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Occurrence of Insect Pests in a Tomato Field under a Pesticide-free Dry Season Water-saving Cultivation in Northeast Thailand

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Abstract

The occurrence of insect pests and natural enemies was surveyed in a tomato field subject to water-saving cultivation during the dry season in northeast Thailand. The water-saving cultivation plots were mulched with plastic film or rice straw and watered 5 times during the crop cycle, while the conventional plots were un-mulched and watered 3 times a week. A total of 5 $g \cdot m^{-2}$ of 12-9-6 liquid fertilizer was applied to each plot. Pesticide was not applied to any of the plots. The tomato yields in the plots covered with plastic film or rice straw mulches were 1205 and 934 $g \cdot m^{-2}$, respectively, and that of the conventional plot was 1123 $g \cdot m^{-2}$. These values were almost similar to the local average yield of 1190 $g \cdot m^{-2}$. The prevalence of various insect pests such as aphid, thrips, whitefly, leaf miner, insects belonging to the Coccidae and Miridae families, and cotton bollworm were observed. The water-saving cultivation had little influence on the occurrence of insect pests compared with conventional cultivation. Apart from some yield loss due to the cotton bollworm, the tomato yield remained nearly intact, and the crops sustained no serious damage.

Discipline: Crop production & Insect pest
Additional key words: rainfed agriculture

Introduction

In tropical rainfed areas, continuous water supply is one of the limiting factors for vegetable production, especially during dry seasons. In order to develop a water-saving technology for vegetable production, the Japan International Research Center for Agricultural Sciences (JIRCAS) has been conducting a rainfed agriculture project in collaboration with the Thai government. In this research project, a pilot study for water-saving cultivation of tomatoes has been underway in northeast Thailand since 2003. In 2004, 10 farmers participated in the field trial for the development of the water-saving technology. Although the standard irrigation level for tomatoes is 524 mm in northeast Thailand[8], the farmers successfully raised tomatoes in their fields with a water supply of less than 30 mm during this trial[6]. Most farmers used no pesticide; despite this, their crops sustained no serious damage, except for some damage by the cotton bollworm. Tomatoes are a common and important food item in northeast Thailand and are typically used as an ingredient in the traditional papaya salad. In Thailand, the people are well aware of the deleterious effects of residual chemicals; therefore, there is a demand for chemical-free vegetables. Under such circumstances, producing vegetables without pesticides endows the product with additional value. We had prior information that water-saving cultivation could reduce insecticide use[5], although no scientific studies supporting this idea had been implemented. Generally, 3 factors need to be considered before implementing chemical-free cultivation: (1) lack of insects,

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Photo 1. A light trap in the experimental field
Nong Saeng village, Khon Kaen Province
(November 13, 2004)

Photo 2. Experimental field
Nong Saeng village, Khon Kaen Province
(January 17, 2005)

(2) drift of insecticide from neighboring fields, (3) existence of natural enemies. We were interested in assessing whether water-saving cultivation affected the occurrence of and damage by insect pests. Therefore, we monitored insect pests and natural enemies in a tomato field under water-saving conditions. This cultivation not only conserved water but also fertilizer. For the first step, we concentrated on watering levels.

Materials and methods

1. Study site

The study site was Nong Saeng village in northeast Thailand (16°10′21″N, 102°47′36″E, 179 m above sea level), located approximately 30 km south of Khon Kaen City. The lowlands of this area are mainly used as paddy fields, whereas the uplands are used to cultivate crops such as sugarcane and cassava. The plots used for our experiment were located in a dry paddy field after rice harvesting had been carried out. Generally, during the dry season, paddy fields are used for cattle grazing instead of crop production. The paddy fields in this study were surrounded by sugarcane and cassava fields, with no vegetables grown in the vicinity. During the experiment, no insecticides were sprayed in the surrounding fields. The experimental field was used as a mother trial (a kind of demonstration field) for the farmers' participatory trial[6]. There was a farm pond close to the paddy field - a typical feature of vegetable fields in northeast Thailand.

