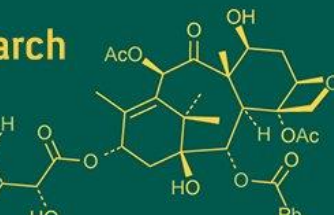
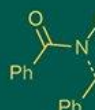


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## Farmers' perception and buying behaviour of bio-fungicides in Aravalli district of Gujarat

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### Abstract

The growing emphasis on sustainable agriculture has increased interest in bio-fungicides as an environmentally friendly alternative to chemical fungicides. The present study was conducted to examine farmers' perceptions, buying behaviour, and challenges associated with the adoption of bio-fungicides in Aravalli district. A descriptive research design was adopted, and primary data were collected from 120 farmers across 12 villages through structured interviews. The data were analyzed using descriptive statistics, Weighted Average Mean (WAM), and Garrett's Ranking Technique. The results indicated that the majority of respondents belonged to the middle age group (36-50 years) and had completed higher secondary education. Farmers perceived bio-fungicides as environmentally safe, which received the highest perception score (WAM = 4.65), whereas confidence in their effectiveness for disease management was comparatively lower (WAM = 3.43). Company representatives and agro-input dealers emerged as the primary sources of awareness. Product performance, previous experience, and dealer recommendations were identified as the most influential factors affecting purchase decisions. Garrett's Ranking Technique revealed that inconsistent field performance, slow visible results compared to chemical fungicides, and lack of awareness were the major constraints limiting adoption. The study concludes that the adoption of bio-fungicides in Aravalli district is gradually increasing; however, wider acceptance requires strengthened extension efforts through field demonstrations, improved technical guidance, enhanced distribution networks, and appropriate pricing strategies to promote sustainable crop protection practices.

**Keywords:** Bio-fungicides, farmer perception, buying behaviour, adoption constraints, Garrett's ranking technique, Aravalli district

### 1. Introduction

Agriculture is the backbone of the Indian economy, serving as the principal source of livelihood for approximately 54.6% of the country's total workforce and contributing nearly 18.8% to the Gross Value Added (GVA) of the national economy (Government of India, Ministry of Agriculture & Farmers' Welfare, 2023) [6]. India is the world's largest producer of pulses, jute and spices, and the second-largest producer of wheat, rice, cotton, sugarcane, groundnut, vegetables and fruits.

Fungal pathogens represent one of the most economically significant biotic stresses in global agriculture, with plant diseases causing collective losses of 20-40% of global crop production annually (Savary *et al.*, 2019) [19]. In India, diseases such as Fusarium wilt, Alternaria blight, Cercospora leaf spot, Phytophthora late blight and soil-borne pathogens including Rhizoctonia solani and Sclerotium rolfsii cause enormous economic damage every year, creating an urgent need for effective and sustainable disease management solutions.

Bio-fungicides are naturally derived biological crop protection agents containing beneficial microorganisms such as Trichoderma spp., Bacillus subtilis and Pseudomonas fluorescens, which suppress fungal pathogens through antibiosis, mycoparasitism, nutrient competition and induction of systemic resistance (Kohl *et al.*, 2019) [10]. The global bio-fungicides market is projected to grow from USD 3.18 billion in 2025 to USD 5.84 billion by 2031 at a CAGR of 10.66% (Mordor Intelligence, 2025) [13], while India recorded a CAGR of 16.6% from 2020 to 2024, reflecting strong demand for sustainable farming alternatives.

Aravalli district of Gujarat was selected as the study area, where farmers cultivate diverse kharif crops (groundnut, maize, cotton), rabi crops (potato, wheat, chickpea) and vegetable crops (tomato, chilli, capsicum).

The warm humid conditions during the kharif season create near-ideal conditions for the spread of fungal pathogens, making disease management a critical priority for farming families in this region.

The study aimed to examine farmers' socio-economic profile and perception of bio-fungicides, understand their buying behaviour, and identify key barriers to bio-fungicide adoption in the Aravalli district.

