

Evaluation of Trapping Effect of Different Color Swatches on Pests and Natural Enemies in *Rosa sterilis* S.D.Shi Orchard

Tianlei Liu^a, Chunlei Cong^b and Xiaoqian Zhang^c
College of Agriculture, Anshun University Anshun, Guizhou Province, China

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Abstract: With the continuous expansion of the planting area of *Rosa sterilis* S.D.Shi, insect pests have become one of the important factors restricting the development of *Rosa sterilis* S.D.Shi industry. This study aimed to select the color swatches with good trapping effect to provide a basis for pest control in *Rosa sterilis* S.D.Shi Orchard. 5 different color plates were selected to trap and kill the insects in the *Rosa sterilis* S.D.Shi orchard. There were significant differences in different color plates' trapping and killing effects on insect pests. Among them, the yellow board had the best trapping effect on the pests of Cicadellidae and Cicadellidae, reaching 83.8 and 129.0 per month, which was significantly different from that of other color plates, and the trapping effect of the blue board on leaf beetle pests was 126.2 per month, which was significantly higher than that of blackboard and yellow board. The trapping effect of the green board on Calliphoridae, Muscidae, and bugs was the best, with 174.0, 476.2, and 48.6 insects per month, respectively. The trapping effect on natural enemies showed significant differences in trapping and killing effects of different color plates on natural enemies of Muscidae and Coccinellidae, in which the trapping effect of the blue board was higher than that of blackboard and yellow board. The trapping and killing effect of the yellow board was significantly higher than that of blackboard and blackboard, and the trapping effect of the yellow board was higher than that of blackboard and blackboard, and the trapping and killing quantity of yellow board was 16.0 per month, which was significantly higher than that of whiteboard and blackboard. The benefit-damage ratio was different on different color plates. The maximum ratio of blackboard and yellow board was higher than 0.40, the fluctuation of blue board, whiteboard, and green board were lower, and the benefit-damage ratio was not higher than 0.28. The comprehensive data show the comprehensive benefit of blue board, green board, or whiteboard in controlling pests in *Rosa sterilis* S.D.Shi orchard is better. It is suggested that the appropriate color swatch should be selected for control according to the occurrence law of insect pests in different periods to reduce its influence on natural enemy insects.

1 INTRODUCTION

Rosa sterilis S.D.Shi, one of the important economic trees, and is planted widely in the southwest and central south mountainous areas of China. It was authorized by the National New Plant Variety Protection in 2015 and became the first local endemic variety in Guizhou Province. Because it is rich in SOD, flavonoids, and various vitamins, amino acids, and mineral elements, it has the laudatory name of "King of Vitamin C" (Wang 2015). In recent years, Anshun City has made great efforts to develop the

Rosa sterilis S.D.Shi industry has become one of the characteristic industries for farmers to get rich, centralized planting and eco-tourism. With the continuous expansion of the planting area of *Rosa sterilis* S.D.Shi, insect pests have become one of the important factors restricting the development of *Rosa sterilis* S.D.Shi industry. Pest control of Anshun *Rosa sterilis* S.D.Shi Tratt is necessary to ensure fruit yield and quality. Chemical control is the primary means of orchard pest control at present. Many growers unilaterally pursue the control effect and continuously use a single pesticide to control pests,

^a  <https://orcid.org/0000-0002-1524-8020>

^b  <https://orcid.org/0000-0001-9257-9993>

^c  <https://orcid.org/0000-0002-1062-5747>

resulting in their drug resistance and harm increasing year by year, seriously affecting fruit quality and yield (Jia et al.2021). It is easy to increase pesticide residues in fruits and endanger human health. Therefore, control measures other than chemical pesticides (Mao et al.2006). should be sought. As a green and pollution-free physical prevention and control technology, color trapping has the advantages of no pollution, no pesticide residues, harmless to non-target organisms, relatively safe to natural enemies, low cost, strong specificity, easy to use, and easy to operate. It has been more and more widely used in organic agricultural production. It is one of the most practical and straightforward techniques for detecting pest population dynamics and controlling pest populations (Gen et al.2012, Wu et al.2007.).

