Original Research Article

Banana Production in Indapur Tahsil Pune District: An Analysis of Farmer Awareness from a Technological and Geographic Perspective.

ABSTRACT

The Indapur tehsil an arid climate region is gaining recognition as a prime location for banana cultivation. In this region an investigation was carried out to assess the expertise of farmers in banana cultivation, with a specific focus on their understanding of geography, implementation of modern agriculture practices, challenges faced, and factors that contribute to successful production. The research involved 270 banana farmers from various villages in the area, on-site observations, and official data of the region. Results indicated that farmers had a solid grasp of drip irrigation and the application of liquid fertilizer through this system, potentially influenced by subsidies and efficient utilization of water and fertilizers. Farmers displayed a moderate understanding of soil quality, organic farming, tissue culture plantlets, banana variety selection, year-round farming, and crop protection. Age, education, and farming experience had an impact on farmers' perceptions on the implementation of modern agricultural practices. The perception index also highlights the necessity for focused attention on aspects such as foliar agrochemical applications, bunch feeding, the use of tensiometers in irrigation, mulching, crop rotation, diseases caused by Fusarium wilt, intercropping, cold storage, and ISO certification. The newly established region for banana cultivation requires strengthening of farmer organizations and communication channels to address issues such as cost of agrochemicals, fertilization, irrigation methods, disease control, market and price. The success rates of banana farmers in the area vary depending on socioeconomic status, soil fertility, water availability, suitable climate conditions domestic and export market support. The findings of the study could offer recommendations to farmers, policymakers, and agricultural services to enhance support and promote sustainable banana farming in the region.

Kew words: *Arid climate. Agricultural practices. Banana. Socioeconomic. Sustainable farming. Technological adoption.*

1. INTRODUCTION

Fruits are vital for health and the economic stability of farmers and nations. Among various fruits, bananas are the most consumed globally, appealing to all demographics. The international banana market is worth over 10 billion dollars annually, and bananas have consistent demand worldwide (FAO, 2023). In India, bananas are a key economic crop, with the country being a global leader in cultivation, production and domestic consumption (FAO, 2023). However, with current population growth rates, projections indicate that the global population will reach 8. 5 billion by 2030 and 9. 7 billion by 2050, necessitating a 70 percent rise in food production (Anonymous, 2024; FAO, 2024). Currently, India is the most populous country, with a population of 1. 486 billion (UN, 2024). On a global scale and within India, the Green Revolution in the mid-20th century played a major role in enhancing food security. However, climate change and excessive chemical fertilizer use pose risks to crop production, including bananas (Varma and Bebber,2019). These chemicals also negatively impact soil health, soil microorganisms, and the environment (Onyeaka et al., 2024). The heavy use of chemicals in farming raises concerns about safety for producers, consumers, and the environment. Furthermore, rising awareness and WTO agreements concerning sanitary and phytosanitary measures and technical trade barriers have led to increased rejection of chemically contaminated products in domestic and

international markets (Aryal and Aryal, 2023). Addressing environmental and socio-economic challenges is crucial in modern agriculture practices. Awareness and safe methods are needed to meet the growing demand for bananas (FAO, 2024, Gelaye and Negash, 2024).

2. STUDY AREA

Indapur tahsil is one of the tahsils in the Pune district consisting of 143 villages along with one urban centre in the study area (CDAP, 2017). There are eight revenue circles in the tahsil. Indapur lies approximately between 17°50' N to 18°10' N latitude and 74°40' E to 75°10' E longitude. The terrain is predominantly flat with gentle slopes, characteristic of the Deccan Plateau. The average elevation is approximately 530 meters (1,739 feet) above sea level (Bhore et al., 2021). The Bhima River and its tributaries, such as the Nira River, play a significant role in shaping the local topography and supporting agriculture. Tropical semi-arid climate (hot and dry). The region receives an average annual rainfall of 500–700 mm, with most precipitation occurring during the monsoon season (June to September) (Ogale, 2022). High fertility and water retention, suitable for crops like sugarcane, cotton, and bananas. The Bhima River is the lifeline of Indapur, providing water for irrigation, drinking, and other needs (CDAP, 2017; Dhobale, 2020)

