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Full Length Research Paper

Determination of optimal diameter of sex pheromone trap for oriental fruit moth

ZHAO Zhiguo, RONG er-hua, ZHANG Jintong and MA Ruiyan*

Agronomy College, Shanxi Agricultural University, Taigu, Shannxi 030801, China.

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The oriental fruit moth (OFM) is one of the major fruit pests worldwide. Although the application of insect pheromones partially relieves the pressure of chemical pesticide on environmental pollution and food safety, the controlling effect is still poor because of the incompatibility of field application standard. This study was designed to examine the correlationship between the OFM catch and the diameter of sex pheromone trap, and then to obtain the optimal diameter. The results demonstrated that the catch was on the rise along with the increase of diameter within the limit of 10 to 35 cm. The correlationship equation is that $y = -0.0025x^3 + 0.0164x^2 + 0.00003x + 0.1043$ (R2 = 0.9639), when the x = 4.333 (namely, the diameter of sex pheromone trap is about 25 cm), the catch reached the maximum 0.2089. Therefore, we suggest that the optimal diameter of sex pheromone trap is 25 cm, with a hope to provide a reference for field experiment.

Key words: Oriental fruit moth, sex pheromone trap, diameter.

INTRODUCTION

The oriental fruit moth (OFM), *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae), has been one of the most destructive fruit pest for many years in most countries because of the following features, such as wide distribution, long generation time (3 to 7), and miscellaneous feeding habit (Kanga et al., 1999). In Chinese, the OFM is also regarded as a very serious agricultural pest, especially in northeast China, North China, East China, and Northwest China. OFM larvae attack both shoots and fruit of its native host plant, but this moth also is known to feed on quince, almond, medlar, and to a minor degree on cherry and plum (Siegwart et al., 2011). In the orchard with serious attack, the incidence of fruit or shoot damage often reaches up to 50 to 80% and thereby brings about great loss in fruit production. Presently, the main pest control method in agricultural production is dependent on chemical pesticides, and fruit growers always rely on experience for the prevention and control of pest insects. Thus, chemical pesticides were only applied when lots of pest insects have occurred or no pest was present in the orchard, which finally caused pesticide consumption beyond the actual demand, followed by more pesticide residues, ecological environment deterioration, and improved pests drug-resistance. This seems to contradict the concept of food safety and ecological balance. In 1969, (Z)-8--dodecen-1-yl acetate was first identified as the sex pheromone of OFM, which promote the pheromone as an alternative method to control moth (Kang et al., 1985; Trimble et al., 2007).

A sex pheromone is a chemical signal emitted by insects in trace amounts, possessing strong physiological activity, and species specificity, and usually used to monitor and control insects (Karlson et al., 1959). Therefore, it is also termed a biorational pesticide. The application of insect pheromone is a new technology that have the virtue of specificity, efficient, non-toxic, non-pollution, no harm for beneficial insect, so that it meets the requirement of sustainable development of agriculture, and conforms the integrated pest management (IPM) strategy that emphasis on the regulation principle of pest control, without killing the pest (Tang et al., 2004). More attention was attracted from

*Corresponding author. E-mail: maruiyanscience@gmail.com. Tel/Fax: 86-0354-6286003.

