



Factors Influencing and Problems Faced by Farmers in the Adoption of Biostimulants in Dantiwada Taluka of Banaskantha District, Gujarat

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Agriculture is the backbone of the Indian economy. Approximately 60 to 70 percent of the Indian population is engaged in agriculture, contributing nearly 20 percent to the nation's GDP. Recently, there has been a notable shift in agricultural input practices, with various agencies emphasizing the use of biological alternatives such as biostimulants. This study investigates the factors influencing and the challenges faced by farmers in adopting biostimulants in Dantiwada Taluka of Banaskantha District, Gujarat. Using multi-stage sampling, 200 farmers were selected as respondents. The results revealed that a majority of the farmers (78%) belonged to the 36-50 years age group, and

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nearly 79 per cent had a family size of 3 to 5 members. In terms of education, 27 per cent of the respondents had primary education, 50.5 per cent had completed secondary education (SSC), and 21 per cent had higher secondary education (HSC). Most farmers engaged in farming along with animal husbandry, with a majority earning between ₹1 lakh and ₹5 lakhs annually. The average landholding was between 2 to 5 acres. Regarding crop patterns, groundnut was the dominant crop during the Kharif season (100%), potato was the most cultivated crop in Rabi, followed by wheat, mustard, and amaranth. In the Zayad season, groundnut again led, followed by pearl millet, muskmelon, and watermelon. Survey findings indicated that 82.5 per cent of the farmers were aware of biostimulants, and among them, 86 per cent had used them in their fields. Most users believed that biostimulants enhanced flowering and increased crop yields. Dealer and distributor recommendations were the most influential factor in encouraging farmers to adopt biostimulants. The primary challenges identified were the lack of proper technical knowledge and the delayed visible effects of biostimulants. Despite these challenges, the market potential analysis showed promising opportunities. The projected seasonal market for biostimulants in Dantiwada was valued at approximately ₹5.25 crore, indicating considerable demand.

Keywords: Farming; biostimulants; farmers; awareness; chemical inputs.

1. INTRODUCTION

India experienced a severe food crisis between 1947 and 1960, marked by widespread food shortages, recurring famines, and poor climatic conditions that significantly hampered agricultural production (Nelson et al., 2019). During this time, the per capita availability of food was estimated to be as low as 417 grams per day, which is far below the nutritional requirements for a healthy population (Sharma & Singhvi, 2017). In response to this challenge, transformative measures were sought to combat chronic hunger and poverty.

Globally, agricultural advancements were being made by scientists like Norman Borlaug, whose development of high-yielding, disease-resistant crop varieties led to a revolution in food production (Unger, 2015). Inspired by such innovations, India initiated the Green Revolution in 1966-67 under the leadership of Dr. M. S. Swaminathan (Swaminathan & Kesavan, 2015). This movement introduced scientific farming practices involving high-yielding seeds, chemical fertilizers, pesticides, and improved irrigation systems. By the early 1980s, India achieved self-sufficiency in food grain production and reduced hunger (Verma et al., 2019).

However, the Green Revolution also had unintended consequences. Environmental degradation, deforestation, salinization, biodiversity loss, and pollution became pressing issues. Excessive chemical input use led to declining soil fertility and contamination of water bodies. India emerged as one of Asia's largest pesticide users, which contributed to pesticide residue accumulation in ecosystems (Ameen & Raza, 2017). Despite regulatory efforts, improper

chemical usage in South Asia continues to adversely impact human health and the environment (Gyeltshen, 2021).

Recent studies further indicate that while per capita food availability has increased, undernourishment and related health issues persist. Overreliance on synthetic inputs contributes to non-communicable diseases and ecological imbalance (Deshmukh et al., 2023).