3. METHODOLOGY

The study used a mixed-method approach, combining surveys and interviews. The tehsil consists of 144 villages. A list of banana growers was created, and data were gathered from 270 randomly selected banana farmers across various villages in Indapur tehsil. Information on modern techniques adoption, technology challenges, geographic awareness, water management practices, and the impacts of challenges was gathered. The parameters and variables were detailed in Fig. 1, 2, 3, and table 1 and 2. Secondary data was obtained from official records and reports from the Agriculture Department of Indapur Tehsil, the horticulture section of Pune district, Maharashtra state, and the Directorate of Economics and Statistics. Both primary and secondary data were analysed using SPSS and Excel. Descriptive statistics were used to assess application extent.

The study measured banana growers' awareness of variables on a scale ranging from well-known to not known, and strongly agree to undecided (Table 2). Frequencies of known and unknown responses were determined by combining certain categories (known (agree)=well-known + known or strongly agree +agree and unknown (not agree) = partially known/agree + unknown/disagree + undecided or unsure). Awareness levels were assessed using an index formula: Awareness Index = frequency of known - frequency of unknown/n, with n being 270. An index value above 0.5 indicates awareness, while below 0.5 indicates unawareness. This evaluation followed World Banana Forum guidelines, covering soil management, fertilization, climate conditions, modern techniques adoption, technology challenges, water management, crop production, waste and energy management, harvesting and processing, and health and safety measures.

4. RESULTS AND DISCUSSION

4.1 Gender and Banana Farm Size

In the tehsil region, there is a growing trend of farmers switching to banana cultivation, with a total land area of 2,333 hectares used for this purpose in 2023. The demographic characteristics of the farmer illustrated in Fig. 1 indicated that, most banana growers in the area use their own land, and all surveyed farmers family head were men. This trend reflects the traditional land tenure system that favours men in property transfer and resource control. Family sizes are balanced among banana growers, with many living in joint families. Women also participate in labour-intensive tasks such as planting, applying inorganic fertilizers, and intercultural tasks, in

banana farming, but men prioritize modern technology. Respondents own cows, other livestock, and engage in dairy farming (Fig.1). Some have multiple sources of income, and most banana growers had medium incomes. Research shows that farm size influences the adoption of modern techniques in banana cultivation and suggests improvements in the banana agribusiness system (Hamdani and Santoso, 2023).

4.2 Age of Respondents

The majority of banana farmers in the study area are aged 36 to 55 years, with a significant proportion being over 56 years old (Fig. 1). Older farmers may resist modern technology due to their farming experience and financial concerns. In contrast, younger farmers show interest in advanced technologies and aim to increase production quality and income. This age distribution is essential for understanding how social traits affect the adoption of modern technology in banana farming. Based on research and prior findings (Van Thanh and Yapwattanaphun, 2015; Hamdani and Santoso, 2023), it has been observed that young, educated farmers are more likely to introduce innovative methods in banana cultivation.

4.3 Formal Education

Banana growers in the region have strong educational backgrounds, ranging from primary to postgraduate levels (Fig.1). This is evident in their successful use of modern technologies and expansion of banana farming land, even without prior experience in banana cultivation. Formal education was found to influence farmers' decisions to adopt new technologies and enhance productivity in multiple studies (Abedin and Bose, 2023). The results revealed that, farmers' education levels were important in determining their adoption of banana production technology.

