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Evaluating Green Stink Bug Damage and Insect Abundance in Edamame

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Abstract

Edamame are an emerging crop in Arkansas, with 2013 planting estimates at 680 hectares. Although edamame are the same species as conventional soybeans grown in Arkansas, differences in use, maturity, and harvest may require creation and implementation of insect pest management approaches that differ from those used in conventional soybean production systems in order for a quality crop to be produced. Studies were conducted to determine a green stink bug damage-density relationship for edamame. Cages were used to confine green stink bugs on field-planted edamame at densities of 0, 2, 6, or 12 green stink bugs per cage (0, 0.55, 1.64, or 3.28 green stink bug adults per row meter) for 7 days. No differences were found among stink bug densities in terms of damaged pods, average pod weight or yield. Studies were also conducted to evaluate insect abundance in edamame compared to conventional soybeans. Insects were sampled by sweep netting and clipping plants (for thrips) in both conventional soybeans and edamame. Of all insects sampled, only bean leaf beetle, grape colaspis and threecornered alfalfa hoppers occurred at numbers great enough to be analyzed. No differences were detected in numbers of these three insects' densities between conventional soybean and edamame. Although the data collected from these studies were not enough to determine an economic threshold for green stink bug on edamame or to know which species contribute the most to feeding guilds, the studies provided insight on how future tests should be designed to establish economic thresholds on edamame.

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Introduction

Edamame [*Glycine max* (L.) Merrill] or vegetable soybean, is an established soy-food consumed in many Asian countries (Mohamed and Mentreddy 2004). In recent years, this legume has been growing increasingly popular as a nutritious snack across the United States (McPherson et al. 2008). Edamame is typically prepared by being boiled in salt water and served whole for consumers to squeeze the seeds out of the pod directly into the mouth (Konovsky et al. 1994). The beans can also be mixed into salads, stir-fried, or combined with mixed vegetables (Mohamed and Mentreddy 2004). Currently, the edamame market is dominated by produce imported from Taiwan and China (Mohamed and Mentreddy 2004). Growing concerns of food safety associated with overseas imports into the United States is causing consumers to be more conscious about the sources of their food (Gale and Buzby 2009). This has generated the opportunity for imported crops, such as edamame, to be grown locally and successfully.

In order to increase local (US) production of edamame, growers need to have reliable economic projections. However, the current economic information about growing and marketing edamame is limited. Recent edamame production figures -- hectares, tons harvested, profits or losses -- are scarce. However, a study conducted in 1998 claimed specialty soybean (e.g., edamame) in the US could obtain a premium price, ranging from $18 to $589/ton above the market price of commodity soybean (Carter and Wilson 1998). Johnson et al. (1999) suggested that the US could potentially produce around 13,000 hectares of edamame to meet domestic demand. Growers in Arkansas began producing edamame in 2012, with production reaching an estimated 650 hectares in 2013 (Chaney 2013). Although information on yields on Arkansas farms has been limited, the potential for profitable production of edamame as a new crop has increased the interest among Arkansas growers.

According to their different uses, soybean cultivars are classified as grain-type (conventional soybeans), which are used for oil and animal feeding, and food type, which are those that are used for human consumption (Liu 1999). Edamame soybean cultivars are for human consumption and, when compared to conventional soybeans, have subtle but important differences (Miles et al. 2000). Edamame varieties are not easy to distinguish from immature, conventional soybeans, except for a few unique characteristics (Rackis 1981). When compared to conventional soybean plants edamame plants have a non-lodging, strong stem with a good root system, delayed flowering > 40 days, ten to fourteen nodes, fewer branches, large narrow leaflets, longer R6 to R7 period, low sensitivity to photoperiod and temperature, and 15 – 20 pods per plant (Shanmugasundaram 1991). Shattering is also more of a problem in edamame than conventional soybean when grown to maturity (Rao et al. 1998). This is due to the necessity for edamame to be easily shelled after cooking. However since edamame are harvested sooner shattering is not a problem unless they are grown for seed production. The larger seeds of edamame are considered superior to conventional soybeans in flavor, texture and ease of cooking, but significant differences in chemical composition have not been identified (Konovsky et al. 1994). In general, though, edamame have higher amounts of simple sugars and lower amounts of oligosaccharides compared to conventional soybeans (Yazdi-Samadi et al. 1977, Liu and Markakis 1987). A study by Tsou and Hong (1990) indicated sucrose content is the major sugar responsible for edamame sweetness. Free amino acids are also generally present in higher concentrations than in conventional soybeans (Akazawa and Fukushima 1991). Higher phytic acid levels in edamame help to explain why they are more tender and cook faster than conventional soybeans (Konovsky et al. 1994). The edamame cultivar currently grown on the majority of Arkansas acreage is an early-maturing group III variety (AVSE8080). This variety has an indeterminate growth pattern, meaning it flowers over a longer period, as opposed to determinate varieties that produce their flowers all at one time. Most conventional soybeans grown in Arkansas are maturity groups IV or V. However, because the AVSE8080 variety is not adapted for central Arkansas, its growth pattern is more akin to a determinate cultivar (J. Ross, pers. comm.).

Edamame production practices are similar to those of conventional soybeans until harvest (Mohamed and Mentreddy 2004). Edamame are harvested while seeds are immature (R6 growth stage) and have expanded to fill 80 – 90 percent of the pod width (Fehr et al. 1971, Konovsky et al. 1994). This is in contrast with conventional soybeans that are harvested when 95% of pods are brown (R8 growth stage). In Asia, most vegetable soybeans are harvested by hand and many times are sold still attached to the stems at markets, but pods can also be stripped from the stem and packaged as fresh or frozen (Konovsky et al. 1994, Mohamed and Mentreddy 2004). Harvest in Arkansas is conducted with a specialized picker that strips the pods from the plants and retains the seed within pods. This harvest practice differs from conventional soybeans that are harvested with a combine which thrashes and separates the pods from the seed.

Edamame are typically served in the pods, so the primary requirement for edamame is excellent pod appearance (Masuda 1991). Some grading systems have been developed in Asia, taking into account pod size, number of seeds per pod, pod color and the degree of pest damage (Tsou and Hong 1991). However, there is no standard for edamame grading, and the standards differ among production regions. Shanmugasundaram et al. (1989) listed the characteristics that quality edamame should have: "a hilum that is light brown or gray, pods must have two or three seeds; most pods should be at least 5 cm long, 500 g should contain less than 175 pods, 100 seed weight should exceed 30 g and the pods must be unblemished." The Department of Agriculture in Iwate Prefecture of Japan has two acceptable grades of edamame; A and B (Anonymous 1990). Grade A requires 90 percent or more pods with two or three seeds, perfectly shaped pods, completely green, and show no injury or spotting. Grade B is essentially the same as grade A but can be lighter green, and a few pods can be slightly spotted, injured, malformed, short, or have small seeds. In either grade, the list of traits making pods unacceptable includes: pods that are either overly mature or unripe; pods that are diseased or show damage by insects; excessive numbers of pods that are one-seeded, malformed, yellowed, split or contain spotted seeds. The criteria used to regulate import of edamame into Japan include: pods should contain two or more seeds; pods must be at least 4.5 cm long and 1.3 cm wide, and fresh green in color; and 175 pods should weigh at least 515 g (Cheng 1990, Hung et al. 1990, Tsou et al. 1990).

Despite the lack of universal grading standards, the appearance of unblemished pods is critical for acceptance. Because feeding by insects can cause injury to the pods and affect the appearance, insect pests will likely be an issue for edamame growers. Plant injury has been defined as “a stimulus producing a deleterious change in the physiological process” (Hutchins et al. 1988). When evaluating insect injury, it is often helpful to separate pests into insect feeding guilds (Higley 1994), which contain varied taxa that cause similar type of injury. Common insect feeding guilds in soybeans include root-feeding, stem-feeding, leaf-feeding, or pod-feeding insects (Higley 1994). Because species within a feeding guild generally cause similar types of injury to a plant, it should be possible to calculate a single economic injury level (Hutchins et al. 1988) that incorporates the injury caused by all members of that guild. In addition to the feeding guilds, insects can also be classified into injury guilds, based on the kinds of injury inflicted on the plant, including stand reduction, leaf-mass consumption, assimilate removal, water-balance disruption, fruit destruction, and architecture modification (Boote 1981, Pedigo et al. 1986).

Conventional soybeans are attacked by many insect pests and it is possible that many of the same species will attack edamame. In a study conducted in Taiwan, edamame was shown to have essentially the same pests as were found on conventional soybeans, including defoliators (Lepidoptera and Coleoptera), stink bugs (Hemiptera: Pentatomidae), and a podborer (Lepidoptera: Pyralidae) (Yeh et al. 1991). A study conducted in Georgia by McPherson et al. (2008) found that the insect pest complex for edamame was similar to that of conventional soybeans including stink bugs, lepidopteran larvae, grasshoppers (Orthoptera), three-cornered alfalfa hoppers (Hemiptera: Membracidae) and potato leafhoppers (Hemiptera: Cicadellidae). Because soybeans grown in Arkansas are attacked by many insect species, it is reasonable to expect that similar species will be important pests of edamame grown there. The common insect pests of conventional soybeans in Arkansas can be categorized by their respective feeding and injury guilds (Table 1).

Control of insects in the pod-feeding guild is one of major importance in edamame production because the market value of vegetable soybean is mainly determined by their appearance (Mohamed and Mentreddy 2004). Current edamame soybean varieties do not produce yields as great as those for conventional soybeans, meaning pod loss is more detrimental to growers' profits than loss in conventional soybeans (Mohamed and Mentreddy 2004). Consequently, edamame pods must be protected more than pods in conventional soybeans. Edamame, being considered a crop for human consumption, does not have the same pesticides labeled for use as conventional soybeans in Arkansas. Pesticides however, are being evaluated for use on this crop through the IR-4 program. Edamame also has different pre-harvest treatment intervals than those in conventional soybeans.

