

Billion-dollar microbe market transforming global vegetable supply chains

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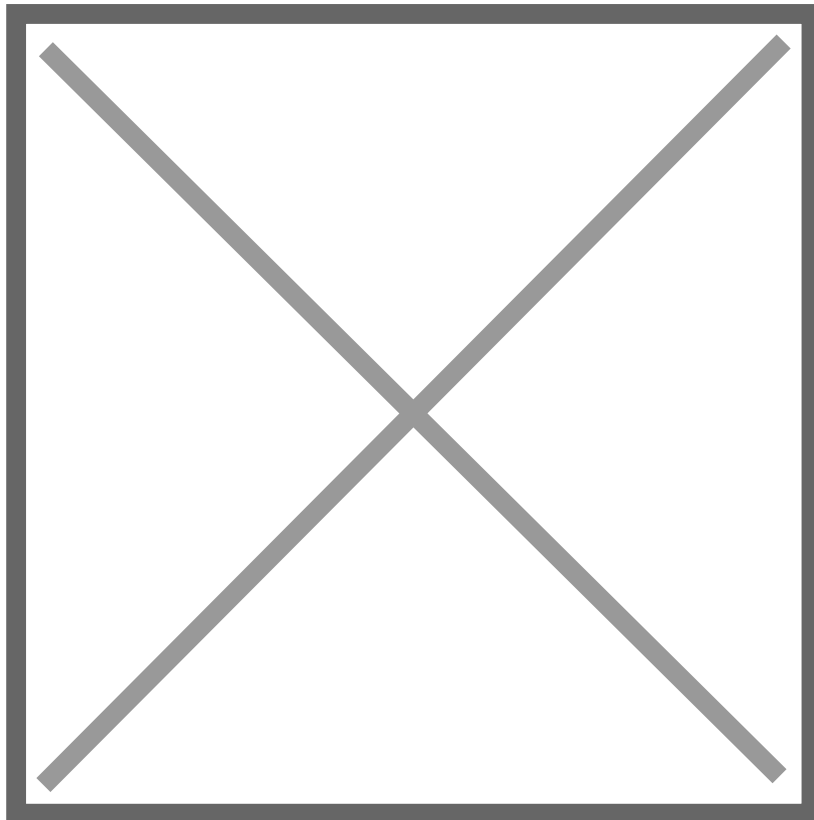


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For decades, synthetic nitrogen and phosphate fertilisers were the workhorses of the Green Revolution—turbocharging yields, slashing food prices, and feeding billions. But that victory came with a steep bill: degraded soils, polluted water, rising greenhouse gases, and dependence on inputs whose prices swing with global markets. The rules of fertilisation are now being rewritten.

In high-value vegetable farming, the shift is unmistakable. Sustainability mandates, precision agtech, and microbial breakthroughs are pushing growers toward a new playbook. Biofertilisers — living microbes that boost nutrient uptake, soil health, and crop resilience — are stepping out of the margins and into the heart of production. They don't just cut the fertiliser bill; they raise produce quality, strengthen plants against stress, and slot neatly into sensor-driven, fertigation-ready systems from India to Denmark. The question is no longer if they work — but how fast they can scale and reshape the economics of vegetable farming.

From Idea to Instrument: The Biofertiliser Opportunity

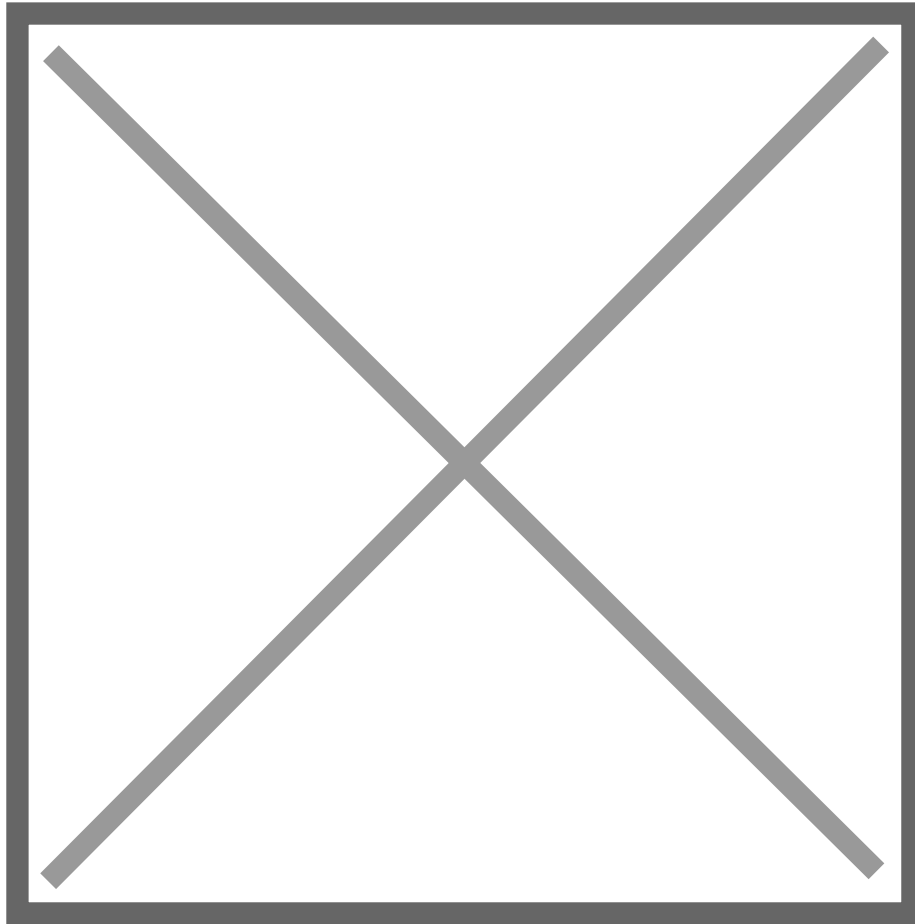


The science behind biofertilisers is solid. Symbiotic bacteria like *Rhizobium*, phosphate-solubilising microbes, and mycorrhizal fungi unlock bound nutrients, fix atmospheric nitrogen, and boost water-use efficiency. Meta-analyses show that, under proper management, biofertilisers can replace 20–30 per cent of synthetic N/P in vegetables without sacrificing yield — while improving firmness, vitamin levels, and shelf life.