4.4 Access to Subsidies, Credit and Crop insurance

All the banana growers in the area took part in subsidy programs for drip irrigation and crop insurance (Fig.1). Government subsidies of substantial amount for drip irrigation and crop insurance scheme for a nominal one-rupee fee, greatly benefit banana farmers. These programs help farmers transition to banana cultivation and protect against damage from weather events such as unpredictable cyclones, strong winds, and heavy rainfall. Many banana farmers were able to access loans (Fig.1), enabling them to implement modern agricultural methods and make investments in labour and farming machinery, all of which necessitate financial resources in cash. The current study, as well as prior research (Kumari et al., 2018), suggest that the ability of banana farmers to manage risks and adoption of modern technology is greatly impacted by their access to credit.

4.5 Access to Information on Technology Adoption

Banana growers claim that having access to information plays a significant role in influencing their decision to proceed and adopt modern banana farming methods. They primarily acquire information about the benefits and technological aspects of banana farming through conversations with friends, family members, experts at fertilizer shops, fellow

Fig.1: Demographic profile of respondent banana growers

IL=illiterate; PS= Primary school; SSC, school; HSC= higher secondary school, Gd= graduate; PG= post graduate; J= joint; N= nuclear; F= farming; D= dairy; S= service; B= business; R=Relatives; FSA= fertilizer shop agriculturist; FG=farmers group; A= agents; SM=social media;

GS= government staff; M= marginal; L=low; Me= medium; H=high; A=available; NA= not available; FS=small; FM= medium; FL=large.

farmers, exhibitions, and social media. Some farmers transitioned to banana cultivation after participating in seminars and workshops organized by various government agricultural departments, banana tissue culture company representatives, non-governmental organizations, and innovative farmers. The current study and earlier research (Abedin and Bose, 2023; Hamdani and Santoso, 2023), indicated that improved access to information from different sources contributes to advancements in banana farming techniques.

4.6 Understanding of Soil, Climate and Fertigation

The data in Table 1 shows farmers' understanding of soil traits, weather conditions, monsoon timing and adequacy, and fertigation requirements for banana farming.

4.6.1 Soil type:

The best soil for growing bananas has a pH level between 6 and 7.5 (Abhishek, 2021) and is found along the Bhima and Nira River corridor in Indapur tehsil. This area has different types of soil like black, red, alluvial, sandy, and sandy loams (Bhore et al., 2012; CDAP, 2017). Farmers in the region are aware of the soil type and its water retention capacity. 63% of farmers tested banana field soil for pH and minerals with help from banana and fertilizer related companies and government organizations. Some farmers didn't test their field soil because other crops grew well in their fields. Earlier reports (Bhore et al., 2012; CDAP, 2017) also show that the soil in the region is slightly acidic or alkaline and has good drainage and organic matter, nitrogen, phosphorus, and potash, which are good for growing bananas in Indapur tehsil.

4.6.2 Climate

Bananas thrive in warm and humid climates, with wind speeds below 80 km/hr. They can tolerate temperatures ranging from 13°C to 44°C (Reay, 2019). These conditions align with the geography and weather of the Indapur tehsil region (Dhobale, 2020; Salunkhe, 2023). Most respondents were unable to describe these weather conditions scientifically (Fig.2). The region experiences a hot tropical climate with mild summers, gentle winters, and dry conditions except during the southwest monsoon (Dhobale, 2020; Bhore et al., 2021). It falls into a dry and semi-arid agro-climatic zone with limited and irregular rainfall. Temperatures range from 6.8 °C to 42.3 °C (Ogale, 2022)., occasionally hindering banana growth in extreme conditions. However, the Grand Naine variety of banana is preferred by local farmers crop shows resilience due to adequate water resources and the limited duration of adverse conditions (kvk. icar.gov. in, 2023).

Fig. 2: Understanding about soil, climate and application of fertilizers among the banana growers. a. Soil testing carried out before banana plantation b. Farmers understanding about climate c: Application of manure and fertilizers

The main factor affecting banana cultivation is rainfall. A study in Indapur found a negative correlation between rainfall and banana cultivation over 24 years due to low rainfall (CDAP, 2017; Ogale, 2022). Despite this, banana cultivation is increasing using water from various sources such as Ujani dam's backwater, fed by the Bhima River, and from the Nira River, along

with the Nira left canal and Khadakwasla canal system (Bhore et al.2021; Ogale, 2022).

