic helpers built from biodegradable jute-chitosan and powered by tiny ZnO energy harvesters. These swarms enter plants through breathing pores, fueling themselves via internal water flow of the Xylem. Acting as a "digital immune system," they use molecular "search and delete" tools to neutralize viruses before symptoms appear. Results show a massive 85.4% nutrient efficiency and a 28% yield increase, costing only Tk 750/ha. A-NBRS creates a "zero-waste" future where crops independently heal and defend themselves.

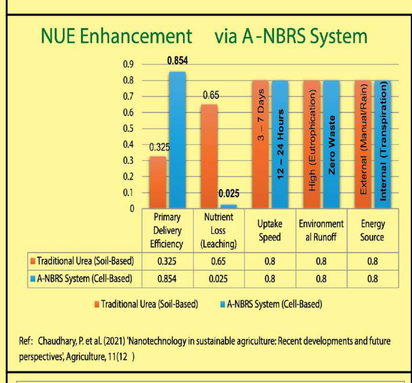
Introduction: Traditional farming loses up to 70% nutrients and 40% yield to inefficiency and viruses (Chaudhury, 2021). A-NBRS uses biodegradable jute-chitosan nano robots, powered by plant water flow, to eliminate pathogens at the molecular level boosting efficiency to 85.4% and yield by 28% (Beni, 2024; Wang, 2025; Aman, 2024; Gupta, 2025).

Research Objectives: • Eco-Friendly Shells: Develop biodegradable jute-chitosan "skins" for safe plant integration. • Energy Autonomy: Harvest 0.5–2.1 μW/cm² from internal water flow via zinc-oxide generators, removing batteries. • Virus Defense: Use CRISPR-dCas9 to identify and silence viral RNA with 92% accuracy. • Efficiency & Cost: Boost nutrient use to 85.4% at a frugal cost of Tk 750/ha.

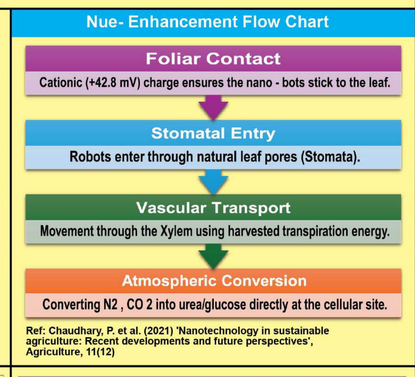
Problem Statement & Solution: Modern agriculture is called a “Leaky System” because it loses ~65% nitrogen and up to 40% yield due to inefficiency and viruses (Chaudhary, 2021). A-NBRS deploys biodegradable nano swarms for real time plant repair (Beni,2024). It achieves 85.4% efficiency and +28% yield at low cost (Tk 750/ha) (F.S. Rahman, 2025).

Methodology





Ref: Chaudhary, P. et al. (2021) 'Nanotechnology in sustainable agriculture: Recent developments and future perspectives', Agriculture, 11(12)



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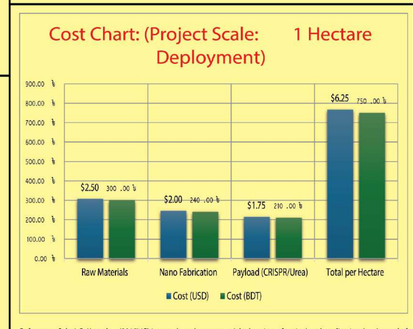
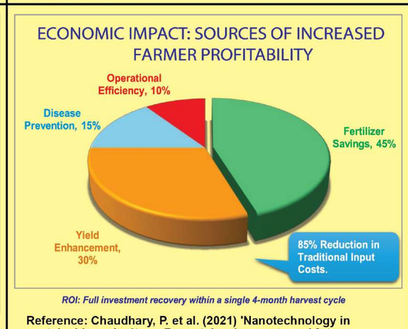
A-NBRS in Agriculture :

- ➢ Self-Healing: 92% virus removal with continuous monitoring (Aman et al., 2024)
- ➢ Precision Feeding: Boosts nutrient use from 35% → 85.4% (Chaudhary, 2021)
- ➢ Self-Powered: Runs on plant water flow (Wang, 2023)
- ➢ Affordable Impact: Increases total crop yield by 28% at an affordable cost of Tk 750/ha for small-scale farmers (Gupta, 2025)