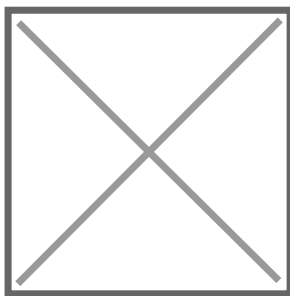
The market is catching up fast. IMARC Group projects the global biofertiliser sector to hit \$2.5 billion in 2024, growing at over 11 per cent CAGR through 2030 — faster than most ag inputs. In high-value vegetable farming, where residue limits and sustainability standards are strict, adoption already tops 20 per cent.

But scaling isn't frictionless. Microbes are living products — they need cold chains, soil-specific tailoring, and precise timing. Farmers used to the consistency of synthetics can face uneven results if biofertilisers meet the wrong soil pH, moisture, or temperature.

Policy Landscape: Aligning Incentives, Compliance, and Adoption



Government policy is now the biggest accelerator ?? or brake ?? on biofertiliser adoption. In India, programmes like PKVY and NMSA are subsidising bio-inputs, funding farmer training, and running demo plots to de-risk adoption for both smallholders and commercial hubs. Fertiliser control rules and mandatory nutrient-use efficiency reporting are nudging growers toward balanced nutrition. States such as Maharashtra, Gujarat, and Tamil Nadu add extra firepower with cold-chain support, certification, and advisory services ?? lowering the operational barriers to microbial use.

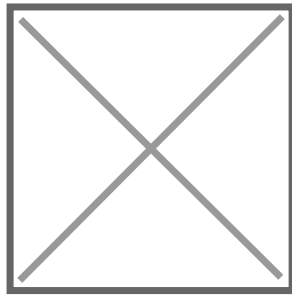


• With over a century of microbial expertise, now renewed by the merger of Novozymes and Christian Hansen, we are working to redefine how crops are nourished, protected and optimized. We work not only to replace chemical inputs, but also harness nature's own solutions for improved and more resilient cropping systems, all while allowing growers to unlock additional yields from every acre. Our philosophy has always been to integrate our global R&D expertise with local needs. We see this in action in different ways. At the business level, as a deeply innovation driven company, we invest roughly 10 per cent of our turnover in R&D, a very significant proportion of our revenue •

• Kate Brandon Sutton, Head of Plant Biosolutions Applied R&D, Novonesis

Precision agriculture is the force multiplier. Sensor-guided fertigation, drones, and AI agronomy platforms sync microbial application with crop growth stages, maximising yield response. But, as Katie Whittiker of Novonesis points out, India's smallholder-heavy farm structure makes scaling a challenge. Subscription-based digital agronomy and shared drone services are emerging as cost-efficient solutions to bridge the gap.

"Protected cultivation adds another layer of opportunity, particularly around urban consumption centres where quality, consistency, and residue compliance are non-negotiable. Here, biofertilisers and biostimulants can be precisely delivered through drip systems, aligning with the closed-loop, resource-efficient nature of greenhouses and shade-net operations", opined Kattie. "Companies like Novonesis, which collaborate with cooperatives and input distributors, play a crucial role in bridging research-led innovation with last-mile farmer adoption ensuring that advanced microbial solutions reach growers with proper guidance and compliance support", she added.



"Our long term partnerships with platforms like Benchling underscores our investment in cutting-edge R&D innovation and development of next-gen Biosolutions for emerging agricultural segments. We aim to do this in precision farming and protected agriculture segments by " Expanding the suite of microbe-based inputs tailored for high-value crops; Collaborating with organizations and cooperatives to enable data-driven decision making at the level of the farm and the field, and Supporting growers with robust stewardship programs that facilitate seamless adoption, and help maximize returns on investment "

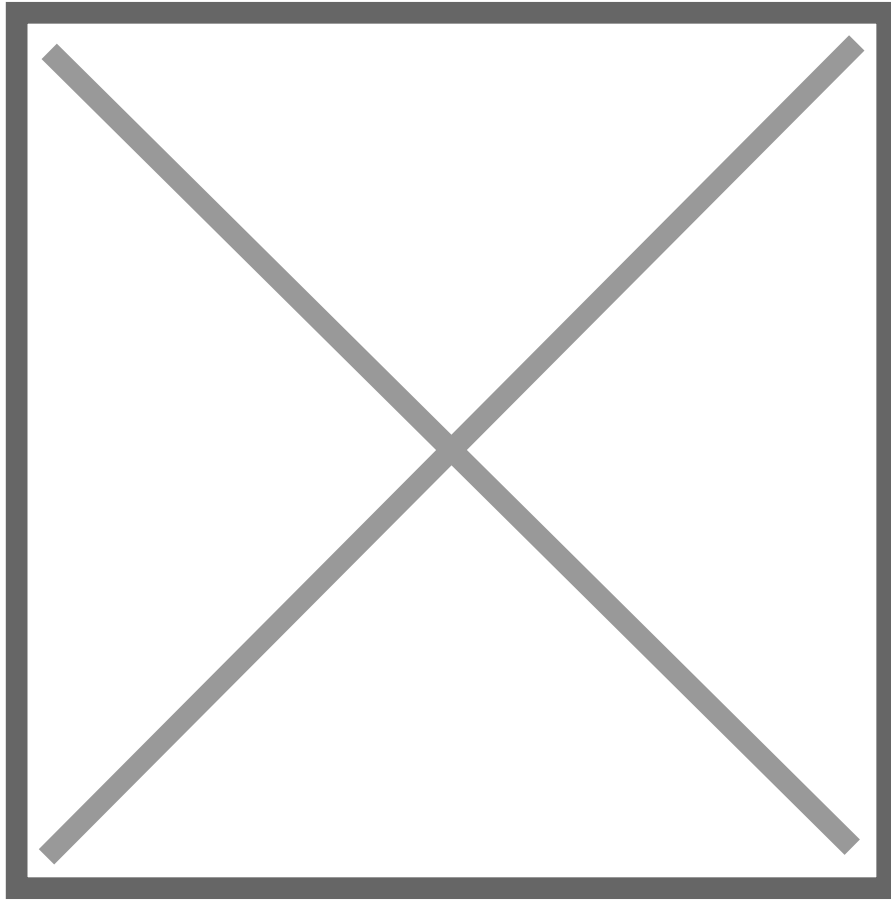
" Katie Whittiker, Head of Plant BioYield Business Unit, Novonesis

Globally, regulation is uneven but decisive. The EU's Fertilising Products Regulation (FPR 2019/1009) sets strict efficacy, safety, and traceability standards critical for exporters facing tight nitrate and residue limits. In the Middle East and Africa, policy levers are tied to EU compliance: Turkey, Morocco, and Egypt are rapidly adopting microbial fertilisers to secure greenhouse exports, while Sub-Saharan rules remain patchy a hurdle and opportunity for new entrants.

