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Green Control Effectively Reduces Fruit Flies (*Bactrocera* spp.) Dorsalis Population and Damage in Pitaya (*Hylocereus* spp.)

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Abstract

To clarify the green and efficient control technology of Fruit Flies (*Bactrocera* spp.) in pitaya orchards, this study systematically investigated four categories of control measures: physical, chemical, agronomic, and ecological, and analyzed their effects on fruit fly population, infested fruit rate, and orchard microenvironment. The results showed that physical high-temperature burning combined with sticky traps and lure traps could rapidly kill eggs, larvae, and pupae in the soil, reducing the infested fruit rate by 85.71% compared with the control, featuring both green safety and rapid efficacy. Chemical pesticide spraying exhibited a significant inhibitory effect on adults, decreasing the number of adults trapped by lure bottles by 77.53% with a long residual effect. The combined application of physical and chemical measures achieved both rapid and long-lasting control. Biodegradable film mulching significantly reduced soil surface temperature and destroyed the habitat of fruit flies, lowering the trap catch by up to 63.58%. Bagging young fruits blocked oviposition at the source and reduced the infested fruit rate by 88.41%, making it the preferred control method in production. Drip irrigation and low-level sprinkler irrigation increased orchard humidity and favored fruit fly infestation, requiring supporting control measures. Night supplementary lighting improved trapping efficiency but tended to aggravate insect aggregation, so it was recommended to be used in conjunction with film mulching. For ecological control, intercropping loofah with pitaya could construct an ecological barrier of "repellence + trapping". Free-range poultry in orchards achieved a fruit fly

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reduction rate of 34.62% - 61.29% and reduced pesticide costs by 1710 - 2925 CNY/ha. The study confirmed that single control measures had limitations, and the coordinated integration of physical, chemical, agronomic, and ecological measures could realize the green and efficient control of fruit flies, providing technical support for pesticide reduction, quality improvement, and green high-quality development of the pitaya industry.

Keywords

Pitaya, Fruit Fly (*Bactrocera* spp.), Green Control, Fruit Quality, Integrated Pest Management

1. Introduction

Pitaya (*Hylocereus* spp.) is an important economic fruit in tropical and subtropical regions. Large-scale cultivation has been established in China, playing a key role in promoting rural revitalization and the high-quality development of tropical agriculture [1] [2]. With the expansion of cultivation area and intensification of production, pests and diseases have become a bottleneck restricting the industry [3]-[5]. In particular, fruit flies have developed into a devastating pest and a quarantine target for import and export trade [2] [6]-[8].

Fruit flies (*Bactrocera* spp.) is characterized by rapid reproduction, weak dispersal ability, and overlapping generations, and exhibit strong host preference for pitaya [9] [10]. Outbreaks frequently occur, leading to yield losses of 30% - 60% or even total crop failure, resulting in complete loss of commercial value. This severely damages farmers' income and restricts industrial development, representing a grim situation [10]-[12].

At present, conventional chemical insecticides dominate fruit fly management. However, since larvae bore into fruit tissues, insecticides can hardly reach the target, leading to unsatisfactory control efficacy [12]. The revised Regulations on Pesticide Administration in 2022 explicitly prohibits the use of highly toxic and extremely toxic pesticides in fruit and vegetable production [9]. Illegal abuse of pesticides may cause excessive residues, induce pest resistance, form a vicious cycle, and damage the ecological environment [1] [6] [13] [14]. Although traditional physical and agricultural control measures are environmentally friendly, they are labor-intensive, limited in coverage and inefficient [15] [16].

Given the urgent demand for high-quality, green and safe pitaya products and the prominent contradiction between fruit fly damage and control difficulties, the popularization of green prevention and control technologies is imperative [12] [16] [17]. Green control should be centered on ecological regulation, integrating physical, chemical attract-and-kill strategies, biological agents and other comprehensive measures. Effectively reducing pest population density and damage, avoiding pesticide residues, and achieving improved control efficiency and fruit quality are critical for production [2] [12] [16] [18] [19]. This study focuses on green control technologies against fruit flies in pitaya, aiming to provide theoretical and practical references for alleviating fruit fly damage, improving fruit quality, and promoting the high-quality development of the pitaya industry.

2. Materials and Methods

2.1. Observation of Fruit Fly Life History and Damage to Pitaya

Combined with planting experience, the morphological characteristics and behavioral rhythms of fruit flies were observed and described, and the damage of fruit flies to pitaya during the maturation period was investigated [4] [5] [9].

2.2. Physical and Chemical Control

2.2.1. Physical Control

Physical control treatment (Tphysical): A liquefied gas flame spray gun was used to spray flame at 800˚C - 1000˚C, avoiding the basal stems and roots of pitaya plants. The flame was swept rapidly across the soil surface for 0.5 - 1.0 s to instantly burn weeds, insect eggs, and pathogens on the surface without tillage. The treatment was applied twice at 15-day intervals.

