

SOCIO-ECONOMIC AND EXTENSION DETERMINANTS OF INTEGRATED PEST AND DISEASE MANAGEMENT ADOPTION IN LABLAB (*LABLAB PURPUREUS*) AND RELATED GRAIN LEGUMES: A SYSTEMATIC SCOPING REVIEW

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ABSTRACT

Lablab (*Lablab purpureus* (L.) Sweet) is a multipurpose legume whose productivity is limited by pod borers, aphids, storage bruchids and viral and fungal diseases. Integrated pest and disease management (IPDM) packages exist, but little is known about why smallholders do or do not adopt them. This review asks which socio-economic, extension and institutional factors shape IPDM adoption in lablab and analogous smallholder grain-legume systems. A systematic scoping review was conducted following PRISMA-ScR guidance. We de-duplicated and screened records from Google Scholar (semantic and full-text search) and PubMed (n = 400) against population–concept–context criteria; we retained 12 studies from database searching and 8 from citation and targeted searching. We charted data on setting, crop, design, sample, analytical model, and reported determinants, and synthesised them narratively with an evidence matrix. Only three included studies concern lablab, and none estimates an adoption model; the evidence base is dominated by common bean and cowpea in East and West Africa, with two Indian studies. Across systems, extension contact, training frequency, access to crop information and membership of farmer groups were the most consistent positive correlates of adoption. Education and off-farm income were generally positive; age was negative or inconsistent; land size was mixed. In Lablab, farmers rank economic returns as both the main motivation and the main constraint, with poor prices, weak market channels and lack of improved varieties prominent. Labour, cost and yield risk, insecticide promotion and subsidies, and weak seed systems constrain adoption, and gender shapes both preferences and access. IPDM adoption in lablab is best understood as an investment decision conditioned on market incentives and knowledge access rather than a purely technical choice. Priorities are household-level adoption studies in lablab (particularly in India, the crop's centre of diversity), measurement of adoption intensity and dis-adoption, and gender-disaggregated analysis.

KEYWORDS: Lablab purpureus; dolichos bean; integrated pest management; technology adoption; agricultural extension; gender; smallholder farmers; grain legumes

1. INTRODUCTION

Lablab (*Lablab purpureus* (L.) Sweet), known as dolichos, hyacinth or field bean, is one of the most diverse domesticated legumes. It is used as a pulse, a green-pod vegetable, forage and green manure (Maass et al., 2010). Although the species originated in Africa, its greatest agro-morphological diversity is in South Asia. In India, it has been cultivated for more than three millennia and has been bred since the 1930s, notably at Tamil Nadu Agricultural University and the University of Agricultural Sciences, Bangalore (Maass et al., 2010). In eastern Africa, the crop is being re-examined for drought-prone mixed farming systems. In northern Tanzania, farmers grow it for soil fertility, sale, livestock feed and food during drought, mostly intercropped (Missanga et al., 2023). Biotic stress is the main yield constraint. In participatory surveys in Tanzania, 83.9% of lablab growers named pests and diseases as their principal production problem. Pod borers and aphids dominated in the field, bruchids caused damage in 87.1% of stores, and bacterial wilt and late blight were the main diseases (Letting et al., 2022). Storage bruchids (*Callosobruchus* spp.) are a major barrier to wider utilisation (Letting et al., 2021). In Tamil Nadu, the spotted pod borer *Maruca vitrata* is a key pest of garden lablab. Farmers typically rely on synthetic insecticides, yet integrated modules have achieved significantly lower larval populations than farmers' practice, with benefit–cost ratios of 1.95–1.99 (Preethi et al., 2022). Heavy reliance on insecticides in grain legumes raises familiar concerns about resistance, residues, operator health and cost (Pretty & Bharucha, 2015; Togola et al., 2023).

Integrated pest and disease management (IPDM) combines host-plant resistance, cultural practices such as intercropping and sanitation, biological and botanical control, monitoring and the judicious use of selective pesticides. Field evidence from lablab supports several components. Intercropping lablab with maize reduced the abundance of some damaging insect species, and some indigenous accessions were more tolerant of insect pests than commercial varieties (Forsythe, 2019). Elsewhere, technical efficacy has rarely been enough to secure adoption. A global survey of IPM practitioners found that insufficient training and technical support for farmers was the most frequently cited obstacle. Developing-country respondents ranked the need for collective action within farming communities as the most important obstacle (Parsa et al., 2014). Policy and institutional bottlenecks reinforce these barriers. They include production-first agricultural policy, under-funded extension, input regulation that favours conventional pesticides and pesticide subsidies (Day et al., 2022).