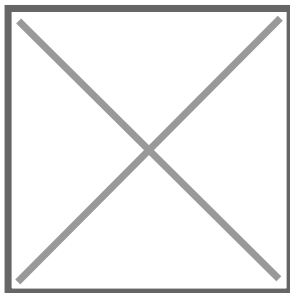
Denmark offers a glimpse of the future: subsidies tied to nitrogen cuts, public-private R&D under the IBIS platform, and carbon-credit monetisation create a strong business case for biofertiliser use.

Policy isn't just compliance it rewires market economics. Where governments integrate incentives, adoption rises faster, microbial performance is more consistent, and ROI for suppliers and growers improves.

Precision Vegetable Farming Meets Biological Inputs



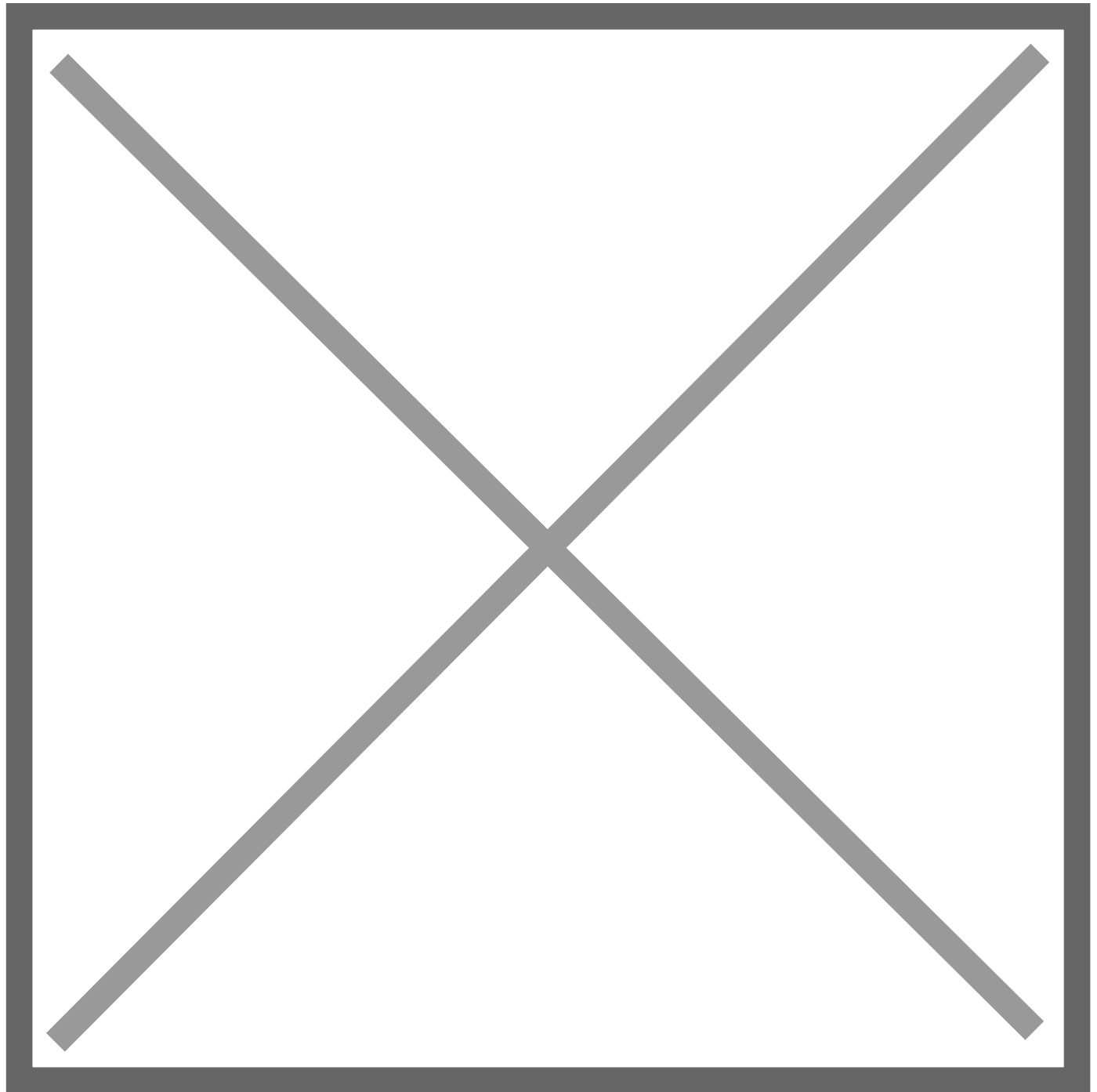
Digital agriculture and microbial biosolutions are redefining performance standards in high-value vegetable farming. In both CEA and irrigated fields, blanket fertiliser applications are giving way to real-time, demand-driven nutrition. IoT soil sensors, AI-powered fertigation, and multispectral imaging now work in sync to deliver the right nutrients at the right moment – maximising efficiency and yield.



“• Extensive global and regional trials on vegetable crops – including tomatoes, chilies, and leafy greens – consistently reveal that India’s average yields remain well below global benchmarks. This productivity gap underscores a significant opportunity for bio-inputs such as biofertilisers and biostimulants to drive both yield gains and sustainability outcomes. When integrated with optimised agronomic practices, biological solutions have delivered yield improvements exceeding 10 per cent compared with conventional methods. In India, fertigation-based trials have recorded yield increases of up to 18 per cent in tomatoes and chilies, while greenhouse experiments in Vietnam have demonstrated markedly improved nutrient uptake and superior quality in leafy vegetables. Validated through close collaboration with growers and research institutions, these results confirm the reliability of microbial inputs under real-world conditions ”