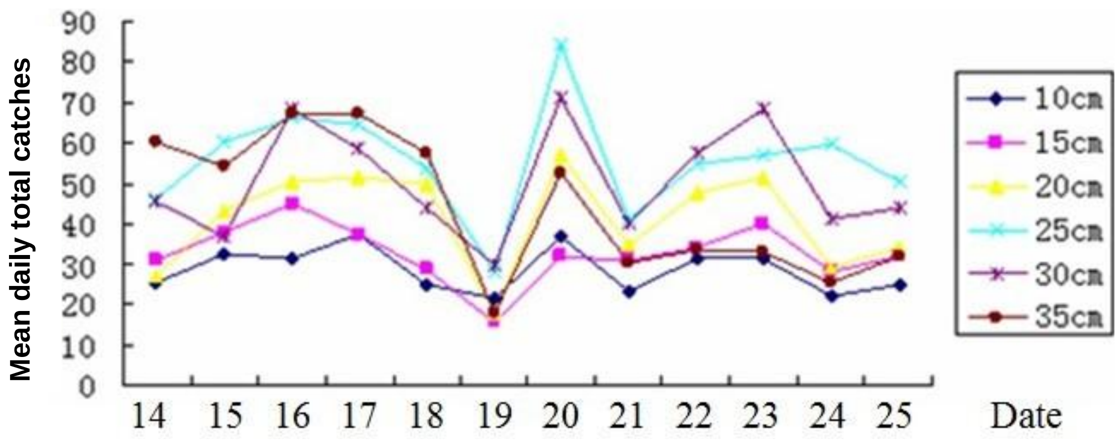

Figure 1. Mean daily OFM catches in each treatment.

domestic and foreign agricultural scientists. Since the 1980s, multiple insect pheromone products have come out, and achieved significant results in the pest inspection (Sanders et al., 1996; Hui, 2001; Kovanci et al., 2004; Trimble et al., 2004; Myers et al., 2007). Therefore, sex attractant application has become an indispensable means in pest quarantine, inspection, and controlling.

Although its research and utilization are developing rapidly, a sharp contrast is still present from the needs of the prevention and controlling of pest. Recent observations have indicated that this technology is not widely applied domestically and that fruit growers benefit less. The main reason lies in the incompatibility of field application standard. Therefore, this study is aims to use sex pheromone of OFM in peach orchard to find the optimal diameter of sex pheromone trap, and to provide a reference for accurate control and reduction of pesticides use. Importantly, we attempt to prepare for large-scale application and popularization in future.

MATERIALS AND METHODS

Sex pheromone lures (Institute of Zoology, Chinese Academy of Sciences) were used to monitor OFM populations in each treatment. Rubber septa was loaded with 200 µg of OFM pheromone containing 95% (Z)-8-dodecen-1-yl acetate and 5% (E)-8-dodecen-1- yl acetate. Pheromone lures were valid for 60 days.

Field description

Field experiments were conducted in a peach orchard in Taigu County of Shanxi (longitude 37°20′28.72''E, latitude 112°32′01.06'' N). The study area is influenced by a temperate continental climate. It is cold and dry in winter, while in summer, it is hot and rainy with a temperature of 15 to 35°C in July and August, which is the peak period for the second generation of OFM. Therefore, sex pheromone trap experiment was performed during this period to effectively control OFM. The trees in this orchard are all growing luxuriantly with an average age of 10～20 years old, and spacing in the rows and between rows of 3 × 3 m.

Experiment design

The experiment was arranged with six treatments (that is, 10, 15, 20, 25, 30, and 35 cm in diameter of pheromone traps) and four replications. The interval between each trap was 20 m. The pheromone traps were made from a hard-plastic basin, 8 cm deep. Then a thin wire passed through the lure and made the lure fix in the middle of basin. Three wires were then applied to hang the basins in the upper canopy of trees at least 1.5 m above the ground. Water and washing powder were added into the basin and maintain the lure at 0.5 to 1.0 cm above the water surface. The OFM were attracted by the lures and they entered the traps. When the OFM fell into the water, they were quickly killed by the insecticide. The efficacy of treatments was evaluated by comparing captures of OFM in pheromone-baited traps. The OFM catches were checked daily at 6:00 to 9:00 in the morning from 14th August 2010 to 25th August 2010 and then the traps were emptied.

Statistical analysis

Analysis of variance (ANOVA) was conducted using the SPSS16.0 software package. Comparison among treatments was performed using Duncan's multiple range test at the 0.05 probability level.

