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Knowledge and Adoption Level of Improved Sorghum Practices in Bundelkhand Region of Uttar Pradesh

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HIGHLIGHT

- Significant knowledge–adoption gap existed in crop protection and seed treatment adoption rates.
- Education, income, landholding, and attitude significantly influenced adoption.
- Knowledge and attitude emerged as strongest predictors of adoption.
- Affordability of key input and climatic constraints driving the knowledge–adoption gap in sorghum cultivation.

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Keywords: Knowledge, Adoption, Sorghum, Technology, Bundelkhand, Uttar Pradesh.

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ABSTRACT

Productivity of sorghum in Bundelkhand remained constraints due to lower adoption of recommended practices. The data were collected for this study during February to April 2024 to assess the knowledge and adoption levels of farmers towards improved sorghum production technologies and to identify their determinants. An ex-post facto research design was followed in two purposively selected districts of Uttar Pradesh. A total of 200 sorghum growers were selected through multistage sampling, and data were collected using a semi structured and pre-tested interview schedule. Descriptive statistics, chi-square test, and regression analysis were used for data analysis. The results revealed that seed rate and sowing time recorded the highest knowledge and adoption scores, whereas crop protection and seed treatment showed the lowest adoption levels. A majority of respondents possessed medium knowledge, but overall adoption still low, indicating a clear knowledge adoption gap. Education, landholding, annual income, attitude, and knowledge score significantly influenced adoption behavior. The study concluded that socio-economic resources and psychological factors played a decisive role in enhancing adoption of improved sorghum technologies. The study revealed a significant knowledge–adoption gap, with input constraints and climatic factors emerging as the major barriers to the adoption of improved sorghum production practices.

INTRODUCTION

Millets have recently attracted significant attention and respect due to their richness in nutritional composition. It is often regarded as a "poor man's food", but it is now acknowledged as a superfood with enormous health benefits. The Indian government recognized millets as Nutri-Cereals in April 2018 to promote their production

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and consumption, generating demand both domestically and internationally and giving people access to wholesome food (Yadav et al., 2023). The United Nation also declared 2023 as the International Year of Millets (IYoM-2023) on the proposal of the Government of India (Harish et al., 2024). Among millets, Sorghum is the most commonly cultivated millet crop, with 39.62 million hectares and 58.92 million tons of production globally. Sorghum assumes a crucial role as a cash crop, serving as a vital source of income as well as nutrition for farmers (Rao et al., 2014; Amrutha et al., 2024). Despite India being the fourth-ranking producer (4.4 million tonnes) of sorghum globally in 2023-24 (ANGRAU, 2023–24), it faces challenges of low productivity (Sandeep et al., 2018). According to the Government of India (2022–23) Department of Agriculture and Farmers Welfare, Directorate of Economics and Statistics and Ministry of Agriculture and Farmers Welfare, the Bundelkhand region records approximately 65,461 hectares under sorghum cultivation with a total production of about 105,235 tonnes, resulting in an average productivity of 1.61 tonnes per hectare (Sah et al., 2021). Modern agricultural technologies provide an achievable way to increase production, strengthen resilience, and eventually improve household food security (Vattekkad et al., 2025). These technologies include improved seed varieties (HYVs) and mechanization to climate-smart agriculture (CSA) practices and digital tools (Senyolo et al., 2021). Bundelkhand region of Uttar Pradesh is basically depend upon agriculture yet it faces significant challenges regarding natural calamities and low level of urbanization. Sustainable livelihood is also difficult due to combination of irregular rainfall, low crop yield and poor economic returns. Under the Bundelkhand condition, sorghum is considered a climate-resilient crop due to its drought tolerance and adaptability under moisture stress, making it an important for region. Adoption of improved sorghum cultivation practices increases the productivity and facilitates the growth of non-farm and agro-processing businesses, and accelerates the shift from low-productivity subsistence farming to a high-productivity agro-industrial economy (Just & Zilberman, 1988). Adoption of many of the improved technologies is low, which creates a larger problem of suboptimal production and necessitates greater regulatory action (Jat et al., 2022; Singh et al. 2023). Most studies emphasize that access to information and asset holdings (financial, natural, human, and social) (Aryal et al., 2019; Deressa et al., 2009; Khanal et al., 2018; Singh, 2015) play a crucial role in the adoption of these techniques (Veettil et al., 2021). Existing studies indicate a significant decline in sorghum area and production in the Bundelkhand region, with nearly 59% reduction in area during 2000–2020, despite its suitability for drought-prone conditions. Productivity levels also remain relatively low, suggesting underutilization of improved technologies, while a negative relationship between irrigation expansion and millet cultivation reflects a shift away from sorghum (Sah et al., 2021). Therefore, a clear research gap exists in understanding the knowledge and adoption level of improved sorghum practices among farmers in Bundelkhand, which is essential to bridge the gap between technology availability and its field-level utilization.

