Research Article

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Impact assessment of integrated pest management technology for ber fruit fly (*Carpomya vesuviana* Costa) under arid and semi-arid regions of Rajasthan

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ABSTRACT

The adoption of IPM approaches in ber resulted in a lower incidence of fruit damage, with a 65% mean reduction compared to farmer's practices. Mean higher yield of 111.2 q/ ha was recorded in the demonstration compared to 77.84 q/ ha in farmer's practice, representing a 42.86% increase. This has resulted in higher mean net returns of Rs. 1,79,640/- ha with a Benefit Cost Ratio (BCR) of 3.76 in the demonstration, compared to Rs. 1,08,248/- ha in farmer's practice with a BCR of 2.72. The current study's findings clearly indicated that using IPM technology against the ber fruit fly was more effective and economical than conventional methods.

Introduction

The ancient fruit known as ber (*Ziziphus mauritiana* Lamk) is native to India and many other Asian nations, it has been cultivated nationwide for hundreds of years. Ber is the fruit crop that requires the least amount of care and inputs to grow. It is a significant fruit crop that is widely cultivated throughout the country's arid and semi-arid regions, including Rajasthan, Haryana, Punjab, Gujarat, and others. The National Horticulture Board reports that in 2018–19, India produced 5,39,000 MT of ber crop on 50,000 hectares of land (Anonymous, 2018-19). It is a long-standing and reputable fruit crop in the state of Rajasthan.

Approximately 80 insect pest species have been known to attack ber trees (Butani, 1979). Depending on the location, type, and time of year, these pests directly harm significant export crops, resulting in losses ranging from 40% to 80% (Kibira *et al.*, 2010). New insect species have emerged because of climate change, severely harming crops. The peak activity period of a given insect species can differ significantly depending on the location. With the exception of the ber fruit fly, *Carpomyia vesuviana* Costa, the majority of these have been classified as minor pests. This major insect pest is well-established in all countries where ber is grown. In India, it is one of the most infamous monophagous pests. The majority of *Ziziphus* species cultivated worldwide are infested by fruit flies, which inflict internal harm. In extreme situations, it can result in yield loss of up to 80% or even 100% (Karuppaiah, 2014). Fruit fly losses are so severe that

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they are now proving to be a limiting factor in the successful cultivation of ber in all districts of Rajasthan and Haryana that produce ber. Very few ber trees are immune to its attacks (Lakra and Singh, 1984).

Integrated pest management (IPM) technology has been shown to be the best alternative to minimise fruit fly infestation while lowering the load of chemical pesticides to achieve higher yield and income. This is because increased reliance on pesticides for pest control has been shown to be unsustainable and cost-ineffective. IPM techniques that were found to be effective against conventional practice were demonstrated in the demonstration, including deep summer ploughing in orchards, soil racking to expose pupae, the use of methyl eugenol lure traps at 12 traps/ha for fly monitoring and collection, the application of quinalphos 25 EC @ 2 ml/ liter water at the pea size stage of fruits, and the use of neem oil 1500 ppm @ 4 ml/ litre water 20 days after the initial spray. The majority of farmers were found to not employ integrated approaches for pest management, which led to a significant extension gap between farmer's techniques and demonstrated technology. In order to close that gap, KVK, Pali used FLDs to demonstrate integrated pest management (IPM) technology, which aims to increase both marketable yield and quality production, to control ber fruit flies at farmer's fields.

Material and Methods

The current study was conducted by the ICAR-CAZRI, Krishi Vigyan Kendra, Pali-Marwar (Rajasthan) during three consecutive years 2021 to 2023 at KVK farm (Lat. 25.802174°; Long. 73.288608°) and farmer's fields (Gajangarh: Lat 25.824319°, Long 73.200850°; Jadan: Lat 25.841148°, Long 73.483889° and Hingola Kalan: Lat 25.654284°, Long 73.506476°). Before conducting FLDs, gathered the basic information on ber cultivation techniques, acceptable high yielding varieties, and the occurrence of insect-pests in ber ecosystem through field surveys and farmer meetings to determine the current pest management tactics and, as a result, IPM practices for fruit fly management were implemented. The yield data was obtained from FLD orchards along with local farming practises for comparative analysis. Under demonstration plots, we have provided critical inputs such as neem oil 1500 ppm, methyl eugenol trap and quinalphos 25 EC to manage the fruit fly and provided technical advice on other IPM practices like cultural and mechanical practices throughout the season.