Some insects have a strong tendency to specific wavelengths of color. For example, fruit flies and leafhoppers like to fly to yellow objects. They are using this feature, pests in *Rosa sterilis* S.D.Shi Orchard can be detected or controlled by hanging different color swatches(Zheng et al.2014). As a means of insect prevention and control, the color plate can effectively prevent and control the occurrence of many kinds of color-attracted pests in *Rosa sterilis* S.D.Shi orchard kills a small number of pests in the early stage, reduces the number of insect pests, and ensures the ecological stability of *Rosa sterilis* S.D.Shi orchard(Yang et al.2012). According to the occurrence law of some pests, the correct use of color plates can more effectively control the occurrence of insect pests and reduce the number of pesticides (Zhang et al.2016, Li et al.2015).

The concept of green prevention and control should always run through the research process of pest control in *Rosa sterilis* S.D.Shi Orchard, focusing on agricultural control and physical control. Color plate trapping is a pest control method (Wu et al.2016, Li et al.2012). developed according to the color taxis of pests. At present, the technology of yellow plate trapping insects in fruits and vegetables in China has been widely used to prevent and control pests, and some achievements and progress have been made. Crops are related to melons and vegetables and of loquat, pear, flowers, rice, wheat, and so on. For example,Hui Lu et al. investigated thrips in banana flowers using color plates(Lu et al.2011), Huaijiang Zhang et al. conducted trapping effects on pear gall midges with different color swatches(Zhang et al.2015), and Dan Chen et al. used yellow boards to study Bemisia Tabaci in greenhouse vegetables(Chen et al.2012). The results showed that yellow plates had apparent trapping and killing effect on Bemisia Tabaci. Xuedong Shao et al. used a color swatch to

study the regularity of *Drosophila melanogaster* in wine grapes in the Yantai area (Shao et al.2019). The results show that the killing effect of a color plate on natural enemy insects is relatively small, does not affect environmental ecology, and crop quality is harmless to humans and animals and is beneficial to pest control (Kuang et al.2010, Kong et al.1999).

When using a color swatch to trap and kill orchard pests, we should also consider the occurrence peak of natural enemy insects and avoid being trapped and killed by natural enemy insects during the peak period to reduce their population and destroy the dynamic balance and diversity of orchard insects (Du et al. 2019). Mastering scientific application technology in orchards can effectively improve the effect of color plates on trapping and killing pests and reduce the adverse effects on natural enemies. At present, the research report on using a color plate to trap and kill pests in *Rosa sterilis* S.D.Shi orchard has not been reported yet. In order to explore the trapping and killing effects of different color swatches on pests and natural enemies, five color swatches were placed in the *Rosa sterilis* S.D.Shi base, and the trapping effects of these five color swatches on pests and natural enemies in the *Rosa sterilis* S.D.Shi orchard were compared. The purpose of this study is to provide a theoretical basis for the correct use of color swatches to control pests in *Rosa sterilis* S.D.Shi Orchard.

2 MATERIALS AND METHODS

2.1 Materials

Five color swatches of white, black, yellow, blue, and green (produced by Quanzhou Lupusen Biotechnology Co., Ltd.) are selected with a specification of 20 cm 25 cm.

The survey plot is located in Maguan Town, Maguan Town, Puding County, Anshun City, Guizhou Province (25.21~26.38 N -105.13~106.34 E). The area belongs to the humid climate of subtropical monsoon, with an annual average temperature of 15.1 °C and average annual precipitation of 1378.2mm.

