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RESEARCH ARTICLE

Farmers' perceptions towards rice, green gram and groundnut production systems in Odisha

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Abstract

Agriculture in Odisha is characterized by diverse production systems where rice, green gram and groundnut play critical roles in food, nutrition and income security. This study assessed farmers' perceptions and attitudes towards these three crops to identify gaps and opportunities for improving production systems. A multistage random sampling design was employed to select 320 farmers across Baragarh (rice), Sonepur (green gram) and Jajpur (groundnut) districts. Data were collected through pretested interviews in Odia and analysed using a modified Likert scale and Chi-square tests to examine associations between perception and socioeconomic variables. Results revealed that ecological conditions, particularly soil and temperature, were generally perceived as favourable for all three crops, while rainfall variability was a recurring constraint. Input supply for fertilisers, improved seed varieties were largely satisfactory, but credit access, labour availability and irrigation emerged as major bottlenecks. Advisory services (training, demonstrations, timely guidance) and government policy support (procurement, incentives, crop insurance, remunerative pricing) were inadequate, limiting the adoption of improved practices. Socioeconomic factors such as age, education, income and market access significantly influenced perception levels. Overall, most farmers fell into the medium perception category, indicating scope for targeted interventions. The findings underscore the need to strengthen extension services, improve institutional credit and irrigation infrastructure and enhance policy implementation to bridge perception gaps. This study provides actionable insights for researchers and policymakers to enhance the productivity, resilience and sustainability of rice, pulse and oilseed systems in eastern India.

Keywords: farmer perceptions; government policy support; green gram cultivation; groundnut farming; rice production systems; sustainable agriculture

Introduction

Agriculture remains the backbone of rural livelihoods in Odisha, where rice, green gram and groundnut are key crops ensuring food and nutritional security. Rice is the dominant staple, providing calories for the majority, while pulses like green gram and oilseeds such as groundnut contribute proteins, essential fatty acids, minerals and income diversification (1-3).

For rice, recent research underscores the promise of site-specific nutrient management (SSNM) via tools such as rice crop manager (RCM), which help tailor fertiliser regimes to local soil and crop needs. This has been shown to increase yields by 17-19 % over traditional fertiliser practices, while improving nutrient use efficiency and reducing greenhouse gas emissions (4). Also, "climate-smart" rice varieties (for example, CR DHAN 801) have been tested in drought-prone zones of Odisha, showing enhanced resilience, stable yields and economic viability under moisture stress (5). Recent advances in precision nutrient management and climate-resilient rice varieties offer pathways to raise productivity and stabilise supply under increasingly erratic weather. Site-specific nutrient management and precision tools have been shown to improve rice yields, nutrient use efficiency and environmental outcomes in South Asia (6). Climate-smart varieties evaluated in Odisha (e.g., CR DHAN 801) have demonstrated greater stability under moisture stress, directly strengthening local food security (5).

Green gram (*Vigna radiata*), being a pulse rich in plant protein, iron and other micronutrients, plays a dual role in nutrition security and as a nitrogen-fixing crop in crop rotations. Recent trials in Odisha have demonstrated that simple interventions like seed biopriming with biofertilizers (e.g., *Rhizobium*) significantly improve germination, nodulation, growth, seed yield and farmer returns under rain-fed conditions (7). The rice-fallow initiative has sought to use post-rice residual moisture to grow green gram, increasing cropping intensity, soil health and incomes (8). Seed and crop bio-inputs further enhance pulse performance: recent trials of *Rhizobium*-based seed biopriming for green gram report improved germination, nodulation and yields under rainfed conditions, offering low-cost, high-impact options for resource-constrained farmers (9).

Groundnut similarly contributes to both nutritional and livelihood security, supplying protein, healthy oils and cash income. Technological advances in groundnut include improved cropping geometry and optimised nutrition regimes. For example, field experiments show that adjusting row spacing and nutrient levels can significantly enhance pod yield, haulm yield and profitability (10). Additionally, breeding and crop-improvement efforts are addressing issues such as aflatoxin contamination and oil quality to ensure safety and marketability (11). Groundnut contributes oils, protein and marketable surplus; agronomic refinements such as optimised plant spacing and variety selection have produced measurable increases in pod and haulm yields and farmer profitability in recent experimental evaluations (9).

Given these developments, understanding farmers' perceptions and attitudes becomes critical. Their knowledge, acceptance, risk perceptions, socio-economic constraints and exposure to extension or mass media influence whether these technologies are adopted (12). As Odisha scales up climate-smart agriculture, mechanised seeding, nutrient-management tools and rice-fallow intensification, such social dimensions may determine the extent to which food and nutrition security benefits are realised. Agricultural production systems worldwide are transforming rapidly due to technological innovations, climatic shifts and evolving policy frameworks. Farmers' perceptions and attitudes toward these changes play a pivotal role in determining the pace and extent of innovation adoption, influencing sustainability and productivity (13). This study assesses farmers' perceptions, attitudes and behavioural responses to evolving crop production systems in Odisha, providing insights for targeted interventions.

Materials and Methods

The study purposively selected three districts that represent major production centres for the target crops in Odisha. Baragarh was chosen for rice as it recorded the states' highest production at 13.58 LMT with a yield of 3252 kg/ha, substantially higher than the state average of 2409 kg/ha. Sonepur was selected for green gram owing to its strong performance in pulse cultivation, where yields (537 kg/ha) exceeded the state average for pulses (485 kg/ha). Jajpur was selected for groundnut as it is one of the states' leading producers, reporting a yield of 1547 kg/ha compared to the state average of 1431 kg/ha. These above-average yield levels and significant contributions to state output reflect the comparatively advanced production environments of these districts, thereby justifying their purposive selection for the present investigation (14). This progressiveness is reflected in their significant contribution to the states' overall production of rice, pulses and oilseeds. The sample for the study was drawn using a multistage sampling technique, which involved the selection of beneficiaries, villages and blocks within the respective districts. A multistage sampling approach was used to select 80 farmers from four villages, representing a mix of traditional and modern farming systems from each district. The total sample size was 320.

Selection of respondents

Farmers were operationally defined as individuals or groups engaged in farming activities. A complete list of farmers was obtained from block and district agricultural departments and cross-verified with local sources such as sarpanches and teachers. From four villages, 20 farmers each were randomly selected, constituting a total sample of 80 respondents for each district. An interview schedule, developed with expert guidance and literature review, was pretested on 10 % of the sample. Though prepared in English, it was administered in Odia to ensure accurate responses. Data collection, carried out from April to November 2024 with support from local leaders and agricultural officers, followed an ex-post facto research design.

Data analysis

Perception of rice, green gram and groundnut

The study assessed farmers' perceptions of rice, green gram and groundnut technology in terms of how it is understood, accepted and practised in the study area. A modified Likert scale was used to analyse perceptions across four key dimensions: ecological condition, input supply, advisory services and government policy system (10). The ecological condition has four items against which responses were taken on a three-point continuum, such as not suitable, suitable and most suitable, associated with their assigned scores of 1, 2 and 3, respectively. The dimension input supply has seven items to which responses were received on a three-point continuum, such as easily available, available and not available, with their corresponding assigned scores of 3, 2 and 1, respectively. The dimension advisory services was comprised of six items against which responses were collected on a four-point continuum as easily available, available, occasionally available and not available, with their corresponding assigned scores of 4, 3, 2 and 1. The last one, named government policy system, consisted of five items to which responses were taken on a three-point continuum of available, occasionally available and not available, with the scores assigned to them as 3, 2 and 1, respectively. Cumulative and mean scores were calculated and gap percentages were derived to evaluate farmers' perceptions systematically.

The total obtained score is equal to the sum of scores from all respondents concerning the variable.

$$\text{Mean score} = \frac{\text{Total obtained score}}{\text{Total number of respondents}} \quad \text{Eqn. 1}$$

$$\text{Gap percentage} = \left(\frac{\text{Maximum possible score} - \text{Mean score}}{\text{Maximum possible score}}\right) \times 100 \quad \text{Eqn. 2}$$

The gap percentage reflects the difference between farmers' existing perception levels (mean score) and the desired levels (maximum score) across various dimensions of hybrid rice cultivation. This measure helps identify gaps in farmers' understanding or acceptance of hybrid rice, which can guide stakeholders in addressing specific lacunae. Scores from each dimension were aggregated to obtain the overall perception score for every respondent. These individual scores were then averaged and the standard deviation was calculated. Using the half standard deviation method, lower and upper limits were set to categorise farmers' perceptions into three levels: low, medium and high. A summary of this classification is presented in Table 1 for a clearer depiction of respondents' perception levels.

Standard deviation of scores (SD, denoted as s):

$$s = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \mu)^2}{N}} \qquad \text{Eqn. 3}$$

Where,

X_i = score of the i^{th} individual in the respective variable, N = total number of respondents, μ=mean score. The respondents were classified according to their perception scores as per the defined criteria. The number of farmers in each category was then counted and converted into percentages to present the results.

Socio-economic profile of farmer respondents

The profile study considered two categories of independent variables. The first category included demographic and economic variables such as age, family size, farming experience and annual income. These were analysed directly by recording responses against set criteria, with frequencies and percentages calculated from the total sample. The second category comprised qualitative variables like education, achievement motivation, risk orientation, extension participation, mass media exposure and market accessibility. These were measured using standardised scales and procedures developed and validated by respective authors, with minor modifications for suitability to the present study. The tools and techniques employed for analysing these variables are briefly outlined in Table 2, which provides an overview of the methods applied for data analysis.

Table 1. Classification of respondents based on the scores obtained for the overall perception level

Category	Criteria
Low	Less than (Mean - ½ SD)
Medium	Between (Mean ± ½ SD)
High	Greater than (Mean + ½ SD)

Standardised tools were used to collect responses, which were converted into individual scores. The mean and standard deviation of these scores were calculated and the half-standard deviation method was applied to classify respondents into low, medium and high categories (Table 3).

