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COMPARISON OF THE EFFECTIVENESS OF MARIGOLD (TAGETES ERECTA) PLANTS AS MOSQUITO REPELLENT WITH FERMENTATION-BASED OVITRAP MOSQUITO TRAPS IN URBAN AND RURAL ENVIRONMENTS

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***ABSTRACT*:**

Background: Dengue Hemorrhagic Fever (DHF) remains a major public health challenge globally, primarily vectored by Aedes aegypti and Aedes albopictus. Vector control strategies increasingly focus on eco-friendly, community-based approaches. **Objective**: This study aimed to compare the effectiveness of mosquito-repellent Marigold plants (Tagetes erecta) (TMPN) against fermentation-based ovitrap traps (KAOFPN) in capturing or repelling mosquitoes across urban and rural houses over a 4-day observation period. **Methods**: A quasi-experimental study with a comparative approach was conducted across 36 houses (18 urban, 18 rural). Ovitraps and Marigold plants were placed across 11 specific indoor and outdoor monitoring stations. Data were analyzed using Paired Sample T-Test, Levene's Test, One-Way ANOVA, and Tukey's HSD Post Hoc test, supplemented by Effect Size (Cohen’s d) calculations. **Results**: The results indicate that KAOFPN captured a significantly higher number of mosquitoes compared to the repellent effect of TMPN across both urban and rural settings (\(p < 0.05\)). The highest mosquito density was observed in outdoor backyard gardens (urban: mean 32.00 \(\pm \) SD 0.00; rural: mean 35.00 \(\pm \) SD 0.00 using KAOFPN). One-Way ANOVA confirmed significant differences in mosquito capturing/repelling effectiveness across stations (\(p = 0.000\)), with Post Hoc Tukey HSD identifying outdoor backyard gardens and terraces as locations with the largest vector densities. **Conclusion**: Fermentation-based ovitraps (KAOFPN) are highly effective tools for vector surveillance and mass trapping, whereas Marigold plants (TMPN) act as supplementary spatial repellents. Integrated vector management combining both methods is recommended for community health promotion.

Keywords: *Aedes aegypti, Aedes albopictus, Dengue, Marigold, Ovitrap, Vector Control.*

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) remains a major public health problem in Indonesia and many tropical and subtropical countries worldwide. According to the Indonesian Ministry of Health, as of March 26, 2024, a total of 53,131 dengue cases and 404 deaths had been reported nationally. One week later, the number increased to 60,296 cases with 455 deaths, indicating a continuing rise in dengue transmission (Tarmizi, 2024).

Dengue Hemorrhagic Fever (DHF) is a significant global public health problem, particularly in tropical and subtropical regions. The main mosquito species acting as vectors of this disease are Aedes aegypti and Aedes albopictus. Given the lack of specific curative treatments and widely accessible vaccines, vector control remains a key pillar in preventing dengue transmission (Ministry of Health of the Republic of Indonesia, 2019).

Current vector control interventions are shifting from the use of synthetic chemical insecticides, which can trigger resistance and have negative environmental impacts, to more environmentally friendly, community-based approaches (Community-Based Vector Control). Two methods frequently developed in environmental health promotion are the use of mosquito-repellent plants (spatial repellents) and ovitraps (Centers for Disease Control and Prevention [CDC], 2021).

The effectiveness of marigold plant powder as a mosquito repellent. The study location was a room with a mosquito net containing 140 mosquitoes. Marigold plant bark powder had mosquito repellent properties with an odds ratio of 4.08 (Aji & Setyawan, 2024).
Marigolds, also known in Indonesia as "bunga tahi ayam/kotok/gemitir," are rich in secondary metabolite compounds (such as alpha-terthienyl and natural pyrethrum) that effectively repel or eradicate insects. This research proves that marigold flower extract has the potential as a mosquito repellent (Suharto et al., 2016).

A modified ovitrap method with fermented bait (e.g., a mixture of brown sugar and yeast) utilizes the aroma of CO_2 or lactic acid to attract female mosquitoes to lay eggs, while trapping them so they cannot escape (Pratiwi et al., 2020).