To monitor the activity of flies' methyl eugenol trap were installed at the time of first flowering and the lure of trap were change at 25-30 days interval. According to fly activity, one foliar spray with neem oil 1500 ppm @ 4 ml per litre water done before the flowering as precautionary measure and subsequent spray of quinalphos 25 EC @ 2 ml per litre water was applied at the pea size stage of fruits to prevent the egg laying of fruit flies. Thereafter, another spraying of neem oil with same concentration applied after 20 days of second spray. On the other hand, farmers were allowed to continue with their conventional techniques in the event of a local check where majority of farmers were relied on the use of Monocrotophos 36 SL to control this pest which is already banned in orchard crops. Field days and farmer meetings were conducted so that other farmers could learn about the benefits of the varieties and technologies on display. For comparison study, data on several parameters such as fruit yield and per cent damage by fruit fly were gathered separately from both improved practise (IP) and farmer's practise (FP). Furthermore, data were tabulated and analysed by using statistical tools like frequency and percentage. The extension gap, technology gap and technology index were worked out as per formulas given by the Samui *et al.* (2000) and Prasad *et al.* (2022).

$$\text{Per cent increase in yield (kg/ha)} = \frac{\text{Yield gain in IP plot} - \text{Yield gain in FP plot}}{\text{Yield gain in FP plot}} \times 100$$

$$\text{Technology gap} = \text{Potential yield} - \text{Demonstration yield}$$

$$\text{Extension gap} = \text{Demonstration yield} - \text{Yield under existing practice}$$

$$\text{Technology index} = [(\text{Potential yield} - \text{Demonstration yield}) / \text{Potential yield}] \times 100$$

$$\text{Impact on yield (\% change)} = \frac{\text{Yield of demonstration plot} - \text{Yield of farmer's practice}}{\text{Yield of farmer's practice}} \times 100$$

Results and Discussion

Yield performance

The marketable ber fruit yield was considerably higher in the demonstrated plots with IPM technology compared to existing practices during all three years of the study, according to the findings of frontline demonstrations (FLDs) held at farmer's fields during *Kharif*, 2021-22 to 2023-24 (Table 1). The severity of insect pests, the microclimate that prevailed during the season, variations in orchard management techniques, and other social and economic problems all contributed to ber's annual fluctuations in fruit yield. In 2021-22, 2022-23, and 2023-24, the average yield (Fig. 1) under improved practice (IP) was 10885, 11099, and 11376 kg ha^{-1}, respectively, compared to 7160, 7672, and 8521 kg ha^{-1} under farmer's practice (FP). The mean yield for all three years was 42.85% higher in demonstration plots (11120 kg ha^{-1}) than in existing practice (7784 kg ha^{-1}). Similar yield increases were noted by Kumar *et al.* (2024) in papaya and Nyangau *et. al.* (2017) when evaluating the IPM technology for mango fruit flies. The results also showed that the district's ber growers, who embraced the latest agricultural technologies implemented in the KVK's frontline demonstration plots, saw a notable increase in the average marketable fruit yield of ber throughout the study period as a result of IPM practices.

