International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor 8.176 Volume 12, Issue 10, October 2025
Website- www.aarf.asia, **Email** : editor@aarf.asia , editoraarf@gmail.com

Role of Agricultural Extension Services and Socioeconomic Factors in Shaping Plant Disease Management Practices Among Farmers of Rajasthan: A KAP-Based Analysis

Anupama Yadav[1], Indra Jeet Sharma[2]

[1]Research Scholar, Department of Botany, Faculty of Basic Sciences, Maharishi Arvind University, Jaipur, Rajasthan – 302041, India

[2] Associate Professor, Department of Botany, Faculty of Basic Sciences, Maharishi Arvind University, Jaipur, Rajasthan – 302041, India

ABSTRACT

Agricultural extension services and socioeconomic characteristics are widely recognized as key drivers of technology adoption and knowledge uptake in smallholder farming systems. This study investigates the influence of extension service access, educational attainment, farm size, landholding pattern, and membership in farmer organizations on Knowledge, Attitudes, and Practices (KAP) related to plant disease management in Rajasthan, India. Using a structured KAP survey administered to 420 farmers across six agro-climatically diverse districts, this research employs multivariate regression analysis, path analysis, and stratified subgroup comparisons to disentangle the independent and mediated effects of socioeconomic variables on KAP outcomes. Results indicate that regular extension contact was associated with a 2.8-fold increase in composite KAP scores ($\beta=0.43$, $p<0.001$), while secondary education and above was associated with a 1.9-fold improvement over illiterate farmers ($\beta=0.31$, $p<0.001$). Farm size moderated the relationship between attitude and practice, with medium farmers showing significantly higher practice scores than marginal farmers despite comparable attitudinal scores. Membership in farmer producer organizations (FPOs) showed an independent positive effect on practices (OR=2.74, p=0.002), suggesting that collective action and peer learning are important behavioral levers. Path analysis confirmed that extension contact operates both directly on practices and indirectly through knowledge improvement. These findings have strong implications for the design of differential extension strategies targeting marginal farmers, illiterate communities, and those lacking organizational membership. A socially differentiated approach to agricultural extension is recommended to reduce KAP disparities and enhance equitable plant health management in Rajasthan.

Keywords: Agricultural extension, socioeconomic factors, KAP analysis, plant disease management, farmer organizations, Rajasthan, path analysis

1. INTRODUCTION

Plant disease management in smallholder agriculture operates within a complex web of knowledge systems, economic constraints, social structures, and institutional supports. While the technical dimensions of plant disease management—including the development of resistant varieties, biocontrol agents, and novel fungicides—continue to advance, their uptake at the farm level remains heavily mediated by farmer-level factors such as knowledge, attitudes, and socioeconomic positioning. The Knowledge, Attitudes, and Practices (KAP) framework provides a structured analytical lens through which these behavioral dimensions can be systematically assessed and their determinants identified.

In the context of Rajasthan, India's largest state by area, plant disease management is challenged by extreme climatic variability, fragmented landholdings, limited farmer education, and an agricultural extension system that is widely considered underresourced relative to the farming population it serves. The state has a ratio of approximately one extension worker per 1,300 farmers, well below the recommended norm of 1:800 (Rajasthan Agriculture Department, 2022). This structural deficit has direct implications for knowledge transfer and the promotion of evidence-based disease management practices.

Beyond extension access, socioeconomic factors such as education, land size, income, and social capital—including membership in farmer collectives and producer organizations—have been shown to significantly influence agricultural knowledge uptake and technology adoption (Singh & Chand, 2019; Spielman et al., 2020). However, the specific pathways through which these factors shape plant disease management KAP remain underexplored in the Indian context, particularly in arid and semi-arid agricultural systems.

This study was designed to address this gap by examining the independent and mediated effects of extension contact and key socioeconomic variables on plant disease management KAP among Rajasthan's farming communities. Specifically, the study sought to: (i) quantify the association between extension contact frequency and KAP scores; (ii) assess the independent contribution of education, farm size, and farmer organization membership to KAP outcomes; (iii) delineate the pathways through which extension contact influences practices directly and indirectly; and (iv) identify subgroups of farmers with the greatest KAP deficits warranting prioritized extension attention.

2. REVIEW OF LITERATURE

Agricultural extension has long been recognized as the primary institutional mechanism for bridging the gap between scientific knowledge and farm-level practice. Early diffusion-of-innovations research by Rogers (1983) established that extension contact was the most potent channel for accelerating the adoption of agricultural technologies among subsistence farmers. More recent meta-analyses have confirmed that

extension contact significantly improves agricultural productivity (Faure et al., 2012), with effect sizes ranging from 0.20 to 0.52 standard deviations depending on the context and mode of delivery.

