

QR CODES: A PATHWAY TO TECH-LED DISSEMINATION OF AGRICULTURAL INFORMATION

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ABSTRACT: Quick Response (QR) codes have emerged as a powerful tool to bridge the gap between digital information and users by providing instant and easy access to online resources. The present study evaluated the effectiveness of QR code-based dissemination of potato extension publications and identified demographic factors influencing farmers' successful access to these digital resources. The study involved 100 farmers from western Uttar Pradesh participating in training programmes organized at ICAR–Central Potato Research Institute, Regional Station, Modipuram, Uttar Pradesh. QR codes linked to online extension publications were provided to participants and their ability to access the documents was recorded. Information on age, gender and education was collected and analysed using binary logistic regression. Overall, 65% of respondents successfully accessed the QR code publications. The regression model was significant (LR $\chi^2 = 34.04$, $P < 0.001$) with 75% prediction accuracy. Age negatively influenced QR code access ($P = 0.007$), while educational level had a significant positive effect ($P = 0.015$); gender was non-significant. Follow-up assessment indicated that most respondents found the publications useful, whereas preference for printed materials, limited smartphone access and lack of awareness remained important constraints. The findings demonstrated the potential of QR codes as a low-cost and scalable tool for agricultural information dissemination.

KEYWORDS: QR code technology, Digital extension, Demographic determinants, Binary logistic regression, Potato

INTRODUCTION

The rapid advancement of digital technology has transformed the way agricultural information is generated, disseminated and accessed. Among the emerging digital communication tools, Quick Response (QR) codes, a type of two-dimensional barcode, have become an effective means of connecting users with digital content by providing instant and convenient access to online resources through smartphones. Their widespread adoption has enhanced information dissemination

across diverse sectors, including education, healthcare, marketing and agriculture. In the agricultural sector, QR codes have recently gained attention as a simple, low-cost and user-friendly technology for linking farmers to digital advisory services, technical publications and multimedia extension resources (Atheequlla *et al.*, 2024). Similarly, smartphone-based agricultural applications have been reported to improve farm management, facilitate timely access to technical information and contribute to enhanced agricultural productivity (Meena *et al.*, 2018).

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Agricultural extension and communication plays a pivotal role in transferring research-based technologies from scientific institutions to farmers. However, conventional methods of disseminating extension literature, such as printed bulletins, folders and leaflets, are often constrained by high printing costs, limited distribution, delayed delivery and restricted accessibility (Davis, 2008; Feder and Savastano, 2006). Consequently, the diffusion of technologies developed by research organizations to the farming community remains relatively slow. With the rapid penetration of smartphones and internet connectivity in rural India, QR codes offer an efficient alternative for delivering digital extension materials directly to farmers, enabling instant access to updated information while substantially reducing the cost and logistics associated with printed publications (Faure *et al.*, 2012).

Within agricultural sector, potato crop has a prominent role to play in Indian food and nutritional security and the economic growth as its diversified utilization is increasing consistently by way of processing and export. According to the Final Advance Estimates (2023–24) released by the Ministry of Agriculture and Farmers' Welfare, India

recorded a production of 57.05 million tonnes of potato from an area of 2.32 million hectares, with an average productivity of 24.6 tonnes per hectare. The crop registered a compound annual growth rate (CAGR) of 4.2 per cent per annum in production (Anonymous, 2025) (Fig 1). However, there is still huge scope of harnessing the potential of this crop as if the single indicator of productivity per unit area is analyzed critically in comparison to developed global economies. Researchers at the ICAR–Central Potato Research Institute, India, estimated that under current farm management practices, actual potato yields in the country reach only 42–45 percent of their potential, but could increase to approximately 80 percent through the adoption of modern technologies (Singh *et al.*, 2015).

Analysis of variations in yield in different states of the country also points towards magnitude of adoption level of modern potato agro-technologies by the potato growers. In Indian states such as Chhattisgarh, Jharkhand, Odisha and most of North East India, potato yields remain low, at only 7–15 t/ha, which may be attributed, among other factors, to limited knowledge and skills related to modern cultivation technologies (Kharumnuid *et al.*, 2022; Anonymous, 2025).