Adoption theory gives a lens for these observations. Diffusion-of-innovations theory holds that uptake depends on perceived relative advantage, compatibility, complexity, trialability and observability. It also depends on the communication channels and social systems through which knowledge flows (Rogers, 2003). Agricultural economics frames adoption as a constrained investment decision shaped by farm size, risk, human capital, labour, credit, tenure and supply constraints (Feder et al., 1985). Meta-analyses confirm that education, extension, credit, group membership and land tenure are positively associated with adoption on average. The same studies warn that the size and even the sign of these effects vary widely across technologies, cultures and geographies (Knowler & Bradshaw, 2007; Ruzzante et al., 2021). This heterogeneity matters for lablab. Because crop-specific adoption studies are scarce, inferences must be drawn carefully from analogous legume systems.

No previous review has assembled the socio-economic and extension evidence on IPDM adoption in lablab. This review addresses three questions.

RQ1: What household, economic and extension factors are associated with IPDM adoption in lablab and analogous smallholder grain-legume systems?

RQ2: What institutional and market constraints limit adoption?

RQ3: What evidence gaps must be closed before lablab-specific policy can be designed with confidence?

The review also proposes a conceptual framework (Section 4) to guide future empirical work, including household surveys of lablab growers in South India.

2. METHODS

2.1 Review design

Because the lablab-specific literature is small and methodologically heterogeneous, a systematic scoping review was chosen rather than a meta-analysis. Scoping reviews are suited to mapping the extent and nature of evidence and identifying gaps where effect sizes cannot be pooled. Reporting follows the PRISMA extension for scoping reviews (PRISMA-ScR; Tricco et al., 2018), and the study flow is shown with the PRISMA 2020 diagram (Page et al., 2021).

2.2 Eligibility criteria

Eligibility was defined using the population–concept–context (PCC) framework. *Population*: smallholder farmers producing lablab or another grain legume (common bean, cowpea, pigeonpea, groundnut) in low- and middle-income countries. *Concept*: empirical analysis of adoption, non-adoption, preference for, or constraints to IPM/IPDM components (resistant varieties, cultural, biological and botanical control, monitoring, judicious pesticide use), with explicit attention to socio-economic, extension or institutional explanatory factors. *Context*: on-farm or community settings; any study design (econometric, choice experiment, participatory appraisal, mixed methods, meta-analysis). Studies reporting only agronomic efficacy were not charted as evidence but were cited for context. Studies limited to non-legume crops were excluded unless the legume formed part of the IPM system studied (for example, push–pull intercrops). Peer-reviewed articles, theses and conference papers in English or French were eligible.

2.3 Information sources and search

Records were identified from Google Scholar (n = 99), SciSpace semantic search (n = 201), SciSpace full-text search (n = 100) and PubMed (n = 0). The search combined crop terms ("Lablab purpureus" OR lablab OR dolichos OR "hyacinth bean" OR "field bean" OR "common bean" OR cowpea OR pigeonpea OR "grain legume") with concept terms ("integrated pest management" OR IPM OR IPDM OR "integrated crop management" OR biopesticide OR "push-pull") and outcome terms (adoption OR uptake OR determinant OR constraint OR perception* OR extension). Backwards and forward citation searching of included studies and targeted searches on lablab pest management in India and East Africa identified eight further eligible studies during revision.

2.4 Selection of sources

After removal of 36 duplicates, 364 records remained. Because the AI-assisted search tools return results ranked by semantic relevance, the 100 highest-ranked records were screened on title and abstract; the remaining 264 lower-ranked records were not screened. This cut-off is a limitation and is discussed in Section 7. Of the 100 screened records, 86 were excluded (irrelevant crop or population, 52; intervention outside IPM/IPDM, 18; no adoption or determinant analysis, 16). Fourteen full texts were assessed and two were excluded as outside the target crop context, leaving 12 studies from database searching. With eight studies from other methods, 20 studies

were charted (Figure 1; Table 1).