In plant disease management, the role of extension contact has been specifically documented by several Indian studies. Sharma et al. (2018) found that farmers receiving at least two extension visits per season had 42% higher knowledge scores regarding powdery mildew management in pea compared to farmers with no contact. In Rajasthan specifically, a study by Verma and Jain (2020) documented that farmers enrolled in Krishi Vigyan Kendra (KVK) programs showed significantly lower rates of pesticide misuse and higher rates of seed treatment adoption than non-enrolled counterparts.

Education has consistently emerged as a powerful moderator of agricultural extension effectiveness. Educated farmers are better positioned to access, process, and apply technical information (Asres et al., 2021). In a pan-India survey, Choudhary et al. (2021) reported that farmers with secondary schooling demonstrated over three times higher adoption rates of integrated pest management (IPM) compared to illiterate farmers. However, education alone is insufficient without complementary extension contact, suggesting interactive rather than additive effects between these variables.

Farmer organization membership—including self-help groups (SHGs), cooperatives, and farmer producer organizations (FPOs)—provides access to collective resources, peer learning, and market linkages that can circumvent individual knowledge deficits (Doss, 2022). Research from Maharashtra and Madhya Pradesh has shown that FPO members are significantly more likely to adopt recommended crop protection practices and less likely to over-rely on calendar-based chemical sprays (Trebbin, 2014; Kumari et al., 2022). The peer network effects within such organizations may partially compensate for limited formal extension contact.

Path analysis has been employed in several KAP studies to decompose direct and mediated effects of socioeconomic variables on agricultural practices (Anandajayasekeram et al., 2008). This methodology allows researchers to distinguish between extension's direct effect on practices and its indirect effect through knowledge improvement—a distinction with significant programmatic implications. If the primary pathway is indirect (through knowledge), then educational content of extension messages is critical; if direct effects dominate, then trust, relationship, and demonstration-based mechanisms may be more important.

3. MATERIALS AND METHODS

3.1 Survey Design and Sample

The study employed the same 420-farmer sample as the parent KAP study (Yadav & Sharma, 2025a), drawn from six districts of Rajasthan using multi-stage stratified random sampling. The independent variables of interest in this paper were: (a) extension contact frequency (regular, occasional, rare/never);

(b) education level (illiterate, primary, secondary, graduate and above); (c) farm size (marginal <1 ha, small 1–2 ha, medium >2 ha); (d) farmer organization membership (FPO/SHG member vs. non-member); and (e) household income quintile.

3.2 Measurement of KAP

Knowledge was measured using 25 items across eight disease management domains, with each item scored 0 or 1, yielding a maximum knowledge score of 25. Attitude was measured on an 18-item Likert scale (1–5), with a maximum attitude score of 90. Practice was measured using 22 items, with higher scores reflecting adoption of more recommended management practices (maximum score: 22). Composite KAP scores were standardized to a 100-point scale for comparability. Scores ≤40% were classified as low, 41–70% as moderate, and >70% as high.

3.3 Statistical Analysis

Descriptive and bivariate analyses were performed to characterize KAP by extension contact and socioeconomic stratum. Analysis of Variance (ANOVA) with Tukey's post hoc test was used for continuous KAP score comparisons across categorical independent variables. Multivariate linear regression with stepwise variable entry was used to identify independent predictors of composite KAP score. Path analysis was conducted using structural equation modeling (SEM) in AMOS 24.0 (IBM), with extension contact, education, and farm size as exogenous variables, knowledge as a mediator, attitude as a secondary mediator, and practice as the endogenous outcome. Model fit was assessed using CFI (>0.90), RMSEA (<0.08), and SRMR (<0.05).

4. RESULTS

4.1 KAP Scores by Extension Contact Frequency

Extension Contact	Knowledge Score (Mean±SD)	Attitude Score (Mean±SD)	Practice Score (Mean±SD)	Composite KAP (Mean±SD)
Regular (n=88)	18.4±3.1	72.6±8.4	16.8±2.9	72.4±9.1
Occasional (n=196)	13.7±3.8	64.3±9.7	11.2±3.5	55.8±10.3
Rare/Never (n=136)	9.2±3.4	56.8±10.1	7.4±2.8	40.6±8.7
F-statistic (p-value)	F=87.4 (p<0.001)	F=52.3 (p<0.001)	F=112.6 (p<0.001)	F=94.7 (p<0.001)

Table 1: KAP scores by extension contact frequency. All pairwise comparisons were significant at p<0.05 by Tukey's HSD test.

Regular extension contact was associated with substantially higher KAP scores across all dimensions. The composite KAP score of regularly contacted farmers (72.4±9.1) was nearly 78% higher than those with rare or no contact (40.6±8.7). The largest absolute effect of extension contact was observed for practice scores, suggesting that extension primarily facilitates behavioral change through modeling, demonstration, and direct recommendation.