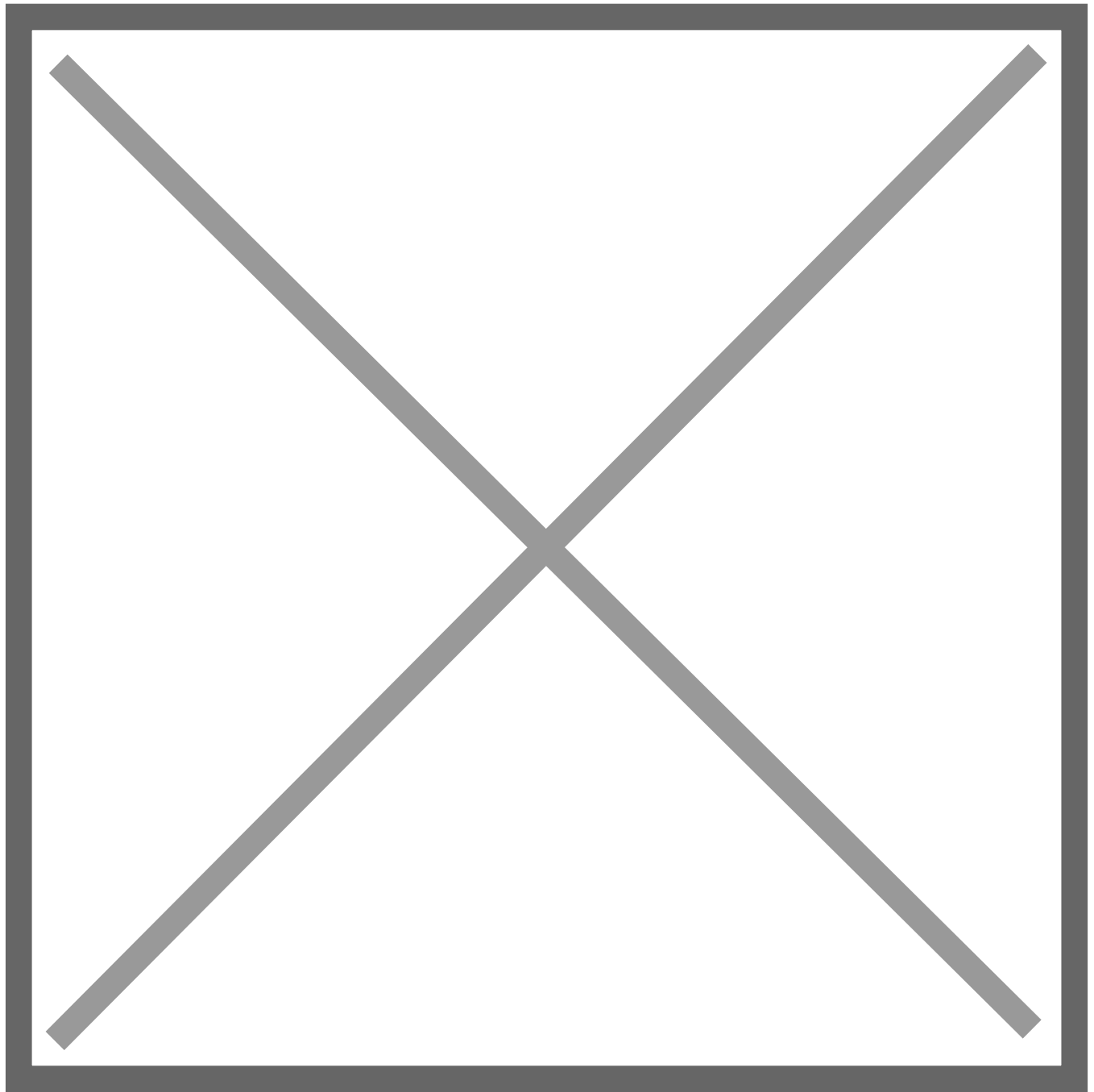
– Shanmugam Sambanthan, Commercial Head, Agriculture ,South Asia, Middle East and Africa, Novonosis

Globally, the impact is striking. Israeli drip-irrigation pioneers like Netafim and Rivulis inject biofertilisers directly into root zones, boosting microbial colonisation and cutting synthetic nitrogen use 20–30 per cent without hurting yields. In Europe, greenhouse tomato growers combine microbial consortia with precision nutrients to hit nitrate-residue targets while sustaining export-grade productivity. A 2023 Wageningen study found 12–15 per cent yield gains and up to 40 per cent nitrate reductions when biofertilisers were paired with variable-rate fertigation.



India is steadily moving toward this model, though adoption is concentrated in progressive clusters. Agritech start-ups are embedding microbial inputs into AI-driven agronomy platforms, giving smallholders access to tools once reserved for corporates. Subscription services for drones, sensors, and fertigation-as-a-service are lowering financial barriers. Early pilots in Nashik report tomato yield gains of 10–18 per cent and synthetic nitrogen savings of up to 35 kg/ha through precision-linked biofertilisers.

Protected cultivation is another growth lever. Greenhouses and shade-net houses near urban centres enable year-round, residue-free, premium vegetables with lower post-harvest losses. Novonesisâ?? biofertiliser and biostimulant range, tailored for drip-irrigated systems, has delivered firmer bell peppers and cucumbers, higher marketable yields, and 12â??15 per cent better nutrient-use efficiency, boosting grower margins.