Subsequently, yellow double-sided sticky traps (25 cm × 20 cm) were hung in the middle of pitaya rows, with the lower edge 70 - 80 cm above the ground (one trap per row). One lure bottle containing 2.00 mL of methyl eugenol attractant was hung at each end of the rows, 80 - 100 cm above the ground.

2.2.2. Chemical Control

Chemical control treatment (Tchemical): Low-toxicity insecticides were sprayed during the peak activity period of adult fruit flies (after 18:30). The insecticides included 18% abamectin EC (1500-fold dilution), 0.5% emamectin benzoate EC (1000-fold dilution), 25% deltamethrin EC (3000-fold dilution), 10% lambda-cyhalothrin EW (1500-fold dilution), and 50% cyromazine WP (3000-fold dilution).

The pesticides were evenly sprayed on the canopy and fruit surfaces, applied three times consecutively at 5-day intervals to avoid phytotoxicity.

Soil surface temperature (˚C) was measured at 0 s, 30 s, 90 s, and 180 s, and soil moisture (%) at 3 cm below the surface was measured at 0 h, 4 h, 12 h, and 24 h for physical control, chemical control, and control (Control) groups, with five row replications.

2.2.3. Fruit Fly Population Counting

One yellow double-sided sticky trap was placed in the middle of each experimental row (20 plants per row), and one lure bottle was hung at each end, with five replications per treatment. The total number of trapped fruit flies was recorded on the 16th day.

2.2.4. Calculation of Infested Fruit Rate and Larval Count

Five fruits per plant and five plants per treatment were randomly harvested. Infested fruit rate (%) = (number of infested fruits/total number of surveyed fruits)

× 100. Infested fruits were dissected to count the number of fruit fly larvae.

2.3. Irrigation Control

Low-level sprinkler irrigation treatment: Micro-sprinklers were installed between rows, 25.00 cm above the ground with a spacing of 60.00 cm.

Drip irrigation treatment: Drippers were placed near plant roots with a spacing of 15.00 cm.

Equal and uniform irrigation was applied daily at 10:00 - 12:00 and 17:00 - 18:00, respectively. The control group received no irrigation. The counting method in 1.2.3 was repeated.

2.4. Mulching Control

Mulching treatment (Tcover): Black PBAT/PCA biodegradable film was laid between rows, with basal stems exposed to avoid growth inhibition. The control group (Control) received no mulching.

From the 2nd day after mulching, soil surface temperature was measured at 6:00, 9:00, 12:00, and 18:00 every other day, with five measurements in total. The counting method in 1.2.3 was repeated.

2.5. Supplementary Lighting Control

Supplementary lighting treatment: Night supplementary lighting (20:00 - 04:00) was applied 5 - 6 days after pitaya flowering, with 250 - 300 lx light irradiating the middle and lower parts of fruiting branches. The control group received no lighting. The counting method in 1.2.3 was repeated.

2.6. Bagging Control

Bagging treatment (Tbag): Young fruits were bagged with sterilized non-woven insect-proof bags (15 cm × 20 cm) and tightly tied 3 - 5 days after flowering. The control group (CK) received no bagging. The methods in 1.2.3 and 1.2.4 were repeated.

2.7. Intercropping Experiment

Three experimental treatments were set: pitaya intercropped with loofah, loofah monoculture, and pitaya monoculture, with conventional cultivation management. The counting method in 1.2.3 was repeated.

2.8. Free-Range Poultry Experiment in Orchards

Based on surveys in major producing areas such as Guangxi, Guangdong, Hainan, and Yunnan, free-range poultry treatment and control groups were established. The counting method in 1.2.3 was repeated (Table 1).

2.9. Data Analysis

Data analysis and visualization were performed using SAS 9.0 (Duncan's multiple range test, $p = 0.01$) and GraphPad Prism 9 software.