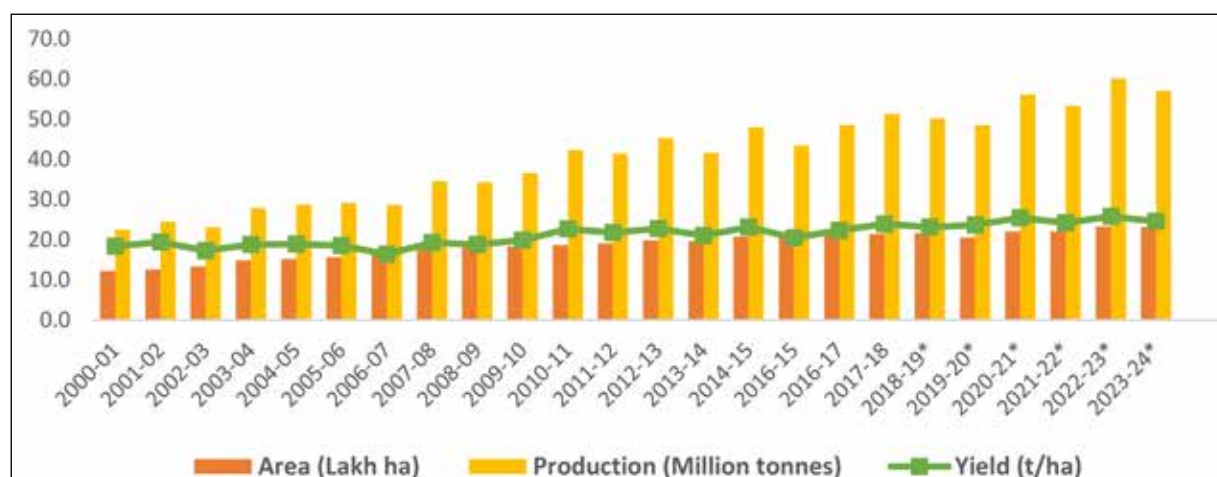


Fig. 1. Area, production and productivity of potato in India (2000–2024) (Anonymous, 2025)

These observations suggested that potato growers of different regions with lower potato productivity have difficulty in access to modern technologies developed by the research institutions. Although smartphones are increasingly available among farmers, limited empirical evidence is available regarding the practical use of QR codes as a mechanism for delivering agricultural extension publications. Furthermore, the socio-demographic factors affecting farmers' ability to access QR-enabled extension material remain poorly understood

Against this background, the present study was undertaken to evaluate the effectiveness of QR codes as a digital tool for disseminating potato extension publications among farmers. Specifically, the study aimed to assess farmers' ability to access QR code-linked publications, identify the demographic factors influencing successful QR code utilization using binary logistic regression analysis and assess farmers' perceptions regarding the usefulness of QR code publications for agricultural information dissemination. The findings are expected to provide useful insights for research organizations, extension agencies and policymakers in developing efficient, scalable and farmer-friendly digital extension systems that complement conventional information dissemination approaches.

MATERIALS AND METHODS

Development of QR Code publications

ICAR-Central Potato Research Institute (CPRI) and the All India Coordinated Research Project on Potato (AICRP-Potato) collectively undertake over 95% of potato research in India (Singh *et al.*, 2015). The institute consistently publish and update numerous farmer-focused, region-specific publications, including technical and extension bulletins, folders and leaflets to address evolving

needs. To facilitate timely and cost-effective dissemination of knowledge, selected key publications have been digitized and made accessible via QR codes, enhancing outreach to farming communities. The methodology involved uploading the extension bulletins to the internet and obtaining the corresponding weblinks. QR codes for these documents were generated using online QR Code generator (<https://www.qrcode-monkey.com>). For this study, standard black-and-white QR codes with the ICAR logo were used to maintain simplicity, clear identity and compatibility with all participants' mobile devices.

Collection of data

The generated QR codes were printed on plain white sheets, with each QR code linked to a specific extension publication hosted online. During the training programmes, the printed QR codes were presented to the participating farmers. Respondents were guided to scan the QR codes using the camera application of their smartphones. Upon scanning, the corresponding web link appeared on the mobile screen, enabling participants to access and view or download the publication. For each respondent, demographic information including gender, age and educational level was recorded using a structured schedule. The primary outcome variable was successful access to the QR-code publication, defined as the participant's ability to successfully view or download the linked publication after scanning the QR code. This outcome was recorded as a binary response (1 = successfully viewed/downloaded the publication; 0 = unable to view/download the publication). During the subsequent crop season, participants were contacted through structured follow-up interviews to assess their utilization and their perceived usefulness and effectiveness of the shared QR code publications.

Data analysis

Collected data were compiled in Microsoft Excel and analysed in R programming language. Descriptive statistics, including frequencies and percentages, were used to summarize the demographic characteristics of the respondents and the utilization pattern of QR-code publications. Binary logistic regression analysis was employed to identify the demographic factors influencing successful access to QR-code publications. The dependent variable was successful QR-code access (1 = successfully viewed/downloaded the publication; 0 = unsuccessful). Independent variables included age (years), gender (Male = 1, Female = 0) and educational level, which was treated as an ordinal variable representing increasing educational attainment.