Table 3. Classification of respondents based on the scores obtained for individual variables

Category	Criteria
Low	Score less than (Mean - ½ SD)
Medium	Score between (Mean ± ½ SD)
High	Score greater than (Mean + ½ SD)

Respondents were grouped by score ranges (low, medium, high), frequencies in each category were counted and then converted into percentages to present the distribution of respondents across categories.

Chi-square analysis

The Chi-square test is applied to determine whether an association exists between attributes classified under categorical data (21). It's application is particularly useful when research involves variables measured on different scales, such as ordinal (e.g., education level, achievement motivation, risk orientation, extension participation, mass media exposure and market accessibility) and ratio (e.g., age, family size, farming experience and annual income). Conventional parametric tests like correlation are not suitable for such data because they require specific scale conditions. In contrast, the Chi-square test, a powerful non-parametric tool, can handle data of varying measurement scales, provided the data are expressed in categories.

This test becomes especially valuable when two or more categories are present across variables. It works by comparing the frequency distribution of one variables' categories across the categories of another variable. The results are commonly presented in a contingency table, where rows represent the categories of one variable and columns represent those of the other, thereby enabling clear observation of relationships between the two sets of attributes.

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} \qquad \text{Eqn. 4}$$

Where,

X^2= Chi-square statistic

O_i= Observed frequency in each category

E_i= Expected frequency in each category

Expected frequency formula

$$E_{ij} = \frac{(\text{Row total}) \times (\text{Column total})}{\text{Grand total}} \qquad \text{Eqn. 5}$$

Table 2. Variables and their methods of empirical measurement

Variables	Method of measurement	References
Age	Chronological age of respondents (in completed years)	-
Education level	Assessed using the procedure suggested by the previous study	(15)
Family size	Assessed using the procedure suggested by the previous study	(16)
Farming experience	Assessed using the procedure suggested by the previous study	(16)
Annual income	Schedule developed specifically for this study	-
Achievement motivation	Assessed using the procedure suggested in the previous study	(17)
Risk orientation	Measured using Supes' scale, with modifications of the previous study	(18)
Extension participation	Schedule developed specifically for this study	-
Mass media exposure	Procedure adapted from a previous study with modifications	(19)
Market accessibility	Measured using the procedure suggested by the previous study	(20)

Before applying the Chi-square test, all continuous variables (e.g., age, income, family size and farming experience) were categorized into class intervals based on their respective mean and standard deviation values. This categorization facilitated their conversion into discrete classes, enabling meaningful categorical comparisons in subsequent Chi-square analysis.

In the analysis, scores from both dependent and independent variables are first transformed into categorical values such as 1, 2, 3 and so forth, depending on the number of categories within each variable. This transformation ensures that all data are standardised for categorical analysis. The Chi-square test is then applied to examine potential relationships between the variables. In this analysis, the observed values are the empirical frequencies obtained from the categorised independent variables, while the expected values are the theoretical frequencies computed from the distribution of the dependent variable under the null hypothesis of independence. Once the Chi-square statistic is calculated, it is evaluated against a critical value from the Chi-square distribution, which depends on the degrees of freedom determined by the structure of the contingency table. Alternatively, the test statistic can be assessed using its *p*-value obtained through statistical software (SPSS) or Chi-square tables. If the computed Chi-square value exceeds the critical threshold, or if the *p*-value is smaller than the predetermined significance level (α), the null hypothesis is rejected. This indicates a significant association between the categorical variables. On the other hand, if these conditions are not met, the null hypothesis cannot be rejected, suggesting no meaningful relationship between the variables.

Results and Discussion

Perception of rice farmers toward rice cultivation

Ecological condition

A majority of respondents (52.5 %) rated soil as the most suitable ecological factor for rice production, followed by 32.5 % who rated it as suitable, with a mean score of 2.4 and a gap of 20.8 %, as shown in Table 4. Climate was rated less favourably, with 40.0 % most suitable, 35.0 % suitable (mean = 2.2, gap = 28.3 %). Climate was rated lower than soil because farmers perceive it as highly variable and unreliable, shaped by their direct experience of erratic rainfall and rising temperatures. This contrasts with soil, which they view as stable and manageable. Their perceptions explicitly link climate to risk and vulnerability in rice farming, explaining the lower favourability ratings. Temperature showed comparatively lower suitability (37.5 % most suitable, 32.5 % suitable, mean = 2.1, gap = 30.8 %). Rainfall was perceived least suitable: only 25.0 % most suitable, 33.8 % suitable and the largest proportion, 41.3 % not suitable (mean = 1.8, gap = 38.8 %). Overall, farmers rank ecological factors in this order of perceived suitability: soil > climate > temperature > rainfall. The farmer perceptions shown in Table 4 align with previous studies in which soil quality was consistently rated highly by rice producers as a supportive factor for cultivation (22). Conversely, rainfall and temperature were associated with lower suitability, reflecting concerns over increasing climate variability (23). Research indicates that erratic rainfall and rising temperatures were perceived as constraints to sustainable rice production in Indian rice producer regions (17).

Input supply

The supply of inputs varied considerably across categories (Table 5). Fertilizer emerged as the most accessible input, with 68.75 % of respondents reporting it as easily available and a mean score of 2.59 (gap = 13.75 %). Suitable variety (65.00 % easily available) and quality seed (62.50 % easily available) followed closely, with mean scores of 2.56 and 2.49, respectively. Moderate availability was reported for plant protection chemicals (56.25 % easily available, mean = 2.44, gap = 18.75 %) and irrigation (48.75 % easily available, mean = 2.31, gap = 22.92 %). However, labour force and credit facility were perceived as the most constrained inputs: only 41.25 % rated labour as easily available (mean = 2.18, gap = 27.50 %), while just 36.25 % reported credit as easily available (mean = 2.03, gap = 32.50 %). Overall, farmers ranked inputs in descending order of accessibility as: fertilizer > suitable variety > quality seed > plant protection chemicals > irrigation > labour force > credit facility.

The results indicate that chemical inputs such as fertiliser and seeds are relatively accessible, while institutional and resource-based supports (labour and credit) remain significant bottlenecks. These findings are consistent with earlier studies across India (Table 5). High availability of fertiliser and seeds aligns with evidence that government procurement systems and private input markets ensure widespread distribution of these inputs to rice farmers (24). Research indicates that varietal availability and seed quality remain strong in irrigated rice belts, though issues of adulteration and timeliness persist (22). On the other hand, the limited availability of credit facilities reflects a broader trend reported in Odisha and other eastern Indian states, where access to institutional finance remains constrained by procedural complexity, collateral requirements and delays. Farmers in these contexts

Table 4. Perceptions of the rice farmers towards the ecological condition

Condition	Most suitable (%)	Suitable (%)	Not suitable (%)	Mean score	Gap (%)
Soil	52.5	32.5	15.0	2.4	20.8
Climate	40.0	35.0	25.0	2.2	28.3
Temperature	37.5	32.5	30.0	2.1	30.8
Rainfall	25.0	33.8	41.3	1.8	38.8

Table 5. Perceptions of the rice farmers on the supply of inputs

Inputs	Easily available (%)	Available (%)	Not available (%)	Mean score	Gap (%)
Suitable variety	65.00	26.25	8.75	2.56	14.58
Quality seed	62.50	23.75	13.75	2.49	17.08
Fertilizer	68.75	21.25	10.00	2.59	13.75
Plant protection chemicals	56.25	31.25	12.50	2.44	18.75
Irrigation	48.75	33.75	17.50	2.31	22.92
Labour force	41.25	35.00	23.75	2.18	27.50
Credit facility	36.25	30.00	33.75	2.03	32.50

often rely on informal credit sources, which may explain the high gap score (32.50 %) in this study. Labour scarcity has also been noted in several rice-growing areas due to rural out-migration, mechanisation pressures and increasing labour costs. Similarly, research indicates that labour shortages are emerging as a critical constraint, particularly during peak transplanting and harvesting seasons (23). Finally, irrigations' moderate ranking reflects farmer concerns about erratic rainfall and inadequate water infrastructure issues, echoed in climate-resilience studies, which show that unreliable irrigation systems limit timely input use and productivity in rice farming.

Thus, while chemical inputs are reaching farmers effectively, structural challenges in credit access, labour availability and irrigation support persist and require policy attention. Strengthening credit delivery mechanisms, improving rural employment programs and investing in irrigation infrastructure would directly address the highest input-related gaps perceived by rice farmers in this study.

Advisory services

The results indicate that most farmers reported very limited access to advisory services. Training (mean = 1.66, gap = 58.44 %) and close monitoring (mean = 1.73, gap = 56.88 %) were perceived least available, with nearly 60 % of respondents stating they were not available (Table 6). Timely guidance (mean = 1.93, gap = 51.88 %) and demonstration (mean = 2.00, gap = 50.00 %) also reflected substantial deficits. The relatively better-rated services were literature supply (mean = 2.56, gap = 35.94 %) and exposure visits (mean = 2.09, gap = 47.81 %), but even these showed considerable limitations.

The poor accessibility of advisory services, particularly training, monitoring and timely guidance, echoes studies across eastern India that highlight weak agricultural extension networks and low farmer participation in capacity-building programs (25). Literature supply being relatively better rated suggests that while informational materials are reaching farmers, interactive, field-based extension support remains weak.

Government policy system

The results indicate that perceptions towards policy support were also unfavourable (Table 7). Incentives and remunerative prices were least accessible, both with a mean score of 1.34 and high gaps of 55.42 %. Procurement facilities (mean = 1.44, gap = 52.08 %) and crop insurance (mean = 1.54, gap = 48.75 %) were also perceived as largely unavailable. Subsidies fared slightly better (mean = 1.81, gap = 39.58 %) but remained inadequate.

Table 7 shows strong farmer perceptions of poor availability of government policy support systems. The services with the worst gaps are remunerative price (75 % "not available"), incentives (72.5 %), procurement (62.5 %) and crop insurance (60 %). Only subsidy is somewhat better, though still with a large gap (approximately 45 %). Research indicates that although crop insurance schemes (such as PMFBY (Pradhan Mantri Fasal Bima Yojana)) have been introduced to mitigate risk, adoption by farmers remains low, largely due to low awareness about insurance products (26). Research also highlights issues like delay in payments, strict quality norms and procedural complexity in procurement systems, which restrict smallholders' access (27). For example, a study in Kerala on paddy procurement constraints found that delayed payment of procurement price and difficulty meeting quality standards are key challenges (28).

