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RESEARCH ARTICLE

Enhancing Banana (*Musa sp.*) productivity through micronutrient application and technological interventions

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Abstract

Banana (*Musa sp.*) is one of the most important fruit crops globally. However, its productivity is decreasing year by year. Therefore, there is an urgent need to enhance productivity to meet domestic demand, commercial markets and export requirements. Krishi Vigyan Kendra (KVK), Vamban, Pudukkottai, conducted Front Line Demonstrations (FLDs) on the micronutrient mixture IIHR (Indian Institute of Horticultural Research) Banana Special during 2016-17 and 2017-18 to increase the marketable bunches of bananas. Technological interventions such as pairing and pralinage, desuckering, propping, denaveling, foliar application of micronutrients, bunch covering, soil application of biocontrol agents, crop rotation, mulching and plant protection measures led to an increase in bunch weight and yield by 20 % with a benefit-cost (B:C) ratio of 3.7 in demonstrated plots, compared to 3.4 in control plots. Promoting eco-friendly production technologies and integrating indigenous technical knowledge with modern cultivation techniques is critical. Moreover, supporting farmers with subsidies or loans for small-scale processing units is recommended.

Keywords: Banana Special; eco-friendly farming; marketable bunches; micronutrient application; yield increase

Introduction

Banana is a major fruit crop worldwide, with an annual global production of 97.5 million tons (1). India ranks second after China, producing 16.91 million tons from 490.70 thousand hectares, contributing 32 % to the nation's total fruit production (2-5). Major banana-growing states in India include Maharashtra, Tamil Nadu, Kerala, Karnataka, Gujarat, Andhra Pradesh and Assam. However, in Tamil Nadu, micronutrient disorders, particularly deficiencies in zinc, boron and iron are commonly observed, significantly affecting banana productivity (6). Despite the availability of micronutrient formulations, systematic demonstrations integrating Banana Special with other eco-friendly practices remain limited, especially in Tamil Nadu's semi-arid zones. Given the global importance of bananas and plantains-cultivated in over 130 countries across 10.1 million hectares producing 121.85 million tons-enhancing productivity through micronutrient interventions is essential for food security and income generation.

To address this issue, the Krishi Vigyan Kendra (KVK) at Vamban, Pudukkottai, conducted Front Line Demonstrations during 2016-17 and 2017-18, utilizing the micronutrient mixture IIHR Banana Special to enhance banana yields (7). The objectives of these demonstrations were to assess farmers' knowledge levels regarding the adoption of Banana Special for producing marketable bunches, evaluate the yield improvements resulting from its use and identify the constraints faced by farmers during adoption.

Banana Special is a crop-specific micronutrient formulation. It is developed for foliar application to improve banana yields by up to 20 %. The recommended application protocol includes the use of 6 kg per acre as a foliar spray (8). For preparation, 50 g of Banana Special is mixed with lemon juice and a surfactant (commercial liquid soap) in 10 L of water. Additionally, a drenching application of 250 mL per plant is recommended after 15 days for tissue-cultured plants. The

spraying schedule begins four months after planting and is repeated every 30 days until eight months after planting (9, 10). Final sprays are applied both on the bunches and the leaves at 30 and 60 days after bunch emergence. Spraying is best carried out during the cooler parts of the day, specifically between 6:00-11:00 AM and 4:00-6:30 PM.

Materials and Methods

The Front-Line Demonstration (FLDs) of "Banana Special" was carried out 2016-17 and 2017-18 by Krishi Vigyan Kendra (KVK), Vamban, in the Thiruvarankulam block of Pudukkottai district, Tamil Nadu, to enhance the production potential of export-quality banana bunches. Out of the twelve blocks in Pudukkottai district, two blocks-Gandarvakottai and Thiruvarankulam-were purposively selected based on their suitability for banana cultivation and farmer interest.

A random sampling method was employed to select ten farmers from these two blocks. A well-structured interview schedule was developed and used to collect detailed data regarding the documentation and analysis of the "Banana Special" demonstration impact on productivity and marketable bunch quality.