### 1.1 Objectives of the Study

- To study the socio-economic profile of farmers
- To study the perception of farmers towards bio-fungicides
- To study the buying behaviour of farmers towards bio-fungicides
- To identify problems faced by farmers in the adoption of bio-fungicides

## 2. Materials and Methodology

The study was undertaken to examine farmers' perception and buying behaviour towards bio-fungicides in Aravalli district of Gujarat, and was based on both primary and secondary data collected through a descriptive research design.

### 2.1 Research Design

The study employed a descriptive research design to examine farmers' perceptions, buying behaviour, and challenges associated with the adoption of bio-fungicides in Aravalli district of Gujarat. A non-probability sampling approach was adopted, and respondents were selected using the purposive sampling technique. The sample comprised 120 farmers drawn from selected villages of Aravalli district. Primary data were collected through personal interviews using a structured schedule. The collected data were analyzed using descriptive statistical tools, Weighted Average Mean (WAM) for assessing perception and buying behaviour factors, and Garrett's Ranking Technique for identifying and prioritizing the constraints faced by farmers in the adoption of bio-fungicides.

### 2.2 Study Area and Sample Selection

Aravalli district of Gujarat was selected purposively based on the company's recommendation and the extent of agricultural activities in the region. From the district, 4 talukas — Modasa, Bhiloda, Meghraj and Shamlaji — were selected purposively. A total of 12 villages were selected across these talukas and 10 farmers were interviewed from each village, yielding a total sample size of 120 farmers.

### 2.3 Weighted Average Mean

The Weighted Average Mean method was used to analyze the Likert scale. After gathering all the completed schedules from the respondents, total responses for each item were gathered and tabulated. To use the Likert scale for interpretation, a weighted mean to represent each question was computed. To compute the weighted mean, each value was multiplied by its weight. Products were added to obtain the total value. The total weight was computed by adding all the weights. The total value was divided by the total weight. Statistically, the weighted mean was calculated using the formula below:

$$\text{Weighted Average Mean (X)} = \frac{(F1X1 + F2X2 + F3X3 + F4X4 + F5X5)}{Xt}$$

Where,

F = Weight given to each response

X = Number of responses

Xt = Total number of responses

### 2.4 Garrette's ranking technique

Garrett's Ranking Technique was employed to analyze the problems faced by farmers in the adoption of bio-fungicides. The percent position was calculated using the formula:

$$\text{Percent Position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where:

R<sub>ij</sub> = Rank given for the i<sup>th</sup> constraint by the j<sup>th</sup> respondent

N<sub>j</sub> = Number of constraints ranked by the j<sup>th</sup> respondent

Based on Garrett's table, scores will be assigned and mean scores was calculated to rank the constraints.

## 3. Results and Discussion

### 3.1 Socio-economic profile of farmer's

**Table 1:** Socio-economic profile of farmer

| S. No. | Particular                 | Respondents | Percentage |
|--------|----------------------------|-------------|------------|
| 1      | Age Group                  |             |            |
|        | Less than 35 (Young)       | 26          | 21.66      |
|        | 36-50 (Middle)             | 74          | 61.67      |
|        | 51 and above (Old)         | 20          | 16.67      |
|        | Total                      | 120         | 100.00     |
| 2      | Education Qualification    |             |            |
|        | Primary School             | 8           | 6.67       |
|        | Secondary School           | 28          | 23.33      |
|        | Higher Secondary           | 58          | 48.33      |
|        | Graduate                   | 24          | 20.00      |
|        | Post Graduate and above    | 2           | 1.67       |
|        | Total                      | 120         | 100.00     |
| 3      | Occupation of farmers      |             |            |
|        | Farming                    | 32          | 26.67      |
|        | Farming + Animal Husbandry | 63          | 52.50      |
|        | Farming + Business         | 15          | 12.50      |
|        | Farming + Service          | 10          | 8.33       |
|        | Total                      | 120         | 100.00     |
| 4      | Total Land Holding         |             |            |
|        | Marginal (<1 ha)           | 4           | 3.33       |
|        | Small (1-2 ha)             | 19          | 15.83      |
|        | Semi-Medium (2-4 ha)       | 37          | 30.83      |
|        | Medium (4-10 ha)           | 48          | 40         |
|        | Large(>10 ha)              | 12          | 10         |
|        | Total                      | 120         | 100.00     |