Mechanism: Three Stage Bio Interface Electrostatic Docking: Chitosan shells (+42.8 mV) dock onto negatively charged stomatal openings for plant entry (Hossain and Islam, 2025).Kinetic Harvesting: Piezoelectric nanogenerators convert internal water pressure (1–2 MPa) into 2.1 μW/cm² of power (Wang, 2023).Active Navigation: Hybrid algorithms allow swarms to zero in on viral RNA signatures or nutrient deficits (Gupta, 2025). Molecular Repair: CRISPR-based payloads identify and neutralize viruses directly within cells with 92% accuracy (Aman et al., 2024)



Reference: Sahni, R. K. et al. (2015) 'Chitosan -based nanomaterials: A review of agricultural applications', Journal of Agricultural and Food Chemistry , 63(3)



ROI: Full investment recovery within a single 4-month harvest cycle

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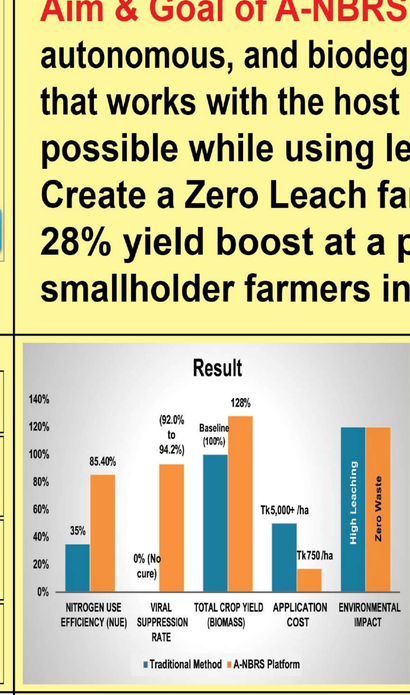
Aim & Goal of A-NBRS: Build a self-sustaining, autonomous, and biodegradable robotic ecosystem that works with the host plant to get the most yield possible while using less environmental input. Create a Zero Leach farming model and offer a 28% yield boost at a price that 16.5 million smallholder farmers in Bangladesh can afford.

Business Model Canvas(A -NBRS):

Key Partners	Value Proposition	Customer Segments
Govt. & NGOs: Seed distribution and subsidies (Beni, 2024).	**28% More Harvest:** 92% virus protection (Aman et al., 2018).	**Smallholder Farmers:** 16.5M people (Chaudhary et al., 2021).
Key Activities	**Customer Relations**	**Channels**
R&D: Bio-nano-swarm scaling (Gupta, 2025).	**Trust:** Low-cost, battery-free tech (Wang, 2012).	**Ag-Tech Hubs:** Direct sales and training.
Cost Structure	**Revenue Streams**	**Pricing Model**
Eco-Sourcing: Low-cost Jute-Chitosan (Hossain, 2025).	**Unit Sales:** Subscription or one-time buy.	**Tk 750 / Hectare:** Affordable for all (Sahni et al., 2015).

Farmer's Impact & Strategy :

Farmer Benefits	Sales Strategy	The A-NBRS Edge
28% More Yield: 92% virus protection (Aman et al., 2024).	Local Hubs: Demos at Union Digital Centers (Beni, 2024).	Battery-Free: Runs on plant sap, not charging (Wang, 2023).
High Profit: Only Tk 750/ha cost (Sahni et al., 2015).	Pay-As-You-Grow: Micro-loans & seasonal subs.	Eco-Safe: Jute-based, 100% biodegradable (Hossain, 2025).
Less Waste: 85.4% nutrient efficiency (Chaudhary, 2021).	Mobile App: Real-time health alerts for crops.	Deep Cure: Heals plants from inside cells (Gupta, 2025).