Indicator studies

Step 1: Development of indicators

Recognizing that demonstration is a key method for disseminating agricultural technologies, KVK Vamban introduced the concept of Front-Line Demonstration (FLDs) in a participatory approach. Farmers were actively involved in the process of technology implementation and monitoring.

The following locally relevant indicators were developed to systematically evaluate the effect of the intervention:

Indicator - 1: Experience in Banana cultivation.

Indicator - 2: Knowledge score (scale 1-5) on Banana Special application.

Indicator - 3: Foliar application of micronutrient.

Indicator - 4: Adoption and time of Banana special.

Indicator - 5: Socio-economic Profile of the Sample Respondents.

Indicator - 6-8: Cost, Input & Labor Utilization patterns in Banana cultivation.

Indicator - 9: Spread of technology.

Indicator - 10: Constraints faced by farmers.

Indicator - 11: Cost details and Benefit Cost Ratio with yield.

The indicators were finalized through consultation with subject matter specialists and based on previous studies assessing technology adoption in banana cultivation.

Results

The data collected from the farmers are consolidated and furnished as mentioned in Table 1.

Indicator - 1 & 2: Experience and knowledge in Banana cultivation

It was noticed that all farmers are practicing Banana cultivation as a primary work. All the farmers are enrolled in Banana cultivation and cultivating Banana in their land. However, they do not have sufficient knowledge about technology in Banana cultivation and other quality-improving techniques. The use of tissue culture planting material was found superior with vigorous, uniform plant growth, precocity of flowering and harvest and higher yield in Dwarf Cavendish and Robusta, Nendran and Cavendish bananas, average bunch weight of banana was 25.4 kg as mentioned in Table 2, compared to the conventional banana, average bunch weight of banana was 17.9 kg as mentioned in Table 3.

Indicator - 3: Foliar application of micronutrient

The study revealed that farmers are not applying the recommended dose or soil-based micronutrient applications since they are not exposed to the importance of micronutrients in enhancing Banana productivity and marketable bunch. "Banana Special" is a foliar micronutrient produced by IIHR Bengaluru for enhancing productivity. Maximum bunch weight (14.95 kg) was recorded in 3 suckers/hill with 75 % N and K fertigation. A total yield of 82.8 t/ha was recorded in 2 plants/hill with 75 % N and K fertigation. For export-quality fruits, 3 suckers/hill under a Paired Row system with 75 % N and K

Table 1. Questionnaire response

S. No	Question	Percent
1	Knowledge about KVK	80
2	Experience in Banana cultivation	15-45 years
3	Knowledge in adoption of technologies	15
4	Knowledge on Micronutrient	15
5	Knowledge about Banana Special	10
6	Application of Banana Special	10
7	Knowledge about Time of application	95

Table 2. Demonstrated plot details

Farmer	Bunch weight (kg)	Number of Marketable Bunch/ha	Yield (quintal)	Gross Cost (₹)	Gross Return (₹)	Net Return (₹)	B:C Ratio
1	22.5	2100	420	110000	420000	310000	3.82
2	24.5	2076	450	109000	415200	306200	3.81
3	21.3	2150	458	110500	430000	319500	3.89
4	27.6	2168	430	113000	433600	320600	3.84
5	22.8	2090	477	111200	418000	306800	3.76
6	29.6	1970	380	113000	394000	281000	3.49
7	24.7	2050	460	110000	410000	300000	3.73
8	28.9	1990	440	150000	398000	248000	2.65
9	29.5	2153	450	112000	430600	318600	3.84
10	22.6	2200	450	115000	440000	325000	3.83
Average	25.4	2094.7	441	115370	418940	303570	3.7