1.1 Need for Bio-Input Products in Agriculture

In light of the adverse consequences of conventional agricultural practices, sustainable approaches are gaining momentum. Today, India produces a diverse array of fertilizers, encompassing both organic and inorganic varieties, each serving a specific purpose in enhancing soil fertility and crop yields (Jaimin & Patel, 2024). One such approach involves the integration of bioproducts into agroecosystems. These include biofertilizers, biopesticides, biostimulants, and other natural farming inputs that can enhance productivity while maintaining ecological balance (Giraldo et al., 2023).

Bio-inputs are derived from biological organisms and are used to improve soil fertility, promote plant growth, and enhance crop health. They serve as effective and environmentally friendly alternatives to chemical inputs, offering farmers a sustainable farming model (Singh & Yadav, 2020).

1.2 Biostimulants

While biopesticides protect against biotic stress (i.e., attack by pests), biostimulants protect the

plant against abiotic stress (*i.e.*, frost, drought, salinity). The effectiveness of these agronomic products can be assessed by, *e.g.*, root mass measurement, the intensity of photosynthesis and the extent of the harvested quantity on experimental plots compared to the control ones and those on which the reference product was used. The effect of biostimulants is very clear when abiotic stress conditions occur. If stress is not present, the differences may not be observed. Biostimulants are thus a means of protection for the plant in the case of abiotic stress (Chojnacka, 2015).

Plant Biostimulants of Microbial Origin: Microbial Plant Biostimulants (PBs) include fungi, bacteria, and Arbuscular Mycorrhizal Fungi (AMF). Through rhizosphere engineering, microbial inoculants like Plant Growth Promoting Rhizobacteria (PGPR) and *Trichoderma* spp. enhance soil fertility and restore microbiomes depleted by crop domestication. Additionally, microbial fermentation now allows large-scale enzyme production for soil application (Papnai et al., 2022). Supply of adequate nitrogen to the soil is necessary for sustained crop production which is directly related to food security (Das et al., 2019).

Plant Extract Based Biostimulants: Plant extract PBs, particularly protein hydrolysates (PHs), contain amino acids, oligopeptides, and polypeptides, produced through enzymatic or chemical hydrolysis. Rich in antioxidants and osmoprotectants like proline and sugars, these extracts improve stress tolerance, productivity, and nutrient use efficiency. Extracts from tropical plants are widely used for their beneficial agricultural effects (Papnai et al., 2022).

Seaweed Derived Plant Biostimulants: Seaweed biostimulants are cost-effective and enhance plant biomass production. Most extracts are derived from brown algae, especially *Ascophyllum nodosum*, using alkali extraction. Liquid extracts and powders are preferred over dried seaweed due to slower decomposition. Popular species include *Macrocystis pyrifera*, *Ecklonia maxima*, and *Laminaria digitata* (Papnai et al., 2022).

Protein Hydrolysate Derived Plant Biostimulants: Protein hydrolysates, produced via acid, alkaline, thermal, or enzymatic hydrolysis, consist of amino acids, oligopeptides, and polypeptides. Applied as foliar sprays or near-root applications, they improve nutrient uptake,

nitrogen metabolism, and crop productivity. They are derived from plant residues and animal waste (Papnai et al., 2022).

Humic Substances Derived Plant Biostimulants: Humic substances (HS), derived from organic carbon products like compost and manure, enhance root and shoot growth. HS improves nutrient uptake and soil organic matter content. Techniques like ultracentrifugation and sedimentation are used for molecular characterization. Extraction involves alkali or acid hydrolysis (Papnai et al., 2022).

Research and development efforts are introducing innovative biostimulants tailored to regional needs. Major companies are investing in collaborations, mergers, and acquisitions to strengthen their market presence. The biostimulant market is expected to grow at a compound annual growth rate (CAGR) of 11.2 percent, reaching approximately \$ 7.6 billion by 2030 (Markets and Markets, 2023).