The socio-economic profile of the 120 surveyed farmers indicated that the majority (61.67%) belonged to the middle age group (36-50 years), followed by those below 35 years (21.66%) and above 50 years (16.67%). All respondents were male, highlighting the predominance of men in agricultural input purchase decisions within the study area. In terms of education, 48.33% of farmers had completed higher secondary education, followed by secondary education (23.33%), graduation (20.00%), primary education (6.67%), and post-graduation (1.67%). The absence of illiterate respondents reflects a relatively educated farming community. Regarding occupation, more than half of the respondents (52.50%) combined farming with animal husbandry, while 26.67% depended solely on farming. Landholding analysis revealed that medium-sized

farms (4-10 ha) constituted the largest category (40.00%), followed by semi-medium farms (2-4 ha) at 30.83%, indicating relatively better resource availability among farmers. Cropping pattern analysis showed that all respondents cultivated cereals/pulses and vegetables. Groundnut was universally grown during the kharif season, while potato (86.67%) and wheat (80.83%) were the dominant rabi crops. In the summer season, watermelon emerged as the most widely cultivated crop (21.67%). The diversified cropping pattern and cultivation of high-value

crops emphasize the importance of effective disease management practices and the potential role of bio-fungicides in sustainable crop protection.

### 3.2 Perception of Farmers towards Bio-Fungicides

Farmer perceptions towards bio-fungicides were assessed using six statements on a five-point Likert scale. The Weighted Average Mean (WAM) scores and rankings are presented in Table 2.

**Table 2:** Perception of Farmers towards Bio-Fungicides (N = 120)

| Rank | Statement                                               | WAM Score | Rank |
|------|---------------------------------------------------------|-----------|------|
| 1    | Bio-fungicides are environmentally safe                 | 4.65      | I    |
| 2    | Bio-fungicides are safer than chemical fungicides       | 4.37      | II   |
| 3    | Bio-fungicides improve soil health                      | 4.22      | III  |
| 4    | Bio-fungicides are suitable for sustainable agriculture | 3.94      | IV   |
| 5    | Bio-fungicides reduce dependence on chemical fungicides | 3.76      | V    |
| 6    | Bio-fungicides effectively manage crop diseases         | 3.43      | VI   |

The Weighted Average Mean (WAM) analysis revealed that farmers strongly perceived bio-fungicides as environmentally safe (WAM = 4.65), which emerged as the highest-ranked attribute. This was followed by the perception that bio-fungicides are safer than chemical fungicides (WAM = 4.37) and improve soil health (WAM = 4.22), indicating a favourable attitude toward their environmental, health, and sustainability benefits. Moderate-to-high agreement was observed for the statements that bio-fungicides are suitable for sustainable agriculture (WAM = 3.94) and reduce dependence on chemical fungicides (WAM = 3.76). However, the statement “Bio-fungicides effectively manage crop diseases” received the lowest score (WAM = 3.43), suggesting relatively lower confidence in their disease-control efficacy. This perception gap may act as a significant barrier to adoption, as farmers are often reluctant to substitute chemical fungicides without assurance of comparable effectiveness. These findings are consistent with the studies of Savaliya *et al.* (2023) <sup>[18]</sup> and Desai *et al.* (2024) <sup>[4]</sup>, which reported that perceived effectiveness is a critical factor influencing farmers’ trust and adoption of biological crop protection products.