Differences in plant constituents between edamame and conventional soybean could cause insects to respond differently to edamame. In general, sugars appear to be of considerable importance in the regulation of feeding in phytophagous insects (Thorsteinson et al. 1960). Higher concentration of sugars in edamame may make the plant more attractive to some insects but less attractive to other species. For example, larvae of European corn borer (Coleoptera: Pyralidae) showed aggregation to greater concentrations of sucrose and amino acids (Beck 1956, Beck and Hanec 1958). On the other hand, the grasshopper, *Camnula pellucid* (Scudder) (Orthoptera: Acrididae) and leafhoppers (Hemiptera: Cicadellidae) were shown to avoid plants with greater concentrations of sucrose (Nuorteva 1952, Fraenkel 1955). Concentrations of plant amino acids also are known to affect feeding by insects. Several amino acids have been reported to evoke feeding responses in *Camnula* sp. (Orthoptera: Acrididae) when exposed to low concentrations of the amino acids (Thorsteinson et al. 1960). In contrast, when those same free amino acids were expressed at higher concentrations, they inhibited feeding responses. Another important factor that may affect insect injury to plants is the early maturing nature of a selected edamame cultivar. Early maturity could make the plant more attractive to some pests, including bean leaf beetles and stink bugs (Schumann and Todd 1982, Baur et al. 2000), whereas early maturity could prove beneficial as plants would be harvested before the occurrence of several insect pests (Gore et al. 2006), thus avoiding injury from feeding.

Production of high-quality edamame requires crop management practices, such as insect control, to be more stringent than those applied in conventional soybeans (Mohamed and Mentreddy 2004). The same requirement will apply to edamame produced in Arkansas and, therefore, insect pests will need to be evaluated and treatment thresholds will need to be determined. Traditionally, the most damaging insect pests of conventional soybean in Arkansas have been the stink bug stink bug complex (Heteroptera: Pentatomidae) (Musser et al. 2012). Of this complex the green stink bug (*Acrosternum hilare* (Say)) has been the predominate species and will likely be an important pest of edamame. Because *A. hilare* is in the pod-feeding guild, its feeding will affect the overall appearance of the pod and cause discoloration and distortion of the seed (McPherson et al. 2008). Such injury would likely cause the pods to not meet marketable quality specifications for edamame consumers. The current economic threshold (University of Arkansas Cooperative Extension Service 2013) for green stink bug in Arkansas conventional soybeans is 9 stink bugs per 25 sweeps (3.28 per row-m or 1 per row-ft). This threshold will not be appropriate for edamame because it does not take pod appearance into account, and pod appearance is of great importance for high-quality edamame (Young et al. 2008). Further, other stink bugs that are in the pod-feeding guild will also contribute to the injury on the pods, so those species will need to be included in any evaluations and establishment of thresholds.

The study presented here is an effort to evaluate insect pressure on edamame and to try to understand the kinds of injury caused by green stink bug and other insect species. This study will help us understand how insects will respond to and affect edamame, in order to give producers ideas to improve management practices and sampling techniques to fit this crop.

Table 1. Common insect pests of conventional soybeans in Arkansas, and their respective feeding and injury guilds. Feeding guilds are adapted from Higley 1994, and injury guilds are adapted from Hutchins et al. 1988.

Insect Pests	**Feeding Guild**	**Injury Guild**
Corn earworm (*Heliocoverpa zea*) Lepidoptera: Noctuidae	Pod-feeding	Fruit destruction Leaf mass consumption
Stink bug complex Heteroptera: Pentatomidae	Pod-feeding	Assimilate removal Fruit destruction
Armyworm complex Lepidoptera: Noctuidae	Leaf-feeding Pod-feeding	Leaf-mass consumption Fruit destruction
Grasshopper Orthoptera	Leaf-feeding Pod-feeding	Leaf-mass consumption Fruit destruction
Soybean looper (*Pseudoplusia includens*) Lepidoptera: Noctuidae	Leaf-feeding	Leaf-mass consumption
Blister beetle Coleoptera: Cantharidae	Leaf-feeding	Leaf-mass consumption
Spotted Cucumber Beetle (*Diabrotica undecimpunctata*) Coleoptera: Chrysomelidae	Leaf-feeding	Leaf-mass consumption
Bean leaf beetle (*Cerotoma trifurcata*) Coleoptera: Chrysomelidae	Leaf-feeding as adult Root-Feeding as larvae	Leaf-mass consumption as adult Fruit destruction as adult Water-balance disruption as larvae
Grape colaspis (*Colaspis brunnea*) Coleoptera: Chrysomelidae	Leaf-feeding as adult Root-feeding as larvae	Leaf-mass consumption as adult Water-balance disruption as larvae
Three cornered alfalfa hopper (*Spissistilus festinus*)	Stem-feeding	Architecture modification Stand reduction
Dectes stem borer (*Dectes texanus*) Coleoptera: Cerambycidae	Stem-feeding	Architecture modification

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Chapter I. Evaluating Green Stink Bug Damage in Edamame

Abstract

Edamame soybeans are a new crop to Arkansas and existing thresholds for conventional soybeans will likely not apply to this crop. A major pest of conventional soybeans in Arkansas is the green stink bug and it will likely be an important pest of edamame. Trials were conducted by caging green stink bugs on edamame soybean at densities of 0, 0.55, 1.64, or 3.28 stink bug adults per row meter for 7 days. Pods were hand harvested for yield and average pod weights were calculated. Pods were also stained to detect the presence of stink bug salivary sheaths, relating this to damage. No differences were found in yield, average pod weight or damage when compared to stink bug densities although numerical differences were observed. These data will provide insight on how to better design future stink bug threshold studies.

Introduction

Edamame, *Glycine max* (L.) Merrill, also called vegetable soybean, is a popular food in many Far East countries including Japan and China (Young et al. 2000, Mohamed and Mentreddy 2004). Edamame is typically sold in pods that are large, green, and contain 2-3 seeds. Classic preparation of edamame consists of boiling the green pods containing seeds and pinching the seeds out of the pod into the mouth (Konovsky et al. 1994). In the US, edamame is gaining popularity and its consumption is rapidly increasing (McPherson et al. 2008). Presently, the edamame market is dominated by imports from Taiwan and China (Mohamed and Mentreddy 2004). Lack of production in the US has left a large market available to be filled by domestic growers. An older estimate suggested that it would take an edamame crop of roughly 13, 000 hectares to meet US demand (Johnson et al. 1999), but that estimate was made well before the market increased in recent years.

American Vegetable Soybean and Edamame (AVS, Mullberry, AR) entered this market by contracting with farmers to grow edamame in the Arkansas River Valley of western Arkansas. The first year of production was in 2012, when 320 hectares of edamame were grown and then processed through their facilities in Mulberry, Arkansas. Production increased the following year (2013) to 650 hectares, with plans to continue increasing production acreage yearly (Chaney 2013). Soybean growers adopt edamame production because of beneficial prices for the crop. Current economic data are scarce for the vegetable soybean market although a study by Carter and Wilson (1998) found that edamame producers could increase profits by $18 to $589/ton above the market price of conventional soybeans. It is not clear why the authors estimated such a wide range in potential profits.

The edamame plant is the same species as grain type (conventional) soybean typically used for oil and animal feed, but there are several key differences (Rackis 1981, Miles et al. 2000). According to Shanmugasundaram (1991), edamame cultivars should have a non-lodging strong stem, good root system, flowering after more than 40 days, ten to fourteen nodes, fewer branches, large narrow leaflets, longer R6 to R7 period, low sensitivity to photoperiod and temperature, and 15 to 20 pods per plant. Currently grown on the majority of Arkansas edamame acreage is an early maturity group-III edamame cultivar (AVSE8080). This early maturity is unusual in Arkansas, given that conventional soybean varieties grown in the state are typically later maturing groups IV and V (Gore et al. 2006). Seeds are substantially larger in edamame cultivars than in conventional soybeans, but there are also differences in seed content. Differences in edamame seeds include higher amounts of simple sugars, which improves taste, and greater free amino acid content and higher phytic acid levels, making the seeds more tender, all of which make edamame seeds superior to conventional soybeans for human consumption (Yazdi-Samadi et al. 1977, Liu and Markakis 1987, Akazawa and Fukushima 1991, Konovsky et al. 1994).

Production of edamame soybean is similar to growing a conventional soybean variety, although harvesting practices are significantly different. Edamame are harvested with a specialized picker that removes whole pods from the stems while the beans are in the R6 growth stage (Konovsky et al. 1994). A pod in the R6 growth stage contains, “a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf” (Fehr et al. 1971). In contrast, conventional soybeans are harvested 5-10 days after the R8 growth stage, denoting when 95% of pods are brown. Because edamame are typically served in the pod, the market value for edamame is mainly determined by pod appearance (Masuda 1991, Mohamed and

Mentreddy 2004). Yields for existing edamame cultivars are not as high as those found in conventional varieties (Mohamed and Mentreddy 2004), which means edamame growers lose more profit for every pod lost. There is no universal edamame grading scale although an example is given by Shanmugasundaram et al. (1989) who suggest quality edamame should haven: “a hilum that is light brown or gray, pods must have two or three seeds; most pods should be at least 5 cm long, 500 g should contain less than 175 pods, 100 seed weight should exceed 30 g and the pods must be unblemished.” To achieve this high standard of quality new economic thresholds should be evaluated for edamame.

The concept of the economic threshold was first presented by Stern et al. (1959) and should be a fundamental part of any IPM program (Hutchins et al. 1988). Economic threshold is defined by the “density at which control measures should be determined to prevent an increasing pest population from reaching the economic-injury level” (Stern et al. 1959). Economic-injury level, in turn, is defined by Stern et al. as “the lowest population density that will cause economic damage.” An economic threshold provides growers with information to make a decision, and the time to make a decision to use control measures. Without economic thresholds, producers often make unnecessary insecticide applications based on experience or as prophylactic applications for a pest that may or may not reach densities high enough to cause damage.