METHODOLOGY

The study was conducted in the Bundelkhand region of Uttar Pradesh, India. It consisted of seven districts namely Banda, Hamirpur, Chitrakoot, Mahoba, Jhansi, Lalitpur and Jalaun. Out of these districts Banda and Chitrakoot districts were selected purposively for the study because both the districts were leading in area and production in Bundelkhand. Two blocks from each district Baberu and Tindwari from Banda, and Karwi and Mau from Chitrakoot were purposively selected for the study due to having comparatively higher area and productivity of sorghum. Data was gathered through Personal interview with the help of a standardized and pre-tested survey questionnaire. Key socioeconomic factors (such as gender, age, family size, education level, consumption expenditures, membership in farmers' organizations, extension offices, institutional and other pertinent factors and distance of a residence from input and output markets) were gathered during the in-person interviews regarding the sorghum varieties grown. From each of the selected four blocks, a list of sorghum-growing villages was prepared in consultation with officials from the Department of Agriculture. Villages were ranked based on the area under sorghum cultivation. Subsequently, five villages from each block (total 20 villages) were selected purposively. From each selected village a list of sorghum-growing farmers was compiled with the help of the respective *Gram Pradhans* and local leaders. From each village, 10 farmers were selected using a simple random sampling technique, employing a random number table to ensure unbiased representation. Thus, a total of 200 respondents (20 villages × 10 farmers). This stratified yet randomised approach ensured both relevance and statistical rigour in data collection. The data was collected from February to April, 2024. An ex-Post Facto and descriptive research design was used for the study as the events had already occurred. A schedule was created to assess farmers' familiarity with specific technologies that were recommended for the sorghum crop. To measure the extent of Knowledge and Adoption a knowledge and adoption test was developed. The response of respondents regarding knowledge was categorised into a three-point continuum (fully knowledge, partial knowledge and poor knowledge) and adoption using (complete, partial and no adoption). The constraints faced by farmers were identified and analyzed using the Garrett ranking technique, wherein respondents ranked the constraints based on their severity. The obtained ranks were converted into percent positions and corresponding Garrett scores, and the mean scores were calculated to determine the final ranking of constraints. Each response was tabulated on MS Excel. Frequency, percentage, class interval method and chi-square test were used to analyse the data with the help of MS Excel and Statistical Package for Social Science (SPSS). To find major determinats affecting the Knowledge and Adoption of the respondents multiple regression is used. As different variables are measured on different level of measurement Z transformation is used to standardize all the variables.

RESULTS

Practice-wise Information on the distribution of respondents regarding the extent of adoption and knowledge of recommended sorghum production technologies (Table 1) shows that there was variation across sorghum production technologies in terms of knowledge and adoption based on Mean Percent Scores (MPS) and rank order. With the highest MPS of 86.50, the seed rate achieved the top spot in terms of knowledge. Sowing time (MPS = 78.17,

Table 1. Knowledge and adoption of sorghum practices

S.No.	Production Technology	Knowledge		Adoption	
		MPS	Rank	MPS	Rank
1	Land Preparation	72.72	III	73.83	III
2	Sowing Time	78.17	II	78.83	I
3	Seed Rate	86.50	I	78.17	II
4	Spacing	59.83		65.50	V
5	Seed Treatment	61.33	VII	49.83	VI
6	Fertilizer Application	71.83	IV	70.33	IV
7	Weed Control	65.54	V	60.67	V
8	Crop Protection	64.83	VI	45.67	VII

Rank II) and land preparation (MPS = 72.72, Rank III) came next. Fertilizer application occupied the fourth rank with an MPS of 71.83, while weed control (MPS = 65.54) and crop protection (MPS = 64.83) were placed at fifth and sixth ranks, respectively. Comparatively lower knowledge was recorded for seed treatment (MPS = 61.33, Rank VII) and spacing (MPS = 59.83, Rank VIII). A similar ranking pattern was also observed for adoption. Sowing time ranked first in adoption with the highest MPS of 78.83, followed closely by seed rate (MPS = 78.17, Rank II) and land preparation (MPS = 73.83, Rank III). Fertilizer application stood at the fourth position with an MPS of 70.33. Practices such as spacing (MPS = 65.50, Rank V) and weed control (MPS = 60.67, Rank VI) occupied middle ranks. The lowest adoption was observed for seed treatment (MPS = 49.83, Rank VII) and crop protection (MPS = 45.67, Rank VIII).