2.2 Test Method

From June to October 2019, the color plate was suspended from the branches of *Rosa sterilis* S.D.Shi in Maguan Town, Anshun City, and the number and hanging date were recorded on the color plate. Three areas were set up, and five color swatches were

randomly hung according to the same height (1.2 m) and spacing (2.5 m). Five color swatches (yellow, black, blue, green, white) were hung evenly according to the same height (1.2 m) and spacing (2.5 m) and repeated three times. The investigation time was carried out from June to October in 2019, including two times per month from June to August, five times in September, and one time in October (the hanging position in each change was the same). The changed color plates were brought back to the laboratory to identify the insects trapped by the color plates or sent to experts for identification, statistics, and preservation. And quantity for statistics, classification, and identification.

2.3 Data Processing

The data were sorted out and plotted by Microsoft Excel 2016 software, and the difference of trapping quantity among different color plates was analyzed by the LSD comparison method. The statistical process was completed by DPS v7.05 software.

3 RESULTS AND ANALYSIS

3.1 Community Composition of Insects Trapped by Color Plates in *Rosa sterilis* S.D.Shi Orchard

It can be seen from Table 1 that the insects trapped by the five color plates are mainly distributed in 11 orders of Diptera, Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Blattella, Leatheroptera, Orthoptera, Homoptera, Odonata, and Phasmida, totaling 23782 heads of 63 families. The dominant group is Diptera, which attracts up to 16616 individuals, accounting for 69.87% of the total, followed by Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, with the number of Coleoptera trapping accounting for 12.30%, Hemiptera trapping accounting for 9.91%, Hymenoptera trapping accounting for 5.93%, and Lepidoptera trapping accounting for 1.40%. It accounts for only 1.60% of the total insect traps.

Table 1: Community composition of insects trapped by a color plate in *Rosa sterilis* S. D. Shi orchard.

Order	Number of individual	Percent /%	Number of families	Percent /%
Diptera	16616	69.87	13	20.63
Coleoptera	2925	12.3	14	22.22
Hemiptera	2118	8.91	8	12.7
Hymenoptera	1411	5.93	8	12.7
Lepidoptera	333	1.4	13	20.63
Blattodea	178	0.75	1	1.59
Dermaptera	111	0.47	1	1.59
Orthoptera	75	0.32	2	3.17
Homoptera	8	0.03	1	1.59
Odonata	5	0.02	1	1.59
Phasmida	2	0.01	1	1.59
Total Total	23782	100	63	100

3.2 Comparison of Trapping and Killing Effects of Different Color Swatches on Main Pests in *Rosa sterilis* S.D.Shi Orchard

It can be seen from Table 2 that the trapping and killing effects of different color plates on the main pests in *Rosa sterilis* S.D.Shi orchard shows that different color plates have significant differences in trapping and killing Muscidae, Calliphoridae, Muscidae, and Pentatomidae. For the pests of Muscidae, the yellow board had the better trapping effect, which was significantly different from the

blackboard, while for the pests of Cercopidae and Cicadellidae, the yellow board had the best trapping effect, with an average of 83.8 and 129 per month, which was significantly higher than that of other color swatches. For the pests of Chrysomelidae, the best trapping effect was blue board, which reached 126.2 per month, which was significantly higher than that of blackboard and yellow board, and the best trapping effect was the green board for Calliphoridae, Muscidae, and Pentatomidae pests. The number of traps reached 174, 476.2 and 48.6 per month, respectively.

Table 2: Comparison of trap-killing effects of different color boards on main pests in *Rosa sterilis* S. D. Shi orchard.