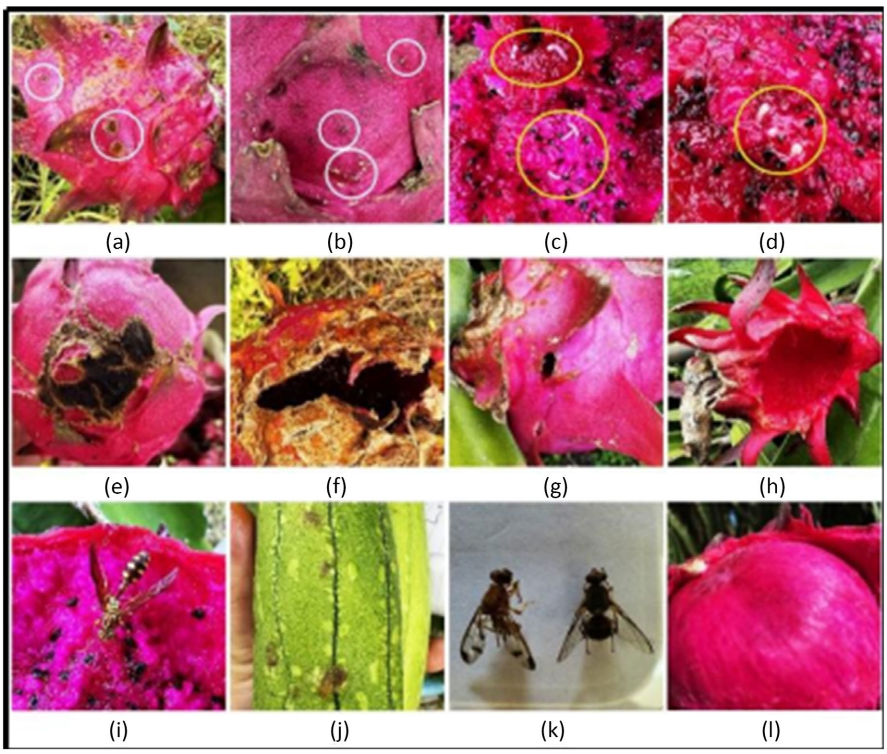
Table 1. Control of fruit flies by free-range poultry in pitaya orchards.

Location	Chicken (ind./667m^2)	Duck (ind./667m^2)	Goose (ind./667m^2)
Long'an	675	225	0
Mashan	675	225	0
Shanglin	675	225	0
Zhuhai	750	225	0
Luoding	750	225	0
Ledong	750	150	75
Sanya	675	150	75
Xishuangbanna	675	225	0

3. Results and Analysis

3.1. Life History of Fruit Fly and Damage to Pitaya

Fruit flies are devastating pests of pitaya, with a wide suitable temperature range (8˚C - 33˚C) and complete metamorphosis (egg → larva → pupa → adult) [3] [4] [9]. Their life cycle is extremely short (about 10 days), with larvae pupating in the soil and adults emerging to lay eggs again, showing obvious overlapping generations. Indoor culture experiments showed that adults lived 33 - 37 days at 24˚C - 27˚C. Adults preferred cool, low-light, humid, and weedy environments, with weak dispersal ability and concentrated damage distribution, leading to high control difficulty [9] [10].



(a)-(b), (j) Oviposition damage by adult flies; (c) (d): Larval feeding in pulp; (e)-(h): Symptomatic fruits; (i) Adult flies feeding on pulp; (k) Adult fruit fly; (l) Healthy fruit.

Figure 1. Symptoms of pitaya infested by Fruit Flies (*Bactrocera* spp.).

Fruit flies were highly sensitive to the color and aroma of mature pitaya fruits, exhibiting obvious host preference and taxis. Female adults laid eggs under the pitaya peel; after hatching, larvae directly bored into and fed on the pulp. Meanwhile, adults also fed on the pulp and laid eggs, severely reducing yield and commodity value and causing significant economic losses [4]-[6] (**Figure 1**).

3.2. Effects of Physical and Chemical Control

1) Soil surface temperature: The control group remained stable at about 25˚C with gentle fluctuation. The physical treatment surged to 300˚C at 0 s and dropped to 27.6˚C at 180 s, showing sharp heating and rapid cooling. The chemical treatment maintained 21˚C - 25˚C with stable change, consistent with the trend of control (**Figure 2**).

2) Soil moisture: At 0 h, the control group was 86.8%, the physical treatment was only 54%, and the chemical treatment reached 98.8%. At 24 h, the three groups rebounded to 90.4%, 96.8%, and 94.6%, respectively. The physical treatment significantly reduced moisture in the early stage and gradually recovered later; the chemical treatment had high moisture, similar to the control (**Figure 2**, **Figure 3**).

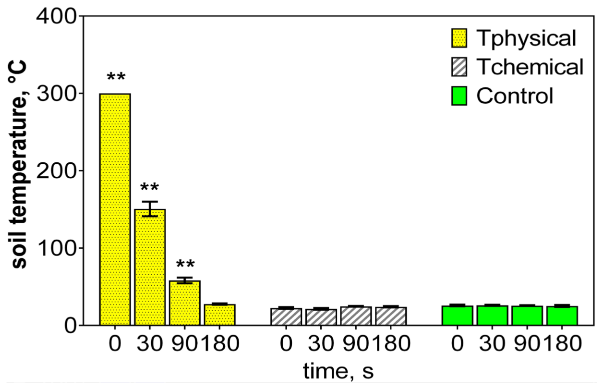


Figure 2. Soil surface temperature under different treatments (Duncan's analysis, P = 0.01).