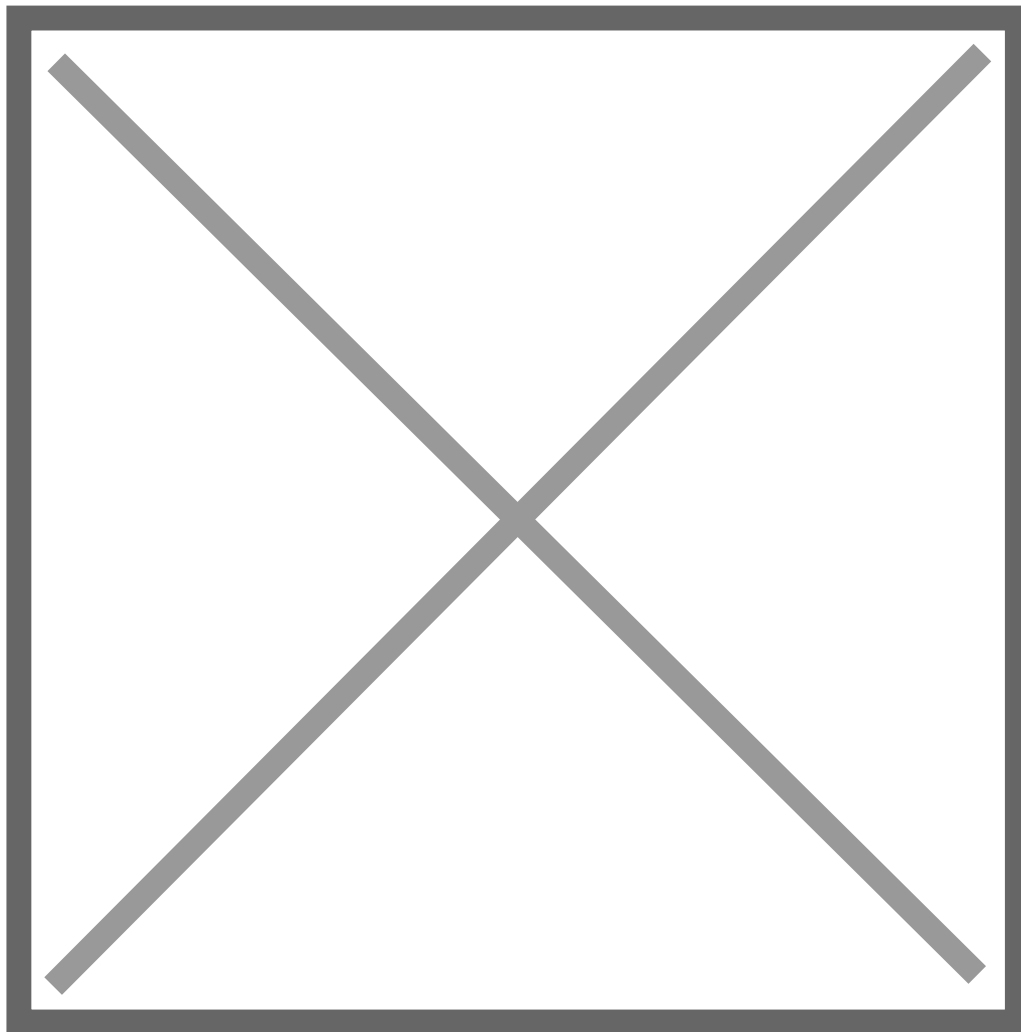


The benefits are clear: lower synthetic fertiliser costs, improved water efficiency, and premiums for low-residue produce. But scaling is local â?? what works for a protected cucumber farm in Bengaluru may not suit an open-field tomato grower in Rajasthan.

Precision tools plus biological inputs arenâ??t just incremental; they mark a structural shift toward climate-resilient, resource-efficient farming. For policymakers, they advance fertiliser-reduction and soil-health goals. For growers, they boost per-hectare profitability while cutting input volatility. For investors, they signal a decade of data-driven, biology-led, sustainability-aligned growth.

Across the globe, this integration is gaining traction. Israeli drip-irrigation firms inject biofertilisers into root zones to optimise colonisation. European greenhouse tomato growers pair microbial consortia with precision nutrients to meet yield and nitrate-residue standards. In India, agritech start-ups are embedding microbial inputs into AI-powered agronomy platforms, bringing precision farming to smallholders.

Benchmarking Regional Pathways: India in Focus



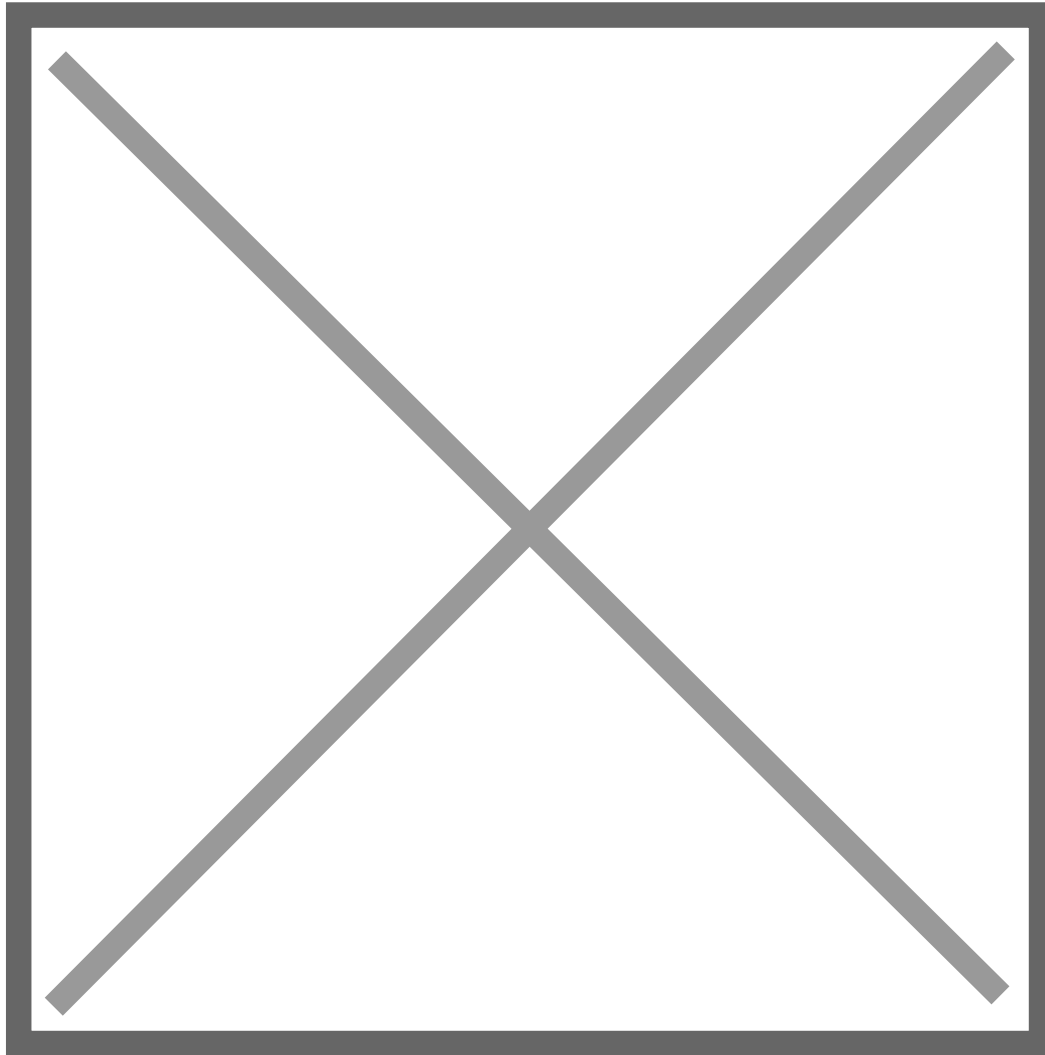
Biofertiliser adoption is global but uneven, following three distinct paths: scale-driven South Asia, scarcity-driven Middle East and Africa, and regulation-led Denmark. Each reflects unique market forces, infrastructure readiness, and regulatory pressures, offering lessons on where the microbial transition will accelerate and how businesses can position themselves.