The biostimulant market in India has shown significant growth in recent years, primarily due to the increasing focus on sustainable agricultural practices and the need for higher crop productivity. Biostimulants play a crucial role in enhancing nutrient use efficiency, improving plant tolerance to abiotic stress, and promoting overall crop health. Their adoption has become essential in addressing challenges like soil degradation, water scarcity, and climate variability (Patel et al., 2022). Indian farmers have shown a growing interest in biostimulants, especially in horticultural crops like fruits, vegetables, and spices. States like Maharashtra, Gujarat, and Punjab have reported higher adoption rates due to favorable climatic conditions and increased farmer awareness (Sharma & Kumar, 2020).

The increasing consumer demand for organic and chemical-free produce has also driven market growth. As consumers become more conscious of food safety and sustainability, farmers are inclined to reduce the use of synthetic inputs and adopt biostimulants as a reliable alternative.

1.3 Objectives

1. To study the socio-economic profile of farmers
2. To find out factors influencing farmers' preference for biostimulants
3. To study the problems faced by farmers in adoption of biostimulants

4. To find out the market potential of biostimulants

2. MATERIALS AND METHODS

The study adopted a descriptive research design to explore various aspects of biostimulant adoption among farmers in Dantiwada Taluka of Banaskantha district, Gujarat. Data collection was conducted in selected villages using a structured interview schedule tailored to the study objectives.

Primary data were collected from 200 farmers through direct interviews, while secondary data were sourced from literature, research publications, and official websites. A non-probability purposive sampling technique was employed to identify respondents. The field survey was conducted over a period of 60 days.

The data collected were compiled in tabular format and analyzed using two key statistical techniques: Weighted Average Mean (WAM) and Garrett Ranking Technique (Nemoto and Beglar, 2014, Guh et al. 2008 & Christy, 2014).

The collected responses were organized into a tabular format and analyzed using two major statistical tools: Weighted Average Mean (WAM) and the Garrett Ranking Technique.

$$\text{Weighted average mean (X)} = (F_1X_1 + F_2X_2 + F_3X_3 + F_4X_4 + F_5X_5) / X_t$$

Where,

F = Weight given to each response
X = Number of responses
X_t = Total number of responses

Each response was multiplied by its respective weight, the products summed, and then divided by the total weight to derive the WAM.

Garrett's ranking was used to study the rank problems faced by farmers in adopting

biostimulants. Respondents were asked to rank all relevant issues based on severity. These ranks were converted into percent position using the formula:

$$\text{Percentage position} = 100 (R_{ij} - 0.5) / N_j$$

Where,

R_{ij} = Rank given for the ith variable by jth respondent
N_j = Number of variables ranked by jth respondent

The percentage positions were then converted into Garrett scores using a standard conversion table. The mean scores were calculated for each factor and used to derive the final ranking.

3. RESULTS AND DISCUSSION

During the study, the following result was found. All the findings and conclusions are drawn from the questionnaires, which were filled by the respondents in person.

3.1 To Study the Socio-Economic Profile of Farmers

3.1.1 Age of farmers

Table 1 shows that the majority of farmers (78%) were in the 36-50 years age group, followed by 12 per cent in the 51-65 years group, and 10 per cent in the 21-35 years group. This indicates that middle-aged individuals are most active in agriculture in the study area.

3.1.2 Annual income of farmers

As presented in Table 2, 73 per cent of the farmers reported an annual income between ₹1 lakh to ₹5 lakhs, 19.5 per cent earned ₹5-10 lakhs, 7 per cent earned more than ₹10 lakhs, and only 0.5 per cent earned below ₹1 lakh. This reflects a moderate income level among most farmers.