Table 1. Yield gap analysis of ber

Year	No. of FLD	Area (ha)	Demo (IP)*yield(kg/ ha)	Local (FP) yield (kg/ ha)	% Yield increase over FP	Ext. gap (kg/ ha)	Tech. gap (kg/ ha)	Tech. index (%)
2020-21	20	10	10885	7160	52.03	3725	3115	22.25
2021-22	20	10	11099	7672	44.67	3427	2901	20.72
2022-23	20	10	11376	8521	33.51	2855	2624	18.74
Average			11120	7784	42.85	3335.67	2880	20.57

*IP=Improved practice; FP= Farmer's practice

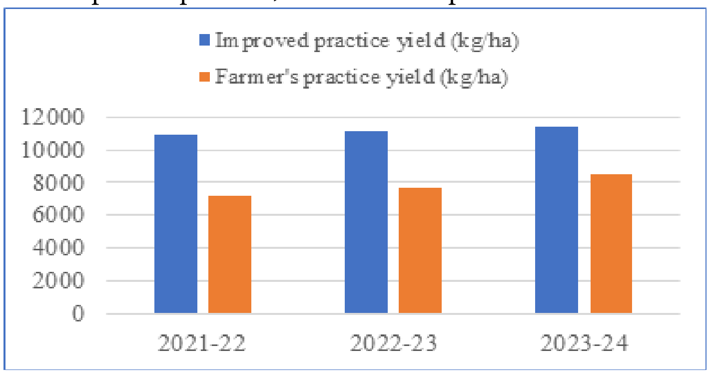

Fig. 1. Yield comparison in improved practice and farmer's practice

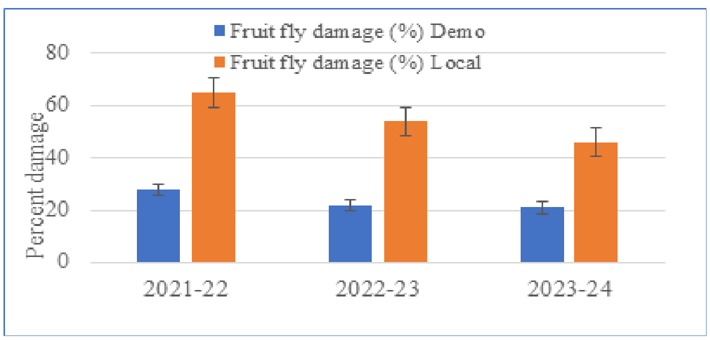

Fig. 2. Per cent damage caused by fruit fly in ber

According to the data (Fig. 2), fruit fly infestation was at its worst in farmer's practices (46–65% damage), whereas in demonstration plots, it ranged from 21-28%. This indicates that Integrated Pest Management (IPM) technology significantly reduced fruit fly damage in demo plots. The results of Kibira *et al.* (2010) corroborate the data regarding the extent of fruit fly infestation.

Gap analysis

The technological gap, which quantifies the discrepancy between the potential and demonstrated yield, was higher in 2021-22 (3115 kg ha^{-1}), 2022-23 (2901 kg ha^{-1}), and 2023-24 (2624 kg ha^{-1}). As indicated in Table 1, the average technology gap during the three years of technology investigation was Rs. 2880 kg ha^{-1}.

It has been demonstrated that there is still a gap in technology demonstration, which prevents adopting farmers from realising the potential yield of improved practices. Differences in orchard management, such as soil fertility, irrigation water availability and quality, insect-pest attack, and fluctuating weather conditions throughout the crop season at various locations, may be the cause of the technological gap assessment. Singh and Sharma (2018) and Kumar *et al.* (2024) reported similar results. The yield difference between a demonstration plot and a conventional plot is measured by this extension gap. The 2021 extension gap was the highest at 3725 kg ha^{-1}, while in 2023 extension gap was the lowest at 2855 kg ha^{-1} (Table 1).

The average extension gap in the improved practices orchard was 3336 kg ha^{-1}. This gap needs to be reduced using a variety of extension strategies, such as frontline demonstrations, capacity building initiatives, *Kisan Gosthies*, etc. on IPM and scientific orchard management practices. These initiatives could help farmers to implement IPM for managing ber fruit flies, which would close the extension gap. The results of Prasad *et al.* (2022), Singh and Sharma (2018), and Sagar and Chandra (2004) corroborated the current studies.

