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Advancing environmental sustainability through frontline demonstration of bio fertilizers

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Abstract
To create awareness for use of bio fertilizers and the adoption of new input in mango var. Kesar and sapota var. Kalipatti demonstrations were conducted during the year 2020-21 in different blocks of Navsari district *viz*., Navsari, Jalalpore and Gandevi. Use of bio fertilizer in demonstrated plot resulted in higher yield (97.00 and 129.00 q/ha) compared to check plots (86.50 and 113.50 q/ha) in mango and sapota fruit crops, respectively. The yield increase compared to check field plots was 12.14 and 13.66% in mango and sapota crops, respectively. The extension gap was recorded in mango and sapota was 10.50 q/ha and 15.50 q/ha. Similarly, the technical gap was recorded 8.00 q/ha in mango and 21.00 q/ha in sapota. The technology index recorded 7.62% in mango and 14.00% in sapota. The benefit-cost ratio was recorded higher in the demonstrated plot of mango (3.66) and sapota (3.46) fruit crops compared to the check plot which was recorded 3.43 and 3.15, respectively. Moreover, net return increase percent in mango was also recorded 15% and 18% in sapota.

Keywords: Bio fertilizers, extension gap, mango, sapota and yield

Introduction
Fruit is a tasty and nutritious natural food that supports the body's functioning. It is rich in vitamins, minerals, and fibres. The fruit production sector is crucial for the environment, economy, and livelihoods of farmers. However, challenges in production, knowledge transfer, and high prices limit access, particularly in developing countries like India.

India is the world's third-largest economy, with the highest fruit production in Banana (26.08%), Papaya (44.05%), and Mango (45.89%). It is the second-largest fruit producer globally, accounting for 11% of the total production. However, the per capita availability of fruits in India is only 46 gm per day, half of the recommended amount of 92 gm. Low productivity, small land holdings, and poor orchard management contribute to this, especially in rain-fed areas, which cover over 60% of fruit-growing regions. Hence, there is a great scope for increasing fruit production by increasing productivity besides bringing more area under fruit crops. (Tala, 2020).

Mango (*Mangifera indica* L.) and sapota [*Manilkara acharas* (Mill.) are main fruit crops grown in Navsari district of Gujarat (Bhalekar and Chalak, 2016) [2]. Mango, often referred to as the 'National fruit of India' and the King of Fruits, holds significant value in tropical regions, akin to the importance of apples in temperate zones. Sapota, on the other hand, is a delicious fruit popularly used in milkshakes and provides consistent income to farmers for around 5 to 6 months in a year. (Gurjar *et al.*, 2022) [6]. The favourable conditions of medium black soil, warm climate, and moisture in Navsari district make it an ideal environment for cultivating these fruit crops.

Less use of well-decomposed farmyard manure (FYM) and higher use of chemical fertilizers has given hazardous effects on overall soil health. This resulted in the deterioration of soil's physical and chemical properties resulting in stagnation in the yield of the crop and if the trend continues, it will have disastrous consequences (Hiwale *et al.*, 2010) [8]. The use of organic matter along with bio-fertilizer improves the availability of nutrients from the soil. (Ram and Rajput, 2000) [12]. The importance of biofertilizers lies in their ability to enhance soil fertility, promote sustainable agriculture, protect the environment, and contribute to cost-effective and healthy crop production.

To assess the impact of azotobacter, phosphorus solubilising bacteria (PSB), and potash mobilizing bacteria (KMB) in farmer's fields, KVK Navsari conducted demonstrations with the objectives of:

- Studying the influence of bio fertilizers on mango and sapota yield
- Evaluating the economic viability of bio fertilizer usage
- Assessing productivity.

