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# Rice striped stem borer, *Chilo suppressalis* (Lepidoptera: Pyralidae), overwintering in super rice and its control using cultivation techniques

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ABSTRACT

Super rice has the potential to deliver very high yields but is also susceptible to attack by the striped rice stem borer, *Chilo suppressalis*. In this study, surveys and field trials were performed to examine this problem and efficient ways were found to lower the borer's population density. It was found that larger super rice plants provided more refuges for borers to evade insecticide contact and had a longer growth period allowing borers to complete their larval development in an intact environment. The current cultivation regime was shown to favour outbreaks of borers. Super rice is harvested leaving tall field stubbles until the following growing season, thus providing food and cover in which borers may successfully overwinter. We found that borer larvae were distributed to a greater height in the plants of super rice than in common rice, making control through agricultural operations more feasible. Burning fields after harvest, which killed 84.5% of borers, seemed the best remedy, though this practice is forbidden in China for ecological reasons. Leaving short stubbles followed by appropriate treatment of the rice straw killed 74.0% of the borer population. In addition, spring irrigation after the pre-pupation dispersal movements of borers killed more than half of the overwintering population. Pre-winter rotary tillage had little effect on borer numbers but enhanced the population reduction effect of irrigation the following spring. Based on the results obtained, efficient control of borers on super rice can be achieved by harvesting leaving short stubbles, followed by rotary tillage and spring irrigation. This regime can reduce the borer population by more than 98%, minimising chemical use and maximising use of a reduced agricultural workforce.



## 1. Introduction

Super rice is characterized by its high yield, usually providing more than 11,250 kg per hectare (Zhao et al., 2006). Most varieties of super rice grow to a larger plant size and have a somewhat longer growth period than normal varieties. They therefore provide a different kind of physical habitat for pest species to inhabit. Perhaps as a consequence, super rice suffers greater pest problems than common rice (Qu et al., 2007; Wang et al., 2008). Yongyou 6 is one of the most widely planted super rice varieties in the middle-southern parts of Zhejiang province, China. It usually grows to more than 1.5 m high and the growing period spans about 157 days (Wang et al., 2008). It has been identified as a quality rice variety with great market potential, increasingly grown since 2001. However, Yongyou 6 has not replaced any of the major rice varieties in areas where it is grown because of its serious pest problems.

The striped rice stem borer, *Chilo suppressalis* (Walker), is one of the most important insect pests rampant in super rice. Especially in the late growing stage, the tall super rice plants provide more refuges for borers to reduce insecticides contact. *C. suppressalis* always causes serious damage to super rice plants and produces large overwintering populations (Qu et al., 2007). The population of *C. suppressalis* increases stepwise generation by generation, so larger overwintering populations will give rise to even larger populations in the following growing season. Therefore, extending the cultivation of super rice could lead to widespread failure in the management of rice borers, and this has necessitated the pursuit of new ways to overcome this problem.

Efficient machinery equipment has been introduced for spraying pesticides onto super rice. However, heavy spraying should be avoided, especially late in the growing season, to minimize the buildup of chemical residues on the rice. The breeding of transgenic

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pest resistant rice varieties is another pest control method currently receiving a lot of interest. But the risks and benefits of transgenics take a long time to evaluate and no transgenic pest resistant rice varieties have yet been released for wider cultivation. In this study, we surveyed the overwintering populations of the striped rice borer on both super rice and common rice and conducted controlled trials to examine various agricultural countermeasures that could be used for the efficient suppression of the pest population.

## 2. Materials and methods

### 2.1. Super rice

Yongyou 6 is a super rice hybrid of hsien and japonic rice developed by the Ningbo Academy of Agricultural Science and Seed Company in Zhejiang province. The surveys and trials were carried out at Nianmuyang village, Daxi town, Wenling city in Zhejiang province, where serious outbreaks of *C. suppressalis* had occurred. Despite conventional cultivation and pesticide application, large borer populations persist in the super rice crops from year to year.

### 2.2. Common rice varieties

Two kinds of common rice, Glutinous rice and ZhongZu 14, were selected as controls because they were planted as single season late crops with a similar harvest time to Yongyou 6. However, borers in common rice fields were usually well controlled, to the extent that there were not enough borers for sampling. Thus, the sampling site was selected at the experimental farm of the China National Rice Research Institute in FuYang County (Zhejiang province), where cultivation practices for the common rice types were conventional, but no pesticides were applied unless a brown planthopper outbreak occurred. Therefore, there were always enough borers present to enable accurate sampling.