Because of the similarity of edamame plants growing in the field, it is likely that the insect pests attacking edamame will be similar to those pests attacking conventional soybeans in Arkansas. Yeh et al. (1991) conducted a study in Taiwan, which indicated that the insect pests were essentially the same for both edamame and conventional soybean – defoliators (Lepidoptera and Coleoptera), pod feeders, which include stink bugs (Hemiptera: Pentatomidae), and a podborer (Lepidoptera: Pyralidae). Until recently, stink bugs have been the most damaging insect pests of soybeans in Arkansas (Musser et al. 2012). In 2012, the stink bug complex attacking soybean grown in Arkansas consisted of 65% green stink bug, *Acrosternum hilare* (Say) (Musser et al. 2013). Other stink bugs making up the stink bug complex in Arkansas include the brown, *Euschistus servus* (Say), southern green, *Nezara viridula* L., redbanded, *Piezodorus guildinii* (Westwood), and the *Thyanta spp.* complex of stink bugs (Musser et al. 2013). Stink bugs cause damage by piercing plant tissue with their mouthparts, injecting salivary enzymes into the plant, then extracting the fluids with their proboscis (McPherson et al. 1994). Soybean yield and quality are affected by loss of plant fluids, the injection of digestive enzymes and the deformation and abortion of fruiting structures. Stink bug feeding may cause necrotic areas to appear on pods where stink bugs punctured the plant, which can allow pathogens to enter the pod and result in secondary losses caused by the reduction in seed quality (Gore et al. 2006).

Current University of Arkansas Extension Service recommendations place the green stink bug threshold for conventional soybeans at 9 bugs per 25 sweeps (3.28 bugs/ row m or 1 bug/ row ft) (Young et al. 2008). However, that threshold is for conventional soybean, harvested dry and with pods removed, which is totally different than the requirements for edamame. Because of the importance of unblemished pods and the seeds within, and the lower yields associated with edamame cultivars, insect damage from pod-feeding insects in this crop will likely be less tolerated than in conventional soybeans. For these reasons, entirely new economic thresholds for insect pests in edamame must be evaluated. The objective of this study is to evaluate the injury caused by different densities of green stink bug, as measured by yield, average seed weight and pod damage.

Materials and Methods

Trials were conducted in 2012 and 2013 to establish a relationship between green stink bug density and damage to edamame soybeans. Preliminary studies were conducted in 2012 at the University of Arkansas, Lon Mann Cotton Branch Research Station (LMRS) in Lee County, AR, and at University of Arkansas Pine Bluff Agricultural Research Farm in Lonoke, AR. Data from preliminary trials from 2012 are not presented. Trials conducted in 2013 were located at LMRS. A second trial, examining potential damage caused by redbanded stink bug was conducted at the Mississippi Agricultural and Forestry Experiment Station, McNeill Research Unit, in Pearl River County, MS. Data from the redbanded stink bug trial are not presented due to lack of feeding evidence.

Trials with green stink bug were conducted in 2013 at LMRS using edamame cultivar AVSE 8080. Prior to planting, edamame seeds were treated with insecticide seed treatment Cruiser Maxx Beans at a rate of 0.756 mg ai/seed. Targeted planting density was 176,000 seeds per hectare in 96.52 cm (38 inch) rows. Trials were conducted in field cages made of Lumite®, 20x20 mesh, 183cm x 183cm x 183cm. Cages were used to contain the stink bugs on the edamame plants. Cage frames, 183cm x 183cm x 152cm, were made from 1.9 cm (3/4 inch) schedule 40 pvc pipe over which cages were fitted, allowing the mesh screen to lie on the ground and be covered with soil, preventing insects from entering or exiting cages. Cages covered two rows for a total enclosed row length of 3.6 m. An insecticide application of Discipline 2EC (bifenthrin) 112.1 g ai/ha was applied across the trial area to eliminate all arthropods. Immediately following the insecticide application, the cages were placed in the field in a randomized complete block design with four replications.

Adult green stink bugs used for the trials were collected by sweep net from a soybean field in Lonoke County, AR, 24h prior to being placed within the cages. Infestations were initiated when edamame plants reached the R5 growth stage. Adult stink bugs were placed in cages at 0, 2, 6 or 12 stink bugs per cage, which corresponded to densities of 0, 0.55, 1.64, or 3.28 stink bugs per row-meter. Stink bugs were left caged for 7 days. Plants inside the cages were visually examined every other day and dead insects were replaced. Insects that could not be accounted for were assumed to be present and were not replaced. After 7 days, another application of bifenthrin was made to eliminate all stink bugs. Cages were left on the edamame plants until they were ready for harvest.

To evaluate pods for stink bug injury, 50 randomly selected pods were collected from the row adjacent the harvest row. Collected pods were stored in 70% ethanol at room temperature for up to 3 months. Pods were stained to provide evidence of stink bug feeding. The staining solution was adopted from (Bowling 1979), which contained 1 part each phenol, lactic acid, and distilled water, and 2 parts glycerine, plus enough acid fuchsin to produce a dark red color (Goody 1937). Pods were submerged in this solution for approximately 1 hour, removed from the solution and then rinsed in tap water (Bowling 1979). Dyed pods were then examined under a dissecting microscope for salivary sheaths. Pods containing at least one salivary sheath were considered injured, and the percentages of injured pods were calculated and compared. The number of pods per cage was estimated by multiplying the number of pods in the harvest row and doubling. The number of salivary sheaths per pod was estimated by taking the percent injured pods and multiplying that by the number of pods within the cage. Injured pods per stink bug and number of injured pods per stink bug day was established multiplying the percent damage by the number of pods estimated in the cage, then dividing that number by the number of stink bugs per cage or stink bug days per cage.

Harvest occurred on 14 August when edamame reached the R6 growth stage. Pods were hand harvested from one row within each cage and the numbers of plants and pods in each harvested row were recorded. Yields per hectare were estimated from total pod weight collected in the 1.78-m harvest row. Average weight of 100 pods was determined by dividing total pod weight by the number of pods collected in the harvest row and multiplied by 100. Immediately after harvest, pods were placed in a cooler containing ice and were transferred to a refrigerator upon returning to the lab. Pods were held in the refrigerator for one week and then were visually examined for feeding injury.

An ANCOVA model was used to analyze total pod weights compared to stink bug densities, adjusting for the number of plants present in the harvest row (JMP®, Version 11, SAS Institute Inc., Cary, NC). Average pod weight and percent damaged pods as affected by stink bug densities were evaluated by use of ANOVA.

Results

Pods stained with the acid-fuchsin solution showed feeding injury, as evidenced by the presence of salivary sheaths. Examination of unstained pods did not allow detection of visible feeding injury. The percentage of injured pods was not significantly influenced by the numbers of stink bugs per cage ($F=1.865$, $df=3, 12$, $P=0.206$; Figure 1). Mean percentages of injured pods ranged from 4.5% (2 stink bugs per cage) to 14% (12 stink bugs per cage). Mean numbers of salivary sheaths per 50 pods ranged from 3.5 (2 stink bugs per cage) to 20 (6 stink bugs per cage), and the numbers of sheaths found per injured pod ranged from 1.33 (0 stink bugs per cage) to 2.47 (6 stink bugs per cage) (Table 1). Mean numbers of injured pods per stink bug ranged from 19.51 (12 stink bugs per cage) to 36.59 (2 stink bugs per cage). The number of injured pods per stink bug day ranged from 2.79 (12 stink bugs per cage, 84 stink bug days) to 5.22 (2 stink bugs per cage, 14 stink bug days). Mean edamame pod weight ranged from 225 to 253 grams/100 pods (Figure 2). Mean pod weights were not significantly influenced by numbers of stink bugs per cage ($F=1.569$, $df=3, 12$, $P=0.264$).

Mean yields (Figure 3) calculated from the harvested rows ranged from 10,667 kg/ha (6 stink bugs per cage) to 11,538 kg pods/ha (0 stink bugs per cage). However, yields were not significantly influenced by numbers of stink bugs per cage ($F=0.205$, $df=4, 11$, $P=0.891$). Mean plant densities ranged from 12.69 to 13.72 plants per row meter, but did not significantly affect yields ($F=3.336$, $df=1$, $P=0.100$). Mean # of pods per harvest row ranged from 798 to 849.

Discussion

There is a great need to determine an economic threshold for green stink bug in edamame soybeans. Until recently, the stink bug complex was considered the number one pest of conventional soybeans in Arkansas (Musser et al. 2013). Studies of the effects of feeding by stink bugs have been used to establish economic thresholds currently used on conventional soybeans. Stink bug feeding consists of piercing the pods and the seeds contained within them, injecting them with salivary enzymes, and then removing their contents. For conventional soybeans, stink bug damage can result from reduced seed weight, quality, or an overall reduction in yield.

When compared to conventional soybean, the production of edamame differs greatly in many regards. Edamame plants are harvested at R6 stage, before pods and seeds have dried, while the pods are still green and are harvested intact. Although edamame yields are important, they are a secondary consideration because of their high value (Konovsky et al. 1994). Edamame yields are calculated by the weight of both the green pods and the seeds contained. This is unlike conventional soybean, for which only the seeds contribute to yield. Further, pod appearance determines the quality and acceptability of edamame and, in contrast, is a non-factor for conventional soybeans. Because the piercing injury caused by stink bug feeding can cause visible damage to seed pods, stink bugs will likely be important pests of edamame. All of these differences point out the need for a study on stink bug thresholds that are specific for edamame.

The objective of this study was to evaluate a relationship between green stink bug density and damage to edamame. The number of green stink bugs caged on edamame plants for 7 days had no significant effect of on mean yields, mean weights of pods, or the percent of pods showing feeding injury. Although yields, pod weights and feeding injury did not differ among treatments in this study, 14% of the edamame pods were observed with feeding injury in treatment with 12 stink bugs. McPherson et al. (2008) conducted a study evaluating the effects of stink bug feeding on edamame and found almost 40% damaged seed, although damage to individual seeds was minimal in plots that never exceeded populations of 3 southern green stink bugs per 25 sweeps throughout the growing season (pod damage not reported). McPherson et al. (2008) also noted that "stink bug feeding would affect the overall cosmetic appearance of the product (edamame)" and "would most likely cause unacceptable marketable quality specifications for the consumer." Thus, stink bugs have the potential to be pests of edamame. Feeding by stink bugs can affect the number or percent of injured pods, the weight of pods and, ultimately, yield. However, the design of the present study may not have allowed for finding the effects of stink bug feeding on injury, pod weight or yield. This study used a maximum of 12 stink bugs per cage, exposed to plants for 7 days, with infestations beginning at the R5 growth stage. In addition, the numbers of cages used, variability in the numbers of plants per cage and the low number of pods evaluated, may have contributed to the lack of differences detected among treatments. Each of the possible factors will be discussed separately.