4.2 KAP Scores by Education Level

Education Level	Knowledge (/25)	Attitude (/90)	Practice (/22)	Composite (%)
Illiterate (n=84)	8.1±2.9	54.6±9.3	6.2±2.5	38.3±8.4
Primary (n=126)	11.4±3.1	61.7±8.8	9.4±3.1	48.7±9.2
Secondary (n=154)	15.3±3.4	67.4±9.1	13.1±3.4	61.8±9.7
Graduate+ (n=56)	19.8±2.7	74.2±7.6	17.6±2.8	75.6±8.5
F-statistic (p-value)	F=104.2 (<0.001)	F=64.3 (<0.001)	F=118.7 (<0.001)	F=108.5 (<0.001)

Table 2: KAP scores disaggregated by education level (n=420). All inter-group differences statistically significant ($p<0.05$).

A clear gradient of KAP scores across education levels was observed. Illiterate farmers scored markedly lower on all dimensions, with composite scores nearly half those of graduate-and-above farmers. The knowledge domain showed the steepest education gradient, while the attitude domain showed a more gradual increase, suggesting that education particularly enhances cognitive processing of disease-related information.

4.3 Effect of Farmer Organization Membership

Farmers who were members of FPOs or SHGs (n=118, 28.1% of sample) demonstrated significantly higher KAP scores compared to non-members across all dimensions. Mean composite KAP scores were 64.8±10.2 for members versus 49.3±11.4 for non-members ($t=11.8$, $p<0.001$). The practice dimension showed the largest membership effect (mean: 14.6 vs. 10.1, $p<0.001$), supporting the hypothesis that peer learning and

collective exposure to recommendations within farmer organizations primarily enhance adoption rather than knowledge per se.

4.4 Multivariate Regression Analysis

Predictor Variable	β (Standardized)	95% CI	t-value	p-value
Extension Contact (Regular)	0.43	0.36 – 0.50	12.84	<0.001
Extension Contact (Occasional)	0.21	0.14 – 0.28	5.92	<0.001
Education (Secondary)	0.31	0.24 – 0.38	8.71	<0.001
Education (Graduate+)	0.39	0.29 – 0.49	7.62	<0.001
Farm Size (Small)	0.14	0.07 – 0.21	3.96	<0.001
Farm Size (Medium)	0.22	0.14 – 0.30	5.42	<0.001
FPO/SHG Membership	0.18	0.11 – 0.25	5.07	<0.001
Income Quintile (4th+5th)	0.12	0.05 – 0.19	3.37	0.001

Table 3: Multivariate linear regression predicting composite KAP score (n=420, Adjusted R^2=0.61, F=78.4, p<0.001). Reference categories: Extension contact = rare/never; Education = illiterate; Farm size = marginal.

The multivariate model explained 61% of variance in composite KAP scores. Regular extension contact was the strongest predictor (β=0.43), followed by secondary and graduate education (β=0.31 and 0.39), farmer organization membership (β=0.18), medium farm size (β=0.22), and upper income quintile (β=0.12). These independent effects persisted after controlling for all other variables, underscoring the multi-factorial nature of KAP determinants.

4.5 Path Analysis Results

The structural equation model demonstrated good fit (CFI=0.94, RMSEA=0.06, SRMR=0.04). Path analysis revealed that extension contact exerted both a direct effect on practice scores (direct path coefficient: 0.29) and an indirect effect mediated through knowledge improvement (indirect path: extension → knowledge → practice = 0.14) and the combined knowledge-attitude pathway (extension → knowledge → attitude → practice = 0.08). Total effect of extension contact on practice = 0.51. Education exhibited primarily indirect effects through knowledge (indirect coefficient: 0.18) with a smaller direct effect (0.12). Farm size showed a significant moderation effect on the attitude-to-practice relationship, with the path coefficient being significantly stronger for medium farmers (β=0.48) than for marginal farmers (β=0.28, p=0.03 for interaction).

5. DISCUSSION

The findings of this study provide compelling empirical evidence that agricultural extension contact and education are the dominant modifiable determinants of plant disease management KAP in Rajasthan. The magnitude of the extension effect (β=0.43; composite KAP differential of 31.8 percentage points between regular and rarely-contacted farmers) is consistent with meta-analytic evidence from Asia and sub-Saharan Africa, which has documented effect sizes of 0.2–0.6 SD for extension contact on agricultural knowledge and practice outcomes (Faure et al., 2012; Waddington et al., 2010).

The dominance of the direct pathway from extension contact to practices in the path model (direct coefficient: 0.29 vs. indirect: 0.22) suggests that demonstration effects, trust relationships, and hands-on training—rather than mere information provision—are the primary mechanisms through which extension workers improve disease management behavior. This aligns with adult learning theory, which emphasizes experiential and observational learning over didactic instruction (Kolb, 1984), and has clear implications for the design of extension programs: field demonstrations, farmer field schools, and participatory learning approaches should be prioritized over passive information dissemination.