### 2.3. Survey of the vertical distribution of overwintering *C. suppressalis* in rice plants

Rice plants were sampled just before the rice was harvested. A hundred rice hills of each variety were sampled. To obtain more borers, only the damaged rice hills, containing some white-headed plants, were sampled. They were cut at ground level, taken back to the laboratory and dissected. The instar of the borer larvae and their vertical position in the rice stems were recorded in detail.

### 2.4. Evaluation of the control effect of different cultivation practices

Field trials were established in 2008 in random plots in paddy fields where rice growth was even and *C. suppressalis* occurred at damaging level. The treatments involved: 1) harvesting so as to leave rice stubbles of different heights (30 and 10 cm); 2) burning or not burning stubbles post harvest; 3) rotary tilling the field or not before winter; 4) irrigating or not early in the following spring. For easy manipulation, large plots about 1000 $m^2$ and five-point sampling methods were employed. In each un-tilled plot, 100 hills of rice stubble or burned stubble residues were sampled by the parallel line sampling method and then dissected for borers. In the tilled plots, the tilled soil layer and all rice stubble residues were inspected in a 1 $m^2$ sample area at each point (equivalent to 13 rice hills). The numbers of live borers per 100 $m^2$ were calculated for each treatment and used as the standard parameter for comparison. The data were subjected to ANOVA and means were separated using Tukey's HSD test ($\alpha = 0.05$) using SPSS software.

**Table 1**
The vertical distribution of *Chilo suppressalis* larvae in plants of different rice varieties at harvest time.

| Rice varieties | | Total larval numbers detected | Distribution of larvae in plants (%) | | |
|---|---|---|---|---|---|
| | | | Within 10 cm above the soil surface | 10–20 cm above the soil surface | >20 cm above the soil surface |
| Common rice | ZhongZu 14 | 315 | 43.2 | 40.9 | 15.9 |
| | Glutinous rice | 384 | 41.2 | 32.8 | 26.0 |
| Super rice | YongYou 6 | 133 | 14.3 | 24.8 | 60.9 |

## 3. Results

### 3.1. Vertical distribution of overwintering *C. suppressalis* in rice plants

Larvae of *C. suppressalis* overwinter in both rice stubble and straw. The ratio depended on their vertical distribution in rice stems at harvest time and the height of rice stubble that remained. The vertical distributions of *C. suppressalis* in common and super rice plants found in this study are shown in Table 1.

The larvae of *C. suppressalis* showed similar vertical distributions in the two common rice varieties. At harvest, most larvae remained in the bottom end of the stems. However, their distribution in super rice stems was very different. Only a few larvae remained at the bottom of the stems, over 60% of them being found at heights >20 cm above ground level.

### 3.2. Development rate of *C. suppressalis* in different rice varieties

The development rate of the larvae could affect the number that overwinter, their body weight and survival rate. In this study the development rate of *C. suppressalis* was compared among the different rice varieties by analyzing their age structure at harvest time. The results are shown in Table 2. Larvae in the two different common rice varieties had similar development rates, the 5th instar being in the majority at harvest time. In super rice, however, most larvae had reached the 6th instar by harvest time, apparently developing faster than in common rice. However, the growth period of super rice is longer and harvest and inspection occurred a week later than in common rice. In late autumn, this period could be enough for the larvae to develop one more instar. Therefore, the duration of growing period may be the most important factor for larval growth, rather then rice variety. The longer growing season of super rice provides the larvae with intact host plants for a longer period, which might be helpful in their growth, overwintering and even reproductive success.

### 3.3. Control effects of different cultivation practices in super rice

Some cultivation regimes have been shown to be effective in controlling the numbers of borers in common rice. Here, trials were carried out to evaluate their effect on *C. suppressalis* in super rice. Based on our results regarding differences in the vertical distribution of overwintering *C. suppressalis* in conventional and super rice plants, stubble shortening and burning were tested together with rotary tillage and spring irrigation of paddy fields (Table 3). Different harvest and field treatment regimes had a significant influence on the population density of overwintering borers. Harvesting leaving tall stubble left most borers in the trial field (2353 borers per 100 $m^2$, SE = 391). Shortening stubbles from 30 cm to