Following Demaris (1992), the logistic regression model for the log-odds of adoption of QR code publications can be expressed as:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1(\text{Gender}) + \beta_2(\text{Age}) + \beta_3(\text{Education}) + \varepsilon$$

where represents the probability of successful QR-code access, β_0 is the intercept, β_1 – β_3 are regression coefficients for the explanatory variables, and ε is the random error term. Model performance was evaluated using the likelihood ratio chi-square statistic, pseudo- R^2 , prediction accuracy and odds ratios (OR). Statistical significance was considered at $P < 0.05$.

RESULTS AND DISCUSSION

Demographic profile of respondents

Demographic profile of the respondents of the QR code publications survey revealed distributions across gender, age, educational attainment and technology utilization patterns, providing crucial insights for

understanding QR code adoption barriers and facilitators (Fig. 2).

Gender

The results revealed that male respondents comprise 94% of respondents compared to only 6% female. In India, women constitute nearly 47% of the agricultural workforce; however, only 13% have access to agricultural extension services and a mere 6% receive formal training (Singh *et al.*, 2025; GoI, 2019). This could be due to the fact that in India, male farmers are better access to resources, decision-making power and exposure to extension services. As a result, men mainly assume responsibility for technology adoption and farm management decisions (Aryal *et al.*, 2020).

Age

The age distribution showed that most respondents (49%) are over 50 years old, followed by 40% in the 35-50 age group. The predominance of older farmers poses challenges for QR code adoption due to lower digital literacy and resistance to new technology, yet their extensive agricultural knowledge and networks can aid technology diffusion once barriers are addressed. Only 11% of respondents are under 35, reflecting broader rural youth migration trends that contribute to an aging agricultural workforce. However, this younger segment demonstrated higher digital literacy and greater openness to innovation, positioning them as key drivers for QR code adoption. Research from rural India suggests that age-tailored training and simplified user interfaces improve acceptance among older and female farmers (Kushwaha, 2025; Jadhav, 2024). To encourage youth engagement in agri entrepreneurship, capacity-building initiatives and ICT-enabled agricultural technology transfer are essential for creating sustainable business