India leads South Asia, accounting for over 60 per cent of the region's \$143-million biofertiliser market in 2024, with 11-12 per cent annual growth projected. Policy is a major driver: PKVY and NMSA subsidise bio-inputs, fund training and demo plots, and incentivise adoption among smallholders and commercial vegetable hubs. Fertiliser controls and nutrient-use reporting further nudge farmers toward microbial solutions, especially where synthetic fertiliser costs are volatile.

Domestic production adds a cost edge. Local *Rhizobium*, phosphate-solubilising microbes, and mycorrhizal inoculants are often 20-30 per cent cheaper than imports, while improved quality control builds trust. Smallholder economics are increasingly compelling: ICAR trials show integrated biofertiliser regimes in tomatoes, brinjal, and capsicum can boost yields 10-18 per cent, improve nutrient-use efficiency up to 25 per cent, and cut synthetic nitrogen by 35 kg/ha under fertigation. These results are reshaping the investment calculus for farmers, distributors, and downstream buyers alike.

Shanmugam Sambanthan, Commercial Head, Agriculture, South Asia, Middle East and Africa, Novonosis, expects India's B2B bio-input market to evolve rapidly, though the highly fragmented agriculture landscape. Currently, bio-inputs are still a small fraction of overall inputs used by farmers. The fragmentation across farmlands provides can be a significant

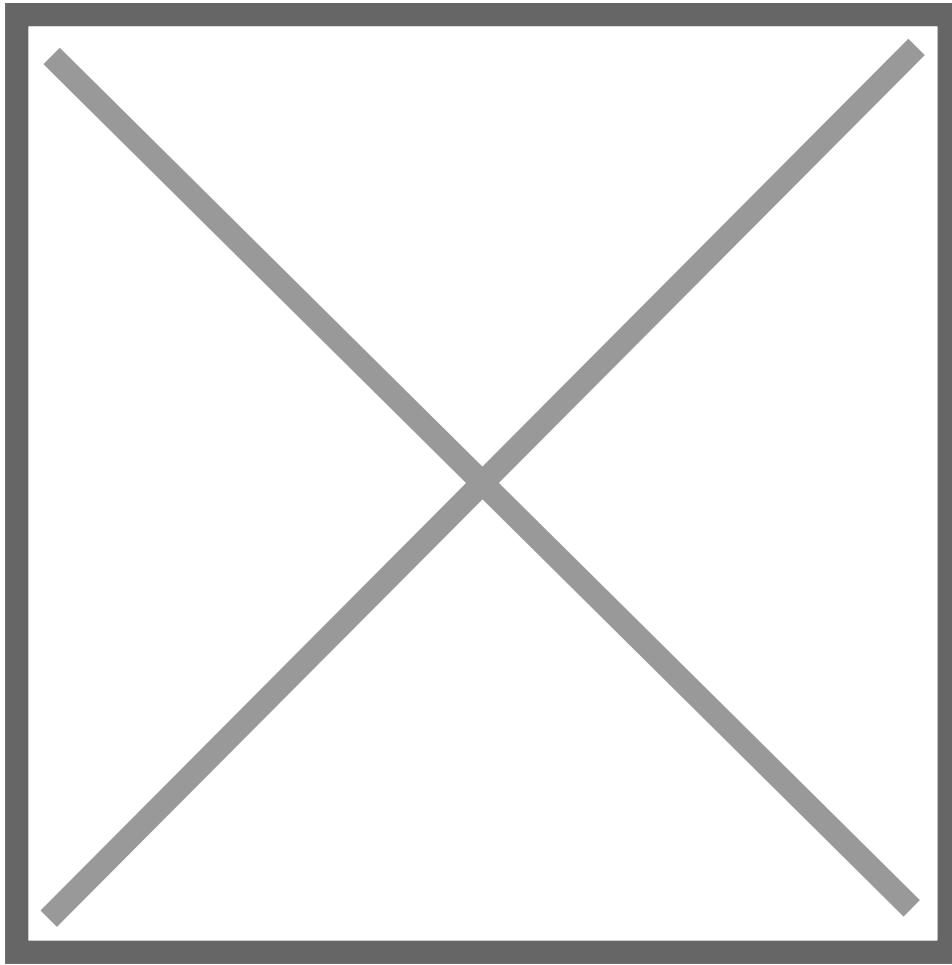
challenges to the adoption of Bio-inputs, particularly when it comes to reaching farmers through the direct trade, and most importantly in providing meaningful services to farmers. Along similar lines, companies including startups in the bio-input space struggle to scale due to the high investment and resource requirements needed for wide market reach â??, Sambanthan opined.



Novonesis has carved a distinct niche in Indiaâ??s bio-inputs market as a B2B innovator, focusing on cutting-edge R&D rather than direct-to-farmer sales. Its strength lies in developing advanced microbial and biostimulant solutions while partners handle market reach, distribution, and farmer engagement â?? a winâ??win that accelerates adoption without diluting focus on innovation, quality, or regulatory compliance. A collaboration with KRIBHCO illustrates this model. By combining Novonesisâ?? next-generation biosolutions with KRIBHCOâ??s distribution network and agricultural expertise, the partnership scales access, ensures reliable supply, and co-invests in farmer awareness programs and demonstration plots across diverse crops and agro-climatic zones.