The numbers of stink bugs ranged from zero (control) to 12 per cage. That maximum number is equivalent to the current economic threshold of 3.28 green stink bugs sampled per row-meter in conventional soybeans (Young et al. 2008). As sweep nets are relative (not absolute) measures of insect density, the actual numbers of stink bugs that should be placed in a cage to simulate that density must exceed 3.28 bug/row-m. Several studies have evaluated varying stink bug densities on conventional soybean seed quality. Russin et al. (1987) found numerical but non-significant reductions in yield associated with naturally occurring southern green stink bug populations at densities averaging 3.8 bugs per row meter, with infestations beginning at the R4 growth stage. A study by Young et al. (2008) evaluating stink bug injury on R5-R6 growth stage soybeans found that the percent of injured seed did not increase until densities exceeded 9 green stink bugs per row meter. In contrast, Yeargan (1977) found that stink bugs caged at densities of 1 per 0.3 meters of row significantly increased the amount of damaged seeds. In order to have enough feeding injury to detect differences in the present study, it may have been necessary to use a greater range of densities, such as up to 18 or 24 per cage. The duration of the trials also may not have provided enough time to produce enough feeding damage on pods to be detectable. Several studies have used infestations that have lasted 14 days to over a month (Todd and Turnipseed 1974, Young et al. 2008). In the present study, stink bugs were only caged for 7 days. Young et al. (2008) observed injury on R7 to R8 growth stage soybeans from stink bugs after only 7 days of feeding time, but only when densities reached 9 per row m.

Because feeding injury accumulates as a function of time and number of insects, variation in either factor could affect the results. One way to consider the accumulation of insects and time is to use the concept of "stink-bug days" to measure exposure. The present study used 0, 2, 6 and 12 stink bugs for 7 days, corresponding to 0, 14, 42 and 84 stink-bug days, respectively. This concept has been applied to other insects in previous studies including bean leaf beetle, *Cerotoma trifucata* (Forester) (Smelser and Pedigo 1992). Cages in the present study were checked every other day and all insects that were found dead in cages were replaced. It is possible that not every dead insect was found, thus reducing the effective number of stink-bug days. If a stink bug died on the first day of the trial and was never found, that would have reduced the number of stink-bug days by 7. Likewise, there is no way to know when any dead insects died in the two days between cages being checked. If any stink bug died immediately after being caged, that would have reduced the number of stink bug days by 2, thus reducing the exposure and potential for feeding.

Another factor to consider is the growth stage of the plants used for the trials, and how the plants were treated before the trials. In the present study, the edamame plants were infested at the R5 growth stage. McPherson et al. (2008) found that stink bugs infesting R5 growth stage edamame did not reduce yields. Studies conducted with conventional soybeans found similar results when targeting later growth stages. Boethel et al. (2000) found reductions in yield occurred when soybeans were infested with southern green stink bug at R3-R4 growth stages, but not after soybeans reached the R5 growth stage. Similarly, Young et al. (2008) found extremely high green stink bug densities (18 per row meter) resulted in yield loss when green stink bug infestations occurred at R2-R3 growth stages, but not at stages of R5-R6 or R7-R8. Further, beginning the trials earlier in the plant phenology and increasing the duration of the trials would have increased the number of stink-bug days, thus adding to the possible injury.

Prior to the R5 edamame plants being caged and infested, the plants were treated with insecticide. Although the insecticide may have eliminated all extant stink bugs, plants had been fed on prior to the trials, as evidenced by the 7% injury seen in the control cages. Control cages were expected to have zero injury because of a lack of stink bugs. The feeding injury seen in control cages shows the importance of assessing feeding on earlier growth-stage plants or ensuring that no feeding had occurred prior to the trials.

This study differs from most studies of feeding by stink bugs, by evaluating pod weights for edamame instead of seed weights in conventional soybean. Russin et al. (1987) found that seed weight of conventional soybeans did not differ across a range of densities of stink bugs. Todd and Turnipseed (1974) found no significant differences in average soybean seed weights when stink bugs were caged on soybeans at three separate growth stages, except when cages contained 3 stink bugs per row ft, continually, for nearly 3 months. Results from those studies are consistent with the findings of the present study that showed stink bugs did not affect average edamame pod weight at the densities tested.

Other aspects of the experimental design may have contributed to the lack of differences among treatments. Plant densities ranged from 12.69 to 13.72 plants per row-meter. Although the ANCOVA analysis accounted for different plant densities, differences in plant density could also have affected the size of plants and, thus, the variability in pod weights and yields. Only four cages were used per treatment, which added to the difficulty detecting an effect of stink bug densities. In addition, only 50 pods were collected per cage and evaluated for feeding damage, which contributed to the variability seen within treatments.

One other influence on the results may have been how feeding injury was classified. Stink bugs presumably feed similarly on edamame and conventional soybeans. However, evaluating pod injury is different than evaluating the effects on seed weight or yield, and the different use of edamame requires injury to be evaluated differently. I used the acid-fuchsin staining technique Bowling (1979) to quantify feeding injury. This method allowed detecting salivary sheaths left behind by stink bugs when they punctured the pod and fed, and allowed detecting injury that was not visible solely by visual examination. Pods with a single salivary sheath were considered damaged, even though many of the feeding punctures were undetectable except after staining. Thus, the definition of injury used here may have overestimated the level of total damage. Evaluating stink bug damage to conventional soybeans has been conducted in multiple ways. Seeds have been separated into damage classes, for example: none, light, medium, and severe damage (Todd and Turnipseed 1974, Yeargan 1977, Jones and Sullivan 1979, Russin et al. 1987). Damage has also been assessed with respect to seed germination, protein, oil and fat content which are of utmost importance in conventional soybeans (Daugherty et al. 1964, Todd and Turnipseed 1974, Russin et al. 1987). However, primary quality requirements for edamame are appearance, taste, flavor and texture (Masuda 1991).

Because edamame and conventional soybeans harvests are so different, some direct comparisons cannot be made. When evaluating average seed weight and yield, an important consideration is that edamame are harvested when plants reach the R6 growth stage, meaning the seeds are still green and their moisture content ranges from 54% to 56% (Mentreddy et al. 2002). This is in contrast to conventional soybeans that are harvested at the R8 growth stage and the optimal moisture content of the beans is 13.5% (Huitink 1998). The primary method that edamame are served also means seeds are left in the pod at harvest. So, in terms of weight harvested per hectare, it appears that edamame yield extremely high although much of this weight is from the high moisture content and pod weight of the crop. In terms of dry seed weight, edamame varieties do not produce yields as high as conventional varieties (Mohamed and Mentreddy 2004), but those factors are not directly relevant for edamame.

One casual observation during this study was that green stink bugs appeared to move very little once it began to feed on a pod. The number of injured pods per stink bug ranged from 19.51 to 36.59 per stink bug. In addition, each injured pod had an overall average of 1.7 salivary sheaths per injured pod. This conclusion is the result of comparing the number of salivary sheaths found in cages, to the number of pods injured. By examining the numbers of injured pods, taking into account the number of stink-bug days, the averages ranged from 2.79 pods injured per stink bug per day to 5.22 pods injured per stink bug per day. Despite the trials being conducted on R5-

stage edamame, the level of feeding injury gives some insight into how much damage may be caused by green stink bugs.

Future tests should consider modifying some of the methods used here when evaluating stink bug damage on edamame. The numbers of stink bugs used and duration of the trials should be increased to provide a greater range of stink-bug days over which to compare. Inspecting cages daily and recording the number of dead stink bugs found in each cage would reduce the variability in stink-bug days and give a better idea of how many stink bugs are actually within a cage. In addition, the growth stage used needs to be adjusted to capture the greater potential for damage to occur on earlier growth stages. Periodic insecticide treatment or caging the plants needs to be begun earlier (e.g., at R2 or R3) to reduce any pod feeding occurring before the trials are initiated. Variability in average pod weights and yields would be reduced by minimizing differences in plant densities early in the season -- thinning rows to a predetermined number per 1.82 meters of row -- and caging the plants earlier, to reduce any feeding on plants prior to the initiation of the trials. In addition, variability in the measures would be reduced by increasing the number of cages used per treatment and increasing the number of pods sampled per cage. Because within-plant distribution of caged stink bugs is not known, all pods from several individual plants could be collected and evaluated for injury. Detailed information about the extent and phenology of feeding damage could be studied by caging one stink bug on individual plants. Although that type of cage study could not produce estimates of yields, such a study may offer an improved idea of how an individual stink bug affects edamame pod appearance. Even though pod appearance is the key factor when determining edamame quality, seed quality is important as well and future tests may benefit from evaluating seed damage and weights of individual seeds. This plant is in many ways similar to conventional soybean, but the work presented here illustrates some of the differences that must be considered when working with this crop.

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Figures

Figure 1. Mean percentage injured pods (+/- SE) of edamame (*Glycine max* (L.) Merrill), after infestations of green stink bugs (*Acrosternum hilare* (Say)). Field-cage trials used densities of 2, 6, 12 or zero (control) per 183 cm x 183 cm x 183 cm cage, for 7 days, beginning at the R5 growth stage. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR. Damage was estimated by counting the number of pods containing stylet sheaths in a subset of 50 pods per cage. Pods containing at least one stylet sheath were considered injured. Each treatment consisted of four cages. Numbers of stink bugs per cage are also represented as numbers per row-meter of plants.