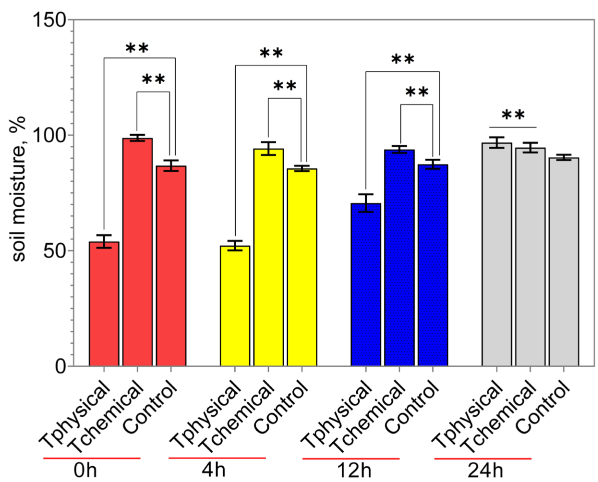


Figure 3. Soil moisture under different treatments (Duncan's analysis, P = 0.01).

3) Adult trapping showed that the physical treatment with sticky traps and the chemical treatment decreased by 51.73% and 63.97% compared with the control, respectively; the lure trap catches decreased by 65.17% and 77.53%, respectively, with significant differences.

4) The infested fruit rate of the physical and chemical treatments decreased by 85.71% and 78.57% compared with the control, respectively, with the physical treatment being superior; the number of larvae decreased significantly by 93.59% and 92.31%, respectively (Table 2, Figure 4).

Physical high temperature can rapidly increase soil temperature and reduce moisture, efficiently killing fruit fly eggs, larvae, and pupae in the soil with strong rapid control efficacy [16] [19], but it significantly affects soil moisture and requires strict

Table 2. Effects of physical and chemical control on fruit fly population and infested fruit rate in pitaya (Duncan's analysis, P = 0.01).

Treatment	Adult population (individuals)		Infested fruit rate (%)	Larval population (individuals)
	Sticky trap	Lure bottle		
Tphysical	36.20 ± 5.72 B	24.80 ± 5.40 B	8	5
Tchemical	27.02 ± 4.97 C	16.00 ± 2.74 C	12	6
Control	75.00 ± 4.47 A	71.20 ± 10.33 A	56	78

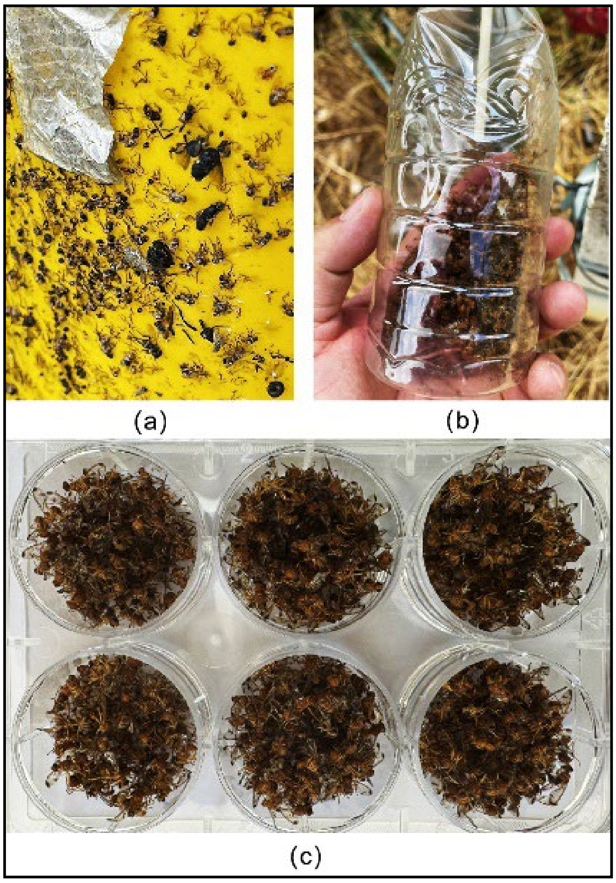


Figure 4. Trapping of fruit flies (*Bactrocera* spp.) (a) Sticky trap; (b) Lure bottle; (c) Trapped fruit flies.

control of treatment duration. Chemical treatment has mild effects on temperature and humidity, close to the natural state, and pesticides can continuously inhibit oviposition and hatching with a long residual effect [16], but long-term single use tends to induce resistance. Both treatments can effectively block the life cycle of fruit flies and significantly reduce adult population, infested fruit rate, and larval density [19]. The physical treatment performs better in controlling infested fruit rate, while the chemical treatment is more effective in inhibiting adults. In summary, physical high temperature is suitable for emergency killing during fruit fly outbreaks, and chemical treatment is suitable for routine prevention; their combined application achieves rapid control and prolonged residual effect, balancing control efficacy and crop safety, supporting the green and efficient control of Fruit Flies (*Bactrocera* spp.) in pitaya.

3.3. Effects of Irrigation Management Control

Sticky trap monitoring showed that the catches of low-level sprinkler irrigation and drip irrigation treatments were 135.00 ± 8.51 and 122.60 ± 5.64 individuals, respectively, significantly increasing by 34.20% and 21.87% compared with the control (100.60 ± 13.28 individuals), with significant differences between treatments.