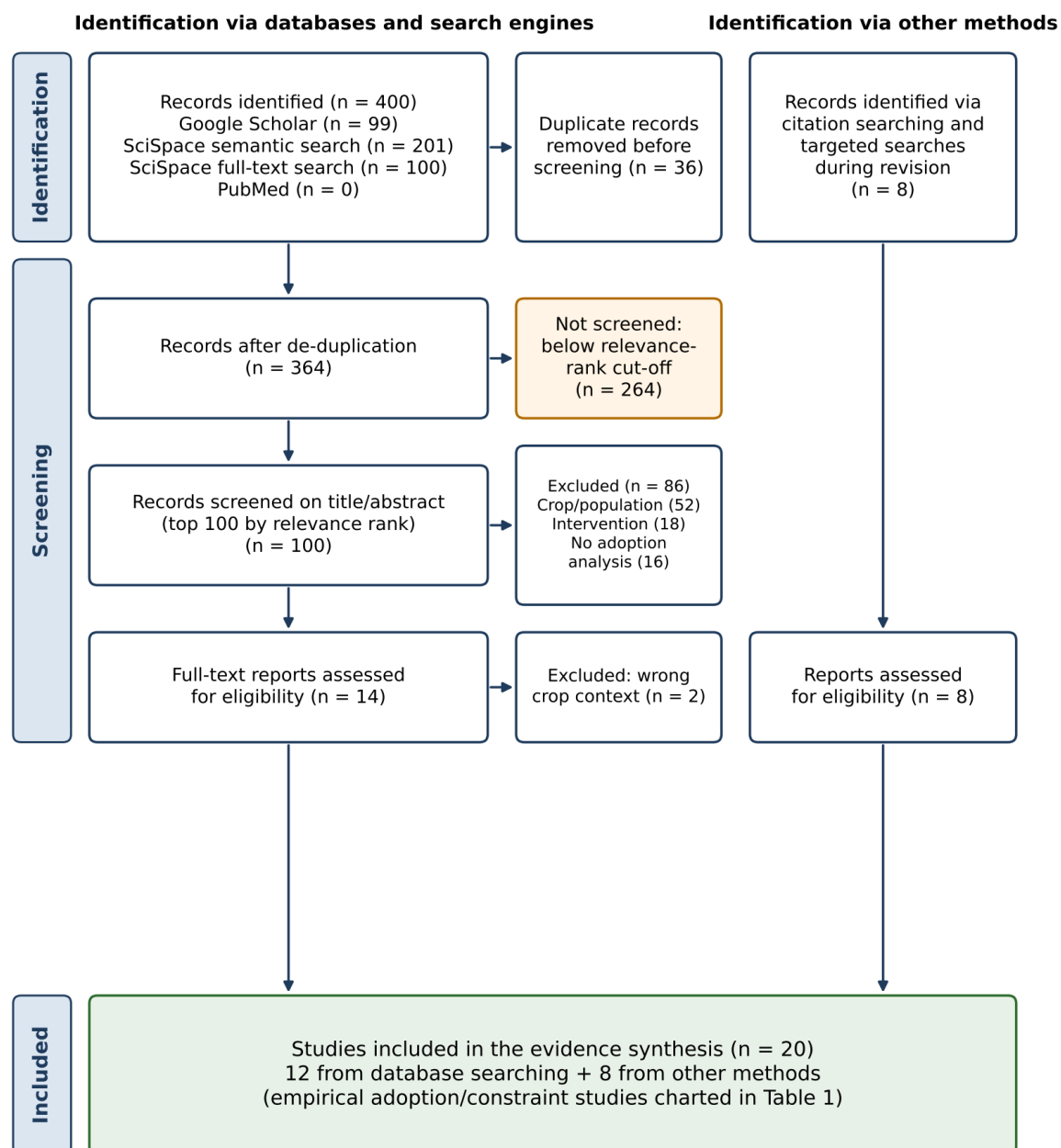


Figure 1. PRISMA 2020 flow diagram of the study selection. Database counts are taken from the screening log; the 'other methods' pathway records studies identified through citation and targeted searching. Theoretical, methodological and agronomic literature cited for context is not counted.

2.5 Data charting and synthesis

For each study, the country, crop, IPM components, design, sample size, analytical model and reported determinants (with direction and significance) were charted. Determinants were grouped into household, economic, extension and information, gender, and institutional categories, and summarised in an evidence matrix (Table 2). Because study designs, outcome definitions (binary adoption, number of practices, stated preference) and covariate sets differ, effect sizes were not pooled. Instead, each determinant was classed as consistent, mixed or limited according to the number and agreement of studies reporting it. Counts of significant associations are descriptive only and do not measure effect magnitude. Formal quality appraisal is not required in scoping reviews, but the main design limitations of each study are noted in Table 1.

3. RESULTS

3.1 Characteristics of the evidence

The 20 charted studies span 2006–2025 (Table 1). Fourteen are from sub-Saharan Africa (Uganda 2, Kenya 2, Tanzania 5, Benin 3, Ghana 1, Burkina Faso 1). Two are from India, two from Brazil, and two are multi-country syntheses. Common bean and cowpea dominate, with six studies each when multi-crop studies are counted. Lablab is the subject of only three studies, all from northern Tanzania: a master's thesis combining interviews and a field trial (Forsythe, 2019), a participatory variety-selection study with 31 farmers (Letting et al., 2022), and a

production-systems survey (Missanga et al., 2023). None of the three estimates an adoption model. Designs include binary or count-data regression models (logit, Poisson, ordered and multivariate probit), a choice experiment, participatory rural appraisal, mixed methods, a quasi-experimental impact evaluation and one meta-analysis. Sample sizes range from 31 to 505 farmers. Most studies are cross-sectional, so the associations they report should not be read as causal effects.

Table 1. Characteristics of the 20 studies charted in the evidence synthesis (chronological).