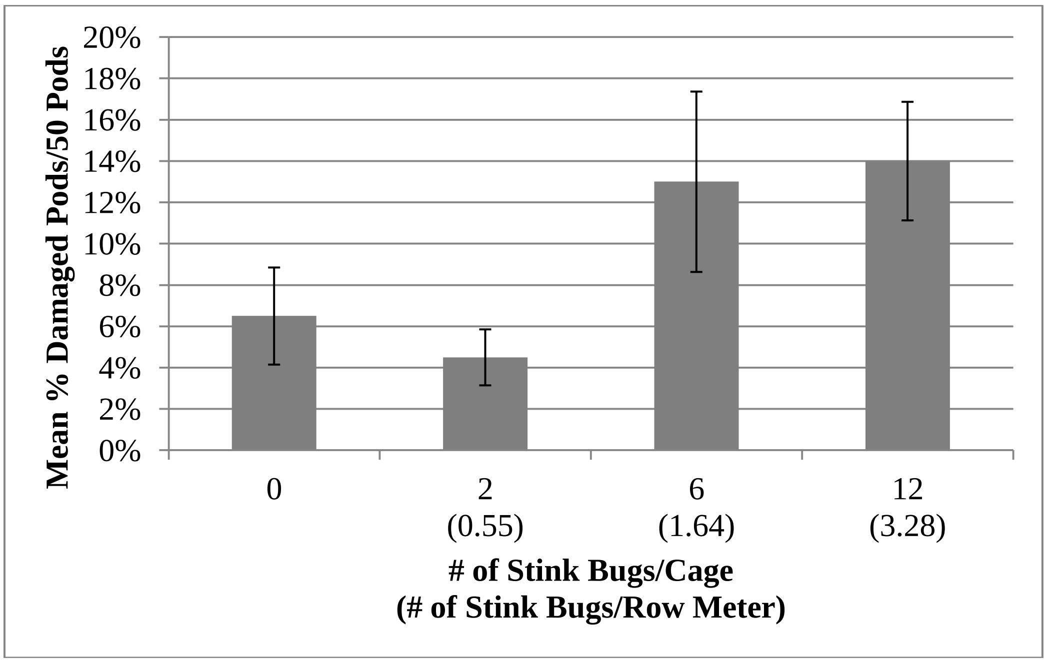


Figure 2. Mean pod weights (100 pods (g), +/- SE) of edamame (*Glycine max* (L.) Merrill), after infestations of green stink bugs (*Acrosternum hilare* (Say)). Field-cage trials used densities of 2, 6, 12 or zero (control) per 183 cm x 183 cm x 183 cm cage, for 7 days, beginning at the R5 growth stage. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR. Weights were estimated by dividing the yield by the number of pods in harvest row, then multiplying by 100. Each treatment consisted of four cages. Numbers of stink bugs per cage are also represented as numbers per row-meter of plants. Y-axis begins at 150 grams.

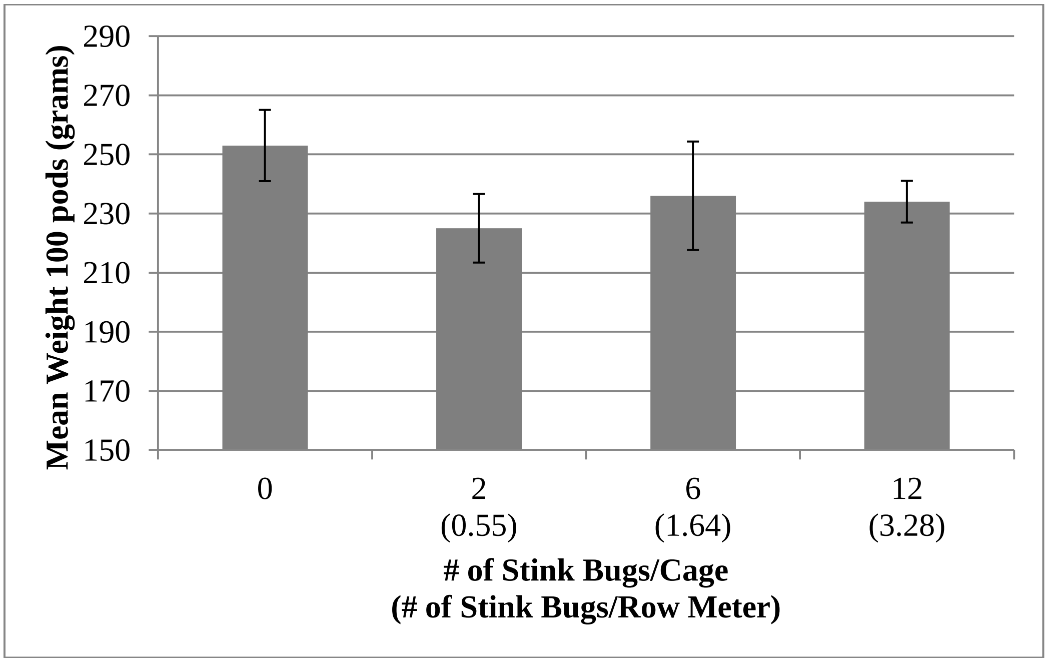
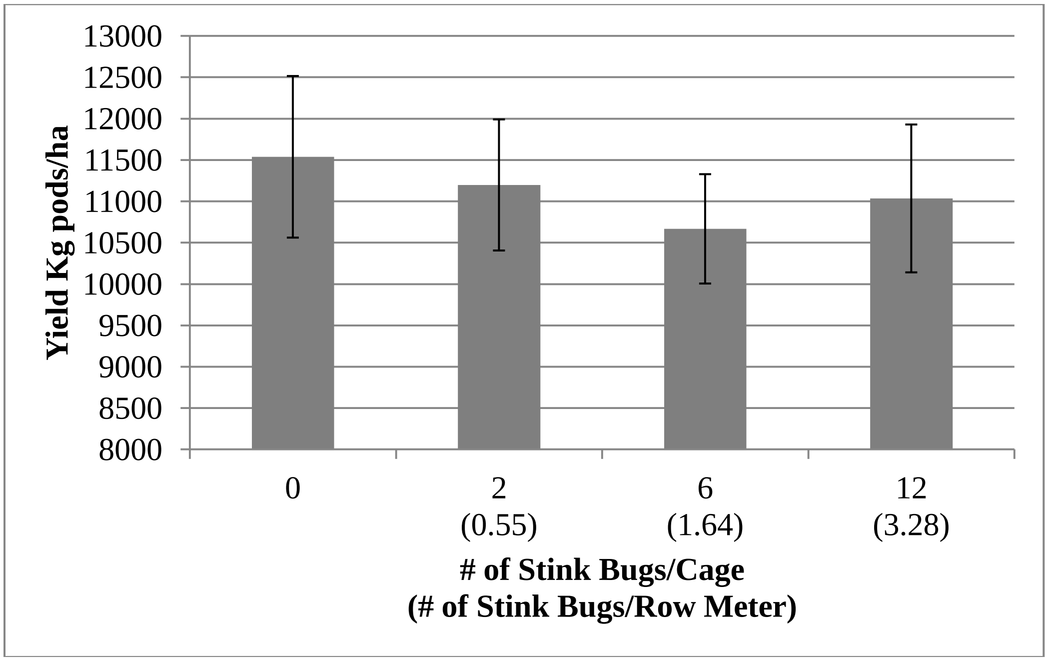


Figure 3. Mean yields (kg/ha, +/- SE) of edamame (*Glycine max* (L.) Merrill) adjusted for plant stand densities, after infestations of green stink bugs (*Acrosternum hilare* (Say)). Field-cage trials used densities of 2, 6, 12 or zero (control) per 183 cm x 183 cm x 183 cm cage, for 7 days, beginning at the R5 growth stage. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR. Yields were estimated by harvesting one row (1.78 m length) of edamame plants per cage, and extrapolating to kg/ha. Each treatment consisted of four cages. Numbers of stink bugs per cage are also represented as numbers per row-meter of plants. Y-axis begins at 8000 kg pods/ha.



Tables

Table 1. Mean number of injured pods (+/- SE), mean number of salivary sheaths (+/- SE) and average number of sheaths per pod (+/- SE), mean number injured pods per stink bug per cage (+/- SE) and mean number of injured pods per stink bug day per cage (+/- SE) after infestations of green stink bug adults (*Acrosternum hilare* (Say)). Field-cage trials used densities of 2, 6, 12 or zero (control) per 183 cm x 183 cm x 183 cm cage, for 7 days, beginning at the R5 growth stage. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR. A sub-sample of 50 randomly selected pods was taken from each cage, stained, and then examined for salivary sheaths and the number of salivary sheaths was recorded for each pod. Pods were considered injured if at least one salivary sheath was found present on the pod surface. The number of salivary sheaths per injured pod was established by dividing the number of salivary sheaths found by the number of injured pods. The number of injured pods per stink bug and number of injured pods per stink bug day was established by determining the percent damaged in the stained subsample of 50 pods and applying it to the number of pods in the harvest row multiplying that by 2, to get the approximate amount of pods per cage, then dividing that number by the number of stink bugs per cage or stink bug days per cage. Each treatment consisted of four cages.

Stink bugs/ cage (Stink bugs/ row-m)	# of injured pods (+/- SE)	# of salivary sheaths (+/- SE)	# of sheaths/ injured pod (+/- SE)	Injured pods/ stink bug (+/- SE)	Injured pods/ stink bug day (+/- SE)
0	3.25 (1.31)	5.00 (2.35)	1.33 (0.24)	--	--
2 (0.55)	2.25 (0.63)	3.50 (0.96)	1.56 (0.33)	36.59 (8.37)	5.22 (1.20)
6 (1.64)	6.50 (2.63)	20.0 (10.93)	2.47 (0.75)	35.80 (14.8)	5.11 (2.11)
12 (3.28)	7.00 (1.87)	11.25 (4.50)	1.44 (0.21)	19.51 (5.32)	2.79 (0.76)

Chapter II. Insect Abundance in Edamame

Abstract

Edamame production is increasing in acreage in Arkansas but little is known about insect pest abundance in this new crop. Tests were conducted in plots of conventional soybean and edamame. Weekly sweep net samples evaluated numbers of insects in the two crop types. Bean leaf beetle, grape colaspis and threecornered alfalfa hoppers were found in great enough numbers to allow for analysis. Insect densities did not differ between edamame and conventional soybeans. Other insects considered pests of conventional soybeans were found in edamame plots, but were not analyzed due to their low numbers.