Comparative dimensions

The comparative analysis highlights that input supply has the highest mean score (2.37) and the lowest gap (21.01 %), implying that among the four most accessible relative to expectations, relative to farmers' expectations (Table 8). Ecological condition also fares moderately: mean score 2.10, gap approximately 29.70 %, showing some degree of satisfaction, though with room for improvement. Advisory service and government policy show substantially lower mean scores (1.99 and 1.49, respectively) and very high gaps (50.2 % each). These two dimensions are perceived as the most deficient. Thus, while farmers perceive physical inputs and ecological conditions comparatively more accessible or better handled, institutional and support systems advisory services and government policy are major perceived gaps.

The high gaps in advisory service and government policy reflect a widespread pattern in agricultural research showing that knowledge support and policy mechanisms are often the weakest links in the service chain for small and marginal farmers. For example, research indicates that a large majority of rice farmers in Pakistan reported dissatisfaction with public extension services; many felt that extension agents visited them infrequently and that demonstrations, advisories and support schemes were poorly executed (29). This corresponds closely with the gap of approximately 50 % in advisory service in our

Table 8. Comparative analysis of different dimensions of perceptions

Condition	Mean score	Gap (%)
Ecological condition	2.10	29.70
Input supply	2.37	21.01
Advisory service	1.99	50.16
Government policy	1.49	50.25

Table 6. Perceptions of the rice farmers towards advisory services

Advisory service	Easily available (%)	Available (%)	Occasionally available (%)	Not available (%)	Mean score	Gap (%)
Training	6.25	12.50	22.50	58.75	1.66	58.44
Demonstration	18.75	11.25	21.25	48.75	2.00	50.00
Exposure visit	21.25	13.75	17.50	47.50	2.09	47.81
Literature supply	28.75	23.75	22.50	25.00	2.56	35.94
Timely guidance	17.50	10.00	20.00	52.50	1.93	51.88
Close monitoring	8.75	15.00	16.25	60.00	1.73	56.88

Table 7. Perceptions of the rice farmers towards the government policy system

Policy system	Available (%)	Occasionally available (%)	Not available (%)	Mean score	Gap (%)
Incentives	6.25	21.25	72.50	1.34	55.42
Crop insurance	13.75	26.25	60.00	1.54	48.75
Subsidy	26.25	28.75	45.00	1.81	39.58
Procurement	6.25	31.25	62.50	1.44	52.08
Remunerative price	8.75	16.25	75.00	1.34	55.42

Table 8. Similarly, it was observed that adoption of sustainable inputs is significantly influenced by access to technical advisory services and awareness of policy incentives (30). Weak advisory and policy support were found to be barriers to adopting greener or improved input practices. This aligns with our findings: the comparatively strong input supply dimension, but weak advisory service and government policy dimensions. Moreover, research indicates that while input supply systems (seeds, fertilisers, machinery, etc.) have become more accessible through both government and private suppliers, the institutional support (credit, extension/advisory services, policy awareness/incentives) remains patchy and insufficiently responsive (31). This underlines the same duality observed in Table 8: relatively good availability of inputs vs. poor institutional/knowledge support.

Overall perception levels

The composite perception scores indicated in Table 9 suggest that a majority of farmers fell into the medium perception category (51.25 %), while 32.50 % were in the low category. Only 16.25 % of farmers reported a high level of positive perception towards rice cultivation. The overall mean score was 1.99 with a standard deviation of 0.37, reinforcing the predominance of medium-to-low perceptions.

The distribution of perception levels in this study (medium being dominant, low substantial and high small) is consistent with patterns found in other agricultural perception studies. In a study of farmers' perceptions of climate change and adaptation strategies in Tamil Nadu, about 63.3 % of farmers had a medium level of perception, with fewer in the low and high categories. Nearly all farmers were aware of climate variability, but less than half perceived it as a major threat; many had moderate concern rather than extremes, indicating many in medium perception categories rather than high (32, 33). In Mewat, Haryana, studies of perceptions of groundwater salinity or climate risk also report a substantial proportion of farmers with moderate awareness or perception, with smaller numbers feeling highly concerned or feeling that adaptation services are excellent (33). These parallels suggest that in many smallholder farming contexts, perceptions are distributed unimodally around a mid-level: many farmers are neither completely pessimistic nor highly optimistic about advisory, policy, ecological or input support systems.

Table 9. Overall levels of perception towards rice cultivation

Category	Criteria	Farmers (No.)	Farmers (%)	Mean	SD
Low	< 1.81	26	32.50		
Medium	1.81 - 2.66	41	51.25	1.99	0.37
High	> 2.49	13	16.25		

Socioeconomic profile of the farmers

The profile characteristics of rice farmers are presented in Table 10. These attributes provide an understanding of the socio-economic, psychological and institutional factors influencing farmers' perception and adoption of hybrid rice cultivation practices.

Age distribution shows that most farmers (51.25 %) belong to the middle-aged group (35-50 years), followed by 32.50 % in the old-age group (> 50 years) and only 16.25 % in the young category (< 35 years). This indicates that rice cultivation in the study area is largely managed by experienced middle-aged and older farmers, which could affect openness to adopting new technologies. Education levels, as measured through a standardised scoring framework, indicated that 45.00 % of respondents were categorised under medium education (score range: 2.54-4.87), while 37.50 % fell into the low category and 17.50 % into the high category. The presence of a substantial proportion of educated farmers suggests potential for understanding modern rice cultivation practices, though a notable segment with low education may limit effective adoption. Family size shows that 52.50 % of farmers have medium-sized families (4-6 members), 31.25 % have large families and 16.25 % have small families. Medium and large family sizes provide adequate labour for timely farm operations, which can positively influence perception and adoption of improved practices.

Table 10. Profile characteristics of the rice farmers

Variables	Category	Criteria	Respondents (number)	Respondents (%)
Age	Young	< 35 years	13	16.25
	Middle	35-50 years	41	51.25
	Old	> 50 years	26	32.50
Education	Low	< 2.54	30	37.50
	Medium	2.54 - 4.87	36	45.00
	High	> 4.87	14	17.50
Family size	Small	< 4	13	16.25
	Medium	4 - 6	42	52.50
	Large	> 6	25	31.25
Farming experience	Less	< 11 years	12	15.00
	Moderate	11 - 20 years	41	51.25
	High	> 20 years	27	33.75
Annual income	Low	< ₹ 93,247	13	16.25
	Medium	₹ 93,247 - 2,56,442	50	62.50
	High	> ₹ 2,56,442	17	21.25
Achievement motivation	Low	< 16.24	15	18.75
	Medium	16.24 - 24.47	39	48.75
	High	> 24.47	26	32.50
Risk orientation	Low	< 4.11	27	33.75
	Medium	13.21 - 15.22	29	36.25
	High	> 15.22	24	30.00
Extension participation	Low	< 4.89	23	28.75
	Medium	4.11 - 7.44	30	37.50
	High	> 7.44	27	33.75
Mass media exposure	Low	< 7.19	9	11.25
	Medium	4.89 - 7.19	26	32.50
	High	> 7.19	45	56.25
Market accessibility	Low	< 35.67	13	16.25
	Medium	35.67 - 48.57	36	45.00
	High	> 48.57	31	38.75

Farming experience analysis indicates that 51.25 % of farmers possess moderate experience (11-20 years), 33.75 % high experience (> 20 years) and 15.00 % less experience (< 11 years). The majority of farmers' moderate to high experience suggests familiarity with local conditions and cropping patterns, facilitating informed decision-making, though it may also result in reliance on traditional methods. Annual household income shows that 62.50 % of respondents fall in the medium-income range (₹ 93247-256442), 21.25 % in the high-income category and 16.25 % in the low-income category. Medium- to high-income farmers are better positioned to invest in quality inputs and adopt hybrid rice technology, whereas low-income farmers may face financial constraints. Achievement motivation was medium for 48.75 %, high for 32.50 % and low for 18.75 % of farmers, indicating that a significant proportion of farmers are driven to improve productivity and adopt innovations. Risk orientation was balanced, with 36.25 % medium, 33.75 % low and 30.00 % high. This suggests that a considerable number of farmers are cautious about experimenting with new practices, which could influence adoption levels. Extension participation indicates that 37.50 % of farmers had medium participation, 33.75 % high and 28.75 % low. Active participation in extension programs enhances knowledge and skill development, contributing positively to the perception of hybrid rice. Mass media exposure shows that 56.25 % of respondents had high exposure, 32.50 % medium and 11.25 % low. High media exposure enables farmers to access timely information about modern rice cultivation, government schemes and market trends, positively affecting perception and adoption. Market accessibility analysis reveals that 45.00 % of farmers had medium access, 38.75 % high and 16.25 % low. Adequate market access ensures better sales of produce and availability of inputs, influencing farmers' perception of profitability and adoption potential.

Overall, the profile analysis indicates that rice farmers in the study area are predominantly middle-aged, moderately educated, medium-income earners, with moderate to high farming experience, active extension participation and high mass media exposure. These characteristics suggest that most farmers have the capacity to adopt hybrid rice cultivation, though targeted interventions may be necessary to enhance perception and adoption among less educated, low-income, or low-extension participation groups.

The results indicate that most rice farmers are middle-aged with moderate experience, reflecting an active and economically engaged farming population. This aligns with a previous study reporting that middle-aged farmers dominate paddy cultivation in Odisha, balancing experience with the physical ability to manage intensive crop systems (31). The predominance of medium education levels suggests gradual improvement in literacy but still lags behind higher educational attainment. Similar findings were reported in a study, where most rice farmers had only secondary-level education, limiting access to advanced technologies and extension services (27). Importantly, mass media exposure was high, indicating increased reliance on mobile phones, television and digital platforms for agricultural information. This finding supports the rising role of ICT (information and communications technology) in bridging extension gaps in eastern India (24).