Study	Country	Crop system	Design; sample	Analysis	Main determinants or findings
Bonabana-Wabbi et al. (2006)	Uganda	Groundnut, cowpea, sorghum	Household survey	Multinomial and ordered logit	Economic/market factors most influential; off-farm income (+) and farm-organisation membership (+) for groundnut
Adetonah et al. (2009)	Benin	Cowpea (<i>Maruca vitrata</i>)	Farmer perception survey	Descriptive	Farmer perceptions of environmental risk and integrated control of the pod borer
Rama Rao et al. (2011)	India (Andhra Pradesh)	Pigeonpea	Household survey	Logit	Age, education, CBO participation, pest recognition, farm size significant; dis-adoption after new insecticides
Kassie et al. (2013)	Tanzania	Maize–legume systems	Plot-level survey	Multivariate probit	Sustainable practices adopted as interdependent bundles; household, plot and institutional factors
Sanya et al. (2015)	Uganda	Common bean (root rot)	Survey; n = 160	Poisson regression	Information access, training frequency, seed-loan scheme, record keeping (+); age (–)
Agyekum et al. (2016)	Benin	Cowpea	Choice experiment; n = 505	Conditional logit	Cost, labour and expected yield loss drive choices; social norms could aid biocontrol
Sharma & Peshin (2016)	India (Jammu)	Vegetables	Quasi-experimental	Impact evaluation	IPM training: little change in non-chemical practices; lower environmental impact quotient
Emongor & Uside (2019)	Kenya	Common bean	Survey; n = 502	Logistic regression	Region, education, extension access, food security and bean market availability significant
Forsythe (2019)	Tanzania	Lablab	Interviews + field trial	Descriptive; trial ANOVA	Economics top motivation and constraint; poor price; intercropping and tolerant accessions reduce pests
Laizer et al. (2019)	Tanzania	Common bean	Survey; n = 169	Descriptive	83% cite insects; 24% can afford pesticides; 6.5% aware of non-chemical options
Djinadou & Acacha (2019)	Benin	Cowpea (neem extracts)	Focus groups, case study; 96 men, 144 women	Gender analysis	Perceptions of botanical control differ by gender, reflecting constraints and opportunities
Ouedraogo et al. (2020)	Burkina Faso	Cowpea	Participatory rural appraisal	Descriptive	Interlocking biotic, abiotic, knowledge and marketing constraints
Letting et al. (2022)	Tanzania	Lablab	Participatory selection; n = 31	Descriptive	Pests/diseases top constraint (83.9%); pod borers, aphids, bruchids; marketability 38.7%; 71% male
Sekabira et al. (2022)	Multi-country	Climate-smart IPM	Meta-analysis	Meta-analysis	Income, tenure, groups, extension (+); land size (–); credit, labour and information market failures

Study	Country	Crop system /	Design; sample	Analysis	Main determinants or findings
Missanga et al. (2023)	Tanzania	Lablab	Socio-economic survey	Descriptive	Mostly intercropped (59%); lack of improved varieties and poor market channels
Acheampong et al. (2023)	Ghana	Bean and cowpea	Survey; n = 154	Multivariate probit	Gender, age, household size, land ownership, training shape adaptation choice
Robusti et al. (2023)	Brazil	Common bean	Interviews with farmers and extension staff	Content analysis	Lack of information/knowledge main barrier to IPM
Ouya et al. (2024)	Kenya	Push–pull (maize) with vegetables	Survey; n = 124	Multinomial logit	Age, education, gender, experience shape choices; men market-oriented, women traditional vegetables
Ferreira et al. (2025)	Brazil	Common bean	Survey; n = 103	Descriptive	Adoption 46.6%; poor IPM understanding, pesticide confidence, monitoring cost
Khonje et al. (2025)	Multi-country (Africa)	Multiple crops	Farm survey	Econometric	Provision of pest alerts associated with better farm performance

CBO = community-based organisation; + / – = direction of association reported by the authors.

3.2 Household determinants

Age. In western Uganda, the age of the household head was negatively associated with the number of bean root-rot management practices adopted (Sanya et al., 2015). In Andhra Pradesh, age significantly influenced the decision to adopt pigeonpea IPM (Rama Rao et al., 2011), and age shaped the vegetable choices of push–pull farmers in Kenya (Ouya et al., 2024). Age also entered the adaptation choices of Ghanaian bean and cowpea farmers (Acheampong et al., 2023). Taken together, the direction of the age effect is negative or context-dependent. The usual explanations are shorter planning horizons and greater risk aversion among older farmers, but older farmers also have more experience, so age and experience should be modelled separately.

Education. Education of the household head was a significant positive determinant of IPM adoption among 502 common bean farmers in Machakos and Bungoma, Kenya (Emongor & Uside, 2019). It was also significant for pigeonpea IPM in India (Rama Rao et al., 2011) and for push–pull vegetable choice in Kenya (Ouya et al., 2024). In Liberia, education and extension access raised IPM adoption (Campbell, 2025, excluded from the charted set; see Section 7). Meta-analytic evidence suggests that education and extension are complementary for knowledge-intensive natural-resource-management technologies, whereas for improved varieties extension can partly substitute for education (Ruzzante et al., 2021). This distinction is directly relevant to IPDM, which is knowledge-intensive.