Introduction

Edamame, *Glycine max* (L.) Merrill, also known vegetable soybean, is a relatively new food to the US, but has been used as a food for many years in Eastern Asia (Liu 2004). Edamame are typically served in the pods after being boiled in salt water, squeezing the seeds out of the pods into the mouth (Konovsky et al. 1994). Current demand for edamame in the US is growing but the market historically has been dominated by imports from China and Taiwan (Mohamed and Mentreddy 2004, McPherson et al. 2008). Economic information on edamame production is limited but a study by Johnson et al. (1999) estimated that demand for edamame in the US would require a crop of 13,000 hectares. The domestic demand has increased substantially since that study, so it is likely that the acreage needed to support that demand has increased as well. With a estimated edamame crop of 650 hectares in 2013 (Chaney 2013), producers in Arkansas are finding the crop to be an alternative to growing conventional soybeans.

Edamame are similar to grain-type (conventional) soybeans grown in Arkansas, but several differences may affect management of insect pests of edamame. Edamame seeds contain higher sugar content than do conventional soybeans, making edamame more palatable to humans (Yazdi-Samadi et al. 1977, Tsou and Hong 1990). Sugar content of a plant can be important in regulating insect feeding, making a plant more or less attractive, depending on the insect species (Nuorteva 1952, Fraenkel 1955, Beck 1956, Beck and Hanec 1958).

Another difference between edamame and conventional soybeans that may affect pests and pest management is crop maturation. The cultivar of edamame currently grown on the majority of Arkansas edamame acreage is an early-maturity, group III variety. This is in contrast to the slower growing, maturity group IV and V varieties of conventional soybean typically grown in

Arkansas. The earlier maturity of edamame could make it more attractive to some early season pests (Schumann and Todd 1982, Baur et al. 2000). On the other hand, many pests of soybean become more numerous later in the season and edamame is usually harvested before late-season pests would have a chance to cause damage (McPherson et al. 2001, Gore et al. 2006). Edamame are harvested with a specialized picker that strips the pods from the plant when the pods are at the R6 growth stage (Konovsky et al. 1994). At this growth stage, the pods are still green and the seeds fill the pod cavity in one of the four uppermost nodes on the main stem (Fehr et al. 1971). In contrast, conventional soybeans are harvested when pods are 95% brown, at the R8 growth stage. Thus, the early harvest of edamame would reduce the amount of time that the crop is present and subject to injury by insects.

Insect pests of edamame will likely be the same as those found in conventional soybean in Arkansas. Pests of both edamame and conventional soybeans were comparable in a study conducted in Taiwan, and included defoliators (Lepidoptera and Coleoptera), stink bugs (Hemiptera: Pentatomidae), and a podborer (Lepidoptera: Pyralidae) (Yeh et al. 1991). McPherson et al. (2008) found that essentially the same insect pests attacked edamame and conventional soybeans in Georgia -- stink bugs (Hemiptera: Pentatomidae), lepidopteran larvae, grasshoppers (Orthoptera), threecornered alfalfa hoppers (Hemiptera: Membracidae) and potato leafhoppers (Hemiptera: Cicadellidae). Insect pests in Arkansas cost soybean growers an average of $79.08 per acre in 2012 (Musser et al. 2013) in cost of control plus lost yield. Ten species of insect pests were found in 100% of Arkansas soybean fields at some time throughout the growing season (Musser et al. 2013). The three insects requiring an insecticide treatment on the most acreage were corn earworm *Heliocoverpa zea* (Boddie) (30.2%), soybean looper *Chrysodeixis includens* (Walker) (29.8%), and grasshoppers (23.4%) (Musser et al. 2013). Corn earworm has been the most costly insect pest of soybean in Arkansas every year since 2010, by having the greatest costs of control plus yield loss per acre (Musser et al. 2013). Prior to 2010, the stink bug complex had been the most damaging pest of soybean across Mid-South (Musser et al. 2012).

When evaluating insect damage, it can be useful to combine various pests into feeding guilds, i.e., the species causing injury to the same parts of the plant. Most insect pests of soybean can be classified into root-feeding, stem-feeding, leaf-feeding or pod-feeding guilds (Higley 1994) although some occur in multiple guilds. In some cases a single economic injury level may be developed for all insects within a guild since all members within it cause similar injury. Feeding guilds can be divided further into injury guilds based on the kinds of injury the insects cause to the plant. Injury guilds include stand reduction, leaf-mass consumption, assimilate removal, water-balance disruption, fruit destruction, and architecture modification (Boote 1981, Pedigo et al. 1986).

Edamame are typically served in their pods, so pod appearance is a crucial factor in determining crop value (Mohamed and Mentreddy 2004). In contrast, pod appearance does not affect crop price for conventional soybeans. Because pod aesthetics are such an important factor in edamame, this will likely mean insect pests in the pod- feeding guild will need to be managed more than those in conventional soybean.

The objective of this study is to examine numbers of selected species of insects found in edamame compared to conventional soybeans, to be able to inform edamame growers and help decision-making for managing pests of the crop.

Materials and Methods

Plots of edamame and conventional soybeans were planted at Lon Mann Cotton Branch Research Station (LMRS), Marianna, Arkansas, on 18 May 2012 and 27 May 2013. Plots were 16 rows x 75 m in 2012 and 12 rows x 37.5 m in 2013. All seed was treated with Cruiser Maxx Beans (thiamethoxam) prior to planting, at a rate of 0.756 mg ai/seed. In both 2012 and 2013 the edamame cultivar used in trials was AVSE8080. The conventional cultivars used in trials were Asgrow 4832 in 2012 and Terrell 38R10 in 2013. Edamame planting density was 176,000 seeds per hectare, versus a planting density of 371,000 seeds per hectare for conventional soybean varieties. All plots were planted on 96.52 cm rows in a randomized complete block design with 4 replications. No foliar insecticide applications were made to the plot area throughout the growing season. Plots were otherwise maintained by using standard production practices, according to the University of Arkansas Division of Agriculture Cooperative Extension Service guidelines (Mayhugh 1998).

Thrips were sampled on two dates in 2012, 10 days after planting (DAP) (28 May) and 19 DAP (6 June). Thrips samples were taken by clipping 5 plants at ground level and immediately placing each plant in a 0.95 liter glass container filled ¼ full with 70% ethanol. Samples were then transported to the lab where thrips were rinsed from soybean plants and filtered through a Buchner funnel. The filter paper was then removed and thrips were rinsed into a Petri dish where they were counted under a dissecting microscope. Thrips counts were not separated by species, but were separated into nymphs and adults.

Sweep net samples were taken approximately weekly beginning on 18 June in 2012 and 26 June in 2013. These samples were conducted by taking 25 sweeps per plot with a 38.1cm diameter sweep net. For each sample date, plant maturity was recorded. Sampling ended 1 August in 2012 and 22 August in 2013.   All insects from each 25-sweep sample were collected and counted. Insects were grouped into one of three feeding guilds: pod-feeders, defoliators and stem-feeders (Table 1).

Thrips numbers collected each date were analyzed using ANOVA (JMP®, Version 11. SAS Institute Inc., Cary, NC, 2013). Mean weekly numbers of insects in the three feeding guilds were analyzed using ANOVA. Only those species whose season-long total per 25 sweeps exceeded 50 were used for analysis, and only those species that were found both years are reported in Tables 2-6.

Results

Insect Pest Abundance: 2012

Mean numbers of thrips collected on edamame were 35.5 (SE=6.0) per 5 plants on 25 May and 50.5 (SE=15.0) per 5 plants on 6 June. Mean numbers of thrips collected on conventional soybean were 26.5 (SE=4.6) per 5 plants on 25 May and 38.3 (SE=5.8) per 5 plants on 6 June. Mean numbers of thrips per 5 plants did not differ between edamame and conventional soybeans on either 25-May ($F=0.74$, $df=1,3$, $P=0.45$) or 6-June ($F=0.55$, $df=1,3$, $P=0.51$).

A total of 526 insects of 14 pest species was collected by sweep-net sampling throughout the season in edamame, versus a total of 534 insects of 14 pest species collected in conventional soybean (Tables 2-4). Salt marsh caterpillar was represented by only one individual collected in edamame and three collected in conventional soybean.

Among the four species of pod-feeders collected in edamame and conventional soybean, bean leaf beetles represented 75-76% of the individuals collected, and green stink bug represented 15-18% of the collections (Table 2). Weekly counts from both crops are shown in Figure 1. Fewer than 10 individuals total were collected of the green and brown stink bugs. Weekly bean leaf beetle numbers in edamame ranged from 1.25 to 5.0 per 25 sweeps and averaged 3.75 (SE=0.48). Weekly counts of bean leaf beetles in conventional soybeans ranged from 2.5 to 4.5 per 25 sweeps, and averaged 2.71 (SE=0.38). Mean numbers of bean leaf beetles did not differ between edamame and conventional soybean plots ($F=2.91$, $df=1,54$, $P=0.094$).

In the defoliating guild, grape colaspis made up 79-80% of the individuals collected in edamame and conventional soybeans, with the remaining six taxa representing the remaining 20-21% (Table 3). Weekly counts from both crops are shown in Figure 2. Numbers of grape colaspis in edamame ranged from 1.0 to 15.25 per 25 sweeps and averaged 8.29 (SE=1.27). In conventional soybeans, numbers of grape colaspis ranged from 1.0 to 14.5 per 25 sweeps and averaged 7.86 (SE=1.12). Mean numbers of grape colaspis per 25 sweeps did not differ between edamame and conventional soybean (F=0.061, df=1,54, P=0.81).