Sticky cards	The number of trapped insects (mean \pm standard deviation)				
	White	Black	Yellow	Blue	Green
Sarcophagidae	37.2 \pm 26.03ab	9.6 \pm 5.99b	75.6 \pm 31.95a	73.2 \pm 58.45ab	69.4 \pm 24.23ab
Calliphoridae	138.0 \pm 100.42ab	12.2 \pm 6.09b	57.2 \pm 46.47ab	73.6 \pm 60.30ab	174.0 \pm 133.20a
Tephritidae	133.4 \pm 94.00ab	19.6 \pm 16.18b	302 \pm 271.82ab	86.6 \pm 80.89ab	476.2 \pm 288.70a
Cercopidae	10.0 \pm 4.48b	16 \pm 9.89b	83.8 \pm 38.66a	6.0 \pm 3.41b	25.2 \pm 11.91b
Cicadellidae	5.4 \pm 3.57b	2.8 \pm 2.08b	129 \pm 65.57a	3.4 \pm 1.36b	25.2 \pm 13.04b
Elateridae	87.4 \pm 61.90a	0.4 \pm 0.24a	35.8 \pm 25.08a	43.4 \pm 36.57a	61.4 \pm 42.22a
Chrysomelidae	85.6 \pm 47.82ab	3.4 \pm 1.89b	17.4 \pm 9.84b	126.2 \pm 65.62a	26 \pm 10.65ab
Stinkbug	29.8 \pm 13.69ab	14.4 \pm 9.78ab	12.0 \pm 5.61b	12.4 \pm 9.23b	48.6 \pm 31.31a
Tettigoniidae	2.4 \pm 1.29a	4.0 \pm 1.61a	3.6 \pm 1.36a	1.8 \pm 0.73a	3 \pm 1.82a

Note: the same letters in the table show that the difference is significant by the LSD method.

3.3 Comparison of Trapping and Killing Effects of Different Color Swatches on Natural Enemy Insects in *Rosa sterilis* S.D.Shi Orchard

As can be seen from Table 3, from the comparison of the trapping and killing effects of different color plates on the natural enemies of *Rosa sterilis* S.D.Shi orchard, it can be seen that the trapping and killing effects of different color plates on the natural enemies of Muscidae and Coccinellidae are significantly

different. However, there was no significant difference in the trapping and killing effects of different colors on the natural enemies of Carabidae, Muscidae, Ichymidae, katydidae, Guogongongnidae. For the natural enemies of Muscidae, the blue board had a higher trapping effect, which was 9.4 per month, which was significantly higher than that of blackboard and yellow board, while for ladybugs, the trapping effect of the yellow board was 16.0, which was significantly higher than that of whiteboard and blackboard.

Table 3: Comparison of trap-killing effects of different color plates on natural enemy insects in *Rosa sterilis* S. D. Shi orchard.

Sticky cards	The number of trapped insects (mean \pm standard deviation)				
	White	Black	Yellow	Blue	Green
Carabidae	1.8 \pm 0.66a	1.6 \pm 0.81a	2 \pm 0.89a	0.8 \pm 0.58a	0.8 \pm 0.37a
Syrphidae	4.2 \pm 2.96ab	0.6 \pm 0.6b	2 \pm 0.95b	9.4 \pm 4.38a	5.8 \pm 2.29ab
Coccinellidae	6.2 \pm 4.50b	5.2 \pm 2.85b	16 \pm 6.25a	10.8 \pm 4.62ab	11.2 \pm 5.76ab
Tachinidae	43.8 \pm 15.81a	18.6 \pm 10.69a	188.4 \pm 157.38a	44.8 \pm 29.24a	41.8 \pm 6.67a
Ichneumonidae	31.4 \pm 9.66a	26.8 \pm 11.15a	73.8 \pm 38.54a	19.8 \pm 7.35a	37.6 \pm 8.69a
Damselfly	0.4 \pm 0.40a	0 \pm 0.00a	0.4 \pm 0.24a	0.2 \pm 0.20a	0 \pm 0.00a
Cleridae	0 \pm 0.00a	0.2 \pm 0.20a	0.8 \pm 0.80a	0.2 \pm 0.20a	0.6 \pm 0.60a

Note: the same letters in the table show that the difference is significant by LSD method.

3.4 Benefit-to-Harm Ratio on Different Color Plates of *Rosa sterilis* S.D.Shi Orchard

Table4 shows that the benefit-to-damage ratio of blackboards is higher than that of other swatches (except June and October). The benefit-to-damage ratio of the blue board is lower than that of other

swatches (except October), and the fluctuation is slight. Secondly, the benefit-damage ratio of the yellow board was higher than that of the whiteboard, blue, and green board and fluctuated wildly in June and August. The fluctuation of benefits and harm of whiteboard and green board is relatively small.