### 3.3 Buying Behaviour of Farmers towards Bio-Fungicides

#### 3.3.1 Source of Awareness

The analysis of awareness sources (Table 3) showed that company representatives were the most important source of information about bio-fungicides, with 97 farmers (80.83%) citing them. Agro-input dealers were the second major source (83 farmers; 69.16%), followed by fellow farmers (56 farmers; 46.67%). Formal extension officers and demonstration or training programs were cited by only 12.50% and 17.50% of farmers respectively, indicating the limited reach of government extension systems in creating bio-fungicide awareness in the study area

**Table 3:** Sources of Awareness about Bio-Fungicides (N = 120, Multiple Response)

| Source of Awareness    | No. of Farmers | Percentage |
|------------------------|----------------|------------|
| Company Representative | 97             | 80.83      |
| Agro-input Dealer      | 83             | 69.16      |
| Fellow Farmers         | 56             | 46.67      |
| Demonstration/Training | 21             | 17.50      |
| Extension Officer      | 15             | 12.50      |

#### 3.3.2 Years of Usage, Purchase Frequency, Place and Mode of Payment

The usage pattern data (Table 4) indicated that 60.00% of farmers had been using bio-fungicides for 1-3 years, while 21.66% had used them for less than one year and 18.33% for more than three years. This recency of adoption suggests that bio-fungicide uptake in the study area is a relatively new but expanding phenomenon, with significant potential for further growth.

With respect to purchase frequency, 53.33% of farmers purchased bio-fungicides every season, reflecting habitual and need-driven usage. Another 31.67% purchased as per disease incidence, indicating reactive buying behaviour. All 120 farmers (100%) procured bio-fungicides exclusively from agro-input dealers; no farmer reported purchasing from company outlets or cooperative societies. This complete dependence on the dealer channel reinforces the pivotal role of agro-input dealers in the bio-fungicide supply chain.

The mode of payment analysis revealed that 53.33% of farmers purchased on credit, 25.00% paid cash and 21.67% used both modes. The strong preference for credit-based transactions underscores the financial constraints faced by farming households and the importance of flexible credit schemes as a market development tool. Among pack sizes, the 1-litre pack was most preferred by 61.67% of farmers, followed by the 5-litre pack (20.83%) and the 500 ml pack (17.50%). No demand was recorded for 100 ml or 200 ml pack sizes, indicating that farmers prefer medium-to-large quantities consistent with the scale of their farm operations.

**Table 4:** Key Buying Behaviour Indicators (N = 120)

| Indicator           | Category                 | Percentage |
|---------------------|--------------------------|------------|
| Years of Usage      | Less than 1 year         | 21.66%     |
|                     | 1-3 years                | 60.00%     |
|                     | More than 3 years        | 18.33%     |
| Purchase Frequency  | Every season             | 53.33%     |
|                     | As per disease incidence | 31.67%     |
|                     | Occasionally             | 15.00%     |
| Place of Purchase   | Agro-input Dealer        | 100%       |
| Mode of Payment     | Credit                   | 53.33%     |
|                     | Cash                     | 25.00%     |
|                     | Both                     | 21.67%     |
| Preferred Pack Size | 1 Litre                  | 61.67%     |
|                     | 5 Litre                  | 20.83%     |
|                     | 500 ml                   | 17.50%     |

### 3.3.3 Factors Influencing Purchase Decisions

The WAM analysis of eight factors influencing purchase decisions (Table 5) revealed that product performance (WAM = 4.35) was the most important determinant of bio-fungicide purchase, closely followed by previous experience

(WAM = 4.19) and dealer recommendation (WAM = 4.03). Ease of application (3.94) and company brand reputation (3.86) ranked fourth and fifth respectively. Credit facility (3.64) and technical guidance (3.42) ranked lower, while availability at shop (WAM = 3.21) was ranked last.

**Table 5:** Factors Influencing Purchase Decisions of Bio-Fungicides (N = 120)

| Rank | Factor                   | WAM Score | Rank |
|------|--------------------------|-----------|------|
| 1    | Product Performance      | 4.35      | I    |
| 2    | Previous Experience      | 4.19      | II   |
| 3    | Dealer Recommendation    | 4.03      | III  |
| 4    | Ease of Application      | 3.94      | IV   |
| 5    | Company Brand Reputation | 3.86      | V    |
| 6    | Credit Facility          | 3.64      | VI   |
| 7    | Technical Guidance       | 3.42      | VII  |
| 8    | Availability at Shop     | 3.21      | VIII |

### 3.4 Problems Faced by Farmers in the Adoption of Bio-Fungicides

Garrett's Ranking Technique was employed to rank the ten

identified problems in bio-fungicide adoption based on responses from all 120 farmers. The results are presented in Table 6.