4.6.3 Fertigation

Plant growth relies on mineral nutrients in the soil, which may be abundant in some minerals but deficient in others (Ogale, 2014: www. shehrikisaan. in; 2023). Supplementing the soil with nutrient minerals from sources like compost, farmyard manure, or chemical salts is necessary (Santosh et al., 2024). Bananas require higher nutrient levels compared to other plants (www. shehrikisaan. in; 2023), and most farmers follow suggested fertilizer application rates for banana crops (Fig.2). This is often due to the presence of domestic animals owned by the majority of farmers and availability of manure. However, a small percentage of farmers use inorganic fertilizers and farmyard manure instead (Fig. 2).

4.7 Adoption of Modern Techniques in Banana Farming

The data in table 2 demonstrated the usage of tissue culture plantlets (seedlings), drip irrigation, liquid fertilizers via drip or foliar methods, and pest management technologies among farmers. It examines how access to these technologies differs based on farm size, education level, and government support.

4.7.1 Tissue Culture Plantlets

Tissue culture technology has become increasingly popular for the commercial production of bananas in recent years (www. shehrikisaan. in; 2023; Salunkhe, 2023). In accordance, 94.8% of farmers in the region prefer using banana tissue culture plantlets for cultivation, while only 5.2% choose suckers as a propagation method. Despite the availability and cost-effectiveness of suckers, farmers favour tissue culture plantlets due to their disease and pest-free nature, which ensures a reliable and high-quality harvest in a specific time frame, ultimately leading to better yields (Parekh et al., 2016; Joshi et al., 2020).

4.7.2 Variety

Selecting the right variety for cultivation is crucial due to environmental differences in India (kvk. icar.gov. in, 2023). Common banana cultivars in India include Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red banana, Nyali, and Grandnaine (G-9), among others (www. shehrikisaan. in; 2023). The preferred variety among farmers is Grand Naine (G-9)(Table 1) due to its resilience and high-quality production (www. shehrikisaan. in; 2023). Grand Naine has well-spaced hands, larger size, uniform yellow color, longer shelf life, and superior quality, leading to strong market demand. Overall, Grand Naine is the most preferred variety in the study area.

4.7.3 Season

Banana is traditionally planted in two seasons: June and July (Kharif/Mrig Baug) and also in October and November (rabbi/Kande Baug) (kvk. icar.gov. in, 2023; Salunkhe, 2023). However, farmers in the Indapur tehsil region have suggested that with the use of drip irrigation systems and tissue culture-raised plantlets, plantations can be carried out year-round. A survey revealed that 51.5% of farmers plant from June to September, 32.6% from October to January, and 15.9% from February to May (Table 1). This shows that banana cultivation takes place throughout the year in this region, allowing farmers to fetch good market prices and have fruit available consistently.

4.7.4 Plant Distance and Density

The distance between banana plants is important for maximum growth and yield (kvk. icar.gov. in, 2023). About,17.8% of farmers rely on their own experience for spacing, while 82.2% follow recommendations from plantlet production companies. Different spacing is recommended for different types of banana plants, with some farmers planting Grand Naine variety at specific

distances for better results (Table 1). This spacing allows for 1452 plants per acre (3630 plants per hectare), and farmers believe it leads to good growth and yield due to competition for nutrients and sunlight.

4.7.5 Biofertilizer and Liquid Fertilizer Application

In the tehsil region, farmers use water-soluble chemical fertilizers and biofertilizers in combination with drip irrigation (Table 1). Typically, micronutrient salts such as ZnSO4, FeSO4, CuSO4, and H3BO3 are utilized through drip irrigation or leaf spraying to combat deficiencies ((www. shehrikisaan. in; 2023).). Banana growers recognize that this fertigation method enhances nutrient delivery to the root zone, resulting in improved uniformity, efficiency, increased yield, and significant savings on fertilizers. These findings were consistent with experimental plots that used drip irrigation for nutrient application, resulting in a 25-30% increase in yields ((www. shehrikisaan. in; 2023).).