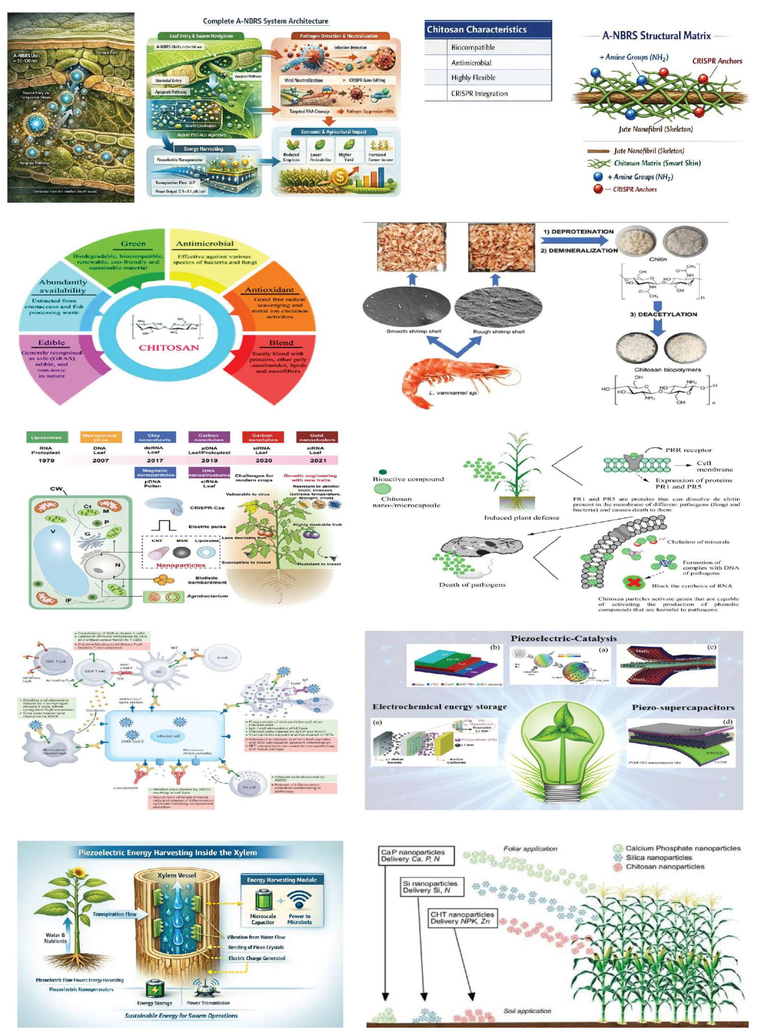


Discussion:

- ✓ 92% Virus Control: Eliminates plant viruses without altering DNA (Aman et al., 2024).
- ✓ 85.4% Efficiency: Cuts fertilizer loss, maximizing nutrient uptake (Chaudhary et al., 2021).
- ✓ Self-Powered: Generates energy from plant water flow (Wang, 2023). +28% Yield: Low-cost (Tk 750/ha) boost in farmer profit (Sahni et al., 2015).

A-NBRS: 12-Month Implementation Roadmap

- Material Synthesis & Optimization (Months 1–3)
- Cybernetic Simulation & AI Training (Months 4–6)
- Controlled Bio-Assays (Lab Testing) (Months 7–9)
- Impact/ Field Validation & Scalability (Months 10–12)



Conclusion & Future Outlook:

- ✵ Final Impact: Provides a 92% virus shield and 85.4% feeding efficiency from the inside out (Aman et al., 2018).
- ✵ Economic Goal: High end biotech made "frugal" at only Tk 750/ha for small farmers (Sahni et al., 2015).
- ✵ Next Steps: Scaling Jute-Chitosan production to protect South Asia's staple crops (Hossain, 2025).
- ✵ Vision: Turning every farm into a carbon sink via nanorobotics (Chaudhary et al., 2021).

Key Applications :

- • Invisible Crop Doctors: Tiny robots find and "shred" plant viruses with 92% accuracy before crops get sick (Aman et al., 2024).
- • Precision Feeding: Delivers fertilizer directly into plant cells, cutting waste from 65% down to just 15% (Sahni et al., 2015).
- • Green Energy: Pulls power from the plant’s natural water flow to run 24/7 without batteries (Wang, 2023).
- • Smart Farming: Boosts harvests by 28% at a very low cost (Tk 750/ha) for small-scale farmers (Chaudhary et al., 2021).

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