2. Light trapping

Because of the possibility of poor insect fauna in these fields, there was a need to obtain detailed information on the fauna in the experimental area in advance. For this, light traps consisting of a 10 W black light fluorescent lamp with a peak spectrum of 352 nm (type FL-10BLB) and a water pan with diameter of 30 cm were set. The black light was suspended from a height of approximately 1.8 m, under which crossed transparent plastic boards were set. The water pan was set 1 m above ground and filled with water mixed with small quantities of kitchen detergent and formalin (Photo 1). The traps were set up at 2 locations in the Nong Saeng village for a total of 7 nights between November 10 and 19, 2004. One was set at the experimental field, while the other was set at a field approximately 400 m south of it. The location conditions of the 2 fields were similar. Insects trapped overnight were collected the following morning and stored in a freezer until their examination. Because numerous insects were trapped each session, only some of the collected insects were examined as follows: all the insects were scattered onto a sheet of paper and randomly divided into several groups. Subsequently, 1 part (approximately 100 mL) was chosen as the sample to be examined and their taxonomical orders identified. Coleopteran insects were further classified into their families.

3. Cultivation

The 2 types of water-saving plots (plastic film or rice straw mulch) and the conventional plots were aligned in a randomized block design, each featuring 3 replicates. The size of each plot was 1 × 20 m. Each plot was divided by a 0.5-m path. One type of water-saving plot was covered with white plastic film mulch (Sekisui Twin White) and the other, with a layer of rice straw approximately 5 cm thick. The conventional plots were unmulched. Tomatoes were seeded on a seedling tray on November 1, 2004, and protected by a 2-mm mesh insect net. Between December 1 and 3, 2004, seedlings (30 d after sowing, approximately at the 5.5-leaf stage) of a local tomato variety, namely, Seeda (*Lycopersicon esculentum* Mill cv. Seeda, determinate type cherry tomato), were transplanted into the plots in rows at intervals of approximately 0.5 m and covered with mulch (Photo 2). The water-saving plots were then irrigated with 20 L of water containing a liquid fertilizer (N-P-K: 12-9-6) diluted up to a ratio of 1:1000 on the day of transplantation with a drip irrigation tape. Additional water (containing fertilizer) was provided at 2, 4, 8 and 12 weeks after transplantation as described above. The conventional plots were irrigated with 20 L of water 3 times a week. Liquid fertilizer (N-P-K: 12-9-6) was added to the water at a dilution ratio of 1:1000, at 0, 2, 4, 8 and 12 weeks after transplantation, so that the amount of fertilizer applied to each plot was the same (N-P-K: 0.6, 0.45, 0.3 $g \cdot m^{-2}$).

These trials were conducted to demonstrate water-saving cultivation to the farmers participating in the technology development[6]. Special care was taken to compare the yield of tomatoes obtained by the farmers' regular farming practices to that obtained with the water-saving technique. Generally, in their home gardens, farmers remove pests and damaged fruits, to protect the crops from further invasion and prevent yield loss during the rest of the season. Therefore, the cotton bollworm, *Helicoverpa armigera,* and the tomato fruits damaged by the same were removed approximately weekly. The damaged fruits were collected and weighed to evaluate the yield loss caused by the cotton bollworm.

4. Field observations

From December 11 onwards, weekly visual surveys of randomly selected tomato plants from each plot were conducted to determine the occurrence of insect pests and natural enemies. The number of plants examined during weeks 1 - 4, 5 - 8 and 9 - 12 were 20, 10 and 5, respectively. The total number of arthropods was counted for individual plants.

On day 51 after transplantation (observation week 6), 2 yellow sticky traps (10 × 15 cm, both sides) (Rincon-Vitova Inc.) were placed in each plot at a height of 30 cm above the tomato plants, and the height was adjusted weekly as the plants grew. The number of trapped arthropods was also counted weekly.