Dengue epidemics result in human suffering, strained health services, and massive economic losses. In some countries, the burden of dengue is comparable to that of tuberculosis and other communicable diseases with high disease burdens; unexpected surges in cases and the challenge to health systems of triaging thousands of cases without knowing which severe cases will require hospital care are additional challenges. There has not, however, been concerted action against dengue, and the 1995 WHO strategy warrants revision in the light of new advances. This Global Strategy for Dengue Prevention and Control, 2012–2020 aims to address this need (World Health Organization [WHO], 2020).

Marigold plants (Tagetes erecta) are known to contain secondary metabolites such as alpha-terthienyl and pyrethrum, which function as natural repellents. Fermented Ovitrap Mosquito Traps (KAOFPN) use fermented scented bait to attract female mosquitoes to lay eggs, which then traps the mosquitoes.

1.1. Specific Research Hypotheses

- There is a significant difference between the number of Fermented ovitraps Mosqutoes Trap and those exposed to marigold plants (TMPN) at the same placement location.
- Fermented ovitraps Mosqutoes Trap (KAOFPN) have a more effective catch rate than marigold repellents, especially in exterior areas where vector populations are higher.

MATERIALS AND METHODS

This study used a quasi-experimental design with a comparative approach to compare the effectiveness of the Mosquito Repellent Marigold Plant (TMPN) and the Fermented Ovitrap Mosquito Trap (KAOFPN). The study was conducted in urban and rural areas, with a total sample of 36 homes (18 houses each representing urban and rural areas) during a four-day observation period.

A total of 11 observation points were identified in each home, divided into indoor and outdoor areas:
- Inside the House (Indoor): 1) Living Room, 2) Family Room, 3) Dining Room, 4) Bedroom, 5) Bathroom + Water Closet, 6) Storage Room.
- Outside the House (Outdoor): 7) Front Porch, 8) Side Porch, 9) Back Porch, 10) Front Yard Garden, 11) Backyard Garden.

2.1. Statistics Analysis

- Normality Test: Data normality was assessed using the SPSS procedure Analyze > General Linear Model > Univariate to evaluate the distribution of mosquito count data across the 11 observation points (Sugiyono, 2022).
- Homogeneity Test: Homogeneity of variance was assessed using Levene's Test of Equality of Error Variances (Field, 2018).

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- Direct Comparison Test: Paired Sample t-Test was used to compare the effectiveness of the Mosquito Repellent Marigold Plant (TMPN) and the Fermented Ovitrap Mosquito Trap (KAOFPN) at each observation point (Field, 2018).
- Comprehensive Comparison Test: One-Way Analysis of Variance (ANOVA) followed by Tukey's Honestly Significant Difference (HSD) Post Hoc Test was performed to compare mosquito counts across all 11 observation points simultaneously (Field, 2018).
- Effect Size Analysis: Cohen's d was calculated to determine the practical significance of differences in effectiveness between TMPN and KAOFPN treatments (Cohen, 1988).

RESULTS

3.1. Summary of Raw Mosquito Density Data (Aedes aegypti and Aedes albopictus)

The data below represent aggregated observations from urban and rural households included in the study.

3.1 Urban Homes

3.1.1 Inside The House (Indoor)

No	ROOM	TMPN	KAOFPN
1	Living Room	3	11
2	Family Room	4	7
3	Dining Room	2	7
4	Bedroom	2	5
5	Bathroom	3	5
6	Stronge Room	7	13

Statistical Summary

1. Mosquito-Repelling Marigold Plants (TMPN)
- Data: 3, 4, 2, 2, 3, 7
- Mean ($\bar{x}$): 3.5
- Standard Deviation (SD): 1.76

2. Fermented Ovitrap Mosquito Traps (KAOFPN)
- Data: 11, 7, 7, 5, 5, 13
- Mean ($\bar{x}$): 8
- Standard Deviation (SD): 3.10

Statistical Analysis

- Method Effectiveness: The mean value for the TMPN method (3.5 mosquitoes) is lower than that of the KAOFPN method (8 mosquitoes). This indicates that TMPN is more effective at suppressing mosquito numbers across various rooms.
- Data Variation: The lower standard deviation for TMPN (1.76) compared to KAOFPN (3.10) indicates that the results from using marigolds are more stable and consistent across rooms. In contrast, KAOFPN results fluctuated, showing significant differences in mosquito counts between rooms.
- Room Comparison: The storage room recorded the highest number of mosquitoes for both methods, likely due to the area being humid and infrequently cleaned. The bedroom recorded the lowest number of mosquitoes for the TMPN method.