Lure trap monitoring showed that the catches of low-level sprinkler irrigation and drip irrigation were 61.40 ± 7.86 and 53.20 ± 6.83 individuals, respectively, increasing by 64.17% and 42.25% compared with the control (37.40 ± 5.55 individuals), with no significant difference between irrigation treatments.

Drip irrigation and low-level sprinkler irrigation are key technical measures for high-quality and efficient pitaya cultivation, and their field application directly affects orchard microclimate and fruit fly occurrence dynamics. Fruit flies prefer humid microenvironments; irrigation increases soil and air humidity in orchards, providing favorable conditions for adult habitat, oviposition, and larval pupation [17] [21], thereby significantly increasing population size, with low-level sprinkler irrigation showing a more obvious promoting effect.

Neither drip nor low-level sprinkler irrigation has direct insecticidal effect and cannot achieve effective control. In production, they need to be combined with other measures to improve comprehensive control efficacy.

3.4. Effects of Mulching Measures Control

Film mulching significantly reduced soil surface temperature in pitaya orchards and optimized the orchard microenvironment. Sticky trap and lure trap monitoring showed that the number of trapped Fruit Flies (*Bactrocera* spp.) in the mulching treatment (17.40 ± 4.04 and 12.60 ± 2.07) decreased significantly by 44.59% and 63.58% compared with the control, with extremely significant control efficacy (**Figure 5**).

The mechanism is that film mulching changes soil surface temperature, inhibits weed growth, destroys the suitable habitat of fruit flies, and blocks the development of their life cycle, thus effectively reducing the population density of fruit flies in orchards.

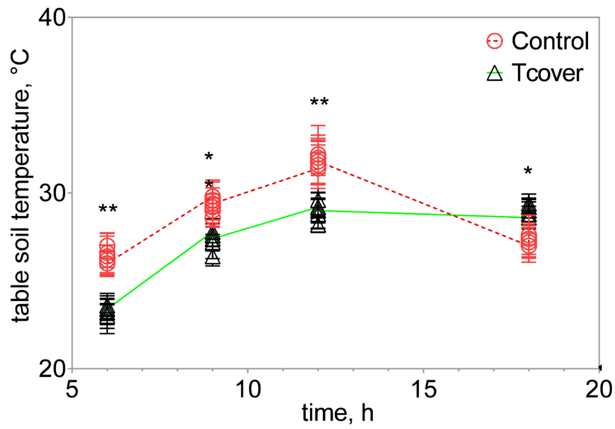


Figure 5. Comparison of soil surface temperature under film mulching (Duncan's analysis, P = 0.01).

3.5. Effects of Supplementary Lighting Measures Control

Sticky trap monitoring showed that the total insect catch and fruit fly catch in the supplementary lighting treatment (183.8 ± 22.72 and 68.8 ± 12.46) increased significantly by 143.77% and 156.72% compared with the control, respectively.

Lure trap monitoring showed that the total insect catch and fruit fly catch in the supplementary lighting treatment (145 ± 25.64 and 87.6 ± 17.8) increased significantly by 223.66% and 461.54% compared with the control, respectively.

Supplementary lighting has dual positive and negative effects: the positive effect is that it prolongs adult activity time, interferes with their life cycle, changes fruit maturation rhythm, significantly enhances the aggregation taxis of fruit flies, and greatly improves trapping efficiency; the negative effect is that the environment created by supplementary lighting is more conducive to adult activity, which will sharply increase the population density in the orchard in a short time and aggravate damage without supporting control measures (**Figure 6**).

Figure 6. Light supplemental measures in pitaya plantations.

3.6. Effects of Bagging Measures Control

The infested fruit rate of the bagging treatment (6.4%) decreased extremely significantly by 88.41% compared with the control (55.20%); the number of insect holes (11) decreased extremely significantly by 97.42% compared with the control (426) (Figure 7).

In terms of fruit quality, the average single fruit weight of the bagging treatment (218.92 g) decreased extremely significantly by 16.09% compared with the control (260.92 g), but it improved fruit uniformity and comprehensive quality (Figure 8).

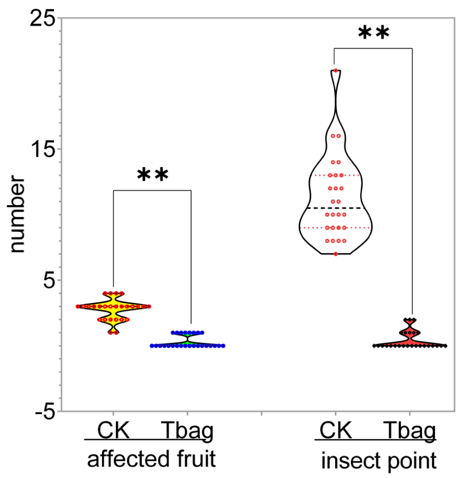


Figure 7. Comparison of fruit fly damage control by fruit bagging (Duncan's analysis, P = 0.01).