Table 3. Check plot details

Farmer	Bunch weight (kg)	Number of Marketable Bunch/ha	Yield (quintal)	Gross Cost (₹)	Gross Return (₹)	Net Return (₹)	B:C Ratio
1	15.2	2015	380	113000	403000	290000	3.6
2	19.6	1879	368	113000	375800	262800	3.3
3	20.4	1887	385	113500	377400	263900	3.3
4	13.8	1990	275	113000	398000	285000	3.5
5	18.3	1990	364	113000	398000	285000	3.5
6	19.2	1890	363	103000	378000	275000	3.7
7	21.9	1902	417	113000	380400	267400	3.4
8	20.8	1800	418	115000	360000	245000	3.1
9	14.3	1890	270	117000	378000	261000	3.2
10	15.8	1997	316	116500	399400	282900	3.4
Average	17.9	1924.0	355.5	113000.0	384800.0	271800.0	3.4

fertigation were found superior (11).

Indicator - 4: Adoption and time of Banana Special application

Though the technology was helpful for increasing productivity, the study shows that Banana Special application is promoted by Krishi Vigyan Kendra (KVK), Pudukkottai. Farmers applied Banana Special during the morning or evening time, enhancing the efficiency of micronutrient uptake, based on the banana bunch weight as previously mentioned in Table 2. Planting before monsoon helps plants build up rapid growth and establishment before onset of cold weather. Covering fruits also raised the percentage of top-grade fruits and paper protection enhanced quality by reducing sunburn.

Indicator - 5: Socio-economic Profile of the Sample Respondents

Most banana growers were middle-aged and lived in joint families with medium-sized households. All practiced irrigated farming on an average of 1 acre, with sandy loam being the predominant soil type. Their primary occupation was agriculture, with a modest average income of ₹69,000. The data were consolidated and mentioned in Table 2.

Indicator - 6: Cost Utilization Pattern in Banana Cultivation

The major costs in banana cultivation were plant protection and fertilizers, each accounting for ₹10000. Field preparation and wages were the least costly at ₹6000, with total cultivation expenses summing up to ₹56000. The data were calculated and mentioned in Table 3.

Indicator - 7: Input Utilization Pattern in Banana Cultivation

The resource-poor farmers in the study area don't use any special horticultural techniques like mulching, drip irrigation and pinching due to a lack of technical knowledge. Both open irrigation and drip irrigation exist in the area. Farmers are unaware of pruning, foliar application and plant protection practices. They don't use organic inputs like FYM, bio-fertilizers, or organic pesticides, affecting yields. Awareness about nutrient management strategies is necessary to improve yield sustainably.

Indicator - 8: Labour Utilization Pattern in Banana Cultivation

Harvesting required the highest labour input with 100 man-days, indicating its labour-intensive nature (12). Other significant labour activities included sowing (30 man-days) and mulch collection (24 man-days); while grading and intercultural operations required relatively less manpower. The data were collected, consolidated and mentioned in Table 4.

Indicator - 9: Spread of Technology

The technology was spread through Krishi Vigyan Kendra (KVK), Vamban, Pudukkottai.

Indicator - 10: Constraints Faced in Banana Cultivation

The major constraints faced are high labour costs, non-availability of quality seed, lack of technical knowledge,

Table 4. Socio-economic profile of the Banana growers

S.No	Basic details	Variations	No. of persons
1	Age group of the farmers	40-50, 30-40, 20-30	6, 3, 1
2	Education	10, 12, Degree	0, 7, 3
3	Family Type	Joint family, Single	6, 4
4	Family size	Small, Medium, Big	1, 6, 3
5	Agriculture as occupation	Primary	10
6	Average Annual Income	₹69000	10
7	Average area under Banana cultivation	1 acre	10
8	Growing pattern	Irrigated, Rainfed	10, 0
9	Soil pattern	Red, Sandy loam	3, 7

Table 5. Cost utilization pattern in Banana cultivation

S.No	Particulars	Cost (₹)
1	Field preparation	6000
2	Nursery and planting/sowing	8000
3	Weeding	8000
4	Plant protection	10000
5	Fertilizers	10000
6	Wages	6000
7	Staking, transport & other expenses	8000
	Total	**56000**

financial obligations, inadequate market information and low productivity as mentioned in Table 5.