Results and discussion

The dry season began from September 22, 2004. Rainfall did not exceed 1 mm throughout the experimental period and the average daytime temperature was 18 to 31 ºC. The flowering of the tomato plants commenced on January 15, 2005, and the tomatoes were harvested from February 5 to April 19, 2005. This is the common cultivation schedule in northeast Thailand. The damage caused by insect pests to the tomato plants seemed negligible with the exception of the cotton bollworm, which caused damage not only in the water-saving plots but also in the conventional plots. The final yields of tomatoes in the water-saving plots with plastic film and straw mulch were 1205 ± 333 and 934 ± 192 $g \cdot m^{-2}$, respectively, while the conventional plots yielded 1123 ± 275 $g \cdot m^{-2}$(means ± SE). These values were almost similar to the average yield of tomatoes, 1190 $g \cdot m^{-2}$, in Khon Kaen Province[3].

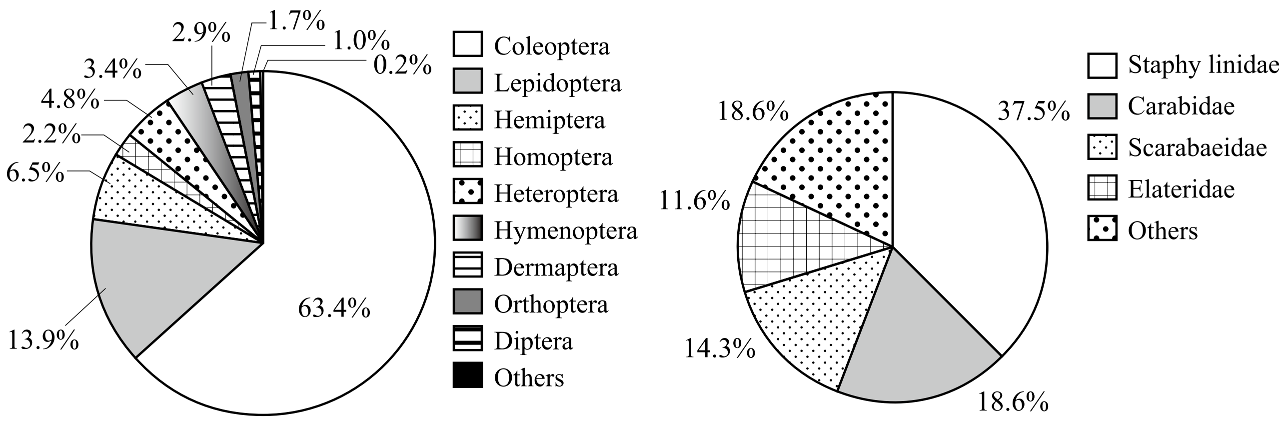

Fig. 1. Orders of insects (left) and families of coleopterans (right) collected by light traps in Nong Saeng village in November 2004

No invasion of the tomato root system was observed from the water-saving plots to the conventional plots and vice versa.

1. Light trapping

It seems that the insect fauna in the environment surrounding the experimental field was not poor, because a total volume of approximately 0.5 L of insects was trapped during each session. The composition of the insects collected at both locations appeared similar. Therefore, the data observed were considered to represent the general composition of insects in the vegetable field that was located near a farm pond. All the data from the different traps were then combined. A total of 2897 insects were examined in the portion of approximately 100 mL. Figure 1 shows the composition of insects collected by the light traps. Approximately 60% of the trapped insects belonged to the Coleoptera order. Among these coleopterans, Staphylinidae, Scarabaeidae, and Elateridae were the major families. Among the other insects trapped, various predators, including ground beetles (Carabidae) and earwigs (Dermaptera), were found.

2. Occurrence of insect pests and natural enemies

Lange & Bronson (1981) pointed that there are many situations where minor pests become major pests and for