Experience and pest knowledge. Farming experience was associated with technology preferences in push–pull systems (Ouya et al., 2024). Specific knowledge appears to matter more than general experience. The ability to recognise insect pests was a significant predictor of pigeonpea IPM adoption in India (Rama Rao et al., 2011). In northern Tanzania, only 6.5% of common bean farmers knew of non-chemical pest control options, and about 43% saw no need to consult extension officers (Laizer et al., 2019). In Brazil, limited understanding of IPM concepts, together with strong confidence in pesticides and the cost of crop monitoring, explained why only 46.6% of common bean producers used IPM (Ferreira et al., 2025).

3.3 Economic determinants

Markets and prices. Bean market availability was one of five significant determinants of IPM adoption in Kenya (Emongor & Uside, 2019). In lablab, economic factors were ranked first both as the reason to grow the crop and as its main constraint. Lablab grain is increasingly sold rather than eaten at home, and poor market price was the dominant constraint. Market expansion and lower transport costs were identified as preconditions for expanding the crop (Forsythe, 2019). Survey and participatory data from Tanzania echo this pattern. Poor market channels and lack of improved varieties were the main challenges reported by lablab growers (Missanga et al., 2023). In a participatory study, 38.7% of farmers cited poor marketability, most sold to middlemen, and farmers reported little access to market information (Letting et al., 2022). Lablab is thus a commercialising crop, and investment in IPDM depends on whether better quality and yield are rewarded by the market. Where prices are low or volatile, the expected return on IPDM falls.

Income, credit and farm size. In Uganda, the availability of off-farm income and membership of farm organisations raised the probability of adopting IPM in groundnut. Across groundnut, cowpea and sorghum, economic and market factors were the most influential category of determinants (Bonabana-Wabbi et al., 2006). A meta-analysis of climate-smart IPM found income and registered land tenure to be positive determinants and

land size owned to be negative (Sekabira et al., 2022). The broader adoption meta-analysis finds land size positive on average (Ruzzante et al., 2021). Farm size therefore has no consistent direction for IPDM, perhaps because many IPDM components are scale-neutral but labour-intensive. Credit access is positively associated with adoption on average. Ruzzante et al. (2021) recommend measuring whether households are credit-constrained rather than simply whether credit is available.

Labour, cost and risk. Costs, labour requirements and potential yield losses were the main attributes driving cowpea farmers' choices between biological and synthetic pest control in Benin (Agyekum et al., 2016). Farmers there knew the health risks of pesticides but continued to apply them out of necessity. In Brazil, the cost of field monitoring was a principal barrier (Ferreira et al., 2025). The availability of new-generation insecticides led some Indian pigeonpea farmers to discontinue IPM practices they had previously adopted (Rama Rao et al., 2011). Unless IPDM saves labour or capital relative to calendar spraying, or is rewarded by the market, its uptake will remain fragile.

Table 2. Evidence matrix of determinants of IPDM adoption in grain legumes.

Determinant	Predominant direction	Supporting studies	Strength
Extension access / contact	+	Emongor & Uside (2019); Sekabira et al. (2022); Robusti et al. (2023); Ruzzante et al. (2021)*	Consistent
Training frequency; information access	+	Sanya et al. (2015); Acheampong et al. (2023); Khonje et al. (2025); Parsa et al. (2014)*	Consistent
Group / CBO membership	+	Bonabana-Wabbi et al. (2006); Rama Rao et al. (2011); Sekabira et al. (2022)	Consistent
Education	+	Emongor & Uside (2019); Rama Rao et al. (2011); Ouya et al. (2024); Ruzzante et al. (2021)*	Consistent
Market availability and price	+ (poor price –)	Emongor & Uside (2019); Forsythe (2019); Letting et al. (2022); Missanga et al. (2023)	Moderate (lablab-specific)
Off-farm income / income	+	Bonabana-Wabbi et al. (2006); Sekabira et al. (2022)	Limited
Credit access	+	Sekabira et al. (2022); Ruzzante et al. (2021)*	Limited
Labour, cost, yield risk	– (barrier)	Agyekum et al. (2016); Bonabana-Wabbi et al. (2006); Ferreira et al. (2025)	Moderate
Pest knowledge / recognition	+	Rama Rao et al. (2011); Laizer et al. (2019); Ferreira et al. (2025)	Moderate
Age	– or mixed	Sanya et al. (2015); Rama Rao et al. (2011); Ouya et al. (2024); Acheampong et al. (2023)	Mixed
Land size	Mixed	Sekabira et al. (2022) (–); Ruzzante et al. (2021)* (+); Rama Rao et al. (2011)	Mixed
Land tenure / ownership	+	Sekabira et al. (2022); Acheampong et al. (2023); Ruzzante et al. (2021)*	Limited
Gender	Context-specific	Djinadou & Acacha (2019); Acheampong et al. (2023); Ouya et al. (2024); Doss & Morris (2001)*	Limited
Seed-system participation / variety access	+	Sanya et al. (2015); Missanga et al. (2023); Letting et al. (2022)	Limited
Insecticide availability, subsidies	– (barrier)	Rama Rao et al. (2011); Day et al. (2022)*	Limited

* Contextual source (meta-analysis, review or general adoption study) not counted among the 20 charted studies. Consistent = at least three charted studies agree and none contradict; Moderate = two or three agree, or lablab-specific support; Mixed = studies disagree in direction; Limited = one or two studies.

