Online ISSN Applied for

Review Article

Agro-Science Letters
Vol. 2, No. 2, April–June 2026

# Knowledge and Awareness Gaps Among Vegetable Growers Regarding Improved Production Technologies: A Review

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https://doi.org/10.48165/asl.2026.2.02.04

ARTICLE INFO

**Article history**
Received: 03.07.2026
Revised: 23.07.2026
Accepted: 21.08.2026

**Keywords**
Improved production technologies

## ABSTRACT

Improved production technologies — integrated pest management, seed treatment, soil testing, drip irrigation, protected cultivation, and Good Agricultural Practices (GAP) — are well established in agricultural research, yet farm-level surveys consistently find that vegetable growers' knowledge of these technologies lags well behind what is recommended. This review synthesizes knowledge-and-awareness surveys of vegetable growers across India, Bangladesh, and comparator studies from Switzerland and the United States, to characterize the size and pattern of these gaps. Across the reviewed studies, "medium" knowledge is consistently the most common category, true "high" knowledge is rare, and even where knowledge is adequate, adoption trails knowledge by a wide margin. The specific technologies with the largest documented knowledge gaps — integrated pest management, seed treatment, and soil testing — are precisely those requiring the most technical judgment, while simpler practices such as recommended varieties and fertilizer timing are comparatively well known. The review closes by discussing the determinants of knowledge level and the implications for extension design.

## INTRODUCTION

Improved vegetable production technologies exist to solve well-documented problems: unmanaged pests reduce yield and drive excessive pesticide use, untested soils lead to wasteful or harmful fertilizer application, and unprotected cultivation leaves crops exposed to weather variability that protected structures could buffer. Agricultural research and extension systems have developed and validated packages of such technologies for decades. Yet a consistent finding across farm-level surveys is that vegetable growers' knowledge of these technologies remains incomplete, and that even where knowledge exists, it does not reliably translate into adoption [1].

This review synthesizes recent knowledge-and-awareness assessment studies conducted among vegetable growers, primarily in South Asia where vegetable smallholding is widespread and survey-based knowledge assessment is a well-established extension-research method, alongside comparator evidence from higher-income agricultural contexts where the barriers to technology adoption are less about basic awareness and more about cost and technical support. The aim is to characterize both the overall size of the knowledge gap and the specific technologies where that gap is largest, as a basis for more targeted extension investment.

## CONCEPTUAL FRAMEWORK: KNOWLEDGE, AWARENESS, AND ADOPTION

Extension research typically distinguishes three related but distinct constructs. Awareness refers to simply knowing that a technology exists. Knowledge refers to a deeper, often graded understanding of how and when to apply it correctly — the construct most commonly measured in the studies reviewed here, typically scored

**Table 1:** Knowledge and Adoption by Practice Category, Tamil Nadu

| Category | Practices | Approx. level |
|---|---|---|
| Well-known practices (knowledge) | Method of transplanting, recommended variety/HYV, fertilizer application, weed management, mulching, seed treatment | 75–90% of farmers knew these practices |
| Poorly-adopted practices (adoption) | Soil testing, soil health card (SHC) recommendations, growth regulators, mulching, foliar spray, plant protection measures | Only 40–48% adoption despite reasonable awareness |

Source: Rani (2020), Agricultural Update [1].

against a checklist of correct practices and classified into low, medium, and high categories. Adoption refers to whether the farmer actually applies the technology in their own fields. The studies reviewed in this paper measure knowledge most directly, but several also measure the downstream gap between knowledge and adoption, which is a central theme of this review [1].

## OVERALL KNOWLEDGE LEVELS: EVIDENCE FROM MULTI-PRACTICE SURVEYS

The most directly relevant baseline comes from a study of 90 vegetable growers in Chellampatti block, Madurai district, Tamil Nadu, which assessed knowledge and adoption across a broad package of recommended vegetable cultivation practices. Average knowledge of recommended technologies across the sample was 74.72%, while overall adoption of those same technologies was only 55.27% — a gap of nearly 20 percentage points between what farmers knew and what they actually practiced [1].

Notably, mulching appears in both lists: farmers are broadly aware of the practice, but consistent field-level adoption still lags. This pattern — reasonable awareness of a practice's existence alongside inconsistent application — recurs throughout the literature reviewed in this paper and is discussed further in Section 6.