**Table 6:** Problems Faced by Farmers in Adoption of Bio-Fungicides (N = 120)

| Sr. No. | Problem                                                           | Mean Garrett Score | Rank |
|---------|-------------------------------------------------------------------|--------------------|------|
| 1       | Inconsistent performance of bio-fungicides under field conditions | 77.3               | I    |
| 2       | Slow visible results compared to chemical fungicides              | 70.1               | II   |
| 3       | Lack of awareness about bio-fungicides                            | 67.2               | III  |
| 4       | Lack of technical guidance about bio-fungicides                   | 62.9               | IV   |
| 5       | Incompatibility with chemical fertilizers                         | 58.4               | V    |
| 6       | Limited availability of bio-fungicides at shops                   | 53.4               | VI   |
| 7       | Need for repeated application of bio-fungicides                   | 46.2               | VII  |
| 8       | Short shelf life of bio-fungicides                                | 42.1               | VIII |
| 9       | Storage problems at farm level                                    | 35.9               | IX   |
| 10      | Others                                                            | 32.1               | X    |

The Garrett's Ranking analysis identified inconsistent performance of bio-fungicides under varying field conditions as the most significant problem (Mean Garrett Score = 77.3; Rank I). This finding reflects the well-documented challenge of environmental variability in determining bio-fungicide efficacy, as living microbial cultures are sensitive to temperature, moisture and soil type (Mishra *et al.*, 2020) <sup>[12]</sup>. The second-ranked problem slow visible results compared to chemical fungicides (Score = 70.1; Rank II) is a critical constraint as farmers are conditioned to expect rapid visual responses from crop protection products.

Lack of awareness about bio-fungicides (Score = 67.2; Rank III) and lack of technical guidance (Score = 62.9; Rank IV) were the next most pressing problems, underscoring the need for stronger extension support and farmer training initiatives. Incompatibility with chemical fertilizers ranked fifth (Score = 58.4), which is significant as farmers often apply multiple inputs simultaneously. Limited availability at shops ranked sixth (Score = 53.4), confirming the distribution gap identified in the competitor analysis. The need for repeated application (Score = 46.2; Rank VII), short shelf life (Score = 42.1; Rank VIII) and storage difficulties (Score = 35.9; Rank IX) were also acknowledged but were considered less pressing by farmers.

### 4. Conclusion

The study revealed that the farming community in Aravalli district is predominantly composed of middle-aged males (61.67% in the 36-50 years age group), with a reasonably educated profile 48.33% having completed higher secondary

education and 20% being graduates. The majority of farmers (52.50%) combined farming with animal husbandry as their primary livelihood, and 40% operated medium-sized landholdings of 4-10 hectares. Groundnut was the universally cultivated kharif crop (100%), potato and wheat dominated the rabi season, and watermelon and pearl millet were the major summer crops.

Farmers in Aravalli district hold a broadly positive and favourable perception of bio-fungicides, especially with respect to their environmental safety, human health safety and beneficial impact on soil health. However, their confidence in the disease manage effectiveness of bio-fungicides remains comparatively weaker, highlighting a critical knowledge gap that needs to be addressed through targeted field demonstrations, farmer training programs and result documentation.

Buying behaviour analysis reveals that bio-fungicide adoption in the district is still in a growth phase, with most farmers having fewer than three years of experience with these products. Company representatives and agro-input dealers together drive the overwhelming majority of awareness and adoption, while formal government extension activities have had negligible impact. The complete dependence on agro-input dealers for procurement, combined with a strong preference for credit-based payments, underscores the financial constraints and limited distribution infrastructure that characterise this market.

The problem analysis establishes that performance inconsistency, slow visible results, low awareness, inadequate technical guidance and limited distribution are the five most significant barriers to bio-fungicide adoption.

Addressing these simultaneously, rather than in isolation, is essential for meaningful and sustained expansion of bio-fungicide use in the study area.

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