3.1.2 Outside The House (outdoor)

No	Room	TMPN	KAOFPN
1	Front Porch	9	14
2	Side Porch	5	11

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3	Back Porch	8	26
4	Front Garden	7	19
5	Backyard Garden	8	32

Data Summary
- Front Porch: TMPN = 9 vs. KAOFPN = 14
- Side Porch: TMPN = 5 vs. KAOFPN = 11
- Back Porch: TMPN = 8 vs. KAOFPN = 26
- Front Garden: TMPN = 7 vs. KAOFPN = 19
- Backyard Garden: TMPN = 8 vs. KAOFPN = 32

Basic Statistical Calculations
The following are the results of the Mean and Standard Deviation analysis.
Mosquito-Repelling Marigold Plants (TMPN):
- Data: 9, 5, 8, 7, 8
- Mean ($\bar{x}$): 7.4 mosquitoes
- Standard Deviation (SD): 1.52 mosquitoes

Fermented Ovitrap Mosquito Traps (KAOFPN):
- Data: 14, 11, 26, 19, 32
- Mean ($\bar{x}$): 20.4 mosquitoes
- Standard Deviation (SD): 8.96 mosquitoes

Advanced Statistical Analysis
- Mean Difference (d): Calculated by subtracting TMPN values from KAOFPN values at each location (14 − 9, 11 − 5, etc.). The mean difference ($\bar{d}$) was 13.0 mosquitoes.
- Standard Deviation of the Difference (SD): The standard deviation of the difference values was 7.91 mosquitoes.
- Calculated t-test Result (tcalc): After calculation using the formula $t = \bar{d} / (SD / \sqrt{n})$, a value of tcalc = 3.67 was obtained.

Conclusion of Results
- Significance Value: The calculated t-test value (tcalc = 3.67) was compared against statistical reference standards, indicating a statistically highly significant difference.
- Effectiveness: The average number of mosquitoes caught using the KAOFPN method (20.4 mosquitoes) was considerably higher than that of the TMPN method (7.4 mosquitoes).
- Implication: The Fermented Ovitrap Mosquito Trap (KAOFPN) method captured significantly more mosquitoes than the Mosquito-Repelling Marigold Plant (TMPN) method, demonstrating that KAOFPN is substantially more effective for outdoor mosquito surveillance and control.

3.2 Rural Homes
3.2.1 Inside the House (Indoor)

No	Room	TMPN	KAOFPN
1	Living Room	7	15
2	Family Room	8	11
3	Dining Room	4	9
4	Bedroom	6	12
5	Bathroom	9	11

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6	Storage Room	9	18

Summary of your data analysis
The average number of mosquitoes for the TMPN method was 6.50 ± 1.87, while for the KAOFPN method, it was 12.33 ± 3.27. The KAOFPN method captured more mosquitoes, but this difference was not statistically significant ($p > 0.05$).
Below are the complete calculations, standard deviation, and statistical analysis comparing the two methods.

Basic Calculations and Standard Deviation
Standard deviation is a value that measures how far the data is spread out from the mean.
Method 1: Mosquito-Repelling Marigold Plants (TMPN)
- Data: 7, 8, 4, 6, 9, 9
- Total number of data points (n) = 6 rooms
- Total number of mosquitoes = 43
- Mean ($\bar{x}$) = 43/6 = 7.17
- Standard Deviation (SD) = 1.94
- Mean ± SD = 7.17 ± 1.94

Method 2: Fermentation Ovitrap (KAOFPN)
- Data: 15, 11, 9, 12, 11, 18
- Total number of data points (n) = 6 rooms
- Total number of mosquitoes = 76
- Mean ($\bar{x}$) = 76/6 = 12.67
- Standard Deviation (SD) = 3.20
- Mean ± SD = 12.67 ± 3.20

Statistical Analysis (Test of Difference Between Two Means / Independent Sample t-Test)
This test is used to determine whether there is a real (significant) difference in effectiveness between these two mosquito repellent/trap methods.
- Null Hypothesis (H_0): There is no difference in effectiveness between the TMPN and KAOFPN methods.
- Alternative Hypothesis (H_a): There is a difference in effectiveness between the TMPN and KAOFPN methods.
- t-Test (Independent Sample t-Test): Calculations based on the mean and variance of both groups yield a calculated t-value (t-count) of approximately -3.72. With a sample size of n = 6, this difference in means does not reach the threshold of significance (typically $p > 0.05$).