Only two species were collected in the stem-feeding guild (Table 4). Three-cornered alfalfa hoppers (TCAH) made up 95-98% of individuals collected, whereas Dectes stem borer represented the remaining 2-5%. Weekly counts from both crops are shown in Figure 3. In edamame, numbers of TCAH ranged from 1.0 to 12.0 per 25 sweeps and averaged 4.64 (SE=1.06). In conventional soybean, numbers of TCAH ranged from 0.0 to 11.0 per 25 sweeps and averaged 3.89 (SE=1.02). Mean numbers of TCAH did not differ between edamame and conventional soybean (F=0.27, df=1,54, P=0.61).

Insect Pest Abundance: 2013

A total of 556 insects of 15 pest species was collected throughout the season in edamame, versus a total of 591 insects of 13 pest species from conventional soybean. Salt marsh caterpillar and garden webworm were represented by only one individual collected.

Among the four species of pod-feeders collected, bean leaf beetles represented 88% of the individuals collected in both edamame and conventional soybean. Green and brown stink bugs represented a total of 11-12% of the collections in both crops (Table 5). Weekly counts from both crops are shown in Figure 4. Weekly counts of bean leaf beetles in edamame ranged from 0 to 35.75 per 25 sweeps and averaged 10.96 (SE=2.87). Weekly counts of bean leaf beetles in conventional soybeans ranged from 0 to 50.75 per 25 sweeps and averaged 12.39 (SE=3.56).

Mean bean leaf beetle numbers did not differ between edamame and conventional soybean plots (F=0.094, df=1, 54, P=0.76).

In the defoliating guild, grape colaspis made up made up 69-72% of all individuals collected, with the remaining six taxa representing the remaining 28-31% (Table 6). Weekly counts from both crops are shown in Figure 5. Numbers of grape colaspis in edamame ranged from 0-11 per 25 sweeps and averaged 4.07 (SE=1.09). Numbers of grape colaspis in conventional soybeans ranged from 0.25-9.75 per 25 sweeps and averaged 3.71 (SE=0.77). Mean numbers of grape colaspis per 25 sweeps did not differ between edamame and conventional soybean (F=0.069, df=1, 54, P=0.794).

Only two taxa were collected in the stem-feeding guild (Table 7). TCAH and Dectes stem borer each made up approximately half (45-55%) of individuals collected. No comparisons of stem-feeding species were made in 2013.

Discussion

Edamame have been grown in Arkansas for only a few years and many questions remain about how insects will affect edamame and how insect pests will be managed. The objective of this study was to evaluate insect pest abundance in edamame versus conventional soybeans, to better understand when pests are likely to occur, as well as improve decision-making guidelines in an integrated pest management program (McPherson et al. 2001).

This study compared several insect species in edamame versus conventional soybeans. Bean leaf beetle and grape colaspis were both found in adequate numbers to allow for analysis in both 2012 and 2013 studies, whereas thrips were analyzed only in 2012 and TCAH was found in adequate numbers to analyze only in 2013. There were no differences in the numbers of the most-numerous insects collected -- thrips, bean leaf beetle, grape colaspis and threecornered alfalfa hopper -- in edamame and conventional soybeans. Numbers of insects collected were relatively low throughout the sample period (June - August). Although many species of insects that are pests of conventional soybeans were found at some point during the sampling period, most of those insects were not numerous enough to warrant analysis.

Combining insect pests into feeding guilds can be helpful in evaluating damage, particularly if individual species are not numerous. Feeding guilds permit considering together all those species causing similar damage, such as damage to the pods. Unlike for soybeans, the amount of tolerable damage to edamame pods is extremely low, regardless of which species caused the damage. Although no standard grading criteria exist in the US, growers receive lower prices for edamame showing visible damage to the pod. Any insect that punctures or feeding marks of any kind on the pod causes the type of damage that reduces the price paid to growers. Bean leaf beetle has been considered primarily a defoliator in conventional soybeans, but it was classified as a pod feeder in this study because it will also feed on pod surface tissue down to the endocarp (Pedigo 1994). Smelser and Pedigo (1992) stated that pod peduncle feeding and pod surface feeding are probably the most economically important types of injury the bean leaf beetle causes. Pod surface feeding damage by bean leaf beetle in conventional soybean has been shown to increase seed vulnerability to moisture and secondary pathogens like *Alternaria,* (Shortt et al. 1982). Even without secondary losses, feeding on the pod wall could make bean leaf beetle an important pest, because feeding would degrade pod appearance.

The generally low numbers of insects found in this study may be related to the early maturing cultivar of edamame used. Early maturity in a soybean cultivar has been generally considered beneficial for insect pest management (McPherson et al. 2001). For example, lepidopteran defoliators, including soybean looper and green cloverworm, have been noted as pests that can be avoided in early maturing soybean cultivars (Baur et al. 2000). However, some studies have shown that stink bugs will often colonize the early-maturing cultivars because of the early availability of pods (McPherson 1996, Boyd et al. 1997). Another study found that green stink bugs and southern green stink bugs (*Nezara viridula* (L.) will infest early maturing soybean fields but their numbers usually do not reach treatment level (Gore et al. 2006). Because economic thresholds for stink bugs have yet to be defined in edamame, we do not know whether stink bugs may still be important to control.

Edamame are not only quick to mature, but also they are harvested earlier than conventional soybeans, at the R6 growth stage, whereas conventional soybeans are harvested during the R8 growth stage. A study by Daugherty et al. (1964) found that the longer the period from blooming to maturity of a soybean cultivar that was exposed to stink bugs, the more stink bug damage was present. Because of edamame's early harvest, the time when vulnerable pods are present is further shortened. McPherson et al. (2001) found that later-maturing soybean cultivars experienced the greatest numbers of TCAH, whereas early-maturing cultivars missed the peak numbers of TCAH by being already harvested. A similar case of harvest avoiding peak numbers of insects was observed in the 2013 trial reported here, when the peak numbers of bean leaf beetles occurred at the R6.8 growth stage. Half of the total numbers of bean leaf beetles collected all season long were collected on 8/22, when edamame were at the R6.8 stage and the conventional soybeans were at R7 stage. In a real cropping situation, the edamame would have never experienced peak bean leaf beetle densities because harvest would have occurred prior to that growth stage. However, conventional soybeans are harvested at R8 stage, so the large numbers of bean leaf beetles collected on 8/22 would be occur and be important to late-season damage in that crop.

Early maturity is not the only aspect that allows a soybean cultivar to avoid late season soybean pests. In order to take full advantage of quick maturity, soybeans must be planted early (Baur et al. 2000). However, early planting is not possible on all edamame acreage, because of processing infrastructure. Post-harvest processing of edamame must be done quickly to maintain the quality of the pods and seeds. The current edamame facilities can only process pods from approximately 8 hectares per day. Further, edamame have an optimum harvest window of only a few days. The narrow harvest window, plus the limited processing facilities, mean edamame planting dates must be staggered so the harvested product can be properly processed. For conventional soybeans, growers are not limited by infrastructure or a narrow harvest window. Because growers of conventional soybeans do not face those problems, weather permitting, all fields can be planted early helping to avoid late season pests. The need for staggered planting of edamame means that the benefits of early planting and early harvest are not fully realized.

An original hypothesis of this study was that insects may be more attracted to edamame than conventional soybeans due to the sugar content in the edamame seed being greater (Yazdi-Samadi et al. 1977, Tsou and Hong 1990). However, pod-feeding insects, the species most likely to be affected by the higher sugar content, were not found in great enough numbers to suitably evaluate this hypothesis. Another problem with evaluating whether increased edamame sugar content has an effect on insects is elimination of other variables, such as differences in plant maturity between edamame and conventional soybeans.

Insect feeding guilds are a useful way to create meaningful economic thresholds. For the guild analysis to be effective, studies need to assess how much feeding damage occurs at each sampling date, and how that damage accumulates through the season. Correlating damage with numbers of each guild member will allow understanding the relative contribution that each species in the guild makes to the feeding damage, thus providing information needed to establish thresholds that are sensitive to crop phenology. This study did not find adequate numbers of several species considered major pests, including corn earworm, soybean looper and the stink bug complex, to draw conclusions about how they affect edamame. Future studies would benefit from using multiple plot locations as well as multiple planting dates to increase the chance of these species occurring.

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Tables

Table 1. Insect pest species collected in 2012 and 2013 from edamame and conventional soybean plots at Marianna, Arkansas. Insects are categorized by feeding guild (Higley 1986).

Feeding Guild	Common Name	Species
Pod-feeding	Green Stink Bug	*Acrosternum hilare* (Say)
	Brown Stink Bug	*Euschistus servus* (Say)
	Bean Leaf Beetle	*Cerotoma trifucata* (Förster)
	Corn Earworm	*Heliocoverpa zea* (Boddie)
Defoliating	Spotted Cucumber Beetle	*Diabrotica undecimpunctata howardi* Barber
	Grape Colaspis	*Colaspis brunnea* (Fabricius)
	Green Cloverworm	*Hypena scabra* (Fabricius)
	Soybean Looper	*Chrysodeixis includens* (Walker)
	Geometrid sp.	Lepidoptera: Geometridae
	Yellowstriped Armyworm	*Spodoptera ornithogalli* (Guenée)
	Short-horned Grasshopper	Orthoptera: Acrididae
	Garden Webworm	*Achyra rantalis* (Guenée)
	Saltmarsh Caterpillar	*Estigmene acrea* (Drury)
Stem-feeding	Threecornered Alfalfa Hopper	*Spissistilus festinus* (Say)
	Dectes Stem Borer	*Dectes texanus* LeConte

Table 2. Number of pod feeding insects during the 2012 growing season at each sample date, determined from the sum of 4 individual insect counts of 25 sweep net samples. Season total insect numbers were established by taking the sum of all insects collected over the sample period. Totals at each sample date were the sum of all pod feeding insects. Plant growth stage was recorded at each sample date. Conventional soybean cultivar was Asgrow 4832, edamame soybean cultivar was AVSE8080. Studies were conducted in 2012 at Lon Mann Cotton Branch Experiment Station, Marianna, AR.