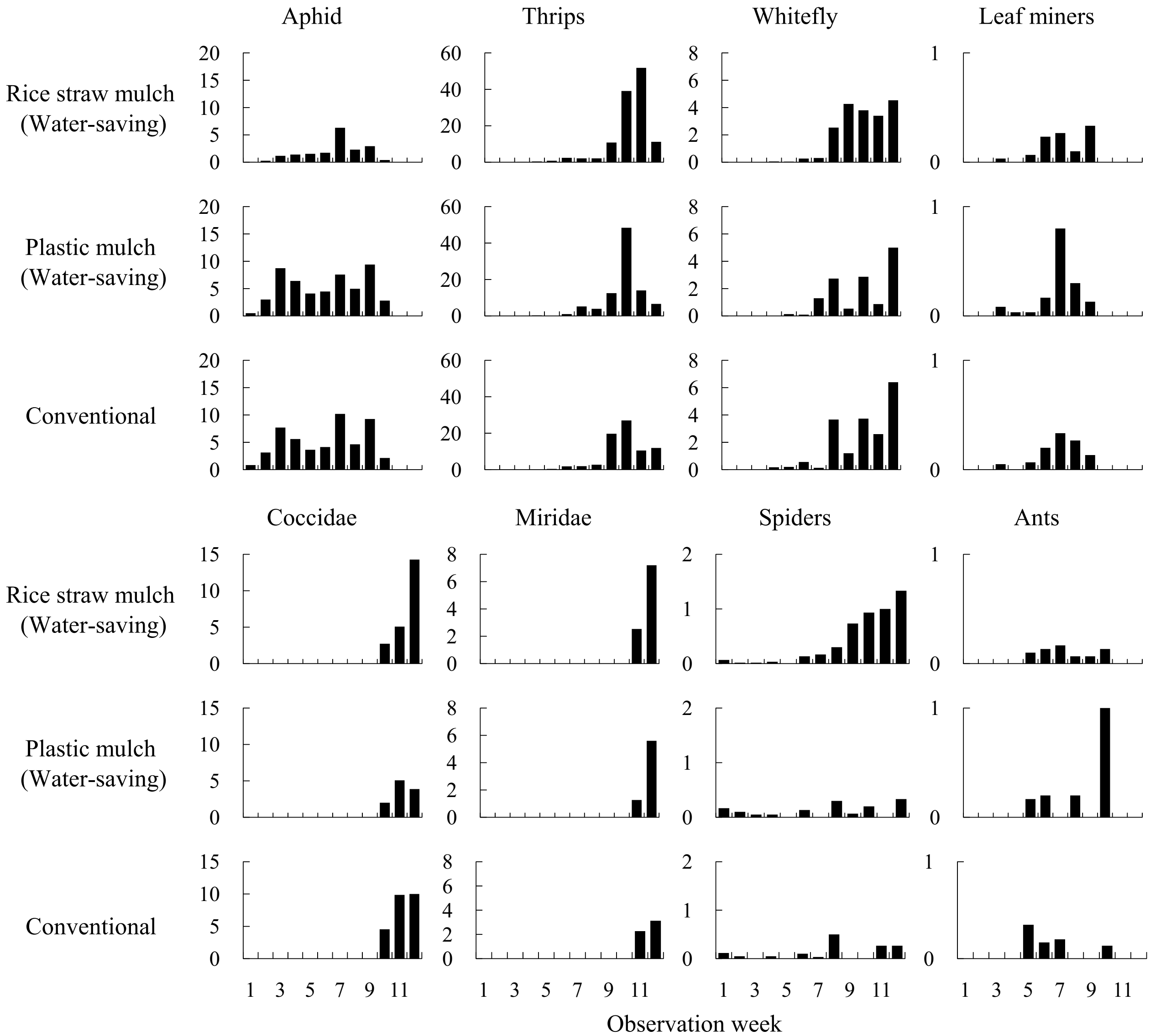

Fig. 2. Seasonal changes in the number of arthropods on the tomato trees

The number of observed arthropods per tomato plant is presented. Aphids, *Myzus persicae*; Thrips, *Thrips palmi*; whitefly, *Bemisia tabaci* (biotype unknown); Leaf miners, *Liriomyza* spp. Other arthropods were not identified. The values shown are means (n = 3). Tomato plants were transplanted to the field between December 1 and 3, 2004. Observation was initiated on December 11, 2004, which is designated as week 1 on the horizontal axes.