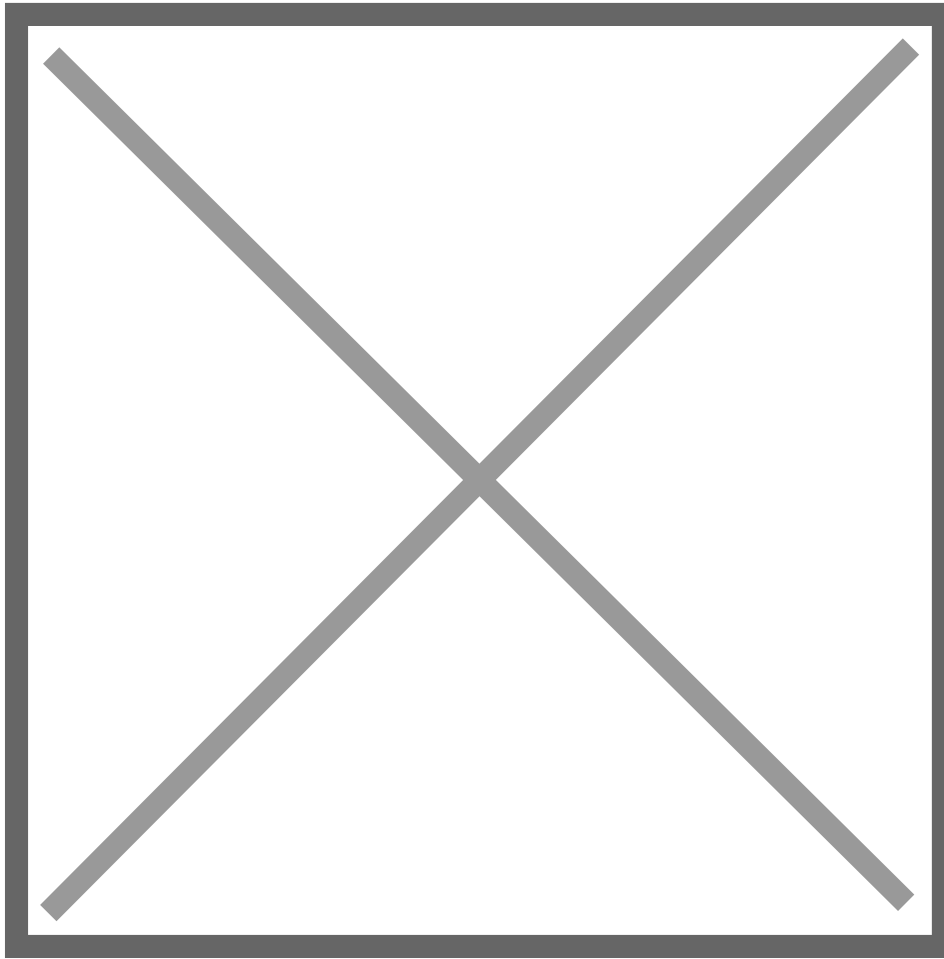
The results are tangible: Irrigated vegetable hubs like Nashik (Maharashtra) and Kolar (Karnataka) report 30â??40 per cent integration for high-value crops such as tomato and capsicum. Adoption lags in rainfed eastern and central regions (10 per cent), constrained by short microbial shelf life, limited cold chains, scarce locally adapted strains, and weak precision-application support.

Policy incentives alone arenâ??t enough. Unlocking microbial adoption will require targeted infrastructure â?? rural cold chains, decentralised production, and last-mile agronomy via cooperatives, FPOs, and digital platforms. With this combined approach, Novonesis is bridging lab breakthroughs and field impact, anchoring Indiaâ??s shift toward precision and protected agriculture.



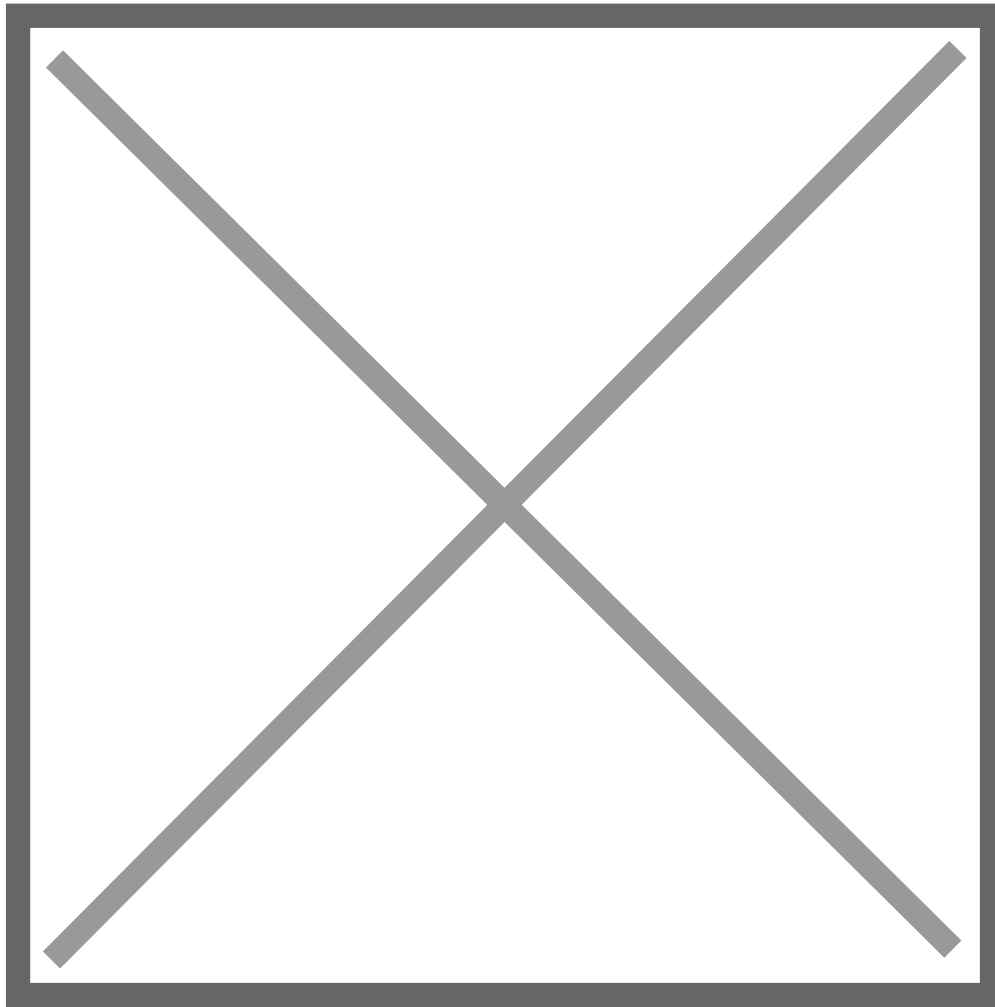
Looking to 2030, expanded cold chains, sensor-linked fertigation, and AI-assisted agronomy could push adoption in irrigated hubs above 40 per cent. In rainfed regions, coordinated efforts â?? government subsidies, bundled private inputs, and micro-advisory services â?? will be essential. India demonstrates that scaling biofertilisers demands a systemic strategy: aligned policy, robust supply chains, precision tools, and farmer-centric delivery. For investors and industry, mastering these regional dynamics is key to maximising impact and minimising risk.