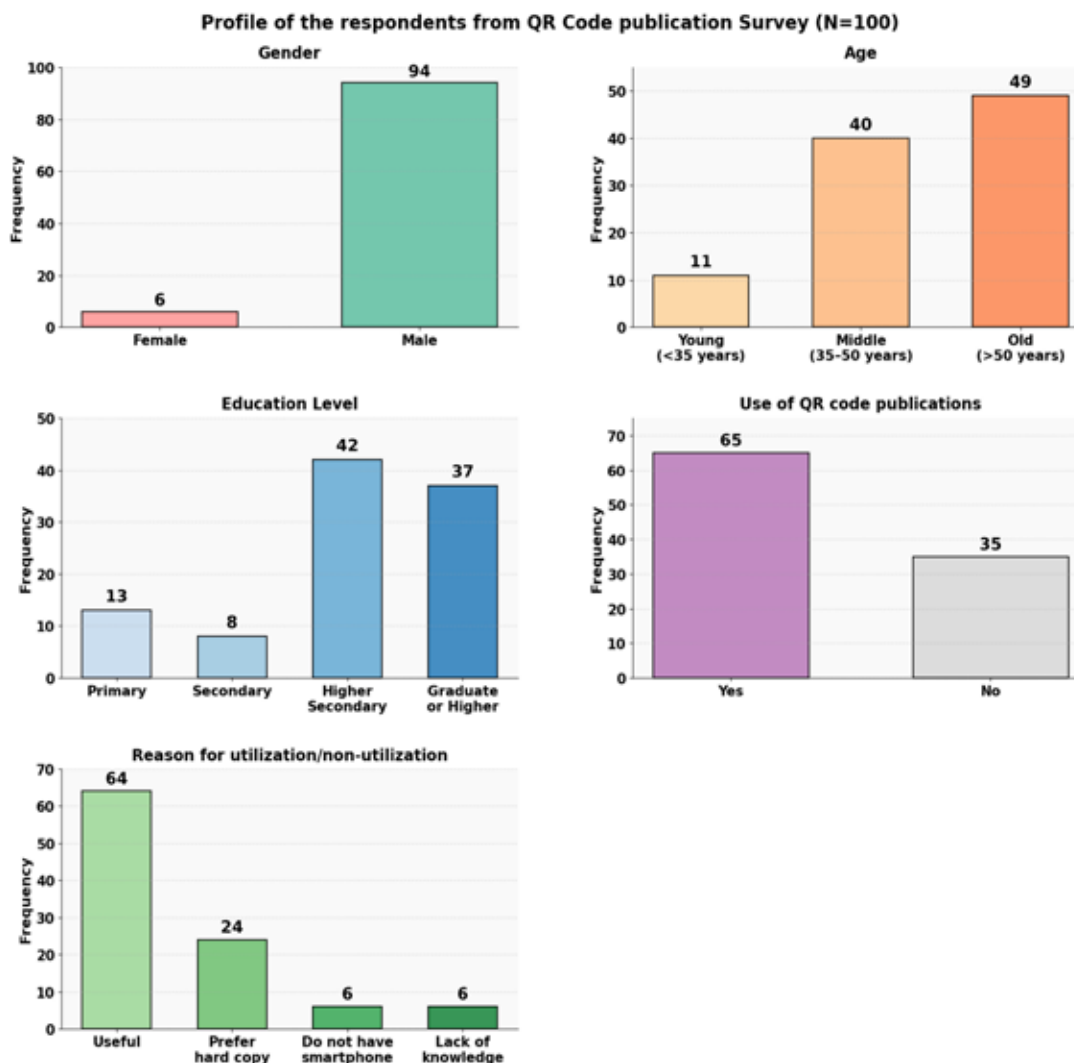


Fig. 2. Demographic distribution and utilization patterns of QR code publications among farmers (N=100)

opportunities (Kushwaha, 2025).

Education

The educational profile reveals a relatively well-educated respondent base, with 42% having completed higher secondary education and 37% holding graduate or higher degrees. Primary and secondary education collectively account for 21% of respondents. This distribution suggests favorable conditions for QR code adoption, as higher education correlates positively with technology acceptance among Indian farmers

(Kushwaha, 2025; Jaiswal *et al.*, 2024; Bajpai & Beriya, 2022). Nonetheless, the presence of respondents with lower educational attainment underscores the necessity for inclusive design and multilingual support systems to ensure equitable access across India (Kushwaha, 2025; Bajpai & Beriya, 2022).

QR-code access and utilization

The primary objective of the study was to evaluate farmers' ability to access agricultural publications using QR codes. The results showed that 65% of the respondents

successfully viewed or downloaded the QR-code-linked publications, whereas 35% were unable to access the documents (Fig. 2). This relatively high success rate demonstrates that QR codes can serve as an effective mechanism for disseminating agricultural information through smartphones. Similar observations have been reported by Atheequlla *et al.* (2024), who highlighted the usefulness of QR codes in improving access to horticultural information among stakeholders.

Out of 65% of the respondents who utilize QR code publications, 64% report finding them useful. This aligns with the Technology Acceptance Model in India, which identifies perceived usefulness as a key driver of adoption intent among farmers (Mishra *et al.* 2024; Zhang *et al.*, 2024; Bhushan & Reddy, 2020). Non-adoption primarily stems from preference for traditional hard copy materials (24%), lack of smartphone access (6%) and unawareness of QR code functionality (6%). The dominance of hard copy preference underscores entrenched habits favoring conventional information sources, along with limited smartphone use and technological literacy issues. (Sangeethmon *et al.*, 2025; Cole & Fernando, 2021; Atheequlla, 2024). These findings underline the critical need for targeted educational initiatives to enhance QR code literacy and facilitate equitable technology adoption among Indian farmers.

Follow-up assessment of QR-code publications

A brief follow-up assessment conducted during the subsequent crop season indicated that 64% of the respondents considered the QR-code publications useful for obtaining agricultural information. Among those who did not continue using the publications, 24% preferred conventional printed extension literature, 6% reported lack of smartphone availability, and 6% indicated limited

awareness regarding QR-code technology (Table 1). These findings suggest that although farmers readily appreciate the convenience of digital publications, traditional extension materials continue to play an important role, particularly among respondents with lower digital literacy or limited access to smartphones. Similar findings have been reported by Cole and Fernando (2021), Mishra *et al.* (2024) and Atheequlla *et al.* (2024), who identified perceived usefulness, accessibility and digital literacy as important determinants of ICT adoption in agriculture.