Relation between the profile characteristics of farmers and their perception towards rice cultivation

The association between the profile characteristics of rice farmers and their perception towards hybrid rice cultivation is presented in Table 11. The findings indicate that several socio-economic, psychological and institutional factors have a significant influence on farmers' perception, while a few variables showed non-significant effects.

Table 11. Association between profile characteristics of the rice farmers and their perception

Profile characteristics	Contingency coefficient	Chi-square value
Age	0.39	14.72*
Education	0.33	9.70*
Family size	0.41	15.93*
Farming experience	0.41	15.77*
Annual income	0.53	30.81*
Achievement motivation	0.35	10.92*
Risk orientation	0.08	0.47^{NS}
Extension participation	0.11	0.92^{NS}
Mass media exposure	0.48	23.33*
Market accessibility	0.35	11.00*

**Significant at 5 % level, * Significant at 1 % level and NS = Non-Significant.

Age was significantly associated with perception at the 1 % level (X^2 = 14.72; C = 0.39), indicating that middle-aged and older farmers, due to their traditional farming experience, may show cautious adoption of hybrid rice, whereas younger farmers are relatively more open to modern technologies. Education also showed a significant association at the 1 % level (X^2 = 9.70; C = 0.33), suggesting that educated farmers are more informed about hybrid rice cultivation, better understand its benefits and are more likely to adopt improved practices. Family size had a significant positive association with perception (X^2 = 15.93; C = 0.41). Medium to large households typically provide sufficient labour for timely farm operations, enabling greater exposure to modern technologies and enhancing adoption potential. However, very large families may also encounter resource constraints, where land and income are spread thinly, potentially limiting the capacity to invest in improved practices. Thus, while family size generally supports adoption, its benefits depend on the balance between available labour and household resources. Farming experience was significantly associated at the 1 % level (X^2 = 15.77; C = 0.41), indicating that experienced farmers possess better knowledge of local conditions, cropping patterns and input management, positively influencing perception of hybrid rice. Annual income had the strongest association (X^2 = 30.81; C = 0.53), highlighting that higher-income farmers have better access to inputs, technology and market facilities, enhancing their perception of hybrid rice cultivation. Achievement motivation showed a significant relationship (X^2 = 10.92; C = 0.35), suggesting that motivated farmers are more proactive in acquiring knowledge, adopting innovations and implementing best practices. Mass media exposure was significantly associated (X^2 = 23.33; C = 0.48), indicating that farmers with higher exposure to newspapers, radio, television and digital platforms are better informed about hybrid rice technologies, government schemes and market opportunities. Market accessibility was significant (X^2 = 11.00; C = 0.35), suggesting that farmers with better access to local and regional markets are more aware of pricing trends and end-use demand, positively shaping their perception of hybrid rice cultivation. In contrast, risk orientation (X^2 = 0.47; C = 0.08) and extension participation (X^2 = 0.92; C = 0.11) were found to be non-significant, indicating that farmers' willingness to take

risks and their level of participation in extension programs did not have a statistically meaningful impact on perception in this study area.

Overall, the analysis demonstrates that age, education, family size, farming experience, annual income, achievement motivation, mass media exposure and market accessibility are key determinants of farmers' perception towards hybrid rice. These results underscore the importance of improving education, access to information and market linkages, as well as leveraging farmers' motivation and experience, to improve the adoption of hybrid rice cultivation.

These findings align with several recent empirical studies, like education, mass media exposure and market accessibility positively influencing farmers' perception of hybrid rice, while age shows a negative association. Younger, educated and media-exposed farmers adopt innovations more readily, highlighting key factors for enhancing rice perception (17). The significant effect of age and farming experience suggests that more experienced and middle-aged farmers are likely to form stronger perceptions about cultivation systems. Research indicates that farmer age and experience significantly influence the adoption of improved rice practices in Odisha.

Education also emerged as a key factor, reflecting that higher education levels facilitate awareness and critical judgment of agricultural policies and technologies. Similar findings were reported previously in Bihar, where education strongly influenced perception and adoption of modern rice technologies (34). The significance of mass media exposure reflects the growing role of ICT and information dissemination in shaping awareness. Farmers with high exposure reported better perceptions, which focus on digital extension platforms significantly improving farmers' access to knowledge in eastern India (24).

Perception of green gram farmers toward cultivation

Ecological condition

The perception of green gram growers towards the ecological conditions required for cultivation is presented in Table 12. The data reveal that most respondents considered soil and temperature as the most suitable factors for green gram production. Specifically, 65.0 % of farmers perceived soil conditions as most suitable, while 67.5 % expressed the same opinion regarding temperature. The corresponding mean scores of 2.6 each indicate a strong level of suitability perception, with relatively lower gap percentages of 15.0 % and 14.2 %, respectively. This suggests that favourable soil texture and optimum temperature conditions provide a conducive environment for the crops' growth, consistent with the crops' physiological needs.

Table 12. Perceptions of the green gram growers towards the ecological condition

Condition	Most suitable (%)	Suitable (%)	Most suitable (%)	Mean score	Gap (%)
Soil	65.0	25.0	10.0	2.6	15.0
Climate	50.0	30.0	20.0	2.3	23.3
Temperature	67.5	22.5	10.0	2.6	14.2
Rainfall	40.0	35.0	25.0	2.2	28.3

In terms of climate, 50.0 % of the growers considered it as most suitable, while 30.0 % viewed it as suitable and 20.0 % as not suitable. The mean score of 2.3 with a gap of 23.3 % highlights that although a majority find the climatic conditions favourable, there exists variability in perception, possibly due to fluctuating weather conditions and climate change-related challenges in the region. Rainfall emerged as the least favourable factor, with only 40.0 % of respondents considering it most suitable and a relatively high 25.0 % perceiving it as not suitable. The lowest mean score of 2.2 and the highest gap percentage of 28.3 % indicate that irregular or inadequate rainfall has been a major constraint for green gram production. This reflects the dependency of the crop on timely and well-distributed rainfall, which is often lacking, thereby negatively affecting yields.

Overall, the findings demonstrate that while soil and temperature are perceived as highly favourable ecological factors, climate and rainfall pose significant challenges. The higher gap percentages for climate and rainfall point to areas where interventions such as promoting drought-tolerant varieties, efficient water management practices and climate-resilient technologies could substantially enhance the suitability of ecological conditions for green gram cultivation. Similar findings were reported previously in a study (35).

Input supply

The perception of green gram growers regarding the supply of inputs is depicted in Table 13. The results highlight notable differences in the availability of various inputs essential for cultivation. It was found that fertiliser was perceived as the most accessible input, with 56.25 % of farmers reporting it as easily available and a mean score of 2.36. The relatively lower gap percentage (21.25 %) indicates that fertiliser supply is relatively better distributed than other inputs, reflecting efficient distribution mechanisms in the study area. In the case of suitable varieties, 43.75 % of respondents considered them easily available, while 23.75 % reported non-availability. Despite a mean score of 2.20, the gap (26.67 %) indicates that varietal choice is not uniformly accessible to all farmers, which could restrict the adoption of improved or high-yielding types of green gram. Quality seed and labour force both received moderate perceptions, with mean scores of 2.11 each and gap percentages of 29.58 %. About 41.25 % of farmers found quality seed easily available, while a significant 30.00 % reported non-availability. Similarly, while 38.75 % of respondents reported adequate access to labour, 25.00 % expressed constraints, pointing to occasional scarcity or higher costs of agricultural labour during peak seasons. Plant protection

Table 13. Perceptions of the green gram growers on the supply of inputs

Inputs	Easily available (%)	Available (%)	Not available (%)	Mean score	Gap (%)
Suitable variety	43.75	32.50	23.75	2.20	26.67
Quality seed	41.25	28.75	30.00	2.11	29.58
Fertilizer	56.25	23.75	20.00	2.36	21.25
Plant protection chemicals	38.75	30.00	31.25	2.08	30.83
Irrigation	31.25	33.75	35.00	1.96	34.58
Labour force	36.25	38.75	25.00	2.11	29.58
Credit facility	28.75	26.25	45.00	1.84	38.75

chemicals were reported as easily available by 38.75 % of farmers, whereas 31.25 % stated non-availability. The mean score of 2.08 and a relatively high gap percentage (30.83 %) suggest that while some farmers have access to pest and disease management inputs, many still face irregular supply or affordability issues. Irrigation emerged as a major constraint, with only 31.25 % perceiving it as easily available, while 35.00 % reported complete non-availability. It had a low mean score of 1.96 with a high gap (34.58 %), indicating a pressing challenge in providing reliable water resources for green gram cultivation, especially in rainfed areas.

The most critical issue identified was the credit facility, where only 28.75 % of respondents considered it easily available, while a high 45.00 % reported non-availability. This factor had the lowest mean score (1.84) and the highest gap percentage (38.75 %). The findings underscore that inadequate institutional credit access compels farmers to rely on informal high-interest sources, thereby increasing financial vulnerability.

Overall, the study reveals that while fertiliser supply is relatively satisfactory, inputs such as irrigation and credit facilities remain major constraints. Moderate availability of suitable varieties, quality seeds, labour and plant protection chemicals reflects the need for policy interventions, improved distribution networks and institutional support to ensure timely and affordable access to critical inputs for green gram cultivation. Similar findings were reported previously in a study (36).

Advisory services

The perceptions of green gram growers towards advisory services are presented in Table 14. The findings reveal significant gaps in the accessibility and delivery of extension services, which play a critical role in guiding farmers towards scientific crop management.