this reason the tomato grower has to be constantly on guard during all phases of tomato production. In addition to the damaging species, there is the very large complex of beneficials that often play a key role in reducing pest numbers[4]. In the case of our study, except for cotton bollworms, all other insect pests were observed in small numbers. Figure 2 summarizes the temporal changes in the number of arthropods found on tomato plants grown under 3 different cultivation conditions. Alate adults of the green peach aphid, *Myzus persicae,* were found throughout the observation period, but their population density was generally low. In particular, the number of aphids in the straw mulch plots was consistently lower than that in the other 2 plot types. The melon thrips, *Thrips palmi,* were the most abundant pests in the tomato field. During observation week 11, their number increased to 53 individuals per plant in the water-saving plots covered with rice straw. In the conventional plots, however, they multiplied more slowly. The sweet potato whitefly, *Bemisia tabaci* (biotype unknown), was found in the latter half of the observation period. This species is economically important because it acts as a vector transmitting the tomato yellow leaf curl disease (TYLCD), which causes serious losses in tomato yields[1]. TYLCD is widespread over north, northeast, and central Thailand. The Seeda variety used in the present study is especially susceptible to this disease. If tomatoes are infected with TYLCD between the seedling development stage in the nursery and the flowering stage, they often produce no yield at all[2]. However, the plants showed no symptoms of the TYLCD during the observation period, which suggests that the presence of the whitefly may not cause economic damage to tomatoes at this time of the year because of its low or lack of virulence. Leaf miners such as the *Liriomyza* spp. were observed during weeks 3 - 9; their population peaked at week 7. Insects from the Coccidae and Miridae families were observed from weeks 10 and 11, respectively.

In the latter half of the observation period, the number of spiders in the rice straw mulch plots was remarkably higher than in plots of the other 2 types. It is very likely that rice straw mulch provides a favorable habitat for spiders. In the rice straw mulch plots, fewer aphids were present in the latter period than in the plots of other 2 types. The application of rice straw mulch has been recommended as a method for maintaining the spider population for natural control of aphids by Reichert and Bishop[7]. According to their study, there was a 70% reduction in the damage caused to vegetables by insect pests when hay or straw was used as mulch; this reduction in damage was caused by the spiders, because mulch is a more suitable habitat for spiders than bare ground. Ants were found during weeks 5 - 10; a spike in the ant population was observed at week 10 in the plastic film mulch plot. However, the reason underlying this occurrence was not clear.

Figure 3 summarizes the temporal changes in the number of arthropods caught by the sticky traps. The number of aphids in the straw mulch plots was consistently lower than that in the other 2 plot types. However, no