Table 1. Age of the farmers

Age (Years)	Frequency	Percentage
21-35	20	10.00
36-50	156	78.00
51-65	24	12.00
Total	200	100

Table 2. Annual income of farmers

Annual Income	Frequency	Percentage
<1 Lakh	1	0.50
1 - 5 Lakhs	146	73.00
5 - 10 Lakhs	39	19.50
> 10 Lakhs	14	7.00
Total	200	100

3.1.3 Education of farmers

Education helps farmers to incorporate the latest scientific advances and technology tools into their daily operations. Table 3, highlights a comprehensive overview of the educational distribution within the studied population, shedding light on the educational composition of the individuals. Table 3 revealed that 54 farmers had studied up to primary level with contributing 27.00 per cent, \leq SSC there were 101 farmers, contributing 50.00 per cent, also 21.00 per cent of farmers had an education level up to \leq HSC and only 3 per cent of farmers were graduates.

3.1.4 Occupation of farmers

Occupation plays an important role in the knowledge of trends in agriculture. There were

mainly four occupations found. Table 4 revealed that, 7.50 per cent of farmers depend only on farming, around 82.00 per cent of farmers were engaged in farming and animal husbandry, also 6.00 per cent of farmers were doing a service with farming and animal husbandry, and 4.50 per cent of farmers occupation was farming and animal husbandry with business.

3.1.5 Family size of farmers

Family size plays an important role in the research. Table 5 highlights about distribution of family sizes within the given population. It revealed that the majority of families fall within the 3-5 members range (79.00%), followed by families with above 5 members (18.00%). There were only 3.00 per cent of families with 2 members.

Table 3. Education of farmers

Education Level	Frequency	Percentage
Up to Primary	54	27.00
\leq SSC	101	50.50
\leq HSC	42	21.00
Graduate	3	1.50
Total	200	100

Table 4. Occupation of farmers

Occupation	Frequency	Percentage
Farming	15	7.50
Farming + AH	164	82.00
Farming + AH + Service	12	6.00
Farming+ AH + Business	9	4.50
Total	200	100

Table 5. Family size of farmers

Family Size	Frequency	Percentage
2 Member	6	3.00
3-5 Member	158	79.00
Above 5 members	36	18.00
Total	200	100

3.1.6 Experience in farming by farmers

Table 6 showed that the vast majority of respondent's 87.50 per cent had more than 15 years of experience in farming. A smaller segment, about 6 per cent, had between 5 to 10 years of experience, while 5.5 per cent reported having 10 to 15 years. Interestingly, only 1 per cent of the respondents were relatively new to farming, with less than 5 years of experience.

3.1.7 Total land holdings of farmers

Table 7 reflected the landholding size of the respondents, showing that a majority 54 per cent owned between 2 to 5 acres of land. About 21.5 per cent of respondents had slightly larger holdings, between 5 to 10 acres, while 12.5 per cent reported owning 10 to 20 acres. A smaller segment 10 per cent had less than 2 acres, indicating the presence of marginal farmers with limited cultivation space. Interestingly, only 2 per cent of the respondents had more than 20 acres of land, reflecting that large-scale land ownership is rare in this region.

3.2 Main Crops Grown by Farmers Across Different Seasons

3.2.1 Main crops grown by farmers in kharif season

Table 8 shows that groundnut is the sole crop grown by all respondents during the Kharif

season, representing 100 percent of the sample. This indicates a strong reliance on groundnut cultivation in the region during this period.

3.2.2 Main crop grown by farmers in Rabi(winter) season

Table 9 shows the main crops grown during the Rabi (winter) season. Potato emerged as the most commonly cultivated crop, reported by 67.50 per cent of the respondents. This was followed by wheat at 19 per cent, mustard at 9 per cent, and amaranth at 4.50 per cent. The data indicates a preference for potato cultivation during Rabi, likely due to its higher market value and better returns. The presence of other crops suggests some level of diversification based on land suitability, market demand, and individual farmer practices.

3.2.3 Main crop grown by farmers in Zayad (summer) season

Table 10 shows the main crops grown during the Zayad (summer) season. Groundnut was the most preferred crop, cultivated by 64.50 per cent of the respondents. It was followed by pearl millet at 22 per cent, muskmelon at 11 per cent, and watermelon at 2.5 per cent. This distribution indicates that while groundnut remains dominant even in the Rabi season, there is a noticeable shift toward crop diversification based on market preferences, irrigation availability, and land suitability.