Training opportunities were reported as the least accessible advisory service. Only 2.50 % of farmers found training to be easily available, while a large majority (62.50 %) stated that it was not available at all. The lowest mean score of 1.58 and a very high gap percentage (60.63 %) underscore the inadequate training support available to growers. This suggests that farmers are largely deprived of structured capacity-building programs that could improve their knowledge and skills in green gram cultivation. Demonstration and exposure visits were moderately accessible, with mean scores of 2.18 and 2.23, respectively. Around 15.00 % of respondents reported demonstrations as easily available, while 27.50 % indicated occasional access. Similarly, 16.25 % of farmers experienced exposure visits as easily available, with 26.25 % occasionally available. The gap values (45.63 % and 44.38 %) reflect that although these methods are recognised as effective tools for experiential learning, their reach remains limited and irregular. In the case of literature supply, 26.25 % of farmers considered it easily available, with a mean score of 2.60 and the lowest gap percentage (35.00 %). This indicates that printed or digital informational materials are more accessible compared to other advisory services. However, the effectiveness of literature supply alone may be limited by literacy levels and the preference of farmers for practical, interactive learning. Timely guidance and close monitoring were also found to be major constraints. A large proportion of respondents (63.75 and 62.50 %, respectively) reported the non-availability of these services. Both recorded very low mean scores (1.68 and 1.64) and high gap percentages (58.13 and 59.06 %). This highlights the absence of consistent, field-based advisory support that can address real-time problems such as pest outbreaks, nutrient deficiencies, or weather-related challenges.

Overall, the results indicate that advisory services for green gram cultivation remain underdeveloped in the study area. While literature supply is comparatively better, the lack of training, demonstrations, timely guidance and close monitoring severely limits farmers' ability to adopt improved practices. Strengthening extension networks through regular training programs, participatory demonstrations, ICT-based advisories and enhanced field-level monitoring could bridge these gaps and empower farmers to increase productivity and sustainability in green gram cultivation. Similar findings were reported previously in a study (37).

Government policy system

The perceptions of green gram growers towards the government policy system are presented in Table 15. The results clearly show that the policy support mechanisms designed for farmers are perceived as inadequate and inaccessible, resulting in significant gaps in institutional trust and effectiveness.

Incentives were reported as largely unavailable, with 67.50 % of respondents indicating non-availability. The mean score of 1.43 and a high gap percentage of 52.50 % reflect that farmers are not adequately benefiting from incentive schemes intended to promote crop diversification or pulse production. Similarly, crop insurance was not widely adopted or accessible, with 65.00 % of respondents reporting non-availability. Its mean score of 1.46 and a gap of 51.25 % suggest poor penetration of insurance schemes such as the PMFBY. This indicates that farmers remain vulnerable to production and market risks due to a lack of reliable risk-mitigation measures. In the case of subsidy, 23.75 % of growers reported availability, while 26.25 % indicated occasional access. The mean score of 1.74 with a relatively lower gap (42.08 %) compared to

Table 14. Perceptions of the green gram growers towards advisory services

Advisory service	Easily available (%)	Available (%)	Occasionally available (%)	Not available (%)	Mean score	Gap (%)
Training	2.50	15.00	20.00	62.50	1.58	60.63
Demonstration	15.00	22.50	27.50	35.00	2.18	45.63
Exposure visit	16.25	23.75	26.25	33.75	2.23	44.38
Literature supply	26.25	28.75	23.75	21.25	2.60	35.00
Timely guidance	11.25	8.75	16.25	63.75	1.68	58.13
Close monitoring	6.25	13.75	17.50	62.50	1.64	59.06

Table 15. Perceptions of the green gram growers towards the government policy system

Policy system	Available (%)	Occasionally available (%)	Not available (%)	Mean score	Gap (%)
Incentives	10.00	22.50	67.50	1.43	52.50
Crop insurance	11.25	23.75	65.00	1.46	51.25
Subsidy	23.75	26.25	50.00	1.74	42.08
Procurement	16.25	23.75	60.00	1.56	47.92
Remunerative price	0.00	0.00	100.00	1.00	66.67

other policy instruments shows that subsidies (particularly on seeds, fertilisers, or farm equipment) are somewhat accessible, though distribution remains uneven and inadequate. Procurement facilities were also found to be limited, with 60.00 % of respondents perceiving them as not available. The mean score (1.56) and gap percentage (47.92 %) highlight the absence of an effective procurement mechanism for pulses like green gram, which discourages farmers from expanding production due to uncertainty in market security. The most critical issue identified was the remunerative price. All respondents (100.00 %) reported non-availability, resulting in the lowest possible mean score of 1.00 and the highest gap (66.67 %). This finding underscores a serious deficiency, as the absence of assured and fair pricing mechanisms leaves farmers vulnerable to market exploitation and low returns despite their production efforts.

Overall, the results demonstrate that government policy support for green gram cultivation is perceived as weak, with particularly severe gaps in incentives, crop insurance, procurement and pricing. While subsidies provide some relief, the absence of assured remunerative prices and effective procurement policies has led to low farmer confidence. Strengthening policy interventions by ensuring fair minimum support prices (MSP), efficient procurement mechanisms, effective insurance coverage and timely delivery of subsidies could significantly improve the viability and sustainability of green gram farming. Similar findings were reported previously in a study (38).

Comparative dimensions

The comparative analysis of different dimensions of farmers' perceptions towards green gram cultivation is presented in Table 16. The findings indicate significant variation across ecological, input, advisory and policy dimensions, highlighting areas of strong support and those with critical gaps. Among the four dimensions, ecological condition was rated highest, with a mean score of 2.39 and the lowest gap percentage (20.21 %). This implies that farmers generally perceive the natural conditions, such as soil, temperature and climate, to be favourable for green gram cultivation. The relatively low gap suggests that ecological factors are less of a constraint compared to institutional and infrastructural dimensions. In contrast, the dimension of input supply recorded a moderate mean score (2.09) and a gap of 30.18 %. While fertilisers and some varieties were accessible, constraints in irrigation, quality seeds, plant protection chemicals and credit facilities restricted the smooth availability of essential inputs. This indicates that although ecological conditions are suitable, the lack of adequate inputs hinders productivity. The most concerning findings emerged in the areas of advisory services and government policy systems. Advisory services registered a low mean score of 1.98 with a high gap (50.47 %), reflecting farmers' dissatisfaction with the availability of training, demonstrations, timely guidance and field-level monitoring. The limited reach of extension agencies restricts the flow of technical knowledge, thereby affecting the adoption of improved practices. Government policy systems were perceived most poorly, with the lowest mean score (1.44) and the highest gap (52.08 %). The absence of effective mechanisms for incentives, insurance, procurement and remunerative pricing has created a policy vacuum that undermines farmers' confidence in pulse cultivation. In particular, the absence of assured markets and fair prices acts as a strong disincentive.

Overall, the comparative analysis shows that while ecological conditions are largely favourable, institutional support in terms of inputs, advisory services and policy interventions is highly inadequate. Addressing these institutional gaps through strengthened extension systems, reliable input distribution and farmer-centric policies is critical to transforming favourable ecological potential into higher productivity and profitability in green gram cultivation. This studys' outcomes are congruent with the established literature (39, 40).

Table 16. Comparative analysis of different dimensions of perceptions

Condition	Mean score	Gap (%)
Ecological condition	2.39	20.21
Input supply	2.09	30.18
Advisory service	1.98	50.47
Government policy	1.44	52.08

Overall perception levels

The overall levels of perception of farmers towards green gram cultivation are summarised in Table 17. The results reveal that perceptions are distributed across three categories: low, medium and high, indicating varying degrees of awareness, access and acceptance of green gram production practices. A majority of farmers (46.25 %) were classified under the medium perception category, with a mean score of 1.98 and a standard deviation of 0.40. This suggests that while farmers possess a moderate understanding of ecological requirements, inputs and management practices, there remain significant gaps in awareness and adoption of advanced techniques. On the other hand, 38.75 % of farmers fell under the low perception category (< 1.58). This large proportion highlights significant limitations in knowledge, access to resources and exposure to advisory and policy support. The findings suggest that nearly two-fifths of growers are unable to make informed decisions due to a lack of institutional support, inadequate extension services and limited access to reliable input and market systems. Only 15.00 % of the farmers demonstrated a high level of perception (> 2.38). This indicates that a small fraction of the farming community is well-informed and better positioned to adopt improved cultivation practices. Farmers in this category are likely to be relatively younger, more educated and have better access to mass media, extension services and markets, as reflected in earlier findings on correlates of perception. The present results are in agreement with earlier studies (41, 42).

Overall, the results demonstrate that while most farmers fall under medium perception, a considerable proportion remain in the low category and only a small share possesses high perception levels. This skewed distribution suggests the need for targeted interventions such as capacity-building programs, farmer field schools, regular training and strengthened policy support. By addressing the gaps in input supply, advisory services and market assurance, the perception of farmers towards green gram cultivation can be enhanced, thereby encouraging wider adoption and improved productivity.

Table 17. Overall levels of perception towards the green gram cultivation

Category	Criteria	Farmers (No.)	Farmers (%)	Mean	SD
Low	< 1.58	31	38.75		
Medium	1.58 - 2.38	37	46.25	1.98	0.40
High	> 2.38	12	15.00		

Socioeconomic profile of the farmers

The profile characteristics of green gram farmers are presented in Table 18. The findings provide insights into the socio-economic, psychological and institutional attributes of the respondents, which directly influence their perception and adoption of green gram cultivation practices.