RESULTS

Mean daily catches in each treatment

Mean daily catches in each treatment with four replications were shown in Figure 1. From the results, we could find that the dynamic change trend of mean daily catches was generally consistent under different trap diameter, which reflected the activity rhythm of the second generation OFM. The mean daily catches increased as the diameter of pheromone trap increased. From 14th to 19th August, mean daily catches were significantly higher in a diameter of 25 and 35 cm pheromone trap than others. However, from 19th to 25th August, mean daily catches were significantly higher in a diameter of 25 and 30 cm pheromone trap than others.

Table 1. Mean daily OFM catches of 12 days in each treatment.

Diameter of pheromone trap (cm)	Mean daily catches ± standard deviation
10	114.5±22.28[a]
15	130.92±29.5[ab]
20	164.92±48.84[abc]
25	221.83±55.43[c]
30	202.08±55.38[c]
35	176.67±68.94[bc]

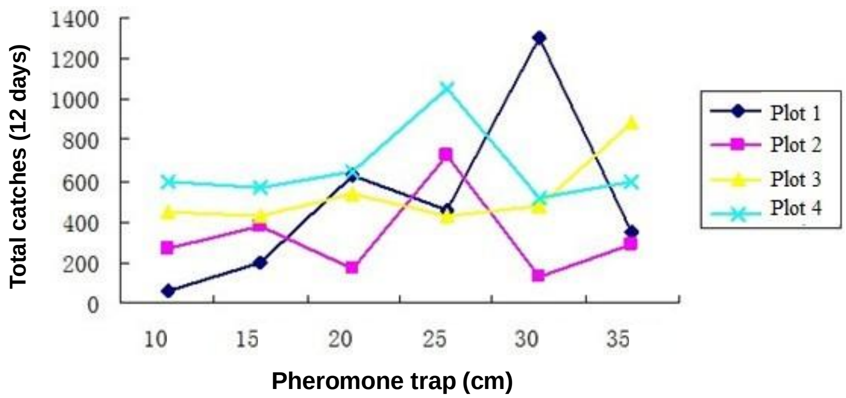

Figure 2. The changes of total OFM catches in different plots under the same treatment.

On 19th August, there was a significant decrease in mean daily catches. We suggested it might result from the rainfall on that day, thus inhibiting OFM activity. Overall, we suggested that a diameter of 25 cm pheromone trap captured the highest OFM daily.

Multiple comparison of mean daily catches among each treatment

Overall, the mean daily catches gradually increased from the 10 to 25 cm pheromone trap and reached the peak value in the 25 cm pheromone trap. Subsequently, the mean daily catches started to reduce in 30 and 35 cm pheromone trap. Mean daily catches of 12 days in each treatment are shown in Table 1. Further, capture data indicated that there was a significant difference in the catches between the diameter of 10 cm pheromone trap and 25, 30, and 35 cm pheromone trap. There was also a significant difference in the catches between the diameter of 15 cm pheromone trap and 25, and 30 cm pheromone traps. No significant difference was observed between the 20 cm pheromone trap and others.

The changes of total catches in different plot under the same treatment

Our results showed that the catches reached the maximum in plots 2 and 4 under a 25 cm pheromone trap treatment. However, the peak of OFM occurred in plots 1 and 3 with a 30 and 35 cm pheromone trap treatment, respectively (Figure 2).

The changes of total catches in the same plot under different treatment

Our results indicated that the trap diameters with the maximum catches were 30, 25, 35, and 25 cm in these four plots, respectively. The catches were stable under 25 cm trap diameters, but varied greatly in 35 cm trap diameters. The results also showed that the maximum occurrence of OFM was around 14th and 21st August; and except for plots 1 and 3, the catches were higher in the 25 cm pheromone trap than others (Figure 3).

The catches trend under different treatment

The capture from 18th to 23rd August was further analyzed and the mean daily catches were calculated (Figure 4). Based on the aforestated description that 21tst August was the peak of OFM, we established the correlationship equation $y = -0.0025x^3 + 0.0164x^2 + 0.00003x + 0.1043$ ($R2 = 0.9639$), when the $x = 4.333$, the catch reached the maximum 0.2089 (Figure 5). The corresponding diameter of pheromone trap was about 25 cm.

