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Q15

How does nanotechnology offer significant advancements in the field of agriculture? How can this technology help to uplift the socio-economic status of farmers?

UPSC Civil Services Mains 2025 · GS III · 15 marks · Crops, Irrigation and Marketing

Major crops - cropping patterns in various parts of the country; different types of irrigation and irrigation systems; storage, transport and marketing of agricultural produce and issues and related constraints; e-technology in the aid of farmers.

Core demand of the question

- **Name nano tools:** nano-fertiliser, nano-pesticide, sensors, packaging, soil mapping
- **Link to farmer income:** less input cost, less residue, better yield if safety is real

Revision summary

Nanotechnology in farming includes nano-fertilisers, lower-dose pesticides, sensors and smarter packaging.

India's public debate has centred on **nano urea** and nano DAP, with still-contested yield evidence.

Gains for farmers would be lower bulk input cost, less residue and better export quality.

Ecotoxicity and weak regulation are the downside.

Uplift needs ICAR-grade proof, fair price and extension, not only a brand.

Introduction

Nanotechnology works at a billionth of a metre. In a field that means a **urea particle** that the leaf can take in, a **sensor** that smells a pest, a **film** that keeps a fruit. India has already put **nano urea** into the public argument. The advancement is real if the science is honest. The farmer's status rises if the bottle **cuts cost and risk**, not if it is only a slogan on a tanker.

Body

Advancements in agriculture

Nano-fertilisers (IFFCO **nano urea** and nano DAP in Indian trials and sales) claim **higher use efficiency**: less bulk urea, less groundwater nitrate, fewer carbon emissions from fertiliser plants. Independent scientists still **debate the yield evidence**; an answer that only repeats the company note is weak. **Nano-pesticides and nano-herbicides** can, in theory, **lower the dose** and the residue. **Nano-sensors** and **lab-on-chip** tools can read soil moisture and nutrient in situ. **Nano-enabled packaging** slows spoilage. **Seed coatings** and **water filters** (nano-silver, carbon) appear in WASH and horticulture. **GIS plus nano-data** is still a lab-to-land climb.

- **Risks: unknown ecotoxicity**, worker inhalation, and **regulatory lag**. A nano that kills a pest and a soil microbe is not progress.

Socio-economic uplift

If **nano urea** truly substitutes a sack, the farmer saves **transport and subsidy leakage** and the State saves a fiscal line. If it does not, the farmer has paid for water. **Precision** can help a smallholder who cannot afford a soil lab. **Lower residue** can open **export** of grapes and spices. **Women** who spray less volume face less chemical load. Uplift fails if nano products are **priced as a luxury**, if extension is only a WhatsApp forward, or if **patent rents** leave the farmer as a buyer of magic.

Public **ICAR trials**, **FCO standards**, and **farmer-field schools** are the ethical path. Nanotech is a **tool of efficiency**. It is not a caste-neutral miracle by itself; land, credit and market still decide status.

Flow diagram

Nanotech -> Nano fertiliser

Nanotech -> Nano pesticide sensors pack

Nano fertiliser -> Lower input if evidence holds

Lower input if evidence holds -> Farmer income and health

Conclusion

Nanotech can make fertiliser, pesticide, sensing and packaging more precise. It can raise a farmer's income if it cuts real costs and residues and if safety is proven. It cannot replace land, water and a buyer.

Facts & figures

Nano urea

A liquid nitrogen product sold at scale in India with claims of higher efficiency; scientists continue to test yield claims in open fields.

Use efficiency

Ordinary urea is poorly taken up by plants; a large share is lost to air and water, which is the scientific case for better formulations.

FCO

The Fertiliser Control Order, the legal list and standard for what may be sold as fertiliser in India.