3.4 Extension, information and social networks

Extension is the most consistently supported determinant in the charted evidence (Table 2). In Kenya, access to extension services was significant at the 1% level (Emongor & Uside, 2019). In Uganda, access to bean information and the frequency of training were positively associated with the number of root-rot management practices adopted. Participation in a farmer-to-farmer seed-loan scheme and record keeping were also positive correlates (Sanya et al., 2015). In Ghana, access to agricultural training was associated with farmers' choice of adaptation strategy (Acheampong et al., 2023). Functional extension systems that raise awareness were identified as a positive determinant in the climate-smart IPM meta-analysis (Sekabira et al., 2022). Among farmers and

extension technicians in Paraná, Brazil, lack of information and knowledge was the main reported barrier to IPM in common bean (Robusti et al., 2023).

Group membership works through social learning and collective action. Membership of farm organisations raised adoption in Uganda (Bonabana-Wabbi et al., 2006), and participation in community-based organisations was significant in India (Rama Rao et al., 2011). Collective action was ranked the top IPM obstacle by developing-country practitioners (Parsa et al., 2014). Social norms could also be used to promote biocontrol in cowpea (Agyekum et al., 2016).

The type of extension matters. Farmer field schools (FFS) improve knowledge and practices and reduce pesticide use in many settings (Van den Berg & Jiggins, 2007). A Campbell systematic review found that these effects are strongest in pilot programmes and weaker when FFS are scaled up (Waddington et al., 2014). An Indian evaluation of a vegetable IPM programme in Jammu found that, after training, adoption of most non-chemical practices did not change significantly. Pesticide application frequency fell substantially only in cauliflower (Sharma & Peshin, 2016). Digital pest alerts are a newer channel. Their provision was associated with better farm performance across several African countries (Khonje et al., 2025), but such channels may disadvantage women where ICT access is unequal (Day et al., 2022). Taken together, extension contact is a necessary but not sufficient condition for adoption. The intensity, quality and follow-up of extension appear to matter as much as access.

3.5 Gender

Gender shapes both technology preferences and the capacity to act on them. In western Kenya, men preferred capital-intensive, market-oriented vegetables when integrating vegetables into push–pull systems, whereas women preferred traditional vegetables (Ouya et al., 2024). In south-western Benin, a study of 96 men and 144 women found that perceptions of neem aqueous extracts for cowpea pest control differed by gender. The authors attributed these differences mainly to the distinct constraints and opportunities men and women face (Djinadou & Acacha, 2019). Gender, age, household size, land ownership and access to training together shaped the adaptation choices of Ghanaian bean and cowpea farmers. Men in that sample reported higher awareness of climate change than women (Acheampong et al., 2023). The lablab evidence contains no gender-disaggregated adoption analysis. In the Tanzanian participatory study, 71% of participants were men, reflecting men's control of land and production decisions (Letting et al., 2022). Classic adoption work suggests that gender gaps in adoption often reflect unequal access to land, labour, credit and extension rather than gender as such (Doss & Morris, 2001). Studies of lablab IPDM should therefore measure these resources directly, not only include a sex-of-head dummy.

3.6 Institutional and seed-system constraints

Resistant or tolerant varieties are the foundation of most IPDM packages, yet lablab growers in Tanzania reported a lack of improved varieties (Missanga et al., 2023). Farmers' own selection criteria prioritised pest and disease resistance, early maturity, yield, seed colour for the market and short cooking time (Letting et al., 2022). Varietal development therefore needs to combine resistance with market and consumption traits. In Uganda, adoption of resistant bean varieties was high (95% of farmers had adopted at least one). Community-based seed production, support to rural input enterprises and continued information access were recommended to sustain uptake (Sanya et al., 2015). At the policy level, IPM in Africa is constrained by production-first policy, weak and under-funded extension, costly registration of lower-risk products, weak enforcement that keeps conventional pesticides cheap, and free pesticide distribution during pest outbreaks (Day et al., 2022). In cowpea, farmers' perceptions of environmental risk and the availability of non-chemical options for *Maruca vitrata* condition their willingness to change practice (Adetonah et al., 2009; Togola et al., 2023). Participatory appraisals in Burkina Faso document an interlocking set of production and marketing constraints among cowpea growers (Ouedraogo et al., 2020).