The majority of farmers who participated in the survey also used fertilizer solutions with micro and organic nutrients, along with adhesive agents such as teepol, on banana leaves, as well as feeding fertilizer granules through leaves to provide micronutrients (Table 1). This approach enhances nutrient absorption through leaves to promptly address deficiencies ((www. shehrikisaan. in; 2023).).

4.7.6 Bunch Feeding

The process of bunch feeding involves the direct application of nutrients and growth solutions to the banana bunch, resulting in improved fruit development, quality, and shelf life across different banana varieties like Champa (Sathish et al., 2021), Ney Poovan (Nayak et al., 2022), and Grand Naine (Shrestha et al., 2023; Reddy et al., 2024). Despite this, there is evidence to suggest that while some farmers believe in the benefits of this method for enhancing nutrient delivery and growth in bananas, many are unaware of the bunch feeding technique. Hence, it is important to educate banana farmers in the Indpur tehsil area about the benefits of bunch feeding.

4.7.7 Drip Irrigation

Efficient management of water is vital in Indapur tehsil due to its semi-arid climate. However, the majority of farmers have sufficient irrigation water, primarily sourced from wells or lift irrigation from rivers. Only a small percentage experience shortages during summer. Farmers attribute the widespread adoption of drip irrigation for banana farming to advancements in the durability and affordability of PVC pipes, tanks, valves, couplings, and drippers. Drip irrigation is now utilized by all farmers and has significantly improved irrigation systems, particularly for banana cultivation (Table 1). This method is especially effective in well-drained soils, helping conserve water and enhance crop yield. The use of drip irrigation has led to increased crop yields, reduced labour costs, and improved fertilizer efficiency (Parekh et al. 2016; Pratibha et al., 2023). While some farmers use electric pumps for irrigation, a small percentage opt for solar pumps (Table 1). Thus, there is need of awareness for use of solar pumps

Table 1: Modern agriculture practices (MAP) followed by banana growers

Sr. No.	Activity	Modern agriculture practice (MAP)	% of follower
•	Banana propagule used	Suckers	5.2
		Tissue culture plants	94.8
•	Banana variety preferred	Grnad Naine (G-9)	91.9
		Shrimanti	5.2
		Gross Michael	3.0
•	Planting season	June to September	51.5
		October to January	32.6

		February to May,	15.9
•	Planting distance and density	1.65 x 1.65 m	30.0
		1.7 x 1.75 m	28.1
		1.82m x 1.52m	24.1
		Newly own specified	17.8
•	Mulching	polythene,	13.7
		Banana leaves, crop straw, sugarcane trash	45.6
		No mulching	40.7
•	Irrigation	Flood/ Sprinkler	0.0
		Drip	100.0
•	Solar energy	Solar pump utilization	28.1
•	Nutrient management	Green manuring	14.4
		Bio fertilizers	19.3
		Liquid fertilizer through drip irrigation	100
		Liquid fertilizer through foliar spray	15.9
		Nutrient granule feeding through leaves	92.2
•	Bunch feeding	Nutrient and growth promoters	12.2
•	Intercropping	Vegetable.	14.1
		Fruit	11.5
		Flower	6.7
		No inter cropping	67.8
•	Prevention of damage due to sunlight, wind and weight,	Bunch covering	47.4
		Use sleeves to encase bunches	32.6
		Crop border covering and frequent watering	93.7
		Propping using bamboo/wooden sticks	36.3
		Propping by tape/string	60.0
•	Pest, disease and weed management and health precautions	Recommended Chemicals used	78.1
		Synthetic chemicals not used	21.9
		Use of recommended weedicides, hand weeding and spading	100
		Farmers take precaution during synthetic chemical applications	89.3
		Safe management of agricultural waste	100
•	Ratoon crop and removal of suckers	Ratoon crop taken by farmers	4.2
		Removal of unwanted suckers	100
•	Crop rotation	Crop rotation followed	91.9
•	Fruit storage	Use of cold room storage	17.4