Results of chi-square and multiple regression analysis (Table 2) revealed the association and contribution of selected independent to dependent variables (knowledge level of sorghum growers). The chi-square analysis indicated that education (χ^2 = 18.103), land holding (χ^2 = 14.489), annual income (χ^2 = 16.968), and attitude (χ^2 = 118.321) had a statistically significant association with the knowledge level of respondents. Among these, the association of annual income and attitude was found to be highly significant. In contrast, variables such as age, occupation, social participation, decision-making ability, scientific orientation, risk preference, management orientation, and sources of information credibility did not show a significant association with knowledge level. These conclusions were further supported by the regression analysis, which identified important knowledge determinants. Education was found to be a substantial and positive predictor of knowledge level (β = 0.42, t = 3.82, $p < 0.01$), suggesting that farmers' understanding of suggested sorghum production technology was greatly improved by higher educational attainment. Additionally, land holding had a substantial positive influence (β = 1.87, t = 3.46, $p < 0.01$), indicating that farmers with bigger landholdings were more knowledgeable. Knowledge was positively and significantly impacted by annual income (β = 0.09, t = 2.98, $p < 0.01$), indicating the importance of economic strength in gaining access to inputs and information. Additionally, the knowledge level of farmers was found to be strongly influenced by social participation (β = 1.26, t = 2.63, $p < 0.01$) and the frequency of using information sources (β = 0.31, t = 3.10, $p < 0.01$). Among the variables, attitude was found to be the most significant driver (β = 0.58, t = 8.29, $p < 0.01$), indicating that farmers' knowledge is greatly enhanced by having a positive attitude toward sorghum farming. On the other hand, age had a negative but non-significant impact on knowledge level, suggesting that respondents' age had no effect on their acquisition of information.

The results of chi-square analysis (Table 3) indicated that several independent variables were significantly associated with the adoption level of sorghum production technologies. Education (χ^2 = 23.765), land holding (χ^2 = 16.756), annual income (χ^2 = 18.005), social participation (χ^2 = 15.050), decision-making ability (χ^2 = 13.565), risk preference (χ^2 = 25.819), management orientation (χ^2

Table 2. Association and determinants of the knowledge level

S.No.	Independent Variable	Chi-square (χ^2)	p-value (χ^2)	β coefficient	Std. Error	t-value	p-value (Regression)
1	Age	3.457	0.484	–0.03	0.02	–1.45	0.149
2	Education	18.103	0.053	0.42	0.11	3.82	0.000**
3	Land holding	14.489	0.025*	1.87	0.54	3.46	0.001**
4	Annual Income	16.968	0.002**	0.09	0.03	2.98	0.003**
5	Occupation	1.581	0.954	—	—	—	—
6	Social Participation	2.876	0.824	1.26	0.48	2.63	0.009**
7	Scientific Orientation	8.124	0.087	—	—	—	—
8	Decision Making	9.232	0.056	—	—	—	—
9	Risk Preference	7.653	0.105	—	—	—	—
10	Management Orientation	1.468	0.832	—	—	—	—
11	Source of Information (Frequency)	5.390	0.250	0.31	0.10	3.10	0.002**
12	Source of Information (Credibility)	8.743	0.068	—	—	—	—
13	Attitude	118.321	0.001**	0.58	0.07	8.29	0.000**

Table 3. Association and determinants of the adoption level

S.No.	Independent Variable	Chi-square (χ^2)	p-value (χ^2)	β coefficient	Std. Error	t-value	p-value (Regression)
1	Age	7.317	0.120	—	—	—	—
2	Education	23.765	0.008**	0.36	0.10	3.60	0.000**
3	Land holding	16.756	0.010**	1.45	0.49	2.96	0.003**
4	Annual Income	18.005	0.001**	0.12	0.04	3.00	0.003**
5	Occupation	9.829	0.132	—	—	—	—
6	Social Participation	15.050	0.020*	1.09	0.45	2.42	0.016*
7	Scientific Orientation	4.436	0.350	—	—	—	—
8	Decision Making Ability	13.565	0.009**	—	—	—	—
9	Risk Preference	25.819	0.001**	0.51	0.13	3.92	0.000**
10	Management Orientation	19.011	0.001**	0.47	0.14	3.36	0.001**
11	Source of Information (Frequency)	25.692	0.001**	0.38	0.11	3.45	0.001**
12	Source of Information (Credibility)	29.316	0.001**	—	—	—	—
13	Attitude	19.602	0.001**	0.41	0.08	5.12	0.000**
14	Knowledge Score	14.283	0.006**	0.62	0.09	6.89	0.000**