## TECHNOLOGY-SPECIFIC KNOWLEDGE GAPS

Looking beyond overall averages, several studies identify precisely which technologies carry the largest knowledge deficits. Data compiled from vegetable-growing regions of India found particularly large gaps in integrated pest management (81.66% of farmers lacking adequate knowledge), seed treatment (80.83%), training on scientific vegetable production technology generally (79.17%), the critical growth stage for irrigation timing (69.17%), and access to soil testing facilities (66.67%) [1].

The pattern in Figure 2 is informative: the technologies with the largest gaps — IPM, seed treatment, and irrigation timing — are precisely those that require diagnostic judgment (assessing pest pressure, evaluating seed condition, reading crop and soil moisture cues) rather than simple, one-time application. This mirrors a broader finding in agricultural extension research that judgment-intensive practices are harder to transfer through conventional, one-directional training than fixed-rule practices such as recommended planting density or fertilizer dose.

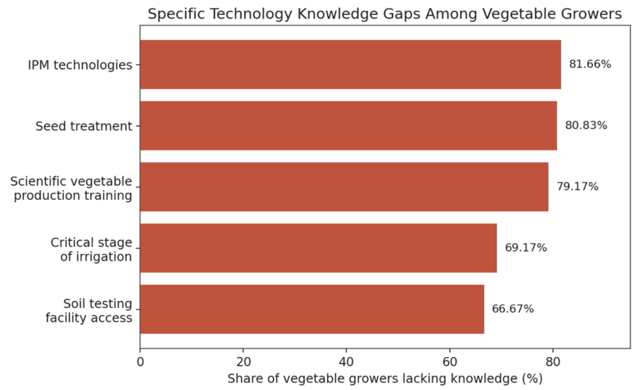


**Figure 2:** Share of vegetable growers reporting inadequate knowledge of specific improved production technologies. Source: Singla & Kaur (2016), as cited in Rani (2020) [1].

## GOOD AGRICULTURAL PRACTICES AND PROTECTED CULTIVATION

### *Good Agricultural Practices (GAP)*

Two independent surveys in Bangladesh point in the same direction on GAP knowledge specifically. A 2025 study of 240 vegetable farmers in Rangpur district found that half of respondents had poor GAP knowledge, 46.7% had moderate knowledge, and only 3.3% reached a "good" knowledge level, using a Bloom's Taxonomy-based assessment [2]. A separate 2026 study in Dinajpur district found 56.7% of vegetable farmers had medium awareness of GAP, while a much larger share — 65.0% — had low adoption of GAP in practice, again illustrating that awareness levels, however measured, consistently exceed practical adoption rates [3].

DOI: https://doi.org/10.48165/asl.2026.2.02.04

### Protected Cultivation (Polyhouse/Greenhouse Technology)

Protected cultivation structures allow vegetable production outside a crop's normal season and command higher market prices, but require distinct technical knowledge — climate control, cover material durability, appropriate crop selection — that differs from open-field cultivation. A study across Jaipur and Alwar districts of Rajasthan found that 74.55% of polyhouse farmers had only medium knowledge of polyhouse cultivation technology, with just 12.27% reaching high knowledge. Farmers scored highest on practical, visible attributes such as cover durability, but lowest on more technical aspects such as which crops are actually suited to polyhouse cultivation and appropriate in-house irrigation methods. A separate study of low-cost polyhouse adopters in Assam similarly found 62.5% at a medium knowledge level regarding recommended off-season cultivation practices [4], [5].

### Irrigation Technology

Drip irrigation delivers water and nutrients precisely to the plant root zone and is widely promoted as a water-saving technology for vegetable production, particularly in water-stressed regions. A study of 120 vegetable-growing households in Rajasthan found that 70.83% had only medium knowledge of the drip irrigation system, with education, occupation, income, and social participation all positively associated with knowledge level [6].(fig 3.)

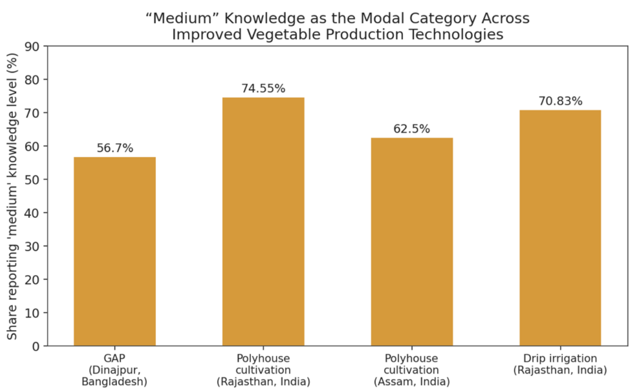


**Figure 3:** "Medium" knowledge is the most frequently reported category across independent studies of different improved vegetable production technologies [2]–[6].