Table 6. Experience in farming by farmers

Experience in Farming	Frequency	Percentage
Up to 5 years	2	1.00
5 to 10 years	12	6.00
10 to 15 years	11	5.50
More than 15 years	175	87.50
Total	200	100

Table 7. Total land holdings of farmers

Total Land (Acre)	Frequency	Percentage
Below 2	20	10.00
2 to 5	108	54.00
5 to 10	43	21.50
10 to 20	25	12.50
Above 20	4	2.00
Total	200	100

Table 8. Main crops grown by farmers in kharif season

Name of the main crop in Kharif	Frequency	Percentage
Groundnut	200	100
Total	200	100

Table 9. Main crop grown by farmers in Rabi(winter) season

Name of main crop in Rabi (Winter)	Frequency	Percentage
Potato	135	67.50
Wheat	38	19.00
Mustard	18	9.00
Amaranth	9	4.50
Total	200	100

Table 10. Main crop grown by farmers in Rabi(winter) season

Name of main crop in Zayad (summer)	Frequency	Percentage
Groundnut	129	64.50
Pearl millet	44	22.00
Muskmelon	22	11.00
Watermelon	5	2.50
Total	200	100

3.3 To find out factors influencing farmers' preference for biostimulants

3.3.1 Farmers' awareness regarding biostimulants

Table 11 indicates that a majority of farmers (82.50%) were aware of biostimulants, suggesting that information was effectively disseminated through agricultural extension services or input dealers.

3.3.2 Usage of biostimulants among farmers

Table 12 depicts that 86 per cent of these aware farmers used biostimulants, reflecting a positive perception of their benefits in improving crop growth and productivity.

3.3.3 Factors that influencing farmers' preferences for biostimulants

Study highlights the factors influencing farmers' preference towards biostimulants. Responses were grouped into five categories: Strongly disagree, Disagree, Neutral, Agree, and Strongly agree. Key factors considered include Dealers/Distributors' recommendation, Quality, Co-farmers' suggestions, Competitive price and others. The importance of each factor was determined using the Weighted Average Mean (WAM).

The analysis revealed that Dealers/Distributors' recommendation ranked as the top influencing factor (WAM 4.31), followed by Effectiveness / Yield improvement (4.13), Quality (3.94), and Co-farmers' suggestions (3.73). Competitive price and Ease of application also played significant roles. However, Brand and Environmental safety/Organic certification were rated the least influential.

Table 11. Farmers' awareness regarding biostimulants

Awareness regarding biostimulants	Frequency	Percentage
Yes	165	82.50
No	35	17.50
Total	200	100

Table 12. Farmers' awareness regarding biostimulants

Usage of biostimulants by farmers	Frequency	Percentage
Yes	142	86.00
No	23	14.00
Total	165	100

Table 13. Factors that influencing farmers' preferences for biostimulants

Sr.No.	Factors	SD	D	N	A	SA	Total	WAM score	Rank
1	Dealers / Distributors recommendation	0	5	26	31	80	142	4.31	1
2	Effectiveness/ Yield improvement	0	9	24	48	61	142	4.13	2
3	Quality	4	9	22	63	44	142	3.94	3
4	Co-farmers' suggestions	4	12	31	67	28	142	3.73	4
5	Competitive price	6	20	42	58	16	142	3.41	5
6	Ease of application	7	38	60	23	14	142	2.99	6
7	Brand	6	36	80	12	8	142	2.86	7
8	Environmental safety/ Organic certification	25	46	50	17	4	142	2.50	8

(SD - Strongly disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly agree) (Nemoto and Beglar, 2014 & Guh et al. 2008)

3.4 To study the problems faced by farmers in the adoption of biostimulants

3.4.1 Problems faced by farmers in the adoption of biostimulants

The third objective highlights the problems faced by farmers and provides insights for the adoption of biostimulants in the study area.