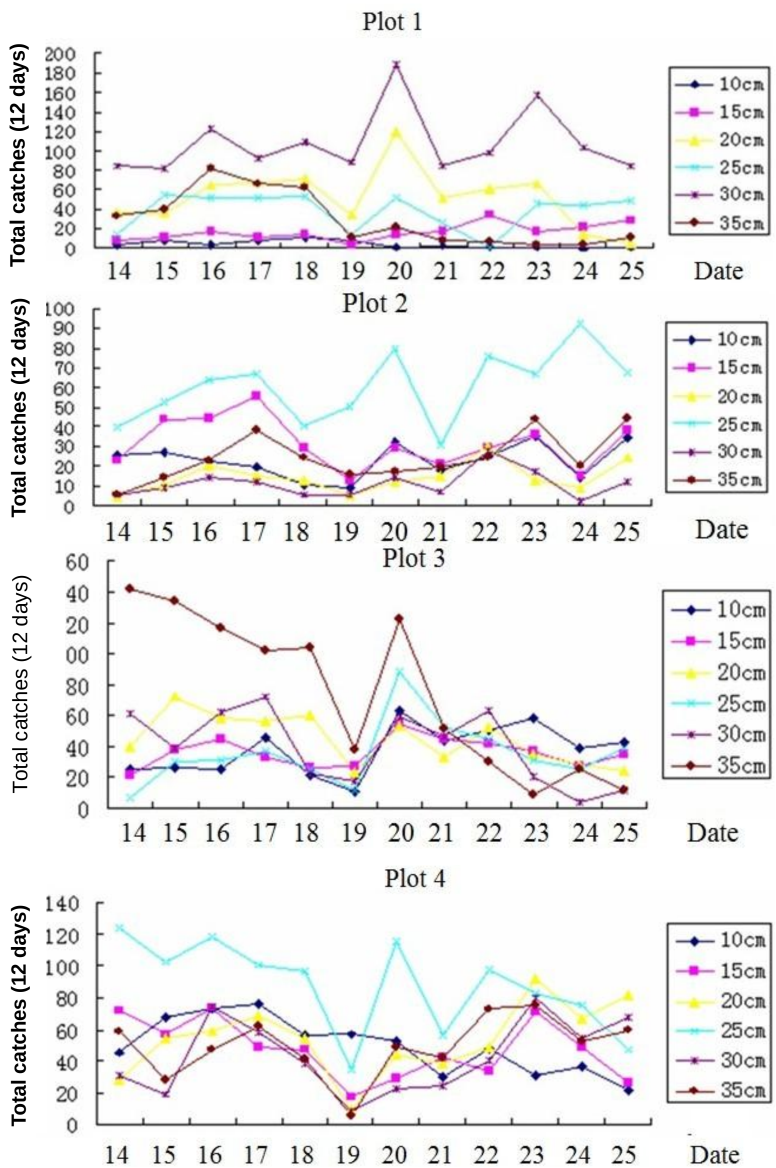

Figure 3. The changes of total catches in the same plot under different treatment.

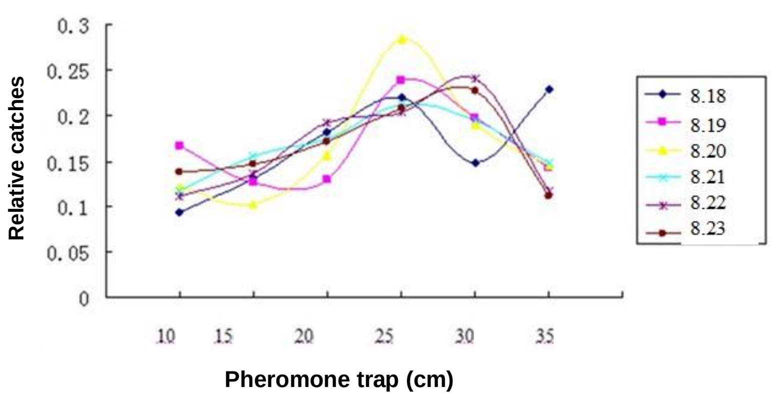

Figure 4. Relative OFM catches of 6 days in each treatment.