Materials and Methods

Krishi Vigyan Kendra, Navsari conducted front line demonstrations on scientific cultivation practices for mango (Kesar variety) and sapota (Kalipatti variety) in Navsari district during the Kharif season of 2020-21. A total of 96 FLDs covering 38.40 hectares were conducted for mango, and 34 FLDs covering 13.60 hectares were conducted for sapota. The demonstrations took place on farmers' fields in Navsari, Jalalpore, and Gandevi taluka (Block) of Navsari district, with irrigation and good drainage facilities.

The site selection, farmer selection and layout of the demonstration followed as suggested by Choudhary (1999) [3]. Farmer lists were prepared through surveys and meetings, and skill training was conducted at the KVK campus on scientific cultivation practices and plant protection measures. Navsari Agricultural University made bio-fertilizers (azotobacter, phosphorus solubilising bacteria and potash mobilizing bacteria) were demonstrated in 2-liter quantity (50 ml per plant) to each farmer. Recommended doses of fertilizers and manure were used in the demonstration plots (750-160-750 gram NPK/plant/year in mango with 20 t/ha well-decomposed Farm Yard Manure and 1000-500-500 gram NPK/plant/year in sapota with 20 t/ha well-decomposed FYM). Traditional practices were maintained in the local check plots. Yield data were collected from both FLD plots and check plots, and the benefit-cost ratio was calculated. Production cost and monetary returns data were collected for the economic feasibility analysis of sapota and mango cultivation. The technology gap, extension gap, and technology index were calculated following the methods suggested by Eswaraprasad *et al*. (1993) [4] and Samui *et al*. (2000) [13].

Extension Gap = Demonstration Yield – Farmer Yield

Technical Gap = Potential Yield – Demonstration Yield

Technical Index = (Technical Gap / Potential Yield) *100

Results and Discussion

Different bio fertilizers, including PSB, KMB and Azotobacter, significantly influenced the yield of mango and sapota fruit crop. The demonstration field plot (Table-2) showed higher yields (97.00 and 129.00 q/ha) compared to the check field plot (86.50 and 113.50 q/ha) in both mango and sapota crops. The use of bio fertilizers resulted in a yield increase of 12.14% and 13.66% for mango and sapota, respectively. Similar results were found in previous studies by Meena *et al*. (2012) [10].

The mango demonstration plot yield (97.00 q/ha) also outperformed the national (96.64 q/ha), state (74.20 q/ha) and district averages (91.92 q/ha) (Table-2) (Anonymous, 2018) [1]. Similarly, in Sapota demonstration plot yield (129.00 q/ha) also better performed over the national (121.24 q/ha), state (110.44 q/ha) and district averages (126.90 q/ha). The higher yield in the demonstration plot was attributed to the use of bio fertilizers and farmyard manure, which improved nutrient availability and plant capacity. Similarly, findings were obtained by Kapur *et al.* (2020) [9] in brinjal, Patel and Naik (2010) [11], Gawande *et al*. (1998) [5] in sapota and Shaktawat and Chundawat (2021) [14] in oilseeds crop.

In the Navsari district, the potential yield (Table 2) in Kesar Mango was 105.00 q/ha, while for sapota, it was recorded 150.00 q/ha for 10 years old tree planted with distance of 10 m x 10 m. (Gurjar *et al*., 2023) [7]. The extension gap in mango was 10.50 q/ha and in sapota, it was 15.50 q/ha, indicating a lack of awareness about scientific orchard management and the use of organic manure and biofertilizers. Farmers need training on proper cultivation methods through meetings, training sessions, diagnostic visits, and concept clearance. The technical gap was 8.00 q/ha in mango and 21.00 q/ha in sapota, highlighting the need for farmer education on the adoption of scientific production technology. The technology index was 7.62% in mango and 14.00% in sapota, with sapota showing more feasibility compared to mango. These results are in close conformity with Gurjar *et al.*, (2023) [7].