Age distribution shows that most farmers (47.50 %) belonged to the middle-aged group (35-50 years), followed by 33.75 % in the old-age group (> 50 years) and only 18.75 % in the young category (< 35 years). This indicates that green gram cultivation is primarily managed by middle and older-generation farmers, suggesting the continuation of traditional practices, while youth participation remains limited. Regarding education, the largest proportion (45.00 %) had a medium level of education (2.54-4.87), while 36.25 % were in the low education category and only 18.75 % possessed higher education. This implies that though nearly half of the farmers have moderate literacy, a significant portion still lack formal education, which may hinder their access to technical knowledge and adoption of scientific methods (43). Family size analysis shows that over half of the respondents (53.75 %) belonged to medium-sized families (4-6 members). Small families accounted for 20.00 %, while 26.25 % reported large families. This indicates a balanced distribution, but larger families may face pressure on landholdings and resources, while medium families provide adequate labour support. In terms of farming experience, half of the respondents (50.00 %) had moderate experience (11-20 years), followed by 26.25 % with high experience (> 20 years). Only 23.75 % had less than 11 years of experience. This suggests that most farmers have long-term exposure to agriculture, which may aid decision-making but could also result in reluctance to adopt innovations due to reliance on conventional methods. Regarding annual income, the majority (48.75 %) fell in the medium-income range (₹93247-256442), while 28.75 % were in the low-income group and 22.50 % were in the high-income category. This highlights that green gram growers are mostly small and medium-income farmers, with financial constraints potentially limiting investment in improved technologies. Achievement motivation was distributed, with 41.25 % at a medium level, 35.00 % at high and 23.75 % at low. This indicates that a good proportion of farmers are motivated to improve their farming outcomes, which is a positive factor for the adoption of innovative practices. Similarly, risk orientation was balanced across the categories, with 35.00 % at medium, 33.75 % at high and 31.25 % at low levels. This suggests that while a section of farmers is willing to experiment with new technologies, another section remains risk-averse, reflecting diverse attitudes towards innovation. Extension participation revealed that 38.75 % of respondents had medium participation, followed by 31.25 % at low and 30.00 % at high. This shows that extension contact is uneven, with limited high participation levels, thereby restricting the effectiveness of advisory services. In terms of mass media exposure, a large proportion (45.00 %) had high exposure, while 28.75 % were at medium and 26.25 % at low levels. This indicates that modern communication tools play an increasing role in disseminating agricultural information, enhancing farmers' access to knowledge resources. Finally, market accessibility was reported as medium by 40.00 % of farmers, followed by 33.75 % at high and 26.25 % at low levels. This shows that a considerable proportion of farmers have good market access, but gaps still exist, which may hinder effective price realisation and input-output transactions.

Overall, the profile analysis reveals that green gram growers are predominantly middle-aged, moderately educated, medium-experienced and medium-income farmers, with moderate levels of motivation, risk-taking ability, extension participation and market access. High mass media exposure, however, emerges as a strong positive factor. These characteristics underline the need for targeted extension programs, credit support and policy interventions to enhance farmers' perception and adoption of

Table 18. Profile characteristics of the green gram farmers

Variables	Category	Criteria	Respondents (number)	Respondents (%)
Age	Young	< 35 years	15	18.75
	Middle	35-50 years	38	47.50
	Old	> 50 years	27	33.75
Education	Low	< 2.54	29	36.25
	Medium	2.54 - 4.87	36	45.00
	High	> 4.87	15	18.75
Family size	Small	< 4	16	20.00
	Medium	4 - 6	43	53.75
	Large	> 6	21	26.25
Farming experience	Less	< 11 years	19	23.75
	Moderate	11 - 20 years	40	50.00
	High	> 20 years	21	26.25
Annual income	Low	< ₹ 93,247	23	28.75
	Medium	₹ 93,247 - 2,56,442	39	48.75
	High	> ₹ 2,56,442	18	22.50
Achievement motivation	Low	< 16.24	19	23.75
	Medium	16.24 - 24.47	33	41.25
	High	> 24.47	28	35.00
Risk orientation	Low	< 4.11	25	31.25
	Medium	13.21 - 15.22	28	35.00
	High	> 15.22	27	33.75
Extension participation	Low	< 4.89	25	31.25
	Medium	4.11 - 7.44	31	38.75
	High	> 7.44	24	30.00
Mass media exposure	Low	< 7.19	21	26.25
	Medium	4.89 - 7.19	23	28.75
	High	> 7.19	36	45.00
Market accessibility	Low	< 35.67	21	26.25
	Medium	35.67 - 48.57	32	40.00
	High	> 48.57	27	33.75

improved green gram cultivation practices. The results align with a previous study and indicate significant results (44).

Relation between the profile characteristics of farmers and their perception towards rice cultivation

The association between profile characteristics of rice farmers and their perception towards rice cultivation is presented in Table 19. The findings highlight that only a few variables exhibited significant associations, while most were statistically non-significant.

Table 19. Association between profile characteristics of the green gram farmers and their perception

Profile characteristics	Contingency coefficient	Chi-square value
Age	0.25	5.54**
Education	0.25	5.50**
Family size	0.31	8.63*
Farming experience	0.2	3.53^{NS}
Annual income	0.22	4.25^{NS}
Achievement motivation	0.14	1.58^{NS}
Risk orientation	0.04	0.16^{NS}
Extension participation	0.09	0.68^{NS}
Mass media exposure	0.23	4.49^{NS}
Market accessibility	0.1	0.89^{NS}

**Significant at 5 % level, * Significant at 1 % level and NS = Non-Significant.

Among the characteristics, age showed a significant association with perception at the 5 % level ($X^2 = 5.54$; C = 0.25). This indicates that age influences farmers' outlook, with younger farmers generally being more receptive to new technologies, while older farmers tend to adhere to conventional practices, thereby reflecting contrasting perceptions. Education also recorded a significant association at the 5 % level ($X^2 = 5.50$; C = 0.25). Educated farmers are better informed about innovations and government schemes, leading to more positive perceptions. Family size exhibited a strong and significant association at the 1 % level ($X^2 = 8.63$; C = 0.31). Larger family sizes often provide more agricultural labour, which may positively influence perceptions by easing farm operations. Conversely, smaller families may struggle with labour availability, shaping different perceptions towards the crop. On the other hand, variables such as farming experience, annual income, achievement motivation, risk orientation, extension participation, mass media exposure and market accessibility were found to be non-significant. This suggests that these factors did not have a statistically meaningful relationship with perception in the study area, though they may still play indirect roles in shaping farmers' attitudes. For instance, while mass media exposure and market access provide valuable information and opportunities, their statistical association was not strong enough to establish a significant linkage with perception.

Overall, the analysis shows that age, education and family size are the most influential profile characteristics shaping farmers' perceptions of rice cultivation. These findings emphasise the importance of designing capacity-building and extension programs that specifically target older farmers, less educated groups and families with limited labour availability to improve their perceptions and adoption of improved practices. Similar results have been observed in studies (45).

Perception of farmers toward groundnut cultivation

Ecological condition

The perceptions of groundnut farmers towards ecological conditions are presented in Table 20. The findings reveal that

Table 20. Perceptions of the groundnut farmers towards the ecological condition

Condition	Most suitable (%)	Suitable (%)	Not suitable (%)	Mean score	Gap (%)
Soil	50.0	30.0	20.0	2.3	23.3
Climate	45.0	37.5	17.5	2.3	24.2
Temperature	65.0	25.0	10.0	2.6	15.0
Rainfall	35.0	40.0	25.0	2.1	30.0

ecological factors such as soil, climate, temperature and rainfall significantly influence farmers' evaluation of the suitability of groundnut cultivation. Similar results have been observed in studies (46, 47).

Soil conditions were perceived as favourable, with 50.0 % of farmers considering them most suitable and 30.0 % suitable. However, a proportion of farmers found soils less suitable, mainly due to localised problems such as poor drainage, low fertility, or limited water-holding capacity. These constraints, combined with erratic rainfall and inadequate irrigation support, reduced their confidence in soil suitability for reliable production. The mean score of 2.3 and a gap of 23.3 % indicate that the soil types available in the study area support groundnut cultivation, though some farmers still face challenges due to soil fertility variations or limited organic matter content. Climate was also rated positively, as 45.0 % of respondents found it most suitable and 37.5 % suitable, with only 17.5 % rating it not suitable. The mean score of 2.3 and a gap of 24.2 % suggest that the prevailing climatic conditions are generally conducive to groundnut production. However, occasional climatic fluctuations such as high humidity or unexpected dry spells may reduce farmers' confidence in climate suitability. Temperature emerged as the most favourable ecological factor, with 65.0 % of respondents considering it most suitable and only 10.0 % finding it unsuitable. The highest mean score of 2.6 and the lowest gap (15.0 %) reflect that the crops' requirement for warm and moderately dry conditions is well met in the region. This alignment with the crops' physiological needs contributes to better growth and yield potential. In contrast, rainfall was identified as the weakest ecological factor. Only 35.0 % of farmers considered it most suitable, while 25.0 % found it not suitable. The lowest mean score (2.1) and the highest gap (30.0 %) highlight rainfall variability as a critical concern. Irregular distribution, untimely rains, or prolonged dry spells adversely affect crop establishment and pod development, making rainfall a major limiting factor in groundnut cultivation.

Overall, the results suggest that while soil, climate and temperature conditions are largely favourable for groundnut cultivation, rainfall variability poses significant challenges. Addressing this through supplementary irrigation facilities, watershed management and promotion of drought-tolerant groundnut varieties could enhance ecological suitability and stabilise yields.

Input supply

The perceptions of groundnut growers regarding the supply of inputs are presented in Table 21. The findings reveal variations in the accessibility of critical resources required for effective cultivation. Fertiliser emerged as the most easily available input, with 56.25 % of farmers reporting it as easily accessible and a mean score of 2.39, accompanied by the lowest gap percentage (20.42 %). This indicates that fertiliser distribution mechanisms are relatively effective, ensuring that the nutrient requirements of the crop are largely met. In contrast, irrigation was perceived as the least available input. Only

Table 21. Perceptions of the groundnut growers on the supply of inputs

Inputs	Easily available (%)	Available (%)	Not available (%)	Mean score	Gap (%)
Suitable variety	40.00	30.00	30.00	2.10	30.00
Quality seed	38.75	30.00	31.25	2.08	30.83
Fertilizer	56.25	26.25	17.50	2.39	20.42
Plant protection chemicals	41.25	28.75	30.00	2.11	29.58
Irrigation	28.75	23.75	47.50	1.81	39.58
Labour force	45.00	30.00	25.00	2.20	26.67
Credit facility	35.00	28.75	36.25	1.99	33.75

28.75 % of respondents reported it as easily accessible, while a significant 47.50 % found it not available. The mean score of 1.81 and the highest gap percentage (39.58 %) highlight irrigation as a major constraint, particularly in rainfed areas, limiting crop growth and productivity. Other inputs, such as suitable varieties, quality seed and plant protection chemicals, showed moderate availability, with mean scores ranging between 2.08 and 2.11 and gap percentages of 29-31 %. Approximately one-third of the farmers reported these inputs as not available, indicating uneven access that may hinder the adoption of improved cultivars and pest management practices. The labour force was relatively better available, with 45.00 % of farmers considering it easily accessible and a mean score of 2.20, reflecting adequate human resources for timely farm operations. The credit facility was moderately constrained, with only 35.00 % of farmers reporting it as easily accessible and a mean score of 1.99. The gap percentage of 33.75 % suggests that limited financial support may restrict farmers' ability to purchase inputs and invest in improved cultivation practices.