**Table 2:** Summary of Technology-Specific Knowledge Level Studies

| Technology | Region | Key finding |
|---|---|---|
| Good Agricultural Practices (GAP) | Rangpur, Bangladesh | 50% poor, 46.7% moderate, 3.3% good knowledge [2] |
| Good Agricultural Practices (GAP) | Dinajpur, Bangladesh | 56.7% medium awareness; 65.0% low adoption [3] |
| Protected cultivation (polyhouse) | Jaipur/Alwar, Rajasthan, India | 74.55% medium knowledge; only 12.27% high [4] |
| Protected cultivation (low-cost polyhouse) | Assam, India | 62.5% medium knowledge of recommended practices [5] |
| Drip irrigation | Rajasthan, India | 70.83% medium knowledge; positively linked to education and social participation [6] |

## A DIFFERENT PICTURE IN HIGH-INCOME AGRICULTURAL CONTEXTS

The knowledge-gap pattern documented above is heavily concentrated in the South Asian literature, where basic awareness of established technologies remains incomplete for a meaningful share of vegetable growers. Evidence from higher-income agricultural systems suggests a different constraint structure: awareness of advanced technologies is generally high, but adoption is limited by cost, technical support, and trust rather than by not knowing the technology exists.

A Delphi study of experts on precision agriculture technologies in Swiss outdoor vegetable production identified drivers and barriers to adoption that centred on economic viability, data management complexity, and compatibility with existing farm equipment — not on farmers being unaware that sensors, variable-rate application, or automated monitoring exist [7]. Similarly, a 2025 survey of Florida commercial vegetable growers found that willingness to adopt smart, water-saving irrigation technologies (soil moisture sensors, evapotranspiration-based scheduling, automated controllers) was shaped by farm size, education, income, and crop diversity, with the main barriers identified as high initial cost, lack of technical training, and skepticism about technology reliability — again a distinct barrier profile from the basic-awareness gaps documented in the South Asian literature [8].

This contrast matters for how the findings of this review should be applied: closing a knowledge gap in a context where growers are largely unaware of a technology (as in much of the South Asian evidence) calls for a fundamentally different extension response than closing an adoption gap in a context where growers already understand a technology but face cost or trust barriers (as in the Swiss and Florida evidence). A single, undifferentiated "raise awareness" strategy is unlikely to be equally effective across both settings.

## DETERMINANTS OF KNOWLEDGE LEVEL

Across the reviewed studies, a consistent set of farmer and household characteristics predicts knowledge level:

- **Education:** formal education level is positively associated with knowledge across nearly every study reviewed, from GAP knowledge in Bangladesh to drip irrigation knowledge in Rajasthan [2], [3], [6].
- **Extension contact and training:** training received and extension media contact consistently predict higher knowledge scores, and their absence is cited directly by farmers as a barrier to applying GAP [2], [3].
- **Social participation and organizational membership:** farmers who are members of farmer organizations or cooperatives show significantly higher knowledge of irrigation technologies, consistent with the role of peer networks in technology diffusion [6].
- **Farm and household economic factors:** income level, land holding size, and occupation (full-time versus part-time farming) show positive, though sometimes non-significant, relationships with knowledge level depending on the specific technology and study context [6].
- **Techno-savviness and scientific orientation:** in more recent, digitally-mediated extension contexts, comfort with technology and a general scientific orientation predict knowledge gain more strongly than traditional socio-economic status, suggesting the determinants of knowledge may be shifting as extension delivery digitizes.

## THE KNOWLEDGE–ADOPTION GAP: WHY AWARENESS DOES NOT ALWAYS TRANSLATE

A recurring and consequential finding across this review is that knowledge levels consistently exceed adoption levels, sometimes substantially. In Tamil Nadu, the knowledge-adoption gap was nearly 20 percentage points overall, and considerably wider for specific practices such as soil testing and plant protection measures, where awareness was reasonable but adoption remained low [1]. In Dinajpur, medium GAP awareness (56.7%) coexisted with low GAP adoption for the majority of farmers (65.0%) [3].

The reviewed studies point to several explanations for this gap that are distinct from knowledge itself: rising input costs and unavailability of timely, quality inputs; lack of access to services such as soil testing facilities even where farmers know such testing is recommended; and structural constraints such as land tenure or capital access that limit farmers' ability to act on what they know [1], [3]. This distinction matters for programme design: interventions that only add more information (additional training sessions, more awareness campaigns) will have limited effect on adoption where the binding constraint is input cost or service availability rather than knowledge itself.