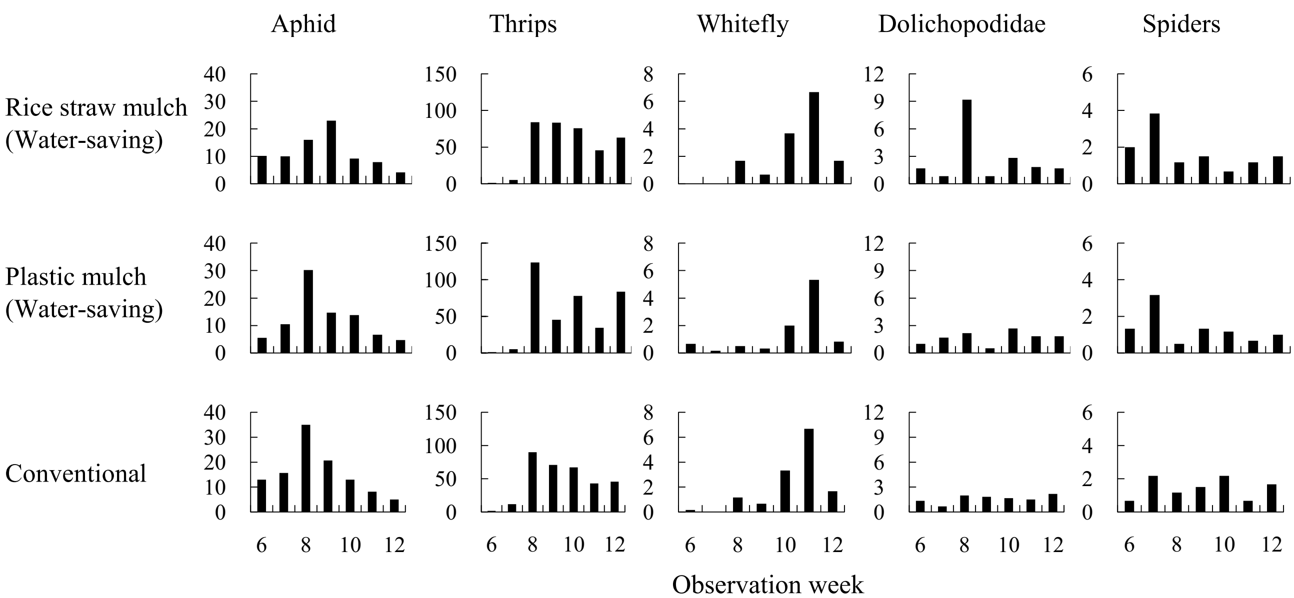

Fig. 3. Seasonal changes in the number of arthropods caught by sticky traps

The number of arthropods collected per trap is presented. The values are means of 6 replications. The observations started from week 6 on the horizontal axes of Fig. 2.

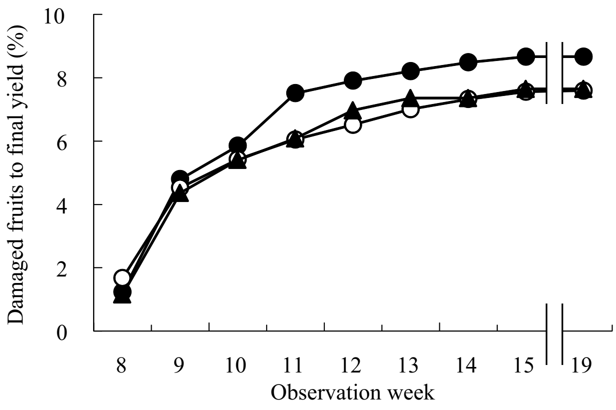

Fig. 4. Damage by the cotton bollworm, *Helicoverpa armigera*

Cumulative damage caused by *H. armigera* expressed as the percentage weight of damaged fruits relative to the final yield of tomatoes. Values shown are the mean of 3 replications.
—●—: Plastic, —○—: Rice straw, —▲—: Conventional.

remarkable differences were observed in the number of insects collected by the traps among the treatments. The number of aphids peaked during weeks 8 - 9. The numbers of thrips and whiteflies caught by sticky traps peaked at weeks 8 and 11, respectively. Thrips peaked 2 - 3 weeks earlier than those on the plants, while those of whiteflies were 1 week earlier than those on the plants. The long-legged flies (Dolichopodidae), which are considered natural enemies of pest insects, were trapped in all the plots. A small number of insects from the Miridae family were also trapped in the rice straw mulch plots.

The cotton bollworm was observed from the beginning of the flowering stage. Although its numbers were generally small, the larvae attacked young fruits and caused direct yield loss. The total damage in weight was 7.6 - 8.7% with respect to the final yield, and minor differences in the total damage were observed among the different treatments (Fig. 4).

Conclusion

We mentioned in the introduction that 3 factors generally need to be considered before implementing chemical-free cultivation: (1) lack of insects, (2) drift of insecticide from neighboring fields, (3) existence of natural enemies. The results of the light trapping show that the insect fauna inhabiting the study site is not poor. In addition, all major insect pests of tomato, such as aphid, thrips, whitefly, leaf miner, insects belonging to Coccidae and Miridae, and cotton bollworm, were observed. Therefore, there was no dearth of insect species at the study site.

Very few pest insects and natural enemies were observed and there were no remarkable differences between the water-saving and conventional plots. Therefore, the low incidence of pests and natural enemies is not influenced by the watering level in the plots.

As mentioned in the introduction, fertilizer input is another factor that may influence the occurrence of insects. In the present study, fertilizer input was low in all the plots. Therefore, it is possible that the low fertilizer levels were responsible for the lack of insect pests. The standard tomato nitrogen fertilizer application in this area is 7.9 $g{\cdot}m^{-2}$ (Khon Kaen Agricultural Extension Office) whereas nitrogen application in this experiment was only 0.6 $g{\cdot}m^{-2}$. Further study is needed to determine whether the fertilizer influences the insect pest population.

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