4. Discussion: an integrated framework for lablab IPDM adoption

The evidence supports a three-level framework (Figure 2). At the **household level**, education, specific pest knowledge, labour and liquidity determine whether a farmer can implement knowledge- and labour-intensive practices. At the **information and extension level**, training intensity, trusted information channels and group membership determine whether farmers know about IPDM, believe it works and can coordinate with neighbours. At the **market and institutional level**, prices, market channels, input regulation, subsidies and seed systems determine whether IPDM pays. Gender relations, agro-ecology, the degree of commercialisation and pest pressure moderate all three levels. Adoption is best measured as the number and intensity of practices adopted rather than a binary choice, and it is followed by continuation or dis-adoption depending on experienced profitability (Rama Rao et al., 2011).

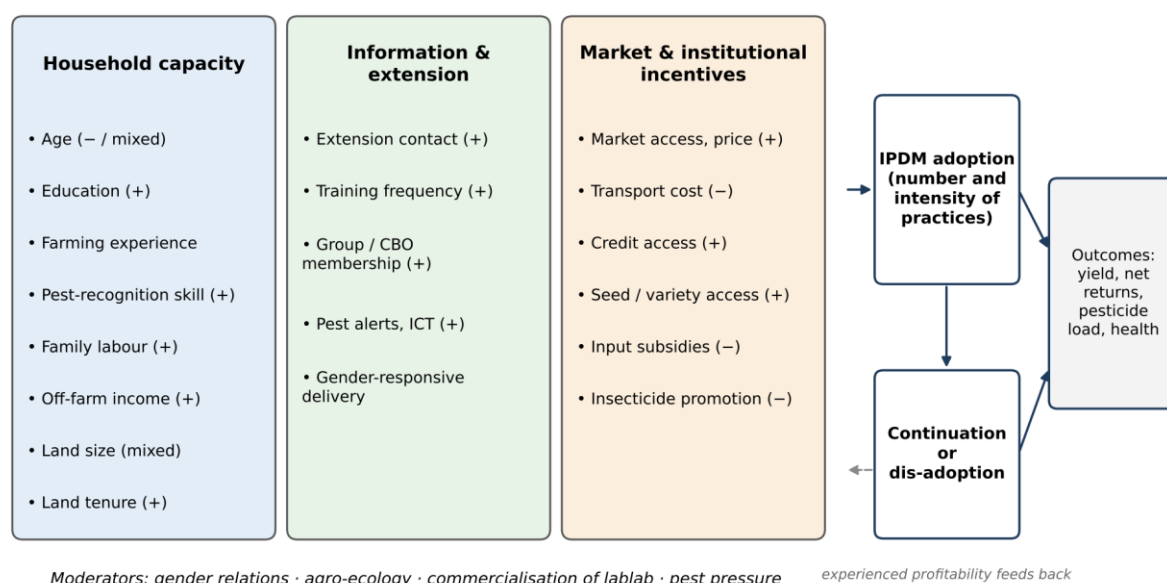


Figure 2. Conceptual framework of IPDM adoption in lablab derived from the synthesis. Signs show the predominant direction of association in the charted evidence (+ positive, – negative, mixed = inconsistent).

Three features distinguish lablab from the analogous crops on which most evidence is based. First, lablab is being commercialised. Where it is sold as grain, as in Tanzania, or as a high-value green-pod vegetable, as in South India, market signals are likely to dominate the adoption decision (Forsythe, 2019; Missanga et al., 2023). The Kenyan finding that market availability drives bean IPM adoption (Emongor & Uside, 2019) is therefore probably more transferable than findings from subsistence-oriented systems. Second, the pest complex of lablab spans field and storage pests (pod borers, aphids, *Maruca vitrata*, bruchids) and vector-borne viruses (Letting et al., 2022; Preethi et al., 2022). An effective IPDM package must therefore integrate several components across the season, which raises its knowledge requirements and makes training intensity more important. Third, vegetable lablab in India is harvested repeatedly over long periods. This creates strong incentives for prophylactic spraying and residue risks, the conditions under which new insecticides have previously displaced IPM in Indian pigeonpea (Rama Rao et al., 2011).

The heterogeneity reported in large meta-analyses (Ruzzante et al., 2021) is a caution against prescribing a universal list of determinants. In this review, the direction of age and land-size effects varied across studies, and several determinants rest on a single study. The determinants that appear consistently (extension intensity, information access, group membership, market access) are also those that policy can change. Demographic variables mainly help target interventions rather than serve as levers.

5. Implications for policy and extension

Recommendations are graded by the strength of supporting evidence (Table 2).