Dual-Speed Adoption: Middle East, Africa, and Denmark



Biofertiliser adoption outside Asia is uneven, shaped by economic pressures, regulation, and infrastructure. The MENA region, Sub-Saharan Africa, and Denmark illustrate three contrasting trajectories.

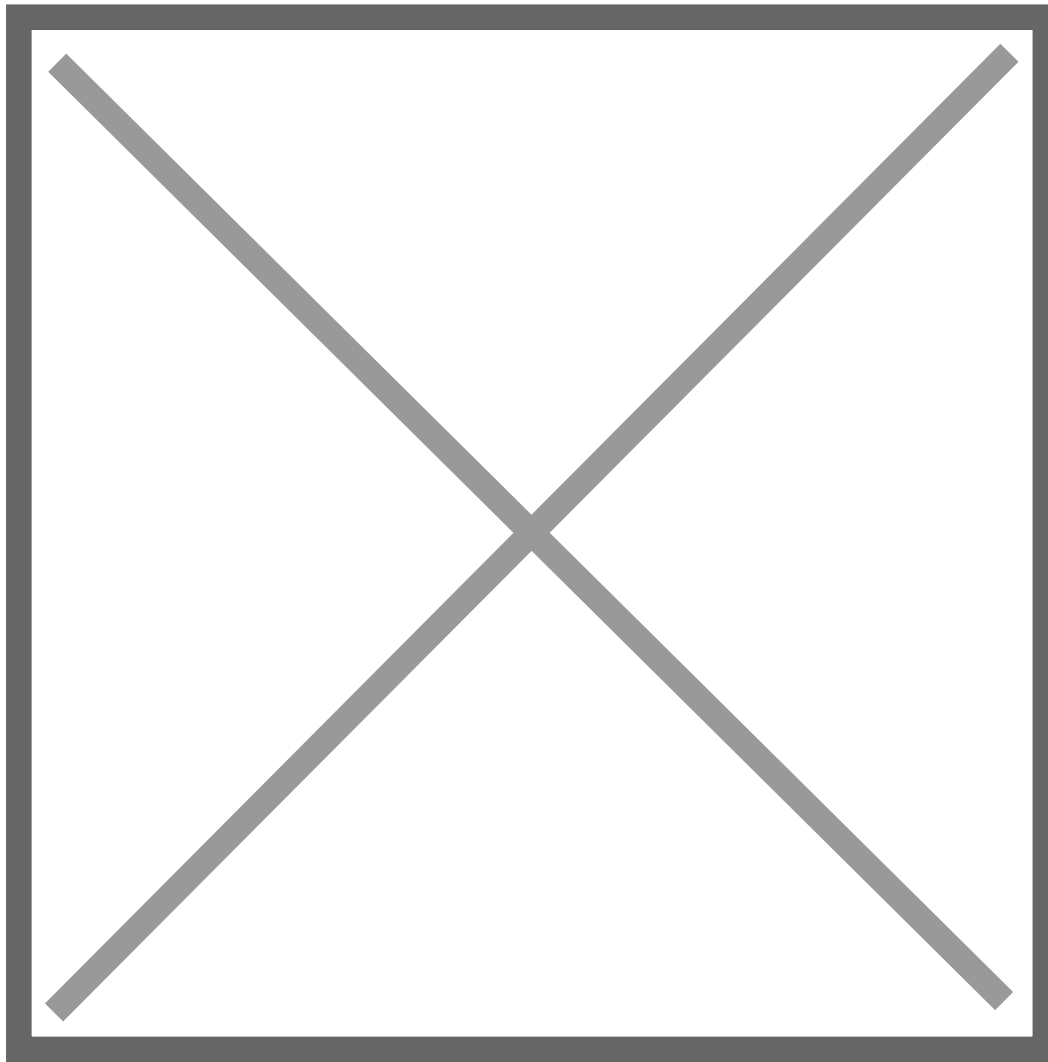
In MENA, adoption is compliance-driven. Turkey, Morocco, and Egypt operate high-value “greenhouse corridors” exporting tomatoes, cucumbers, peppers, and leafy greens to Europe under strict nitrate and residue limits. Microbial solutions injected via drip fertigation reduce synthetic nitrogen by 15–25 per cent while maintaining yields, fruit firmness, and colour – boosting export premiums. EU-aligned certification schemes reinforce adoption, but smaller domestic producers often lack cold chains, verified inputs, and advisory support.



Sub-Saharan Africa faces scarcity-driven adoption. Fertiliser shortages, volatile prices, and degraded soils make biofertilisers a resilience tool. Pilots in Kenya, Tanzania, and Ghana show 10–15 per cent yield gains and reduced water use when inoculants are paired with drip irrigation. Yet adoption remains patchy due to weak regulation, poor cold chains, and inconsistent product quality. Scaling requires harmonised regional regulations, rural cold-chain investment, and farmer education via public–private partnerships. Africa is a “long-game” market demanding localisation, training, and strategic patience.

Denmark exemplifies regulation-led adoption. Policies link subsidies to nitrogen efficiency and greenhouse-gas targets, making microbial use an economic necessity. Public–private partnerships like IBIS fund R&D to tailor microbial solutions for mechanised horticulture. Integrated packages embedded in precision nutrient programmes reduce synthetic nitrogen 25–35 per cent, boost soil carbon within 3–5 years, and generate monetisable carbon credits. Strict quality control and extension services ensure consistent outcomes. By 2030, Denmark is projected to exceed 50 per cent biofertiliser integration in horticultural supply chains, approaching true mainstream adoption.

Outlook: Anchoring the Photosynthetic Transition



The shift to photosynthetic fertilisation is uneven but transformative. In precision vegetable farming, biofertilisers do more than signal sustainability – they reconcile profitability with compliance. In India, scaling cold chains, extension services, and integrated fertigation will turn manufacturing capacity into consistent farmer gains. In MENA, export-driven greenhouse corridors will prove and propagate microbial efficiency. Denmark will showcase regulation-led mainstreaming, where policy and carbon credits accelerate adoption.

The global takeaway is clear: biofertilisers will define the future of precision vegetable farming only when embedded in agronomic, economic, and regulatory systems that reward soil health and input efficiency. For growers and investors, the move from petrochemical to photosynthetic fertilisation is not just green – it’s a competitive edge.

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