Table 4: Benefit-harm ratio on different color boards in *Rosa sterilis* S. D. Shi orchard.

Year-month	White	Black	Yellow	Blue	Green
2019-06	0.22	0.23	0.43	0.15	0.28
2019-07	0.02	0.09	0.04	0.02	0.04
2019-08	0.16	0.44	0.18	0.09	0.11
2019-09	0.04	0.18	0.04	0.03	0.03
2019-10	0.05	0.05	0.05	0.06	0.04

4 CONCLUSIONS

The technology of swatch trapping has been paid more and more attention and has been widely used. The yellow board is the most widely used in pest trapping and killing, and it is used in rice, wheat, cucumber, and other crops (Chang et al.2013, Gong et al.2011, Zhang et al.2009). The results show that the insects in *Rosa sterilis* S.D.Shi Orchard are mainly distributed in 11 orders: Diptera, Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Blattella, Leatheroptera, Orthoptera, Homoptera, Odonata, Coleoptera. The pests in the *Rosa sterilis* S.D.Shi orchard has a solid selectivity for color(Ling et al.2019). The color plate attracts pests belonging to 11 orders and 63 families. The yellow board attracts the most pests, which has apparent trapping and killing effects on Muscidae, Cercopidae, and Cicadellidae.

Compared with other methods, using color swatches to trap and kill orchard pests is relatively convenient and straightforward, which can reflect the trapping effect of different color swatches on different pests and has some limitations for natural enemies beneficial insects. The experimental results show that different color plates also have a high trapping effect on the natural enemy insects in the *Rosa sterilis* S.D.Shi orchard, especially the yellow plate, is the most obvious. A maximum of 1437 natural enemies were trapped, accounting for 46.07% of the total, with the most significant proportion of predatory and parasitic natural enemies. The monthly traps of natural enemies of Coccinellidae, Muscidae, and Ichylidae were 16.0,188.4 and 73.8 respectively.

Therefore, in the process of pest control in *Rosa sterilis* S.D.Shi Orchard, the benefit-to-damage ratio of insects, is essential for selecting color swatches to protect and utilize natural enemies. We should try to choose those color plates that are strong in attracting pests but weak in attracting natural enemies, such as choosing blue board, green board, or whiteboard to

control pests in *Rosa sterilis* S.D.Shi orchard, which can reduce the trapping effect on natural enemy insects. In the *Rosa sterilis* S.D.Shi orchard, the benefits, and harm of trapping insects on the green board, whiteboard, and blue board are relatively small, and the fluctuation is slight. To ensure the overall luring effect of pests. In the *Rosa sterilis* S.D.Shi orchard, the yellow board traps and kills the most apparent number of pests of Cercopidae and Cicadellidae, which are 129.0 and 83.8. However, it is the most harmful to the natural enemies, especially to the natural enemies of Coccinellidae, which causes severe damage to the natural enemies. These results are similar to those found in other pest trapping studies (Wu et al.2019, Xing et al.2019). Wei Wu et al. showed that the natural enemies of lady beetles had vital taxis to a yellow plate (Wu et al.2019), while Xing Kun et al. showed that yellow plate was beautiful to predatory insects of the family Muscidae (Xing et al.2019). Therefore, it is not recommended to use a yellow board for pest control in *Rosa sterilis* S.D.Shi orchard.

To sum up, in the *Rosa sterilis* S.D.Shi Orchard, it is recommended not to use blackboards or yellow boards but to choose blue boards, green boards, or whiteboards to trap and kill pests, significantly reducing the negative impact of color plates on natural enemies. In order to protect and utilize the natural enemy insects, it is suggested that the color plate should be used correctly according to the occurrence dynamics of insect pests to control the population of insect pests effectively, and the second is to select the color plate reasonably for the main pests (such as green board for the control of fruit flies). Reduce the influence of color plate on natural enemy insects in *Rosa sterilis* S.D.Shi Orchard and achieve the best control effect.

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