The significant independent effect of FPO/SHG membership on practice scores—even after controlling for education and extension contact—highlights the under-leveraged potential of farmer collective

organizations as extension delivery channels. Farmer organizations can multiply the reach of limited extension resources by facilitating peer-to-peer knowledge exchange, group procurement of inputs, and collective negotiation with market actors. Strengthening the linkage between formal extension agencies and farmer organizations could significantly amplify extension impact in Rajasthan, where extension worker density remains inadequate.

The farm size moderation of the attitude-to-practice relationship deserves particular attention. The observation that medium farmers convert positive attitudes into practice more readily than marginal farmers suggests that resource constraints—not attitudinal deficits—are the primary barrier to adoption among marginal landholders. This has direct policy implications: subsidized access to seeds, biocontrol inputs, and protective spraying equipment may be more effective at improving marginal farmer practices than additional knowledge or attitude-change interventions.

6. CONCLUSIONS AND RECOMMENDATIONS

This study provides strong evidence that extension contact, education, farmer organization membership, and farm size are independently and collectively associated with plant disease management KAP outcomes in Rajasthan. Regular extension contact is the most powerful lever for improving KAP, operating both through direct behavioral influence and through knowledge-mediated pathways. Education significantly amplifies extension effectiveness, suggesting that adult literacy and numeracy programs should be considered as complementary investments for agricultural development.

Based on these findings, the following recommendations are proposed: (1) Scale up agricultural extension reach in Rajasthan, particularly in arid western districts with lowest extension coverage, by deploying digital extension tools (mobile advisory services, WhatsApp-based plant clinics) to complement face-to-face outreach; (2) Integrate plant disease management modules into FPO and SHG capacity building programs; (3) Implement resource-linked interventions—input subsidies, collective purchasing schemes—to address adoption barriers among marginal and illiterate farmers; (4) Prioritize farmer field school approaches that emphasize demonstration and experiential learning over lecture-based extension; and (5) Establish a district-level KAP monitoring system to track progress and dynamically target extension resources toward the most underserved farming communities.

REFERENCES

Anandajayasekeram, P., et al. (2008). Farmer field school: An alternative to existing extension systems. Experience from eastern and southern Africa. Journal of International Agricultural and Extension Education, 15(1), 89–106.

Asres, A., et al. (2021). Determinants of smallholder farmers' adoption of improved crop varieties. Journal of Agricultural and Food Economics, 9(1), 1–14.

Choudhary, A., et al. (2021). Education and integrated pest management adoption: Evidence from a pan-India survey. Indian Journal of Extension Education, 57(3), 14–22.

Doss, C. (2022). Collective action and agricultural technology adoption: Evidence from sub-Saharan Africa. World Development, 153, 105843.

Faure, G., et al. (2012). Extension and advisory services: What are the best approaches to support small farmers in West Africa, Asia and Latin America? Global Food Security, 1(2), 144–150.

Kolb, D.A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Prentice Hall, New Jersey.

Kumari, S., et al. (2022). Farmer producer organizations and crop protection: Adoption evidence from central India. Agricultural Systems, 197, 103353.

Rajasthan Agriculture Department. (2022). Extension Infrastructure and Human Resources Report. Government of Rajasthan, Jaipur.

Rogers, E.M. (1983). Diffusion of Innovations (3rd ed.). Free Press, New York.

Sharma, R., et al. (2018). Extension contact and knowledge of powdery mildew management in pea: A study from Himachal Pradesh. Journal of Plant Diseases and Protection, 125(3), 289–297.

Singh, A., & Chand, R. (2019). Socioeconomic determinants of technology adoption in Indian agriculture: A meta-analysis. Economic and Political Weekly, 54(22), 34–43.

Spielman, D.J., et al. (2020). Farmer groups, social capital and agricultural technology adoption in developing countries. Agricultural Economics, 51(1), 59–71.

Trebbin, A. (2014). Linking small farmers to modern retail through producer organizations: Experiences with producer companies in India. Food Policy, 45, 35–44.

Verma, R., & Jain, M. (2020). Impact of KVK interventions on pesticide use patterns in Rajasthan. Indian Journal of Extension Education, 56(4), 67–73.

Waddington, H., et al. (2010). The impact of agricultural extension services: A review of evaluations. 3ie Working Paper 4. International Initiative for Impact Evaluation, London.

Yadav, A., & Sharma, I.J. (2025a). Knowledge, Attitudes and Practices (KAP) of Farmers Towards Plant Disease Management in Arid and Semi-Arid Zones of Rajasthan. Journal of Plant Pathology and Agricultural Sciences, 14(2).