## IMPLICATIONS FOR EXTENSION AND POLICY

- **Target diagnostic, judgment-intensive practices first:** IPM, seed treatment, and irrigation timing show the largest documented knowledge gaps and would benefit most from hands-on, Farmer Field School-style training rather than one-off information campaigns.
- **Pair knowledge-building with service access:** knowledge of soil testing is often reasonable, but adoption is limited by facility access; extension investment in this case should prioritize service delivery infrastructure alongside training.
- **Differentiate extension strategy by context:** awareness-building extension makes sense where basic knowledge gaps are large (much of the South Asian evidence reviewed here); cost-sharing, technical support, and trust-building are more relevant where awareness is already high but adoption lags for economic reasons (as in the Swiss and Florida evidence).
- **Track adoption, not just knowledge:** because knowledge assessment is easier to measure than adoption, extension monitoring risks over-relying on knowledge scores as a proxy for programme success; the consistent knowledge-adoption gap documented here suggests this proxy can be misleading.

## DISCUSSION AND RESEARCH GAPS

This review draws primarily on cross-sectional, single-region surveys using broadly similar knowledge-scoring methodologies (categorizing farmers into low/medium/high knowledge based on a structured test or checklist). This consistency in method makes the studies comparable, as reflected in Figure 3, but also means the evidence base shares a common limitation: nearly all studies are cross-sectional snapshots rather than longitudinal tracking of how knowledge changes over time or in response to specific interventions. Very few studies link measured knowledge level directly to yield or income outcomes, leaving open how much practical difference a shift from medium to high knowledge would actually make for a given technology.

The evidence base is also geographically concentrated in India and Bangladesh, with much sparser vegetable-specific knowledge-gap literature from Sub-Saharan Africa, Latin America, and Southeast Asia. The contrast with Swiss and Florida evidence in Section 6 is illustrative rather than systematic — a fuller comparative picture would require equivalent knowledge-level surveys conducted with consistent methodology across income contexts, which does not yet exist in the published literature reviewed here.

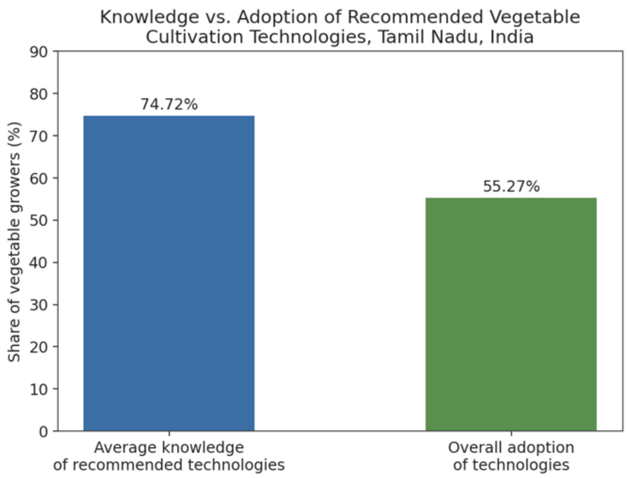


**Figure 1:** Average knowledge versus overall adoption of recommended vegetable cultivation technologies, Tamil Nadu, India [1].

## CONCLUSION

The evidence reviewed here converges on a clear pattern: vegetable growers, particularly in South Asian smallholder contexts, typically possess partial rather than complete knowledge of improved production technologies, with "medium" knowledge the most common outcome across independent studies of GAP, protected cultivation, and irrigation technology. The largest specific gaps concentrate in judgment-intensive practices — integrated pest management, seed treatment, and irrigation timing — rather than simple, fixed-rule practices. Just as importantly, knowledge consistently outpaces adoption, meaning that closing the knowledge gap alone will not close the practice gap: input costs, service access, and structural constraints act as an additional barrier layer that extension design must address alongside, not instead of, knowledge-building. In higher-income agricultural contexts, the constraint structure shifts from basic awareness to cost and trust, underscoring that extension and policy responses to "knowledge gaps" must be calibrated to which gap — awareness, knowledge, or adoption — is actually binding in a given context.

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**How to Cite this Article:** Yadav V.K.. (2026). Knowledge and Awareness Gaps Among Vegetable Growers Regarding Improved Production Technologies: A Review. *Agro-Science Letters*, **2**(2), 18-22. https://doi.org/10.48165/asl.2026.2.02.04