4.7.8 Intercropping

Very small percentage (9.3%) of farmers intercrop with vegetables, pulses, and flowers during the first three months of banana growth. The majority (90.7%) of farmers believe intercropping competes for nutrients, water, and light, damaging the shallow root system of bananas and reducing production quality. Previous studies have shown that intercropping can lower both quality and yield of bananas (Parekh et al., 2016). The results of the present study, along with previous research, suggest that farmers who prioritize growing top-quality bananas avoid intercropping (Hamdani and Santoso, 2023).

4.7.9 Propping

The respondents recognize that banana plants have weak stems which can't support weight of fruit bunch and may fall due to strong winds. To address this issue, some farmers use bamboo or sticks for support while others tie plants together with string. (Table 1). Both methods have

been shown to reduce the risk of damage from weight and wind, thereby minimizing potential losses (FAO, 2024).

4.7.10 Removal of Suckers and Ratoon crop

Banana plants produce suckers after 4-5 months, which can reduce productivity by competing for nutrients (Der et al., 2023). In order to address this issue, farmers in the area regularly remove the suckers every 5-6 weeks, with a preference for focusing on the main crop. A low number (4.8%) of farmers choose to keep just one strong sucker for a second crop, however, it is noted that the second harvest usually has lower quality.

4.7.11 Crop rotation

Crop rotation and keeping the land fallow for a specified period is an effective technique for improving soil quality and controlling diseases in banana plants, making it essential in banana farming. (Fan et al., 2020). A significant majority of farmers (91. 9%) engaged in crop rotation, succeeding the banana crop with maize, jawar, bajara, or different vegetables and seasonal fruits like watermelons and musk melons. A total of 8. 1% adhered to the fallow practice, anticipating a successful new banana crop.

4.7.12 Cold storage:

Bananas need cold storage at 12 to 14°C and 85-90% humidity to last longer, up to six weeks. Cold storage slows ripening, reduces spoilage, and preserves freshness. Cold storage is crucial for quality, market competitiveness, exports, and profits (Bhadke et al. 2024). Lack of cold storage in the tehsil market poses challenges for banana storage. Only 17.4% of respondents know about cold storage options, highlighting the need for more awareness and facilities in the Indapur tehsil region.

4.8 Impact of Geographic Challenges

The study addresses challenges like variable rainfall and possible drought risks, analysing how effectively farmers adjust their methods to manage these problems.

4.8.1 Drought and Bright Sunlight

Most farmers in the study area recognize the challenges of the tropical climate's year-round sunlight, especially bright sunlight in summer (Table 1). Farmers mentioned that the bunches and upper parts of the banana plants are at risk of sunburn and damage from intense sunlight during March, April, and May. To address this issue, 47.4% of farmers use dried banana leaves to cover these areas, while 32.6% use blue plastic sleeves for protection. These methods are similar to those used by banana farmers in Jalgaon, India (Salunkhe 2023).

Extensive research shows how climatic variations affect banana cultivation in different geographic regions (Abdoussalami et al., 2023). In the Indapur tehsil area, 93.7% of farmers reported facing drought and high temperatures in summer, causing stress on their banana crops. They observed issues like wilting and leaf drying, especially at the edges. Banana plants, with large leaves and weak stems, struggle in winds over 80 km/hr (Baral, 2019). Farmers mentioned that strong winds can damage leaves, bunches, or entire plants, leading to crop loss. To combat these problems, farmers watered their crops frequently, used mulching techniques, and planted bordering plants. These observations align with previous findings on the impacts of drought, water stress, light intensity, and temperature on bananas (Abdoussalami et al., 2023; Salunkhe 2023).