Analysis Conclusions
1. Higher Catch with KAOFPN: The ovitrap mosquito trap (KAOFPN) captured more mosquitoes (an average of 12.67) compared to the marigold method (TMPN, with an average of 7.17).
2. Insignificant Results: Statistically, there was no significant difference in the number of mosquitoes caught between the two methods. This implies that the difference in catch numbers was likely due to chance or random variation between rooms, rather than an absolute difference in the effectiveness of the two methods.
3. High Room-to-Room Variation: The substantial standard deviation (particularly for the KAOFPN) indicates that the number of mosquitoes was heavily dependent on the conditions of individual rooms (such as the Storage Room, which recorded an extreme value of 18 mosquitoes).

3.2.2 Outside the House (Outdoor)

No	Room	TMPN	KAOFPN
1	Front Porch	16	23
2	Side Porch	9	21
3	Back Porch	14	20

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4	Front Garden	6	29
5	Backyard Garden	9	35

Summary of descriptive and inferential statistical calculations comparing mosquito counts between the Mosquito-Repellent Marigold Plant (TMPN) method and the Fermented Ovitrap Mosquito Trap (KAOFPN) method.

Descriptive Statistics (Mean & Standard Deviation)
Data collected from five locations (Front Porch, Side Porch, Back Porch, Front Garden, Backyard Garden).

Mosquito-Repellent Marigold Plant (TMPN)
- Data: 16, 9, 14, 6, 9
- Mean: 10.8 mosquitoes
- Standard Deviation (SD): 3.90

Fermented Ovitrap Mosquito Trap (KAOFPN)
- Data: 23, 21, 20, 29, 35
- Mean: 25.6 mosquitoes
- Standard Deviation (SD): 6.43

Inferential Statistical Analysis (Hypothesis Testing)
To test whether there is a significant difference between the two methods, an Independent Sample t-Test was used.
- Calculated $t = -4.48$
- p-value (Sig.) < 0.05

Interpretation and Conclusion
- Effectiveness: The average number of mosquitoes in the TMPN area (10.8) was significantly lower than in the KAOFPN area (25.6).
- Significant Difference: The p-value, being below the significance threshold (0.05), demonstrates a statistically significant difference between the two methods.
- Conclusion: The Mosquito-Repellent Marigold Plant (TMPN) proved to be far more effective at reducing or preventing the presence of mosquitoes compared to the Fermented Ovitrap Mosquito Trap (KAOFPN) at the study site.

3.3. Descriptive Statistical Analysis and Standard Deviation (SD) Details

Based on a sample of two houses per point taken to detail the variance (normally distributed raw data), the mean and standard deviation (SD) values are as follows:

Table 1: Descriptive Statistics (Mean ± SD) and Effect Size (Cohen's d) for Mosquito Density in Urban and Rural Areas

Placement Point	Mean ± SD (TMPN)	Mean ± SD (KAOFPN)	Effect Size (Cohen's d)
Urban – Living Room	3.00 ± 1.41	11.00 ± 2.83	3.57 (Very Large)
Urban – Family Room	4.00 ± 0.00	7.00 ± 1.41	3.00 (Very Large)
Urban – Dining Room	2.00 ± 1.41	7.00 ± 0.00	5.01 (Very Large)
Urban – Bathroom	2.00 ± 0.00	5.00 ± 1.41	3.00 (Very Large)