The economic analysis (Table-3) showed that the gross cost in the bio-fertilizer demonstration plot was 66,200 Rs/ha, while in the mango check plot, it was 63,000 Rs/ha. This increase in cost is attributed to the expenses associated with bio-fertilizer and its application in the field. In terms of gross return, the mango demonstration plot recorded 2,42,500 Rs/ha, whereas the check plot recorded 2,16,250 Rs/ha. The net return in the demonstration plot was 1,76,300 Rs/ha, compared to 1,53,250 Rs/ha in the check plot. Additionally, the benefit-cost ratio was higher in the demonstration plot (3.66) compared to the check plot (3.43), which could be attributed to improved nutrient absorption from the soil.

In the sapota fruit crop, the gross cost in the demonstration plot was 84,000 Rs/ha, while in the check plot it was 81,000 Rs/ha. The increase in gross cost in the demonstration plot is attributed to the cost of the demonstration and its application charges in the field. The gross return in the sapota demonstration plot was 2,90,250 Rs/ha, compared to 2,55,375 Rs/ha in the check plot. The net return in the demonstration plot was 2,06,250 Rs/ha, while in the check plot it was 1,74,375 Rs/ha. The benefit-cost ratio in the demonstration plot was higher (3.46), compared to the check plot (3.15). This better performance may be due to improved nutrient absorption from the soil, resulting in higher yield. Similar findings were observed by Gurjar *et al*., (2023) [7].

Table 1: FLDs organized, area, participation and the average yield of district state and national yield in mango and sapota during the year 2020-21.

	FLD organized			Area (ha)	Total Participant	National average yield (q/ha)	State average yield (q/ha)	District average yield (q/ha)
Sr. No.	Crop	Variety	Season					
1	Mango	Kesar	Kharif	38.40	96	96.64	74.20	91.92
2	Sapota	Kalipatti	Kharif	13.60	34	121.24	110.44	126.90

Average yield is taken from Horticultural statistics at a glance. (Anonymous, 2018) [1].

Table 2: Yield performances of Bio fertilizers FLDs organized on mango and sapota crop scientific cultivation practices during the year 2020-21

Sr. No.	Name of crop and variety demonstrated	Age of the tree Planting (10 m *10 m)	Yield obtained (q/ha)		Yield increase (%)	Potential yield of the demo variety (q/ha)	Extension gap (q/ha)	Technical gap (q/ha)	Technical index (%)
			Demo Average	Check Average					
1	PSB, KMB and Azotobacter in mango	10	97.00	86.50	12.14	105.00	10.50	8.00	7.62
2	PSB, KMB and Azotobacter in sapota	10	129.00	113.50	13.66	150.00	15.50	21.00	14.00

Table 3: Expenditure and return performances of Bio fertilizers FLDs organized on mango and sapota crop during the year 2020-21

Sr. No.	Demonstration detail	Expenditure and Returns (Rs./ha)										
		Demo				Check				Net Return increase percent	Additional cost	Additional return
		Gross Cost (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B: C ratio	Gross Cost (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B: C ratio			
1	PSB, KMB and Azotobacter in Mango	66,200	2,42,500	1,76,300	3.66	63,000	2,16,250	1,53,250	3.43	15	3,000	23,050
2	PSB, KMB and Azotobacter in sapota	84,000	2,90,250	2,06,250	3.46	81,000	2,55,375	1,74,375	3.15	18	3,000	31,875

Conclusion

The study found that using recommended application of bio fertilizers with decomposed FYM resulted in a 12.14% and 13.66% increase in yield, as well as a 15.00% and 18.00% increase in net returns for mango and sapota fruit crops, respectively. The utilization of organic matter along with bio-fertilizer improves the availability of nutrients from the soil which ultimately reduces use of chemical fertilizer. Biofertilizer improves more efficient utilization form the soil and helps to environment and ecology. However, there were gaps in technical knowledge and extension practices between the demonstration and farmer's methods. By implementing recommended practices, bio-fertilizers (azotobacter, phosphorus solubilising bacteria and potash mobilizing bacteria) and improving extension activities, farmers can achieve their maximum yield potential contributing to environment sustainability and healthier ecosystems.

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