4.8.2 Pest, Disease and Weed Management

Banana cultivators in the region experienced minimal challenges related to diseases or pests concerning G-9 and indigenous varieties (Table 1). Nevertheless, 78.1% used chemical pesticides during bad weather based on advice. A marginal percentage of farmers (21.9%) did not use synthetic chemicals. In contrast, banana producers in the Jalgaon district of India and exporters in Malaysia have faced recurrent diseases and pest infestations, which have significantly impacted their crops and economic viability (Salunkhe, 2023).

Concerning weed management, the respondent farmers noted that banana plants grow slowly in the first 1-4 months, allowing weeds to flourish and requiring special attention to weeding during this time. They use herbicides like Glyphosate and Duron along with hand weeding (Table 1). Most farmers take safety measures during spraying. A similar strategy has been documented for weed management in banana plantations due to labour scarcity and rising costs for mechanical weed removal (FAO 2023; Salunkhe 2023). The majority of participants dispose of agricultural waste by sending it to local waste collectors for recycling. Some farmers burn waste safely. About 34% of farmers have a separate storage area for fertilizers and supplies. According to FAO (2023) guidelines, 89.3% of respondents provide training on safe use of pesticides, fertilizers, and equipment in banana farming to ensure employee welfare. They also ensure fair working hours and rest periods for workers.

4.9 Perception of Farmers on Modern Agricultural Practices (MAP):

The study reveals farmers' perceptions of MAP adoption and its benefits (Table 2). The average perception index is 0.4, with high perceptions for drip irrigation and liquid fertilizer application. Factors like soil characteristics, organic cultivation, and crop protection were also considered. Age, educational qualifications, and farming experience also influenced MAP implementation. Strengthening farmers' organizations and diversifying information channels could improve MAP applications. However, the data depicted in table 2 suggested that, attention should be focused on foliar agrochemical applications, bunch feeding, tensiometers, mulching, crop rotation, diseases, intercropping, cold storage, and ISO certification.

Table 2: Farmers' perspective on modern agricultural practices (MAP) and growing bananas

Sr. No.	Statement related to implementing and benefits of MAP applications	Perspective decision by the % of the respondent					Index
		SA	A	PA	NA	UD	
1	The age, education, and farming experience impact MAP implementation.	192	21	30	19	8	0.6
2	Farmers' groups and various communication platforms promotes the use of MAP.	132	48	39	33	18	0.3
3	Understanding soil characteristics and climate is essential for implementing a MAP.	198	28	12	11	21	0.7
4	Organic farming and the use of MAP improve soil and plant health while reducing costs and pollution.	188	44	27	11	0	0.7
5	MAP enhances the performance and sales of the Grand Naine (G-9) variety in state and international markets.	152	58	34	19	7	0.6
6	Compare to suckers, tissue culture plantlets produce healthy, disease-free, uniform good export quality banana	164	48	33	14	11	0.6
7	Drip irrigation delivers water, fertilizers, and biofertilizers to plant roots to reduce waste, avoid overwatering and underwatering, keep plants healthy and hydrated.	238	23	9	0	0	0.9

8	Water-soluble fertilizers, biofertilizers, and agrochemicals applied through spray or root feeding can greatly enhance banana yields.	123	40	39	35	33	0.2
9	Drip irrigation can be done by monitoring soil moisture with tensiometers.	18	27	21	27	177	-0.7
10	Mulching with plant materials or plastic helps retain water by reducing evapotranspiration.	119	55	41	37	18	0.3
11	Crop rotation reduces the need for synthetic agrochemicals to control pests and weeds.	69	77	53	48	23	0.1
12	Using MAP can reduce the risk of fungal diseases like Fusarium TR4 and other related illnesses."	77	94	38	23	38	0.3
13	MAP allows banana cultivation year-round, with the flexibility to adjust planting space and density.	144	73	26	14	13	0.6
14	Workers can enhance their work quality, productivity, and benefits by improving technical skills through MAP.	188	49	21	9	3	0.8
15	MAP helps banana farmers in the area get ISO certification, which is important for selling and exporting their produce.	92	72	63	23	20	0.2
16	Intercropping improves benefits from growing bananas with other crops.	26	28	51	118	47	-0.6
17	MAP helps to protect banana crops and bunches from various environmental threats like sunlight, temperature, wind, weight, pests, and diseases.	194	32	22	14	8	0.7
18	Prolonged storage is not ideal for bananas. Cold storage facilities extend bananas' shelf life, promoting market competitiveness, export promotion, and increasing profitability.	68	88	39	46	29	0.2