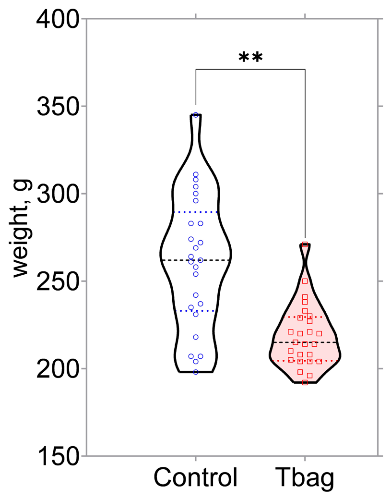


Figure 8. Comparison of fruit weight under bagging control (Duncan's analysis, P = 0.01).

Bagging blocks fruit fly oviposition through physical isolation, controls damage at the source, and reduces pesticide use [18] [20]. Overall, it is an efficient measure balancing control efficacy and commodity value.

3.7. Correlation Analysis

Correlation analysis of parameters in physical and chemical control treatments showed extremely significant positive correlations among temperatures during monitoring periods (r = 0.807 - 0.996) and among moistures (r = 0.971 - 0.991); temperature and moisture showed an overall extremely significant negative correlation (r = −0.816 - −0.978).

Moisture at 24 h was extremely significantly negatively correlated with sticky trap catch, lure trap catch, infested fruit number, and larval number.

Under film mulching, temperatures during different monitoring periods were highly correlated, with an extremely significant positive correlation between 6 h and 12 h (r = 0.951**) and an extremely significant negative correlation with 4 h (r = −0.934**). Temperature was extremely significantly correlated with sticky trap catch and lure trap catch (r = 0.831**, r = 0.960**), showing a significant effect on fruit fly trapping.

Total insect catch was extremely significantly positively correlated with fruit fly number (r = 0.870**, r = 0.825**), which could accurately reflect the population dynamics of Fruit Flies (*Bactrocera* spp.). Infested fruit number was extremely significantly positively correlated with insect hole number (r = 0.860**), and both infested fruit number and insect hole number were extremely significantly positively correlated with fruit weight (r = 0.450**, r = 0.633**), indicating a close correlation between fruit fly damage degree and fruit weight.

3.8. Effects of Intercropping Experiment

Sticky trap and lure trap monitoring showed consistent results: the total insect catch and fruit fly catch in the pitaya-loofah intercropping treatment increased extremely significantly by 109.24%, 143.73% and 105.19%, 81.27% compared with the control, respectively; the loofah monoculture treatment decreased extremely significantly by 14.85%, 47.67% and 22.22%, 59.36% compared with the control, respectively.

Pitaya-loofah intercropping provides habitat and feeding sites for fruit flies and can be used as a supporting trapping measure [21] [22]; loofah monoculture reduces field population density by releasing repellent substances [21]. The combination of the two forms a "repellence + trapping" control system, effectively improving the control efficiency of Fruit Flies (*Bactrocera* spp.).

3.9. Effects of Free-Range Poultry Experiment in Orchards

Free-range poultry in pitaya orchards significantly reduced infestation and pesticide costs compared with the control. The fruit fly reduction rate in the free-range poultry group was 34.62% - 61.29%, the adult trapping reduction rate was 33.33% - 46.97%, and pesticide costs were reduced by 1710 - 2925 CNY/ha, with a positive correlation between control efficacy and cost-saving range (Table 3).

The effects of pesticide reduction and efficiency improvement were more significant in tropical and subtropical producing areas, indicating that this model has good promotion value in the green control of pitaya.

Table 3. Analysis results of experiments on poultry raising (T) vs. conventional planting (CK) in pitaya orchards.

Experimental Site	Reduction Rate of Pest-infested Fruits in T vs. CK, %	Reduction Rate of Trapped Adult Insects in T vs. CK, %	Pesticide Cost Reduction in T vs. CK, CNY/ha
Long'an	55.56	33.37	2475
Mashan	58.33	39.71	1710
Shanglin	61.29	46.97	2835
Zhuhai	40.62	38.81	2100
Luoding	55.17	44.48	1950
Ledong	54.54	33.33	2925
Sanya	34.62	34.33	2925
Xishuangbanna	43.75	38.71	1800

4. Discussion

Fruit Flies (*Bactrocera* spp.) are devastating quarantine pests in pitaya production, characterized by short life cycle, overlapping generations, strong fecundity, preference for cool and humid environments, and strong taxis to mature fruits, easily causing serious economic losses [4] [5] [8] [9] [15].