(i) **Invest in intensive, repeated, practice-based training rather than one-off contact** (consistent evidence). Training frequency and information access, not mere awareness, are associated with adoption (Sanya et al., 2015; Emongor & Uside, 2019). Farmer field schools should be designed with post-training follow-up, because effects weaken at scale (Waddington et al., 2014; Sharma & Peshin, 2016). In India this can be delivered through Krishi Vigyan Kendras and ATMA farm schools on lablab IPDM modules validated in Tamil Nadu (Preethi et al., 2022).

(ii) **Work through groups** (consistent evidence). Farmer groups, community-based organisations and producer companies support peer learning, collective monitoring and bulk purchase of pheromone traps and biopesticides (Bonabana-Wabbi et al., 2006; Rama Rao et al., 2011; Parsa et al., 2014).

(iii) **Link IPDM to markets** (moderate evidence; lablab-specific). Aggregation, market information and quality premiums for low-residue produce can raise the return to IPDM (Forsythe, 2019; Letting et al., 2022; Missanga et al., 2023). Residue-tested procurement for vegetable lablab is an untested but plausible lever.

(iv) **Strengthen seed systems for tolerant varieties** (moderate evidence). Community-based seed production and farmer-to-farmer seed schemes improved uptake of resistant beans (Sanya et al., 2015). Lablab breeding should combine pest and bruchid resistance with market traits (Letting et al., 2021, 2022).

(v) **Make extension gender-responsive** (limited but convergent evidence). Training schedules, venues and channels should match women's time and mobility constraints, and resource gaps such as land, credit and labour should be addressed directly (Doss & Morris, 2001; Djinadou & Acacha, 2019; Acheampong et al., 2023).

(vi) **Align input policy with IPM** (expert and policy evidence). Free or subsidised pesticide distribution and weak regulation undercut IPM. Registration of lower-risk products and enforcement of quality standards would level the field (Day et al., 2022).

6. Research gaps and agenda

Lablab-specific adoption studies. No charted study models IPDM adoption among lablab growers. Household surveys with adequate samples (several hundred farmers) are needed, particularly in South India, where lablab is a commercial vegetable and IPDM modules have been validated (Preethi et al., 2022). Such studies should measure tenure, credit constraint, labour and market participation directly.

Adoption intensity and interdependence. IPDM is a bundle of practices that farmers adopt partially and in combination. Count-data models such as Poisson and negative binomial (Sanya et al., 2015) or multivariate probit models of interrelated practices (Kassie et al., 2013) are more informative than binary logit models of 'adopter' versus 'non-adopter'.

Dis-adoption and dynamics. Evidence on continuation is limited to a single Indian pigeonpea study, which linked dis-adoption to new-generation insecticides (Rama Rao et al., 2011). Panel or recall-based studies should track lablab growers after project support ends.

Profitability. Farm-level evidence comparing the net returns of IPDM and farmers' practice in lablab is limited to on-station or researcher-managed trials. On-farm cost-benefit studies that include family-labour costs are needed to test whether IPDM is privately profitable.

Gender and intra-household decisions. Sex-disaggregated data on who decides, who applies pesticides, who supplies the labour for botanicals and who controls lablab income are absent for lablab and scarce for analogous crops.

Agronomic translation. Promising tolerant accessions and maize-lablab intercropping effects (Forsythe, 2019) must be tested across sites and seasons and linked to variety release and seed multiplication before they can enter extension packages.

7. LIMITATIONS

This review has several limitations. The search relied on Google Scholar and AI-assisted semantic search engines (SciSpace) and did not include bibliographic databases such as Scopus, Web of Science or CAB Abstracts, or Indian thesis repositories such as KrishiKosh. Relevance ranking, rather than exhaustive screening, determined which 100 of 364 de-duplicated records were screened, so relevant studies may have been missed. Most charted studies are cross-sectional and report associations, several are theses, conference papers or articles in regional journals, and outcome definitions differ, so effect sizes could not be pooled. One study meeting the topic criteria (Campbell, 2025) is mentioned but was not charted because it does not specify crops. Finally, most evidence comes from crops other than lablab, and transfer to lablab assumes similar decision structures, which the commercialisation and multi-harvest nature of vegetable lablab may not satisfy.

8. CONCLUSIONS

The evidence on IPDM adoption in lablab is thin. It consists of three descriptive or participatory studies and no adoption models. Evidence from analogous grain legumes is broader and points in a consistent direction. Intensive extension and training, access to crop information, group membership and functioning markets are the most consistent correlates of adoption. Labour, cost, yield risk, insecticide promotion and weak seed systems hold it back, and gender shapes both preferences and capacity. Because lablab is increasingly a cash crop, adoption of IPDM is likely to follow profitability. Extension that is not linked to market and seed-system development is therefore unlikely to achieve lasting uptake. Household-level studies of lablab growers, especially in India, that measure adoption intensity, dis-adoption and gendered decision-making are the most urgent next step.

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Use of AI tools. SciSpace (an AI-assisted literature search engine) was used to identify and rank records. An AI writing assistant was used for language editing and reference checking. The authors verified all sources against the original publications and take full responsibility for the content.

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