The technological gap as a percentage of potential yield was displayed by the technology index. It also shows how advanced technologies can be used in the fields of farmers. The findings (Table 1) show that the year 2021 had the highest technology index value (20.25%), while the year 2023 had the lowest rate (18.74%). The average ber crop technology index over the three years of demonstration was 20.57%. According to Sagar and Chandra (2004), a technology's acceptability and practicality are always inversely correlated with its technology index value; the more widely accepted the proven technology, the lower its index value. Tetarwal (2021) and Kumar *et al.* (2014) came to similar conclusions.

Economic performance

The essential requirement for an enhanced technology to be shown on farmers' fields to calculate the profit margin over current technology is economic viability. ber production and cultivation costs under frontline demonstrations were gathered and analysed to determine the benefit cost ratio, net return (Rs./ ha), gross return (Rs./ ha), and additional income (Rs./ ha). It is essential to comprehend the economic viability of each strategy demonstrated on farmers' fields to assess their profit over current technology.

Table 2. Economic analysis of front line demonstrations on ber

Year	Cost of cultivation (Rs./ ha)		Gross return (Rs./ ha)		Net return (Rs./ ha)		Additioal return (Rs./ ha)	B:C Ratio	
	IP*	FP	IP	FP	IP	FP		IP	FP
2021-22	62735	60613	239470	157520	176735	96907	79828	3.82	2.60
2022-23	68764	66378	266376	184128	197612	117750	79862	3.87	2.77
2023-24	75581	72425	284400	213025	208819	140600	68219	3.76	2.94
Average	69027	66472	263415	184891	194389	118419	75970	3.82	2.78

*IP=Improved practice; FP= Farmer's practice

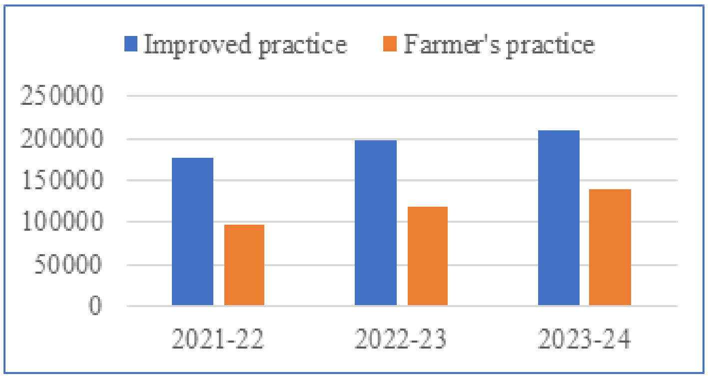

Fig. 3. Net return received from ber crop

Over a three-year period (Table 2 & Fig. 3), proven IPM techniques generated a higher net return of Rs. 194389 ha^{-1} than farmers' techniques (Rs. 118419 ha^{-1}). Furthermore, despite an increased input cost of Rs. 2555 ha^{-1}, the FLD plots provided an average additional return of Rs. 75970 ha^{-1} and a higher average benefit cost ratio of 3.82 when compared to farmers' practice (2.78). The current results are consistent with those of Muriithi *et al.* (2016) and Patel et al. (2013).

Conclusions

IPM demonstrations for the ber fruit fly were effective in reducing (132 per cent) pest damage, increasing yield by 42.85 per cent, and improving farmer's economic condition with an additional return of Rs. 75,970 ha^{-1}. The economic analysis results indicate that the demonstrated technology is more profitable and commercially viable. The use of IPM practices such as methyl eugenol traps, botanicals, and cultural practices can aid in the production of more marketable quality fruits at lower costs. Using this technology, farmers can increase their profits while incurring fewer additional input costs. Scaling up such demonstrations, combined with training programs, has the potential to accelerate IPM adoption while ensuring long-term quality ber production. Future research should concentrate on improving trap designs, botanicals, and biological controls that are specific to regional fruit fly species.

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Conflict of interest

All authors agree to publication and there is no any conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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