Overall, the results indicate that while fertiliser and labor availability are satisfactory, constraints in irrigation, quality seeds, suitable varieties, plant protection chemicals and credit facilities pose significant challenges for groundnut cultivation. Strengthening input supply chains, promoting micro-irrigation, ensuring access to quality seeds and expanding rural credit services are essential for enhancing productivity and adoption of improved cultivation practices. Similar results have been observed in studies (48, 49).

Advisory services

The perceptions of groundnut growers regarding advisory services are presented in Table 22. The findings reveal that access to extension support and technical guidance is limited, which may constrain the adoption of improved cultivation practices. Training was reported as the least accessible service, with only 11.25 % of farmers considering it easily available, while a substantial 41.25 % reported it as not available. The mean score of 1.95 and a high gap percentage (51.25 %) indicate inadequate training opportunities, which limit farmers' knowledge and capacity to implement scientific practices. Demonstration and exposure visits showed moderate availability. About 21.25 % of respondents reported demonstrations as easily available, with a mean score of 2.30 and a gap of 42.50 %. Exposure visits were easily available to 16.25 % of farmers, with a mean score of 2.14 and a gap of 46.56 %. These results suggest that while practical learning opportunities exist, their coverage is irregular and insufficient for most farmers. Literature supply was comparatively more accessible, with 26.25 % of respondents reporting it as easily available and a mean score of 2.51, accompanied by the lowest gap (37.19 %) among advisory services. This indicates that informational materials, such as pamphlets and guides, reach a portion of the farming community, though their effectiveness may be limited by literacy levels and preference for interactive learning methods. Timely guidance had a mean score of 2.16, with 16.25 % of farmers reporting easy availability and a gap of 45.94 %. This indicates that real-time support to address pest outbreaks, nutrient deficiencies, or weather-related challenges is not consistently accessible to farmers. Close monitoring was the most deficient service, with only 8.75 % of respondents reporting it as easily available, a mean score of 1.70 and the highest gap percentage (57.50 %). The lack of regular field-level supervision limits problem-solving and adaptive management, which is critical for improving productivity and reducing risks.

Overall, the findings indicate that advisory services for groundnut cultivation are inadequately delivered. While literature supply and demonstrations are somewhat accessible, key services like training, timely guidance and close monitoring remain largely unavailable. Strengthening extension networks, organising regular farmer field schools, facilitating exposure visits and enhancing field-level monitoring are essential strategies to improve advisory support and adoption of improved groundnut cultivation practices. Similar results have been observed in studies (50, 51).

Government policy system

The perceptions of rice growers towards the government policy system are summarised in Table 23. The findings indicate that farmers experience substantial gaps in policy support, which affects their adoption of improved practices and overall confidence in rice cultivation. Incentives were reported as largely unavailable, with 62.50 % of respondents indicating non-availability. The mean score of 1.49 and a high gap percentage of 50.42 % suggest that schemes aimed at motivating farmers, such as input subsidies or performance-based incentives, have limited reach and are not effectively perceived by the majority of growers. Crop insurance also showed inadequate accessibility. While 16.25 % of respondents reported availability and 22.50 % occasional access, 61.25 % perceived it as not available. The mean score of 1.55 and gap of 48.33 % indicate that farmers remain largely exposed to production and market risks due to poor coverage of insurance schemes such as the PMFBY. Subsidy schemes were perceived as slightly better, with 18.75 % of farmers reporting availability and 23.75 % occasional access. Despite this, 57.50 % considered subsidies unavailable. The mean score of 1.61 and gap of 46.25 % reflect that although subsidies on fertilisers, seeds and equipment exist, their timely

Table 22. Perceptions of the groundnut towards advisory services

Advisory service	Easily available (%)	Available (%)	Occasionally (%)	Not available (%)	Mean score	Gap (%)
Training	11.25	13.75	33.75	41.25	1.95	51.25
Demonstration	21.25	18.75	28.75	31.25	2.30	42.50
Exposure visit	16.25	18.75	27.50	37.50	2.14	46.56
Literature supply	26.25	23.75	25.00	25.00	2.51	37.19
Timely guidance	16.25	20.00	27.50	36.25	2.16	45.94
Close monitoring	8.75	11.25	21.25	58.75	1.70	57.50

Table 23. Perceptions of the groundnut growers towards the government policy system

Policy system	Available (%)	Occasionally available (%)	Not available (%)	Mean score	Gap (%)
Incentives	11.25	26.25	62.50	1.49	50.42
Crop insurance	16.25	22.50	61.25	1.55	48.33
Subsidy	18.75	23.75	57.50	1.61	46.25
Procurement	26.25	27.50	46.25	1.80	40.00
Remunerative price	0.00	0.00	100.00	1.00	66.67

delivery and equitable distribution remain inconsistent. Procurement facilities were accessible to 26.25 % of respondents, with 27.50 % reporting occasional availability and 46.25 % perceiving them as not available. The mean score of 1.80 and gap of 40.00 % suggest that while procurement mechanisms such as the Food Corporation of India (FCI) offer some support, coverage is limited, leaving a significant proportion of farmers without guaranteed market outlets. The most critical issue identified was remunerative price, with 100 % of respondents reporting non-availability. This resulted in the lowest mean score (1.00) and the highest gap (66.67 %), highlighting a severe policy deficit. The absence of assured minimum support prices (MSP) or fair market pricing undermines farmers' incentives to produce and invest in rice cultivation, leaving them vulnerable to market fluctuations.

Overall, the results indicate that government policy support for rice cultivation is perceived as inadequate, particularly in areas of incentives, crop insurance and remunerative pricing. While subsidies and procurement provide partial relief, significant gaps remain. Strengthening policy mechanisms through timely and equitable delivery of incentives, expanding insurance coverage, ensuring effective procurement and guaranteeing fair pricing could enhance farmers' confidence and promote sustainable rice production. Similar results have been observed in studies (48, 50).

Comparative dimensions

The comparative analysis of different dimensions of perception among farmers across rice, green gram and groundnut cultivation is presented in Table 24. The findings reveal a clear pattern in farmers' evaluation of ecological, input, advisory and policy support, highlighting areas of strength and critical gaps. Ecological condition received the highest mean score (2.31) with the lowest gap percentage (23.13 %), indicating that farmers generally perceive the natural conditions, such as soil, climate, temperature and rainfall, to be moderately favourable for crop cultivation. This suggests that ecological factors provide a strong foundation for farming operations across the three crops, though rainfall variability and micro-climatic fluctuations remain limiting factors in some areas. Input supply recorded a moderate mean score (2.10) and a gap of 30.12 %, reflecting partial accessibility to essential agricultural inputs. While fertilisers and some varieties are relatively available, constraints in quality seed, irrigation, plant protection chemicals and credit facilities continue to challenge farmers' ability to adopt improved practices efficiently. Advisory service was perceived as insufficient, with a mean score of 2.13 and a significantly higher gap (46.82 %). Services such as training, demonstrations, exposure visits, timely guidance and close monitoring were reported to be inconsistently available across crops. The high gap emphasises that extension support and technical guidance remain critical bottlenecks in enhancing farmers' knowledge, adoption of innovations and crop management efficiency. Government policy received the lowest mean score (1.49) and the highest gap (50.33 %), indicating that farmers perceive policy support comprising incentives, crop insurance, subsidies, procurement and remunerative prices as largely inadequate. The lack of assured markets and fair pricing mechanisms, coupled with limited coverage of insurance and incentive programs, undermines farmers' confidence and reduces their motivation to invest in improved practices.

Table 24. Comparative analysis of different dimensions of perceptions

Condition	Mean score	Gap (%)
Ecological condition	2.31	23.13
Input supply	2.10	30.12
Advisory service	2.13	46.82
Government policy	1.49	50.33

Overall, the comparative analysis shows a descending trend in perception from ecological conditions to policy support, with ecological factors being the most favourable and government policy being the most deficient. The findings highlight the urgent need for targeted interventions to improve input availability, strengthen extension services and reform policy mechanisms. By addressing these institutional and infrastructural gaps, farmers' overall perception can be enhanced, promoting the adoption of improved technologies and sustainable crop production across rice, green gram and groundnut. Similar results have been observed in studies (46, 47).

Overall perception levels

The overall levels of perception of farmers towards hybrid rice cultivation are presented in Table 25. The findings reveal that perceptions are distributed across low, medium and high categories, reflecting variations in awareness, knowledge and acceptance of hybrid rice technologies.

A majority of farmers (42.50 %) were classified under the medium perception category, with a mean score of 2.00 and a standard deviation of 0.36. This suggests that while most farmers have a moderate understanding of hybrid rice cultivation, including its ecological requirements, input management and market potential, there remain knowledge gaps that limit full adoption of modern practices. The low perception category included 36.25 % of farmers (< 1.65), indicating that over one-third of respondents have limited awareness or access to information on hybrid rice. This group may face constraints such as traditional farming practices, low educational levels, limited extension contact, or poor access to inputs and markets, which reduce their capacity to adopt hybrid rice cultivation. Only 21.25 % of farmers exhibited a high perception (> 2.36), indicating that a small fraction of the community is well-informed, highly motivated and more likely to adopt improved hybrid rice technologies. Farmers in this category are often better educated, have higher exposure to mass media, participate in extension programs and enjoy better market accessibility, as evidenced in earlier profile analyses.