= 19.011), source of information (frequency and credibility), attitude (χ^2 = 19.602), and knowledge score (χ^2 = 14.283) showed statistically significant associations with adoption level. whereas age, occupation, and scientific orientation show a non-significant association with adoption. The regression table also reveals that education had a significant and positive effect on adoption (β = 0.36, t = 3.60, $p < 0.01$), suggesting that educated farmers are more likely to accept recommended methods. The significance of resource availability in adoption behaviour can be seen by the significant predictors like land holding (β = 1.45, t = 2.96, $p < 0.01$) and annual income (β = 0.12, t = 3.00, $p < 0.01$). A positive and significant relationship was found between social activity and exposure to innovations (β = 1.09, t = 2.42, $p < 0.05$). Adoption behaviour is also significantly influenced by psychological and communication-related factors. Adoption was significantly influenced by risk preference (β = 0.51, t = 3.92, $p < 0.01$) and management orientation (β = 0.47, t = 3.36, $p < 0.01$), suggesting that farmers who were ready to take risks and had superior managerial skills were more likely to adopt improved technology. Adoption was also strongly influenced by the frequency of using information sources (β = 0.38, t = 3.45, $p < 0.01$). Among all variables, attitude (β = 0.41, t = 5.12, $p < 0.01$) and knowledge score (β = 0.62, t = 6.89, $p < 0.01$) show the strongest determinants of adoption, indicating that farmers with better knowledge and a favorable attitude towards sorghum production were significantly more likely to adopt recommended practices.

Among the input and resource constraints regarding adoption of improved package of practices (Table 4), high cost of fertilizers and pesticides (mean score 75.20) was the most severe constraint, followed by the non-availability of quality seeds (73.80) and limited access to seed treatment chemicals (71.50). indicating that farmers are significantly affected by both the affordability and availability of inputs, which directly affect the adoption of improved practices such as seed treatment and crop protection. Environmental and climatic constraints like erratic and inadequate rainfall (72.60) was ranked first, followed by moisture stress during crop growth (70.10) and poor soil fertility (67.95). The findings reflect the drought-prone nature of the Bundelkhand region, where uncertain rainfall and soil limitations discourage farmers from investing in input-intensive technologies. Whereas knowledge, skill and extension constraints, such as lack of practical training on seed treatment (68.90) and inadequate field demonstrations (66.75) were the major constraints. Suggesting that although farmers possess significant level of awareness, the absence of hands-on training and effective extension support limit the actual adoption of recommended practices. Lastly in socio-economic and institutional constraints, small and fragmented landholdings (63.40) ranked first, followed by low income and risk-bearing capacity (61.85) and labour shortage

Table 4. Garrett Ranking of Constraints within Each Category

S. No.	Constraints	Mean Score	Rank
	Input and Resource Constraints		
1	High cost of fertilizers and pesticides	75.20	I
2	Non-availability of quality seeds	73.80	II
3	Limited access to seed treatment chemicals	71.50	III
4	Lack of farm machinery for proper spacing	69.90	IV
5	Lack of timely credit facilities	67.85	V
	Environmental and Climatic Constraints		
1	Erratic and inadequate rainfall	72.60	I
2	Moisture stress during crop growth	70.10	II
3	Poor soil fertility	67.95	III
4	Lack of irrigation facilities	65.40	IV
5	Increased pest incidence due to climatic stress	63.75	V
	Knowledge–Skill and Extension Constraints		
1	Lack of practical training on seed treatment	68.90	I
2	Inadequate field demonstrations	66.75	II
3	Poor contact with extension personnel	64.10	III
4	Difficulty in understanding technical practices	62.85	IV
5	Limited awareness of pest and weed management	60.15	V
	Socio-economic and Institutional Constraints		
1	Small and fragmented landholdings	63.40	I
2	Low income and risk-bearing capacity	61.85	II
3	Labour shortage due to migration	60.20	III
4	Poor market support and price fluctuation	58.75	IV
5	Limited government focus on sorghum crop	56.80	V

due to migration (60.20). These factors reduce farmers' ability and willingness to adopt improved technologies, particularly those requiring additional investment and labour.