This study showed that both physical and chemical control could significantly suppress insect population and reduce infested fruit rate, but with different characteristics [13] [14] [18]. Physical high-temperature burning rapidly kills soil-dwelling insect stages without residue or resistance, meeting green production requirements [13] [18], but it greatly affects soil moisture and requires strict control of operation duration. Chemical pesticides have outstanding inhibitory effects on adults with long residual effect, suitable for emergency supplementary control [13] [14], but long-term single use tends to induce resistance and pesticide residues. Their combined use achieves complementarity of rapid and long-lasting effects, enhancing comprehensive control efficacy. Agronomic measures indirectly regulate fruit fly occurrence by altering the orchard microenvironment [19] [21]. Drip irrigation and low-level sprinkler irrigation increase orchard humidity and favor fruit fly habitat and reproduction [17] [21], requiring matching measures such as trapping and film mulching to reduce negative impacts. Biodegradable film mulching reduces soil surface temperature, inhibits weeds, and blocks fruit fly pupation and eclosion, with stable and environmentally friendly control efficacy. Night supplementary lighting interferes with fruit fly life cycle and improves trapping and monitoring efficiency but tends to aggravate insect aggregation in the short term, so it is suitable for combined use with film mulching for temperature control. Bagging physically blocks oviposition at the source, greatly reduces infested fruit rate, and improves fruit commodity quality [18] [20], making it the preferred control measure in production. Ecological control has good application potential [19] [21]. Pitaya-loofah intercropping can form an ecological barrier of "repellence + trapping" and free-range poultry in orchards can prey on pests and reduce pesticide costs [21] with both ecological and economic benefits [22].

In conclusion, single measures have limitations, and the coordinated integration of physical, chemical, agronomic, and ecological measures is the key to achieving green and efficient control of Fruit Flies (*Bactrocera* spp.) [17] [19] [23]. Future research should optimize the combination model to promote the green development of the pitaya industry.

5. Conclusion

This study clarified the control effects of various measures on Fruit Flies (*Bactrocera* spp.) in pitaya. Physical and chemical control both achieve efficient insect control, with the former being green and rapid and the latter suitable for emergency use; their combined application yields the optimal effect. Irrigation improves trapping efficiency and plant insect resistance but requires supporting control measures; biodegradable film mulching destroys fruit fly habitat with green and high efficiency. Supplementary lighting assists monitoring, and its combination with film mulching reduces negative impacts. Young fruit bagging is the preferred measure, significantly reducing infested fruit rate and improving commodity quality. Loofah intercropping constructs an ecological control system, and free-range poultry in orchards realizes biological control, cost saving, and efficiency improvement. In production, multiple measures should be integrated to establish a coordinated green control system, effectively controlling damage, reducing pesticides, improving quality, and supporting the green and high-quality development of the pitaya industry.

Author Contributions

Zusheng Wei: Conceptualization, methodology, investigation, data curation, writing—original draft, writing—review & editing. Jingna Wu, Jingwen Luo: Data curation, formal analysis, writing—review & editing. Xiujuan Yang: Supervision, conceptualization, funding acquisition, writing—review & editing.

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Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to institutional confidentiality policy.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Shelly, T.E., Fezza, T., Cook, P. and Cook, D. (2024) Attractiveness, Longevity, and Release Rates of Multilure Wafers for Trapping Males of the Oriental Fruit Fly and Melon Fly (Diptera: Tephritidae). *Journal of Insect Science*, **24**, ieae095. https://doi.org/10.1093/jisesa/ieae095

[2] Xu, L., Jiang, H., Yu, J., Pan, D., Tao, Y., Lei, Q., *et al.* (2023) Two Odorant Receptors Regulate 1-Octen-3-Ol Induced Oviposition Behavior in the Oriental Fruit Fly. *Communications Biology*, **6**, Article No. 176. https://doi.org/10.1038/s42003-023-04551-5

[3] Zhang, Z., Yang, H., Xing, Y., Xie, F., Chen, C., Zhang, Z., *et al.* (2024) Quality Analysis and Evaluation of Different Batches of Pitaya Fruit (Hylocereus) in South China. *International Journal of Fruit Science*, **24**, 33-43. https://doi.org/10.1080/15538362.2023.2301694

[4] Belbase, P. and Balaji Bhaskar, M.S. (2025) Sustainable Cultivation of Dragon Fruit: Integrated Nutrient and Pest Management Strategies for Enhanced Productivity and Environmental Stewardship. *Agronomy*, **15**, Article 2514. https://doi.org/10.3390/agronomy15112514

[5] Kakade, V., Morade, A., Salunkhe, V., *et al.* (2025) Dragon Fruit Cultivation in New Areas: Challenges, Management Strategies, and Insights from India. *Discover Agriculture*, **3**, Article 168.

[6] Ministry of Agriculture and Rural Affairs Legislative Affairs Department (2022) Regulations on Pesticide Administration. China Agriculture Press.

[7] Ministry of Agriculture and Rural Affairs of the People's Republic of China (2022) Interpretation of the Law of the People's Republic of China on the Quality and Safety of Agricultural Products. China Agriculture Press.