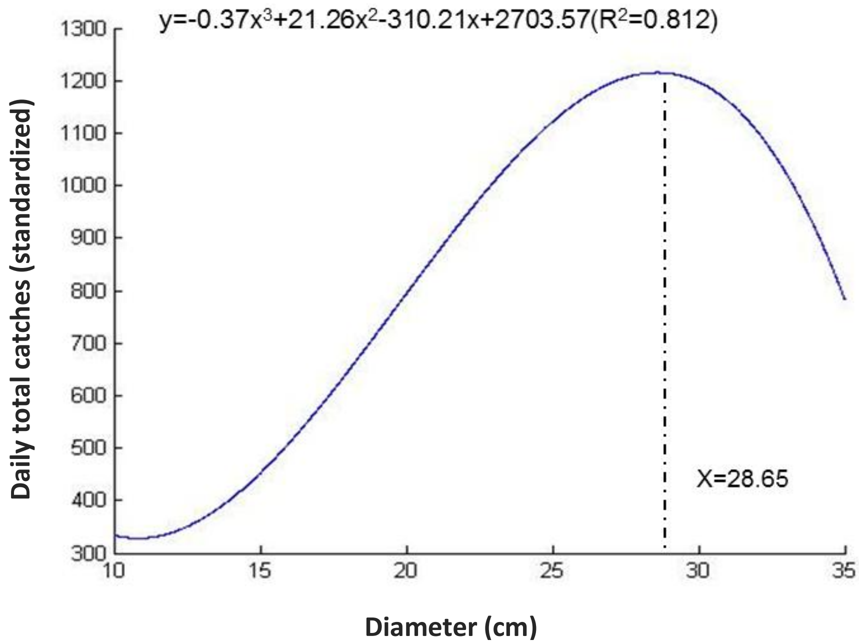

Figure 5. Correlation curve.

DISCUSSION

Usually, the OFM fly into the lure at a Z-shaped path along a concentration gradient (Byers, 2007) followed by circular track taking the lure as the center (Willis et al., 1991). When approaching the source, the OFM would reduce their flight speed and land on the trap (Willis et al., 1994). Therefore, we suggested the radius of circular flight path might be related with the diameter of the traps. In this study, we predicted that the optimal diameter of pheromone trap was 25 cm that could capture the maximum OFM and showed significant difference with others at the 0.05 probability level. Our results seemed to be in accordance with previous reports that demonstrated the optimal diameter of water basin-shaped trap which was 20 to 30 cm with the maximum catches in 25 cm diameter. The catches were relatively lower under a 10 cm and 30 cm pheromone trap treatment, which may be the results of the basin diameter less or more than the circular flight diameter (Willis et al., 1994).

However, there is still some underlying problem in our study. Firstly, more variation would be present in field experiments, thus further study is indispensable to confirm our conclusion. Secondly, the optimal diameter of pheromone trap in plots 1 and 3 was found as 30 and 35 cm, but not 25 cm, indicating that the edge effects from terrain and basin hang sequence should not be ignorable. Importantly, the uneven distribution of air current and terrain, etc (McNally et al., 1981), result in blanking zone formation of pheromone, and thereby could not prevent OFM copulation. However, there has not been a suitable method to control this situation currently, and therefore frequent observation is necessary for the population dynamics. Once a bad sign occurred, pesticide control should be reinforced. In addition, because of reducing pesticides application, pest insects that should have been killed at the same time formerly would increase, namely, the secondary pests rise.

ACKNOWLEDGEMENTS

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