Seven different problems were ranked based on how farmers rated their severity, from Rank 1 (most significant problem) to Rank 7 (least significant problem).

It further analyzes these responses using Garrett's mean score ranking. The findings show that lack of proper technical knowledge is the most critical barrier (mean score: 74.93), followed by delayed effect (63.87) and poor efficiency of biostimulants (56.16). Concerns such as fear of crop failure (50.53) and high cost (43.87) were also noted but had comparatively lower impact. Factors like limited awareness about benefits (36.62) and a smaller product range (25.02) were ranked lower.

3.5 To Find Out the Market Potential of Biostimulants

The market potential is the number of potential buyers, the average selling price, and an estimate of usage for a specific period of time.

$$Q = n \times q \times p$$

Where,

Q = total market demand of a biostimulant

n = number of farmers in the market

q = quantity purchased by an average farmer per year/month/season/land size and dosage

p = price of an average unit according to the quantity

(Vahoniya & Rajwadi, 2023)

Here took a market potential was taken for example, X company's biostimulant product "A" in the Dantiwada taluka of Banaskantha district was estimated by the information collected from the study and the district agriculture office, is presented in Table 15.

Table 14. Problems faced by farmers in the adoption of biostimulants

F	Factor	Garrett's Mean Score	Rank
F1	Lack of proper technical knowledge	74.93	1
F2	Delayed effect	63.87	2
F3	Poor efficiency	56.16	3
F4	Fear of crop failure or adverse effects	50.53	4
F5	High cost	43.87	5
F6	Limited awareness about the benefits	36.62	6
F7	Less product range	25.02	7

(Christy,2014)

Table 15. Market potential for biostimulant product "A"

Dantiwada	
n	14977
p	₹1,300
q (Quantity used per farmer per season)	2.7 liters
Potential market (liters)	40,437.9 liters
Potential market (Rs.)	₹5.25 Crore

(n = Total number of potential farmers, p = Average selling price, q = Average consumption per season)

The market potential of "A" was calculated using the formula $Q = n \times q \times p$, where Q represents the total market demand, n is the number of potential users, q is the quantity used by each farmer per crop season, and p is the price per litre. The price per litre of "A" was taken as ₹1,300 based on current average retail prices for biostimulants products in market. On average, each farmer uses 2.7 liters per season, applying 300 ml per acre across 3 acres with 3 applications per crop season. To determine the number of farmers (n), data from a government census in Dantiwada Taluka was used. By multiplying the number of potential users by the quantity used and the price per unit, the market potential of product "A" in Dantiwada Taluka was estimated to be ₹5.25 crore per crop season.

4. CONCLUSION

The study on the factors influencing and challenges faced by farmers in the adoption of biostimulants in Dantiwada Taluka of Banaskantha District, Gujarat, revealed several critical insights. The majority of respondents were in the 36-50 years age group (78%) and had families of 3-5 members (79%). Most farmers were engaged in both farming and animal husbandry, had annual incomes between ₹1 lakh to ₹5 lakh, and held land ranging from 2 to 5 acres. In terms of cropping pattern, groundnut was the dominant crop in both Kharif

and Zayad seasons, while potato was the most preferred crop in Rabi season. Awareness of biostimulants was high (82.5%), and among those aware, 86 percent had used them in the field. Farmers believed that biostimulants contributed to improved flowering and crop yield. Dealer/distributor recommendations were the primary influencing factor in product selection. The major challenges identified in adopting biostimulants were a lack of proper technical knowledge, delayed visible effects, and limited product range. Finally, market potential analysis showed a promising opportunity, estimating the seasonal market value for biostimulants in Dantiwada at approximately ₹5.25 crore. These findings suggest that with enhanced awareness, improved technical support, and supportive policy frameworks, the adoption of biostimulants can be significantly increased to promote sustainable agriculture in the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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