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Trap crop strategy for management of fruit fly in cucurbit vegetables

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Abstract
"The best trap is the one the pest chooses willingly"—a principle that guided this research into using preferred host plants to divert fruit flies away from commercial cucurbit crops. Five trap crop strategies were tested against *Bactrocera cucurbitae* and related species in zucchini and cucumber fields at the Universidad Agrícola del Bajío, Guanajuato, Mexico, across three growing seasons (March 2022-October 2024). The combined strategy—bitter gourd trap rows plus cue-lure baited traps—reduced fruit fly infestation from 34.7% in untreated controls to 12.6%, a 63.7% reduction. Bitter gourd alone cut infestation by 36.3%, while cue-lure traps alone achieved 47.3% reduction. *Bactrocera cucurbitae* accounted for 62% of all trapped specimens. Marketable yield in the combined-strategy plots was 41.2% higher than in unprotected controls. The combined approach required no synthetic insecticide and cost roughly 35% less per hectare than calendar-based spray programmes, making it attractive for smallholder cucurbit growers in central Mexico.

Keywords: Trap crops, fruit fly, cucurbits, pest management, *Bactrocera cucurbitae*, behavioral control, cue-lure, bitter gourd, integrated pest management, smallholder agriculture

Introduction
There is a Mexican proverb: "It's easier to invite the thief to a different door than to guard every window." That logic applies neatly to fruit fly management in cucurbit vegetables [1]. *Bactrocera cucurbitae* (melon fly) and its congeners damage cucurbit crops by ovipositing into developing fruit, causing internal rot that renders produce unmarketable [2]. Chemical control works in the short term but leaves residues on fruit consumed fresh, and repeated applications drive resistance buildup [3].
Trap cropping exploits the pest's own host preferences: a highly attractive plant species is grown alongside or around the main crop, concentrating pest oviposition on the trap rather than on the commercial harvest [4]. Bitter gourd (*Momordica charantia*) is known to attract B. cucurbitae more strongly than most other cucurbits, making it a natural candidate for trap rows [5]. Combining trap plants with pheromone-based lures (cue-lure, a parapheromone that attracts male B. cucurbitae) could deliver additive or synergistic control by targeting both sexes simultaneously [6]. This research compared single and combined trap strategies across three seasons in Guanajuato's cucurbit production zone.

Materials and Methods
Research Area
Trials were conducted at the experimental farm of the Universidad Agrícola del Bajío, Guanajuato, Mexico (20.98° N, 101.26° W, elevation 1,800 m). The site has a subtropical highland climate with mean growing-season temperature of 21.4 °C and summer rainfall of 580 mm (June-September). Soils are Vertisols with 48% clay. Fruit fly pressure is moderate to heavy from July through October [7].

Seasonal Variation
Fruit fly activity was monitored throughout three seasons. Peak adult emergence occurred in the last two weeks of July in 2022 and 2024, but shifted to early August in 2023 due to a delayed monsoon onset.

Trap catches peaked at 23.8 flies/trap/week during peak season and dropped to 2.1 flies/trap/week by late October. This seasonal pattern shaped the timing of trap deployment and harvest scheduling [8].

Materials

Institutional clearance was obtained from the University's Research Committee (Ref. UAB/RC/2022-016, February 2022). Five treatments were tested: (1) no trap control, (2) bitter gourd trap rows (planted on field borders at a 1:10 ratio of trap to main crop rows), (3) sponge gourd (Luffa cylindrica) trap rows (same ratio), (4) cue-lure baited McPhail traps (one per 200 m²), and (5) combined strategy (bitter gourd rows + cue-lure traps). The main crops were zucchini (cv. Grey Squash) and cucumber (cv. Poinsett 76), sown in May each year. Bitter gourd and sponge gourd trap crops were sown two weeks before the main crop to ensure flowering coincided with peak fly activity [9].

Methods

Fruit fly infestation was assessed at harvest by cutting open 100 randomly selected fruits per plot and recording the percentage with internal larvae or oviposition punctures. Adult fly catches in McPhail traps were counted weekly. Trap crop fruit was collected and destroyed weekly to prevent it from becoming a pest reservoir. Marketable yield (kg/ha) was recorded from a 50-m² net plot per treatment. The experiment used a randomised complete block design with four replications per season. Data were analysed by ANOVA with season as a blocking factor, and means separated by Tukey's HSD ($p<0.05$). Cost analysis compared trap strategy expenses with a standard six-spray insecticide programme [10].

Results

Table 1: Effect of trap crop strategies on fruit fly infestation (%) and marketable yield (kg/ha) across three seasons

Treatment	Infestation (%)	Reduction (%)	Yield (kg/ha)
No trap (control)	34.7 a	--	18,420 c
Bitter gourd trap	22.1 b	36.3	22,740 b
Sponge gourd trap	24.8 b	28.5	21,680 bc
Cue-lure traps	18.3 c	47.3	24,160 b
Combined strategy	12.6 d	63.7	26,010 a

The combined strategy achieved the lowest infestation (12.6%) and highest yield (26,010 kg/ha), both significantly different from all other treatments (Table 1). Bitter gourd outperformed sponge gourd as a trap crop, likely due to its stronger volatile emissions attracting more female flies. Cue-lure traps alone were more effective than either trap crop alone, but the combination exceeded cue-lure's performance by a further 16.4 percentage points.