[8] Ryalls, J.M.W., Garratt, M.P.D., Spadaro, D. and Mauchline, A.L. (2024) The Benefits of Integrated Pest Management for Apple Depend on Pest Type and Production Metrics. *Frontiers in Sustainable Food Systems*, **8**, Article 1321067. https://doi.org/10.3389/fsufs.2024.1321067

[9] He, Y.X., Xu, Y.J. and Chen, X. (2023) Biology, Ecology and Management of Tephritid Fruit Flies in China: A Review. *Insects*, **14**, 196. https://doi.org/10.3390/insects14020196

[10] Biasazin, T.D., Miano, R.N., Cheseto, X., Ndlela, S., Mohamed, S.A. and Dekker, T. (2025) Selective Lure for *Bactrocera dorsalis* Based on Shared Palpal and Antennal Responses across Three Economically Important Tephritid Species. *Journal of Pest Science*, **98**, 1789-1801. https://doi.org/10.1007/s10340-025-01898-y

[11] Liu, H., Hou, B.H., Zhang, C., *et al.* (2014) Oviposition Preference and Offspring Performance of Oriental Fruit Fly, *Bactrocera dorsalis*, and Guava Fruit Fly, *B. correcta* (Diptera: Tephritidae) on Six Host Fruits. *Acta Ecologica Sinica*, **34**, 2274-2281.

[12] Yuan, S.Y., Xiao, C., Kong, Q. and Chen, J. (2005) Oviposition Preference of *Bactrocera dorsalis* Hendel. *Journal of Jiangxi Agricultural University*, **27**, 81-84. (In Chinese) https://doi.org/10.3969/j.issn.1000-2286.2005.01.018

[13] Institute of Plant Protection and Chinese Academy of Agricultural Sciences (2025) Control Technology for Major Invasive Species of Melons and Fruits Achieves Remarkable Results. Science and Technology Daily.

[14] Vargas, R.I., Piñero, J.C. and Leblanc, L. (2015) An Overview of Pest Species of Bactrocera Fruit Flies (Diptera: Tephritidae) and the Integration of Biopesticides with Other Biological Approaches for Their Management with a Focus on the Pacific Re-

gion. *Insects*, **6**, 297-318. https://doi.org/10.3390/insects6020297

[15] Aluja, M. and Messing, R.H. (2023) The Global Epidemic of *Bactrocera* Pests: Mixed-Species Invasions and Risk Assessment. *Annual Review of Entomology*, **69**, 123-145.

[16] Zhang, X.F. (2014) Study on the Role of Odorant-Binding Proteins of *Bactrocera dorsalis* in Host Selection for Oviposition by Females and Their Gene Identification. Huazhong Agricultural University.

[17] Guangxi Characteristic Fruit Industry Innovation Team (2024) The Pest Control Post of the Guangxi Characteristic Fruit Industry Innovation Team Conduct In-Depth Production Research and Promote Green Prevention and Control Technologies. Guangxi Characteristic Fruit Industry Innovation Team.

[18] Akheela, P., Santhoshkumar, T. and Varghese, T.S. (2024) First Report of Bactrocera Dorsalis (Hendel) (Diptera, Tephritidae) on the White—Fleshed Dragon Fruit Selenicereus Undatus (Haworth) D.R. Hunt (Cactaceae) in India. *Entomon*, **49**, 283-286. https://doi.org/10.33307/entomon.v49i2.1190

[19] Clarke, A.R., Armstrong, K.F., Carmichael, A.E., Milne, J.R., Raghu, S., Roderick, G.K., *et al.* (2005) Invasive Phytophagous Pests Arising through a Recent Tropical Evolutionary Radiation: The *Bactrocera dorsalis* Complex of Fruit Flies. *Annual Review of Entomology*, **50**, 293-319. https://doi.org/10.1146/annurev.ento.50.071803.130428

[20] Chinese Academy of Tropical Agricultural Sciences (2023) Technical Regulations for Green Prevention and Control of Pitaya (NY/T 4256-2023). China Agriculture Press.

[21] Zhuang, T. (2024) Research Progress on Green Control Technology of Fruit and Vegetable Fruit Fly Pests. *Open Access Library*, **11**, e1111892. https://doi.org/10.4236/oalib.1111892

[22] Wang, Q., Luo, S., Zeng, X., Liu, H., *et al.* (2022) Selective Trapping Effect of Colored Sticky Traps on Fruit Flies and Non-Target Natural Enemies in Subtropical Fruit Orchards. *Insects*, **13**, Article 725.

[23] Lisboa, C.F., Oliveira, T.A., Pacheco, A.B., Silva, C.S.D., de Jesus, F.L.F., Sanches, A.C., *et al.* (2025) Physical and Chemical Properties of Pitaya Fruits during Storage Using Different Packages. *Brazilian Journal of Food Technology*, **28**, e2023012. https://doi.org/10.1590/1981-6723.1223