Overall, the results highlight that while a significant proportion of farmers hold a moderate perception of hybrid rice cultivation, considerable efforts are required to raise awareness and understanding among the low-perception group. Enhancing training programs, providing timely advisory services, improving input availability and facilitating market access are essential

Table 25. Overall levels of perception towards hybrid rice cultivation

Category	Criteria	Farmers (No.)	Farmers (%)	Mean	SD
Low	< 1.65	29	36.25		
Medium	1.65 - 2.36	34	42.50	2.00	0.36
High	> 2.36	17	21.25		

strategies to improve farmers' perceptions and encourage wider adoption of hybrid rice technologies. Similar results have been observed in studies (48-50).

Socio-economic profile of the farmers

The profile characteristics of groundnut farmers are presented in Table 26. The analysis provides insights into the socio-economic, psychological and institutional attributes of the respondents, which play a crucial role in shaping their perception, decision-making and adoption of improved groundnut cultivation practices (47, 48). Age distribution shows that most farmers (48.75 %) belong to the middle -aged group (35-50 years), followed by 37.50 % in the old-age group (> 50 years) and only 13.75 % in the young category (< 35 years). This indicates that groundnut cultivation is primarily dominated by experienced middle-aged and older farmers, reflecting a reliance on traditional farming practices with limited youth involvement. Education levels reveal that nearly half of the respondents (45.00 %) possess medium education (2.54-4.87), while 23.75 % are in the low education category and 31.25 % have high education. The presence of a considerable proportion of educated farmers suggests potential for understanding and adopting improved cultivation techniques, though gaps remain for less educated groups. Family size analysis indicates that medium-sized families (4-6 members) constitute the largest proportion (42.50 %), followed by small families (36.25 %) and large families (21.25 %). Medium family sizes provide adequate labour for farm operations, whereas smaller families may face labour shortages, impacting timely crop management. Farming experience shows that nearly half of the respondents (48.75 %) have moderate experience (11-20 years), while 40.00 % have high experience (> 20 years). Only 11.25 % are less experienced (< 11 years). This suggests that most farmers have significant exposure to agricultural practices, which can facilitate decision-making but may also result in adherence to conventional methods over innovation. Regarding annual income, the majority (63.75 %) fall in the medium-income range (₹93247-256442), with 26.25 % in high-income and 10.00 % in low-income groups. This indicates that most groundnut farmers are small-to-medium income earners, which may influence their ability to invest in improved inputs and technologies. Achievement motivation was distributed with 46.25 % at medium, 40.00 % at high and 13.75 % at low levels. This reflects that most farmers are motivated to improve farm productivity and adopt innovations, although a small segment lacks the drive to enhance performance. Risk orientation was balanced, with 40.00 % at medium, 37.50 % at high and 22.50 % at low levels. This indicates that a significant proportion of farmers are willing to take calculated risks, which is important for experimenting with new varieties and technologies. Extension participation shows that nearly half (47.50 %) of the farmers had high participation, while 37.50 % had medium and 15.00 % low participation. This reflects relatively strong engagement with extension services, which can positively influence the adoption of improved practices. Mass media exposure was high for 51.25 % of respondents, medium for 38.75 % and low for 10.00 %, suggesting that most farmers have good access to information through newspapers, radio, television and digital platforms, enhancing their knowledge and decision-making capacity. Market accessibility indicates that 45.00 % of farmers had medium access, 42.50 % high and 12.50 % low. This reflects that most respondents have reasonable access to markets, which can influence input procurement, the sale of produce and the perception of profitability.

Overall, the profile analysis indicates that groundnut farmers are predominantly middle-aged, moderately educated, medium- to high-experienced and medium-income earners, with substantial

Table 26. Profile characteristics of the groundnut farmers

Variables	Category	Criteria	Respondents (number)	Respondents (%)
Age	Young	< 35 years	11	13.75
	Middle	35-50 years	39	48.75
	Old	> 50 years	30	37.50
Education	Low	< 2.54	19	23.75
	Medium	2.54 - 4.87	36	45.00
	High	> 4.87	25	31.25
Family size	Small	< 4	29	36.25
	Medium	4 - 6	34	42.50
	Large	> 6	17	21.25
Farming experience	Less	< 11 years	9	11.25
	Moderate	11 - 20 years	39	48.75
	High	> 20 years	32	40.00
Annual income	Low	< ₹ 93,247	8	10.00
	Medium	₹ 93,247 - 2,56,442	51	63.75
	High	> ₹ 2,56,442	21	26.25
Achievement motivation	Low	< 16.24	11	13.75
	Medium	16.24 - 24.47	37	46.25
	High	> 24.47	32	40.00
Risk orientation	Low	< 4.11	18	22.50
	Medium	13.21 - 15.22	32	40.00
	High	> 15.22	30	37.50
Extension participation	Low	< 4.89	12	15.00
	Medium	4.11 - 7.44	30	37.50
	High	> 7.44	38	47.50
Mass media exposure	Low	< 7.19	8	10.00
	Medium	4.89 - 7.19	31	38.75
	High	> 7.19	41	51.25
Market accessibility	Low	< 35.67	10	12.50
	Medium	35.67 - 48.57	36	45.00
	High	> 48.57	34	42.50

achievement motivation, risk-taking ability, extension participation and mass media exposure. These characteristics suggest that while the majority of farmers have the capacity to adopt improved cultivation practices, targeted interventions in training, market support and financial access are necessary to further enhance productivity and perception of groundnut farming.

Relation between the profile characteristics of farmers and their perception towards groundnut cultivation

The association between profile characteristics of groundnut farmers and their perception towards groundnut cultivation is presented in Table 27. The Chi-square analysis revealed that age, education, family size, farming experience, annual income, achievement motivation, mass media exposure and market accessibility had significant associations with farmers' perception. In contrast, risk orientation and extension participation showed non-significant effects.

Age exhibited a significant association at the 1 % level (X^2 = 17.43; C = 0.42), indicating that perception varies with age. Middle-aged and older farmers, due to their long-standing experience and familiarity with traditional methods, may exhibit cautious adoption of innovations, whereas younger farmers tend to be more receptive to improved cultivation practices. Family size was strongly associated with perception at the 5 % level (X^2 = 6.03; C = 0.26). This suggests that households with medium to large family sizes, by virtue of greater labour availability and risk-sharing capacity, are more likely to develop favourable perceptions, which in turn strengthen their readiness to adopt improved practices. Larger families provide adequate labour for timely farm operations, enhancing exposure to modern practices and positively influencing perception. Smaller families, in contrast, may face labour shortages, affecting adoption and outlook.

Farming experience showed a significant association at the 1 % level (X^2 = 23.53; C = 0.47). Farmers with longer experience possess greater familiarity with cropping patterns, soil and climatic conditions and input management, which strengthens their perception of improved techniques. Annual income was highly significant at the 1 % level (X^2 = 26.83; C = 0.50), reflecting that financially better-off farmers have greater access to inputs, technology and markets, which enhances their perception towards groundnut cultivation. Achievement motivation also exhibited a significant relationship (X^2 = 13.23; C = 0.38), suggesting that motivated farmers are more proactive in acquiring knowledge, experimenting with innovations and implementing best practices, thereby improving perception. Extension participation (X^2 = 9.53; C = 0.33) and mass media exposure (X^2 = 16.73; C = 0.41) were significant.

Table 27. Association between profile characteristics of the groundnut farmers and their perception

Profile characteristics	Contingency coefficient	Chi-square value
Age	0.42	17.43*
Education	0.22	4.03NS
Family size	0.26	6.03**
Farming experience	0.47	23.53*
Annual income	0.5	26.83*
Achievement motivation	0.38	13.23*
Risk orientation	0.16	2.2NS
Extension participation	0.33	9.53*
Mass media exposure	0.41	16.73*
Market accessibility	0.38	13.33*

**Significant at 5 % level, * Significant at 1 % level and NS = Non-Significant.

This suggests that farmers who actively engage in training programs, demonstrations and both formal and informal information networks are better informed about crop management practices and technologies. As a result, they tend to have higher perception levels. Market accessibility was also significantly associated (X^2 = 13.33; C = 0.38), demonstrating that farmers with better access to markets are more aware of pricing trends, demand patterns and procurement facilities, which positively influences their perception of crop viability and profitability. In contrast, education (X^2 = 4.03; C = 0.22) and risk orientation (X^2 = 2.2; C = 0.16) were found to be non-significant, indicating that formal education and individual risk-taking tendencies did not have a statistically meaningful effect on farmers' perception in the study area. This suggests that practical experience, access to information and economic capacity may outweigh formal education and risk preference in shaping perception.

Overall, the analysis indicates that age, family size, farming experience, income, achievement motivation, extension participation, mass media exposure and market accessibility are key determinants of farmers' perception towards groundnut cultivation. These findings underscore the importance of targeted interventions that enhance extension services, improve market access and motivate farmers to adopt improved cultivation practices, particularly for groups with lower perception levels. Similar results have been observed in studies (49, 51).

Conclusion

The study revealed that while ecological conditions and input availability for rice, green gram and groundnut in Odisha are generally favourable, critical gaps persist. These gaps are particularly evident in irrigation, credit access, advisory services and policy support. Most farmers exhibited medium perception levels, highlighting untapped potential for improving adoption of recommended practices. Strengthening extension services, enhancing credit and irrigation infrastructure and ensuring timely procurement and price incentives are essential to bridge these gaps. Addressing these constraints can significantly boost productivity, farmer confidence and the overall sustainability of rice, pulse and oilseed production systems in eastern India.

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Authors' contributions

PPT conceptualized the research and designed the methodology. SNM contributed to refining the methodology and validating the data. PBB, RKR, SM assisted in data collection, validation and manuscript refinement. PBB contributed to the methodology,

statistical analysis and interpretation of results. CN participated in data validation and manuscript improvement. SKD assisted in methodology development and result verification. AKG performed statistical analysis and contributed to visualization. SD assisted in the interpretation of findings and preparation of figures. RKR drafted sections of the manuscript and contributed to discussion development. SM revised and refined the manuscript for clarity and coherence. JA coordinated the study and provided overall supervision. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

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