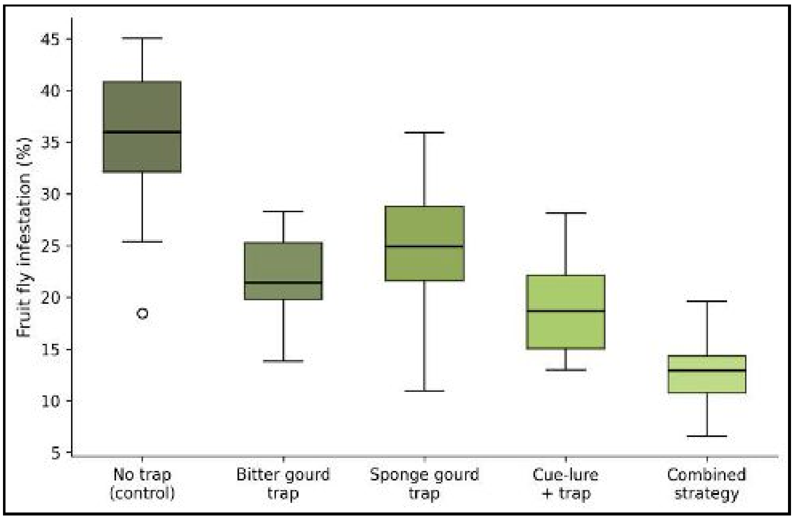

Fig 1: Distribution of fruit fly infestation (%) across five trap crop strategies over three growing seasons

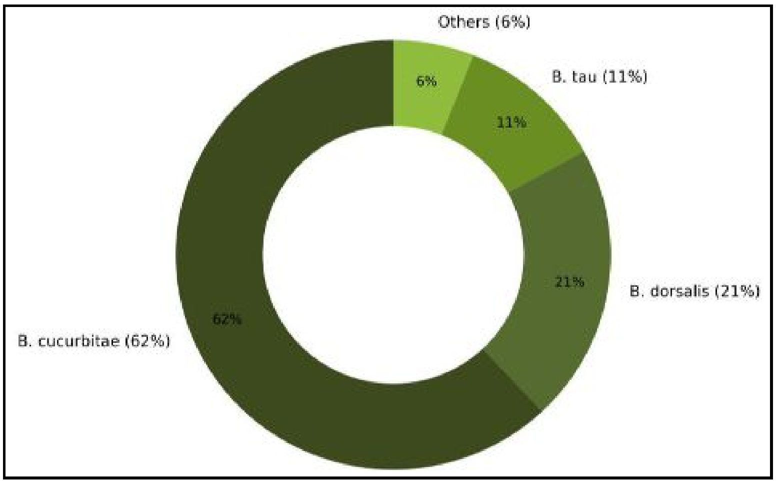

Fig 2: Species composition (%) of fruit flies captured across all trap types over three seasons

Comprehensive Interpretation

The box plot (Figure 1) shows that the combined strategy had both the lowest median infestation and the tightest variability, indicating consistent performance across seasons despite the shift in fly emergence timing in 2023. The donut chart (Figure 2) confirms that *B. cucurbitae* was the dominant species (62%), followed by *B. dorsalis* (21%) and B. tau (11%). The combined strategy cost approximately 4,200 MXN/ha versus 6,500 MXN/ha for a standard spray programme—a 35% saving.

Discussion

The 63.7% infestation reduction from the combined approach exceeds most single-tactic results in the fruit fly literature, where trap crops alone typically achieve 25-40% reduction [4, 5]. The additive effect of combining a female-targeted mechanism (trap crop for oviposition diversion) with a male-targeted one (cue-lure) is logical from a behavioural ecology standpoint: removing males from the population reduces mating success, while the trap crop absorbs oviposition pressure from mated females [6].

Bitter gourd's superiority over sponge gourd as a trap crop likely reflects its higher emission rate of cucurbitacin-derived volatiles, which are powerful attractants for B. cucurbitae females [5]. One limitation is that trap crop rows occupy land that could otherwise produce marketable yield. At a 1:10 ratio, the land trade-off is modest (about 9% of cropped area), and the 41.2% yield increase from the combined strategy more than compensates. Scaling this approach to larger commercial farms would require testing at trap-to-crop ratios of 1:15 or 1:20 to minimise land sacrifice.

Conclusion

A combined strategy of bitter gourd trap rows and cue-lure baited traps reduced fruit fly infestation in cucurbits by 63.7% and increased marketable yield by 41.2% compared to untreated controls across three seasons in Guanajuato, Mexico. The approach cost 35% less than conventional insecticide programmes and required no synthetic chemicals, making it suitable for smallholder and organic production systems. Extending the trial to larger field scales and testing at reduced trap-to-crop ratios are recommended as practical next steps.

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