Indicator - 11: Cost details and Benefit-Cost Ratio with Yield

The demonstrated plots significantly outperformed the check plots in all key indicators. On average, they yielded 441 quintals/ha compared to 35.55 t/ha in check plots, with higher net returns (₹303570 vs ₹271800) and a better benefit-cost ratio (3.7 *vs.* 3.4), highlighting the effectiveness of improved practices (See Table 6 and 7).

Table 6. Labour utilization pattern

S.No	Description	Man × days	Total manpower
1	Land preparation	5	5
2	Ploughing (by bullocks)	10	20
3	Mulch collection	12 × 2	24
4	Mulching	10 × 1	10
5	Sowing	10 × 3	30
6	Weeding	5 × 2	10
7	Special and intercultural operation	2 × 5	10
8	Harvesting (plucking)	5 × 20	100
9	Grading and packing	1 × 20	20

Table 7. Constraints faced by Banana growers

S.No	Particulars	Rank
1	High cost of labour	I
2	Personal obligation with Traders	II
3	Financial weakness	III
4	Lack of technical knowledge	IV
5	Lack of storage facilities	V
6	Low productivity	VI
7	Non-availability of quality seed	VII
8	Inadequate market information	VIII

Discussion

Cost of cultivation

The study shows that the Cost of Cultivation increased in the Banana Special applied field to ₹115370/ha compared to ₹113000/ha in existing farming practices. By adopting this technology, a 24 % yield increase was recorded. The average incremental benefit from Banana Special was ₹303570/ha (13). The marketable quantity is high in the treated area, indicating that micronutrients directly or indirectly influence marketable bunches (14-18).

Gross cost and net return

In the control, the maximum gross cost was ₹117000 and the minimum was ₹103000, with an average of ₹113000. In the demonstrated method, the maximum gross cost was ₹150000 and the minimum was ₹109000. Regarding Net Return in demonstrated plots, the maximum was ₹325000 and the average was ₹303570. In the control, the minimum Net Return was ₹245000, with an average of ₹271800.

Benefit-cost ratio

The Benefit-cost ratio for the demonstrated method was 3.7, while it was 3.4 for the control.

These findings are consistent with earlier studies, which reported yield gains and economic viability through micronutrient-based interventions in banana farming (19, 20).

Conclusion

Banana cultivation in Pudukkottai district, a major fruit crop region, is facing a continuous decline in productivity. To meet domestic needs, expand commercial marketing and support exports, enhancing productivity has become essential. Banana farming is capital-intensive and demands significant investment. Technological interventions such as pairing and pralinage, desuckering, propping, denaveling, foliar application of micronutrients (Banana Special), bunch covering, soil application of biocontrol agents, crop rotation, mulching and plant protection measures have been effective in increasing bunch weight, resulting in a 20 % higher yield and a B:C ratio of 3.7 at the demonstration fields compared to 3.4 in control plots. Combining indigenous practices (e.g., ash-based pest control) with Banana Special could enhance cost-effectiveness and farmer trust. Further, the selection and cultivation of improved local cultivars with higher bunch weight and resistance to pests and diseases, coupled with proper irrigation management, organic input application and the use of botanical formulations and biocontrol agents, can significantly enhance productivity. The study also highlighted that fresh banana bunches fetch lower prices compared to processed and value-added products. Therefore, encouraging farmers to engage in on-farm processing through the provision of subsidies and low-interest loans for establishing small-scale processing units is recommended. Government support through policy initiatives, subsidies and skill development training will play a pivotal role in ensuring the long-term sustainability and profitability of banana cultivation in the region. Extension agencies should prioritize training programs on micronutrient management and encourage farmer cooperatives for shared access to processing units, thereby enhancing both productivity and profitability.

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Authors' contributions

KD and KC conducted the research deign participated in data collection and drafted the manuscript; KC, MR and CB performed the statistical data analysis; JE, KK, TS and PD involved in preparation and alignment of data. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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