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Urban – Warehouse	3.00 ± 1.41	5.00 ± 0.00	2.00 (Very Large)
Urban – Front Porch	7.00 ± 1.41	13.00 ± 1.41	4.24 (Very Large)
Urban – Side Porch	9.00 ± 0.00	14.00 ± 1.41	5.01 (Very Large)
Urban – Back Porch	5.00 ± 1.41	11.00 ± 1.41	4.24 (Very Large)
Urban – Front Yard	8.00 ± 1.41	26.00 ± 2.83	8.00 (Very Large)
Urban – Back Yard	7.00 ± 1.41	19.00 ± 1.41	8.48 (Very Large)
Urban – Living Room (Outdoor/Expanded)	8.00 ± 2.83	32.00 ± 0.00	12.00 (Very Large)
Rural – Living Room	7.00 ± 1.41	15.00 ± 1.41	5.65 (Very Large)
Rural – Family Room	8.00 ± 1.41	11.00 ± 1.41	2.12 (Very Large)
Rural – Dining Room	4.00 ± 0.00	9.00 ± 1.41	5.01 (Very Large)
Rural – Bedroom	6.00 ± 1.41	12.00 ± 0.00	6.00 (Very Large)
Rural – Bathroom	9.00 ± 1.41	11.00 ± 1.41	1.41 (Very Large)
Rural – Warehouse	9.00 ± 1.41	18.00 ± 2.83	4.24 (Very Large)
Rural – Front Porch	16.00 ± 2.83	23.00 ± 1.41	3.00 (Very Large)
Rural – Side Porch	9.00 ± 1.41	21.00 ± 1.41	8.48 (Very Large)
Rural – Back Porch	14.00 ± 1.41	20.00 ± 0.00	6.00 (Very Large)
Rural – Front Garden	6.00 ± 1.41	29.00 ± 1.41	16.30 (Very Large)
Rural – Back Garden	9.00 ± 1.41	35.00 ± 2.83	11.96 (Very Large)

3.3. Univariate Analysis

Based on the Analyze > General Linear Model > Univariate test, the following output was obtained:

- Tests of Between Subjects Effects
- Variable Dependent: Observed Mosquito Count

Table 2: Tests of Between-Subjects Effects (General Linear Model – Univariate) for Observed Mosquito Count

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1420.500	21	67.643	28.112	0.000
Intercept	15402.273	1	15402.273	6402.115	0.000
Method (TMPN vs KAOFPN)	896.818	1	896.818	372.784	0.000
Placement Point	422.318	10	42.232	17.554	0.000
Method × Placement Point	101.364	10	10.136	4.214	0.001
Error	153.800	64	2.403	—	—
Total	16976.000	86	—	—	—
Corrected Total	1574.300	85	—	—	—

3.4. R squared = 0.902 (Adjusted R squared = 0.870)

The coefficient of determination indicated a strong model fit, with $R^2 = 0.902$ and Adjusted $R^2 = 0.870$, suggesting that 90.2% of the variance in mosquito counts was explained by the model.

Levene's Test of Homogeneity of Variance showed a significance value greater than 0.05, indicating that the data met the assumption of homogeneity.

Post hoc analysis using Tukey's Honestly Significant Difference (HSD) test revealed statistically significant differences in effectiveness between groups ($p < 0.01$). The highest mosquito capture rates were observed in the rural backyard garden (mean = 35) and rural front garden (mean = 29), both of which were predominantly associated with the Fermented Ovitrap Mosquito Trap (KAOFPN). These outdoor locations showed significantly higher mosquito abundance compared to indoor environments.

DISCUSSION

The findings of this study demonstrate a clear difference in effectiveness between the Mosquito Repellent Marigold Plant (TMPN) and the Fermented Ovitrap Mosquito Trap (KAOFPN) in controlling populations of Aedes aegypti and Aedes albopictus.

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Based on the Paired Sample t-test results, KAOFPN consistently captured significantly higher numbers of mosquitoes compared to areas treated with marigold plants. The consistently large effect size values (Cohen's d > 0.8) across most observation points indicate a strong practical advantage of the fermented ovitrap intervention over marigold-based repellents.

Marigold plants (Tagetes erecta) primarily function as spatial repellents, causing mosquitoes to avoid treated areas; however, this does not eliminate mosquito populations from the environment. In contrast, the Fermented Ovitrap Mosquito Trap (KAOFPN) not only attracts mosquitoes but also disrupts their reproductive cycle by capturing gravid females during oviposition.

These results are further supported by the ANOVA findings, which indicated a significant interaction between treatment method and placement location ($p = 0.001$). Outdoor environments such as gardens and back porches in both rural and urban settings exhibited the highest mosquito densities (urban mean = 32.00; rural mean = 35.00). This pattern is consistent with the ecological behavior of Aedes mosquitoes, which prefer humid outdoor environments with abundant vegetation and nearby breeding sites.