Determinants of successful QR-code access

To identify the demographic factors influencing successful access to QR-code publications, binary logistic regression analysis was performed using successful QR-code access as the dependent variable and age, gender and educational level as explanatory variables (Table 2). The overall regression model was statistically significant (LR $\chi^2 = 34.04$, $P < 0.001$), indicating that the selected variables jointly explained a significant proportion of the variation in successful QR-code access. The model exhibited satisfactory performance, with a pseudo- R^2 value of 0.266 and an overall prediction accuracy of 75%, suggesting acceptable explanatory power for behavioural studies involving technology adoption.

Educational level emerged as a significant positive predictor of successful QR-code

Table 1. Follow-up feedback of respondents regarding QR-code publications

Parameter	Respondents (%)
Publications found useful	64
Preference for hard-copy publications	24
Lack of smartphone availability	6
Lack of awareness about QR-code technology	6

Table 2. Determinants of utilization of QR Code publications by respondent farmers

Variables	Coefficient	SE	Wald	z	P> z	Odds ratio
Gender	0.7594	1.0882	0.4869	0.6978	0.4853 ^{NS}	2.1369
Age	-0.0779	0.0289	7.2485	-2.6923	0.0071*	0.9250
Education	0.3028	0.1240	5.9574	2.4408	0.0147**	1.3536
const	0.3511	2.4279	0.0209	0.1446	0.8850	1.4207

Model Fit Statistics:

Number of observations = 100

LR chi² = 34.04Prob > chi² = 0.00000Pseudo R² = 0.2655

Log likelihood = -47.08

Accuracy of prediction = 75.0%

*Significant at P < 0.05, ** Significant at P < 0.01, NS: Not significant, OR=Odds Ratio

access ($\beta = 0.3028$, OR = 1.35, P = 0.015). The results indicate that respondents with higher educational attainment were more likely to successfully access QR-code publications than those with lower levels of education. Education enhances digital literacy, improves confidence in handling smartphone applications and increases the ability to retrieve online information. Similar relationships between educational attainment and digital technology adoption among farmers have been reported by Bajpai and Beriya (2022), Jaiswal *et al.* (2024) and Yap *et al.* (2025).

Age was negatively associated with successful QR-code access ($\beta = -0.0779$, OR = 0.925, P = 0.007), indicating that the probability of successfully accessing QR-code publications decreased with increasing age. Older respondents were comparatively less familiar with smartphone-based applications and digital interfaces, whereas younger farmers generally demonstrated greater confidence and proficiency in using mobile technologies. These findings corroborate the observations of Rogers (2003), Jadhav (2024) and Kushwaha (2025), who reported that younger farmers exhibit greater readiness to adopt digital innovations.

Gender did not significantly influence successful QR-code access (P = 0.485). However, this result should be interpreted

cautiously because female respondents constituted only 6% of the study sample. Therefore, although gender was not a significant predictor within the present sample, the limited representation of women restricts broader generalization. Previous studies have similarly reported that gender differences in digital technology use often reflect disparities in access to smartphones, training opportunities and digital literacy rather than differences in the ability to use the technology itself (Venkatesh *et al.*, 2012; Saha *et al.*, 2024).

Implications for agricultural extension

The findings demonstrate that QR codes offer a practical, economical and scalable mechanism for disseminating agricultural information. Unlike printed extension materials, QR-code publications enable farmers to access updated recommendations instantly using smartphones, thereby reducing printing and distribution costs. Nevertheless, the study also highlighted that the effectiveness of QR-code-based extension depends largely on farmers' educational level and digital literacy. Therefore, QR codes should complement rather than replace conventional extension approaches. Capacity-building programmes focusing on

digital literacy, particularly for older and less educated farmers, along with multilingual publications and simple user interfaces, will be essential for maximizing the effectiveness and inclusiveness of QR-code-enabled agricultural extension systems.

CONCLUSION

QR codes demonstrated considerable potential as a rapid and low-cost mechanism for disseminating agricultural information, with 65% of participating farmers successfully accessing the digital publications. Age and educational level were significantly associated with successful QR-code access, whereas gender was not significant in the present sample. Follow-up feedback further indicated that perceived usefulness was high, although preference for printed material, limited smartphone access and low awareness of QR-code functionality remained important barriers. The findings suggest that QR-enabled extension materials should complement rather than immediately replace conventional publications. Digital literacy support, age-appropriate training and simplified access procedures may further improve adoption among diverse farming communities.

ACKNOWLEDGEMENT

The authors acknowledge the help and support rendered by Indian Council of Agricultural Research for carrying out this research work.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVAL

The study involved farmer participants attending training programmes. Participation in the survey was voluntary, and informed

consent was obtained before recording demographic information and responses. No personally identifiable information is reported in the manuscript.

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(MS Received : May 15, 2026; Accepted : September 21, 2026)