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The Seasonal Abundance of the Legume Pod Borer, *Maruca vitrata*, in Kagoshima, Japan

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Introduction

The legume pod borer, *Maruca vitrata* (Fabricius) (Lepidoptera, Pyralidae) is a common, major pest of legumes in the tropics and sub-tropics. It has a wide host range, a broad geographical distribution (extending seasonally to the temperate zone in East Asia) and is very destructive[4, 5, 12, 14, 16]. It feeds on 39 host plants[1], the most frequent of which are cowpea (*Vigna unguiculata*), puero (*Pueraria phaseoloids*), lima bean (*Phaseolus lunatus*), and pigeonpea (*Cajanus cajan*)[14]. In Japan, azuki (*Vigna angularis*) has been reported as a host plant[4]. The larvae infest flower buds, flowers, pods, leaves, and even the stems of the host plants. The grain yield losses from legume pod borer damage are estimated to be 10 to 80%[14, 15] and, in combination with other insect pests or secondary diseases, can completely eliminate seed production. In Japan, this pest is found from Okinawa to Hokkaido, and causes particularly serious damage in Shikoku and Kyushu.

Most studies of the pest's biology have been carried out under laboratory conditions, which have not been truly representative of the insect's natural environment. The seasonal variation in population density of the legume pod borer is poorly understood, but is of considerable importance both for fundamental knowledge of the insect's biology and for pest control practices. Therefore, in 2001, a field investigation was undertaken to study the seasonal variation in legume pod borer larval abundance.

Materials and Methods

The survey was conducted at the experimental farm of Kagoshima University in 2001.

Four species of legume-cowpea, azuki, soybean (*Glycine max*), and red kidney bean (*Phaseolus vulgaris*)-were planted in a plot measuring 12 m×6.4 m (8 rows, 12 m in length) and were covered with black polythene. Each row was divided into four 3-m sections, where 10 plants of each species were placed at equal intervals. The plants were arranged in a completely randomized block design, so they were not necessarily adjacent to the same legume species in neighboring sections. Each species was planted in four replicates. The plants were grown under natural field conditions and were unprotected throughout the period of investigation, although weeds were controlled between the rows.

The four species were planted twice during the season in order to have a continuous crop of plants. The first planting was on April 24, 2001 and the second on May 24, 2001. The survey began 20 days after sowing the first set of seeds. Observations were then made once a week and the number of legume pod borers living on the 40 plants was recorded until the pest could no longer be found.

Results and Discussion

The seasonal abundance of larvae was bimodal (Fig. 1). The first larval infestation occurred from June to mid-August. Larvae were first observed on June 15, 2001 on cowpea and azuki plants, but the infestation began earlier than mid-June, because the larvae that we found were already at the 3rd or 4th instar stage. The infestation peaked in mid-July, when more than 90% of cowpea and azuki flowers were infested. A second, smaller peak occurred in mid-October. The larvae remained present until November 16.