SA=strongly agree, S= agree, PA=partially agree, NA=not agree, UD= unable to decide, n= No. of respondents=270 (First 5 column values in percentage)

4.10 Challenges in Technology Adoption:

The data presented in fig. 3 revealed that, financial constraints, lack of training, and limited outreach hinder the adoption of innovative agricultural practices in the region. Farmers struggle with skilled labour, high costs of modern technologies, adverse weather, and identifying banana varieties.

Fig. 3 . Challenges related to banana farming of the region

Some face uneven plant growth due to mineral deficiencies and difficulty in removing post-harvest biomass (Fig. 3). After harvesting, the large biomass of leaves, pseudo-stem, and underground rhizome remains, making it difficult to remove. Most farmers recycle banana waste to produce organic manure, which aids in water conservation and soil quality. Access to clean water is limited, and transportation and storage methods contribute to losses. Market fluctuations and uncertainty surrounding export opportunities further impede the adoption of these practices.

4.11 Factors That Enhance Prospects in Banana Farming

Bananas are an excellent fruit crop for semiarid regions due to their adaptability, water needs, resilience, durability, and year-round cultivation. Government subsidies for drip irrigation systems, favourable market prices, and job creation have strengthened banana cultivation. Bananas are ideal for transitioning from existence farming and encouraging crop diversification. Financial support from the Pune District Cooperative Bank and nationalized banks has enabled farmers to acquire necessary materials and labour. Banana crop consultants have introduced technological advancements to rural communities. Farmers in the study area are focusing on

improving banana farming, including reducing costs, ensuring export-quality banana varieties, increasing crop insurance coverage, and establishing reliable cold storage facilities.

5. CONCLUSION, RECOMMENDATIONS AND PROSPECTS

The success of banana farming in the study area is due to favourable soil and weather conditions, access to irrigation water, and the use of drip irrigation and fertigation techniques. Additionally, the use of high-yielding G-9 tissue culture plantlets, cold-storage, and export facilities have also played a significant role. Vendors help with harvesting, labour, and transportation, ensuring better pricing and timely payments. Adoption of modern agricultural technologies, demographic factors, and minimal disease occurrence have facilitated the expansion of banana cultivation. Support from government and non-governmental organizations through training, subsidies, and marketing initiatives has been crucial in this success. The reliable infrastructure in Indapur tehsil has shifted cropping patterns from traditional cereals to high-value fruits like bananas. Some growers are experimenting with practices to improve production quality and yield. As a result, Indapur tehsil is becoming a prominent banana hub in Pune district, Maharashtra, India.

Banana growers in the region have different levels of success based on their socioeconomic status. Recommendations include providing training on soil and farming techniques, finding alternative technologies to reduce reliance on bullocks, addressing challenges like droughts and pests with technological solutions, and improving storage facilities. The region's emerging banana production can boost economic development, increase fruit accessibility, and generate employment opportunities. Larger, wealthier farmers have better access to modern practices compared to smaller, traditional farmers who face economic and informational barriers. Geographic awareness also shows significant gaps, particularly among less-educated farmers who may not fully understand how to optimize farming practices based on local environmental conditions. Therefore, needs special attention on education, marketing, export facilities and stability of socioeconomic status.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author confirms that they did not use generative AI technologies like Large Language Models or text-to-image generators while writing or editing the manuscript.

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