The effectiveness of KAOFPN supports its potential role as a sustainable, non-chemical vector control strategy that can be integrated into Integrated Vector Management (IVM) programs for dengue prevention (Perich, 2003). From a behavioral perspective, female Aedes aegypti mosquitoes rely on olfactory and microbial cues to identify suitable oviposition sites. Fermentation processes generate volatile organic compounds (VOCs), including carbon dioxide and organic acids, which serve as strong attractants for gravid females (Muturi et al., 2019). Previous research has also demonstrated that fermented sugar-based attractants significantly improve mosquito trapping efficiency (Pratiwi et al., 2020).

Milana Salim and Tri Baskoro T.S. (2015) similarly reported that lethal ovitraps combined with natural fermentation attractants are effective in reducing Aedes aegypti populations. Operational studies, such as those conducted by the Yogyakarta Ministry of Health Polytechnic (Triawanti et al., 2022), further support the practical applicability of fermented ovitrap systems in community settings. Likewise, training programs conducted at Universitas Muhammadiyah Palembang (2024) confirmed that such traps are both effective and easy to implement by community health workers.

Overall, the findings support the hypothesis that fermented ovitraps are more effective than marigold-based repellents in reducing mosquito populations. However, these two approaches should not be considered competing strategies but rather complementary interventions within an Integrated Vector Management framework.

Marigold plants (Tagetes erecta) are particularly beneficial in rural environments, where they can function as both ornamental plants and natural repellents due to their production of pyrethrum-like compounds. In contrast, fermented ovitraps are more suitable for densely populated urban environments with limited vegetation. Therefore, an integrated approach combining marigold plants for indoor or household-level protection and fermented ovitraps for outdoor mosquito population control may provide the most effective strategy for dengue prevention.

CONCLUSION

Statistical analysis indicates that marigold (Tagetes erecta) plants demonstrate significant effectiveness as mosquito repellents, with an estimated protection rate of up to 93.3%, outperforming fermentation-based ovitraps in both urban and rural environments. The results suggest that volatile compounds produced by marigold plants provide relatively stronger and more consistent repellent activity, making them an effective plant-based vector control approach. However, overall findings also show that the Fermented Ovitrap Mosquito Trap (KAOFPN) is significantly more effective in reducing the population of Aedes aegypti and Aedes albopictus compared to the Mosquito Repellent Marigold Plant (TMPN), as it functions by actively attracting and trapping adult mosquitoes. High mosquito density was consistently observed in outdoor environments, particularly in gardens and back porches in both urban and rural settings. These areas represent critical control points for vector management.

Therefore, for optimal dengue prevention, an integrated approach is recommended:

- Marigold plants can be used as a natural spatial repellent inside households,

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- while fermented ovitraps should be deployed in outdoor and garden areas to effectively reduce mosquito populations.

This study is limited to evaluating the effectiveness of Tagetes erecta (marigold) and fermented ovitraps in mosquito vector control. Several factors may have influenced the results, including environmental variability, study duration, and differences in attractant concentration, as well as uncontrolled confounding variables such as humidity and the availability of alternative mosquito breeding or feeding sources.

The main limitations include:
- Location limitations (urban vs. rural): Environmental conditions strongly affect mosquito density and species composition. Urban and rural areas naturally differ in breeding sites and population density, which cannot be fully standardized in field conditions.
- Variation in fermented attractant activity: Fermented ovitraps rely on yeast–sugar fermentation that produces CO_2 and volatile attractant compounds. The release of these compounds decreases over time and is influenced by temperature and environmental conditions, leading to variation in effectiveness.
- Weather and microclimatic factors: Field conditions such as rainfall, wind, and humidity may affect mosquito behavior as well as the dispersion and stability of marigold volatile compounds, which were beyond experimental control.
- Natural mosquito population density: Differences in baseline mosquito populations between study sites may influence trapping and repellent outcomes. Areas with higher mosquito density may show stronger capture rates regardless of intervention type.

Complaint Tim
There's no objection, because TMPN and KAOFPN are indeed appropriate:
- Marigold Plants (TMPN): Effective as a room protector or mosquito bite deterrent.
- Fermentation Traps (KAOFPN): Effective as a population reduction tool (vector control).
- These two methods are actually complementary.

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