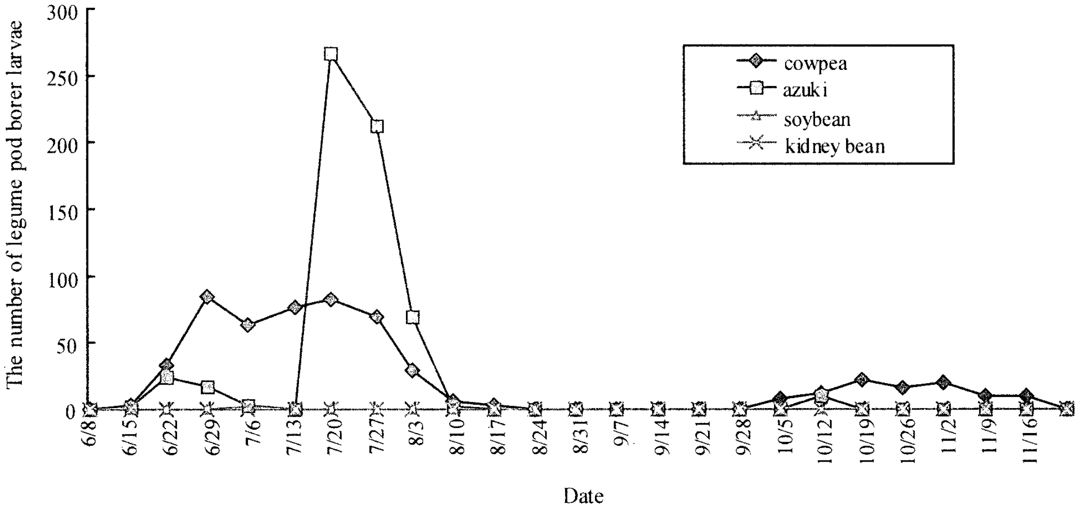

Fig. 1. Seasonal abundance of legume pod borer larvae in the field

From mid-August to September, no larvae could be found on any of the legume plants. In Kyoto, central Japan, many larvae have been found to remain attached to azuki plants from the middle of August to early October[4]. This is probably due to the insect migrating from south to north as the air temperature changes. Similar patterns of bimodal seasonal abundance have been recorded in both Nigeria and Kenya, where the number of larvae was low during the off-season, but the infestation continued nonetheless[8, 16]. In our survey, the infestation was discontinuous, and thus provides a window for controlling the insect by adjusting the planting time.

The lower developmental threshold temperature of the pod borer was found to be 10.71 ℃, and the effective cumulative temperature was 330.53 degree-days (Chi, unpublished data). The average temperature of Kagoshima is 22 ℃ in June, and 27 ℃ in July, so the insect needs approximately 29 days to complete a generation in June and about 20 days in July. We can infer that the insects completed two generations during their initial infestation between June and August.

A six-fold increase in insect abundance was observed between the first and second generations in the field (59 on June 21; 350 on July 17). In a laboratory study, the net reproduction rate (= total egg oviposition per female × emergence rate) was 497.18 (Chi et al., unpublished data). The large difference between the field data and net reproduction rates in the laboratory can be explained by the high mortality of early stages in the field. This mortality could have been caused by climatic factors or natural enemies. In Kenya, the pest has been reported to have several natural enemies[9]; however, in this study, we did not find any effective natural enemies.

The cowpea and azuki plants in our study were more severely attacked than were the soybean and kidney bean plants. An infestation by the legume pod borer depends on both anatomical characteristics and the architecture of the plant. Soybean and kidney bean plants (especially the stems) have thick, dense trichomes, which reduce the rates of larval feeding, movement and oviposition. There was a distinct correlation between insect infestation and trichome density. The trichomes on legumes are often hooked and act as a physical barrier, preventing oviposition by some herbivorous insects and occasionally killing the insects[10, 11, 13]. In a laboratory experiment, Jackai et al.[2] reported that the legume pod borer displayed poorer feeding and development on plants with many trichomes. This characteristic of dense trichomes should be studied as a possibility for breeding resistance into legume plants. The structure of stem tissues, such as epidermis and collenchyma cells, and the nutrient content of the plant may also be important factors in resistance to the legume pod borer. Ntonifor et al.[6] reported that cowpea flowers are bigger, more conspicuous and have more nectar than do soybean flowers, and are therefore more attractive to foraging insect.

The larvae infest the terminal shoots in the early growth stages of the plants. In the second sowing of plants, the first larvae that we found had produced silken threads and joined the leaf buds to the young leaves. Woolley[17] reported that moths were not attracted to a plant until the flower buds were "large enough." However, the larvae were found in the leaves when plants had no flower buds.

Most of the larvae in our study were found on flowers and flower buds. The larvae often formed webbing between flower buds and leaves, especially on azuki plants that were sown in May. Thus, the larvae fed inside a webbed mass of leaves, flower buds and flowers, or bored directly into the legume pods. Insects that feed in such a concealed manner complicate pest control because pesticides and natural enemies have difficulty penetrating the shelter. To date, no economic threshold has been established for this pest. Therefore, chemical and biological control should be done in early June in Kagoshima.

Knowledge of the biology and life cycle of legume pod borers is essential for implementing effective control strategies. Some strategies have been proposed for insect resistance[7], cultural practices[3] and chemical control[5]. We should explore combinations of these strategies while taking the insect's biology into consideration. A longer-term solution to the pest should focus on enhancing natural control processes, particularly effective natural enemies.

Summary

A larval infestation of the legume pod borer was first found on June 15, 2001, in Kagoshima City. The seasonal abundance of the larvae was bimodal, with peaks in mid-July and mid-October. The larvae tended to be attracted to cowpea and azuki plants rather than to soybean and red kidney bean plants.

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