DISCUSSION

The findings show differences between practices, which shows major insights into the pattern of farmers' awareness and adoption of suggested sorghum production technology. Due to its simplicity, widespread familiarity, and frequent reinforcement through traditional farming experience and extension advisory, basic agronomic practices including seed rate, sowing timing, and soil preparation, have a comparatively greater level of knowledge and adoption. These practices have higher Mean Percent Scores (MPS) and rankings in both knowledge and adoption because they are less input-intensive, carry less risk, and have a direct impact on the growth of crops. These finding are consistent with Bhagat et al. (2002) and Kumar et al. (2025), who reported that fundamental practices like sowing time are more readily adopted due to minimal financial risk.

In contrast, crop protection, weed management, seed treatment, and spacing related practices revealed relatively low levels awareness and high adoption gap similar with Gupta et al. (2021). The low MPS and scores for crop protection and seed treatment could be related to their perceived higher cost-benefit uncertainty, lack of practical demonstrations, restricted availability to high-quality inputs, and technical complexity. According to Kumar et al. (2020), sorghum growers have a large technology gap, particularly in the areas of disease management and insect-pest control. Particularly in situations when resources are limited, farmers frequently view these measures as discretionary rather than necessary. The prevalence of low adoption of crop protection techniques also points to a lack of faith in chemical or integrated management techniques as well as insufficient pest and disease detection abilities. This pattern is further supported by the respondents' overall distribution across adoption and knowledge categories. More than half of the respondents show low adoption levels, though most farmers were categorized as having a medium understanding. This demonstrates clearly the existence of a knowledge-adoption gap, where awareness does not always transfer into actual application. These gaps are frequently seen in agricultural extension research and are frequently impacted by financial constraints, risk aversion, delayed inputs, and inadequate field-level assistance. These findings are also in line with the findings of Nain and Bhagat (2005), Kardak et al. (2006), Nain and Chandel (2013), Patil et al. (2017), Patel et al. (2024), Maurya et al. (2024).

These findings are strongly supported empirically by the association and regression analysis. Adoption was further impacted by risk preference, management orientation. Knowledge score, whereas land holding, education, social participation, annual income, source of information utilization, and attitude were revealed as major factors influencing knowledge. The significant and positive impact of education implies that farmers with higher levels of education are more capable of understanding technical advice and weighing its advantages. In the same manner, farmers are better able to experiment with and implement better techniques when they have larger landholdings and higher income levels. The education, income, and landholding significantly influenced adoption behaviour among farmers (Raina et al., 2014; Kumar et al., 2019; Jat et al. (2022). Attitude was found to be the most significant factor influencing adoption and knowledge, highlighting the psychological aspect of technology adoption. A positive perspective on sorghum farming encourages farmers to learn more and implement suggested methods. Although knowledge is not adequate on its own, it is a prerequisite for adoption, as seen by the knowledge score's substantial impact on adoption. Diffusion theory (Rogers, 2003), which emphasizes that awareness and persuasion come before decision-making and execution, is consistent with this conclusion.

The results also indicate that input and resource constraints, particularly high input costs and non-availability of quality inputs, are the major barriers in adoption of recommended sorghum cultivation practices. Environmental factors such as erratic rainfall and moisture stress further discourage farmers from adopting improved practices. In addition, lack of practical training and weak extension support limit the effective implementation of technical recommendations. Socio-economic issues like small and fragmented landholdings and low risk-bearing capacity also contribute to the gap between knowledge and adoption.

CONCLUSION

The study concluded that farmers have moderate to high knowledge of sorghum production technologies in Bundelkhand, however, the adoption level remains comparatively low and strongly influenced by socio-economic and psychological factors. Basic agronomic practices are widely adopted, whereas technically complex and input-intensive practices remain faces low adoption. A significant knowledge–adoption gap exists, indicating that awareness alone does not ensure implementation. Education, income, landholding, and particularly farmers' attitude and knowledge level significantly play important role in shaping adoption behavior. This gap is also attributed to input constraints, climatic uncertainties, limited extension support, and socio-economic limitations. These findings confirm that technology dissemination is not only to transfer information but also strengthening resource access, risk management capacity, and positive behavioral orientation. Therefore, improving input accessibility, strengthening field-level training and demonstrations, and promoting climate-resilient practices are essential to enhance the adoption of sorghum technologies in the Bundelkhand region.

DECLARATIONS

Ethical statement: The study was conducted in accordance with ethical research standards. Participation was voluntary, and informed consent was obtained from all respondents. The confidentiality and anonymity of participants were strictly maintained throughout the research process.

Conflict of interest: The authors declare that there are no conflicts of interest regarding the publication of this paper. The author declares that they have thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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