Sample Date		6/18/2012	6/26/2012	7/5/2012	7/12/2012	7/19/2012	7/25/2012	8/1/2012	Season Totals
Plant Growth Stage		V6	R2	R3	R4	R4.9	R5.2	R5.5	
Edamame	GSB	0	0	1	1	0	7	9	18
	BSB	0	0	1	1	1	0	1	4
	BLB	5	20	10	12	12	6	11	76
	CEW	0	0	0	1	0	0	2	3
	Totals	5	20	12	15	13	13	23	101

Sample Date		6/18/2012	6/26/2012	7/5/2012	7/12/2012	7/19/2012	7/25/2012	8/1/2012	Season Totals
Plant Growth Stage		V7	R1	R2	R3	R3	R4	R4.5	
Conventional	GSB	0	0	0	1	7	4	9	21
	BSB	0	0	1	2	1	0	0	4
	BLB	18	15	15	12	17	18	10	105
	CEW	2	0	0	0	2	2	2	8
	Totals	20	15	16	15	27	24	21	138

GSB – Green stink bug; BSB – Brown stink bug; BLB – Bean leaf beetle; CEW – Corn earworm

Table 3. Number of defoliating insects during the 2012 growing season at each sample date, determined from the sum of 4 individual insect counts of 25 sweep net samples. Season total insect numbers were established by taking the sum of all insects collected over the sample period. Totals at each sample date were the sum of all defoliating insects. Plant growth stage was recorded at each sample date. Conventional soybean cultivar was Asgrow 4832, edamame soybean cultivar was AVSE8080. Studies were conducted in 2012 at Lon Mann Cotton Branch Experiment Station, Marianna, AR.

Sample Date		6/18/2012	6/26/2012	7/5/2012	7/12/2012	7/19/2012	7/25/2012	8/1/2012	Season Totals
Plant Growth Stage		V7	R1	R2	R3	R3	R4	R4.5	
Edamame	SCB	0	3	0	4	4	5	0	16
	GC	1	41	55	61	12	16	46	232
	GCW	1	2	0	0	0	4	5	12
	Looper	1	1	0	0	1	1	0	4
	Geometrid	0	0	0	0	0	6	8	14
	YSAW	3	0	0	0	0	5	0	8
	SHGH	1	2	0	1	0	0	0	4
	Totals	7	49	55	66	18	37	59	291

Sample Date		6/18/2012	6/26/2012	7/5/2012	7/12/2012	7/19/2012	7/25/2012	8/1/2012	Season Totals
Plant Growth Stage		V6	R2	R3	R4	R4.9	R5.2	R5.5	
Conventional	SCB	0	0	6	2	2	4	0	14
	GC	1	48	38	46	11	18	58	220
	GCW	4	9	0	0	0	2	2	17
	Looper	1	0	2	0	5	1	1	10
	Geometrid	0	0	1	0	0	4	1	6
	YSAW	3	0	0	0	0	2	0	5
	SHGH	1	0	0	0	0	0	2	3
	Totals	10	57	47	48	21	31	64	278

SCB – Spotted cucumber beetle; GC – Grape colaspis; GCW – Green cloverworm; Looper – Soybean looper; YSAW – Yellowstriped armyworm; SHGH – Short horned grasshopper

Table 4. Number of stem feeding insects during the 2012 growing season at each sample date, determined from the sum of 4 individual insect counts of 25 sweep net samples, for a total of 100 sweeps. Season total insect numbers were established by taking the sum of all insects collected over the sample period. Totals at each sample date were the sum of all stem feeding insects. Plant growth stage was recorded at each sample date. Conventional soybean cultivar was Asgrow 4832, edamame soybean cultivar was AVSE8080. Studies were conducted in 2012 at Lon Mann Cotton Branch Experiment Station, Marianna, AR.

Sample Date		6/18/2012	6/26/2012	7/5/2012	7/12/2012	7/19/2012	7/25/2012	8/1/2012	Season Totals
Plant Growth Stage		V6	R2	R3	R4	R4.9	R5.2	R5.5	
Edamame	TCAH	3	0	4	13	24	38	48	130
	Dectes	0	0	0	2	1	0	0	3
	Totals	3	0	4	15	25	38	48	133

Sample Date		6/18/2012	6/26/2012	7/5/2012	7/12/2012	7/19/2012	7/25/2012	8/1/2012	Season Totals
Plant Growth Stage		V7	R1	R2	R3	R3	R4	R4.5	
Conventional	TCAH	0	2	2	15	13	33	44	109
	Dectes	0	1	0	1	3	1	0	6
	Totals	0	3	2	16	16	34	44	115

TCAH – Three cornered alfalfa hopper; Dectes – Dectes stem borer

Table 5. Number of pod feeding insects during the 2013 growing season at each sample date, determined from the sum of 4 individual insect counts of 25 sweep net samples, for a total of 100 sweeps. Season total insect numbers were established by taking the sum of all insects collected over the sample period. Totals at each sample date were the sum of all pod feeding insects. Plant growth stage was recorded at each sample date. Conventional soybean cultivar was Terrell 38R10, edamame soybean cultivar was AVSE8080. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR.

Sample Date		6/26/2013	7/2/2013	7/12/2013	7/18/2013	7/29/2013	8/9/2013	8/22/2013	Season Totals
Plant Growth Stage		V6	R2	R3	R4	R5	R5.4	R6.8	
Edamame	GSB	0	0	3	2	2	8	4	19
	BSB	0	0	3	3	2	0	11	19
	BLB	1	0	40	19	11	85	151	307
	CEW	0	0	0	0	0	2	0	2
	Totals	1	0	46	24	15	95	166	347

Sample Date		6/26/2013	7/2/2013	7/12/2013	7/18/2013	7/29/2013	8/9/2013	8/22/2013	Season Totals
Plant Growth Stage		R1	R2	R3	R4	R5	R5.5	R7	
Conventional	GSB	0	0	9	9	6	9	6	39
	BSB	0	0	1	2	2	4	1	10
	BLB	1	0	30	13	9	91	203	347
	CEW	0	0	0	0	0	0	0	0
	Totals	1	0	40	24	17	104	210	396

GSB – Green stink bug; BSB – Brown stink bug; BLB – Bean leaf beetle; CEW – Corn earworm

Table 6. Number of defoliating insects during the 2013 growing season at each sample date, determined from the sum of 4 individual insect counts of 25 sweep net samples. Season total insect numbers were established by taking the sum of all insects collected over the sample period. Totals at each sample date were the sum of all defoliating feeding insects. Plant growth stage was recorded at each sample date. Conventional soybean cultivar was Terrell 38R10, edamame soybean cultivar was AVSE8080. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR.

Sample Date		6/26/2013	7/2/2013	7/12/2013	7/18/2013	7/29/2013	8/9/2013	8/22/2013	Season Totals
Plant Growth Stage		V6	R2	R3	R4	R5	R5.4	R6.8	
Edamame	SCB	0	0	7	2	0	0	0	9
	GC	1	1	22	37	9	44	0	114
	GCW	3	1	2	7	0	0	0	13
	Looper	0	0	0	2	0	0	0	2
	Geometrid	0	0	1	2	0	2	0	5
	YSAW	0	0	3	0	0	1	0	4
	SHGH	1	1	0	2	3	3	0	10
	Totals	5	4	35	52	12	51	0	159

Sample Date		6/26/2013	7/2/2013	7/12/2013	7/18/2013	7/29/2013	8/9/2013	8/22/2013	Season Totals
Plant Growth Stage		R1	R2	R3	R4	R5	R5.5	R7	
Conventional	SCB	1	0	6	1	0	0	0	8
	GC	6	5	22	24	7	39	1	104
	GCW	0	1	6	8	0	0	0	15
	Looper	0	0	0	0	0	0	1	1
	Geometrid	0	0	0	0	1	4	9	14
	YSAW	0	0	2	0	0	2	0	4
	SHGH	0	0	0	1	0	1	3	5
	Totals	7	6	36	34	8	46	14	151

SCB – Spotted cucumber beetle; GC – Grape colaspis; GCW – Green cloverworm; Looper – Soybean looper; YSAW – Yellowstriped armyworm; SHGH – Short horned grasshopper

Table 7. Number of stem feeding insects during the 2013 growing season at each sample date, determined from the sum of 4 individual insect counts of 25 sweep net samples, for a total of 100 sweeps. Season total insect numbers were established by taking the sum of all insects collected over the sample period. Totals at each sample date were the sum of all stem feeding insects. Plant growth stage was recorded at each sample date. Conventional soybean cultivar was Terrell 38R10, edamame soybean cultivar was AVSE8080. Studies were conducted in 2013 at Lon Mann Cotton Branch Experiment Station, Marianna, AR.

Sample Date		6/26/2013	7/2/2013	7/12/2013	7/18/2013	7/29/2013	8/9/2013	8/22/2013	Season Totals
Plant Growth Stage		V6	R2	R3	R4	R5	R5.4	R6.8	
Edamame	TCAH	1	1	0	2	9	8	3	24
	Dectes	1	0	10	6	5	2	0	24
	Totals	2	1	10	8	14	10	3	48

Sample Date		6/26/2013	7/2/2013	7/12/2013	7/18/2013	7/29/2013	8/9/2013	8/22/2013	Season Totals
Plant Growth Stage		R1	R2	R3	R4	R5	R5.5	R7	
Conventional	TCAH	0	1	0	0	9	3	7	20
	Dectes	1	0	14	4	3	0	2	24
	Totals	1	1	14	4	12	3	9	44

TCAH – Three cornered alfalfa hopper; Dectes – Dectes stem borer

<u>**Figures**</u>

Figure 1. Mean numbers of bean leaf beetles per 25 sweeps, at seven sample dates on edamame (JYC2 cultivar) or conventional (Asgrow 4832 cultivar) soybean (*Glycine max* (L.) Merrill). Plots were planted on 18 May 2012 at the Lon Mann Cotton Branch Experiment Station, Marianna, AR. Each mean consisted of four replications.

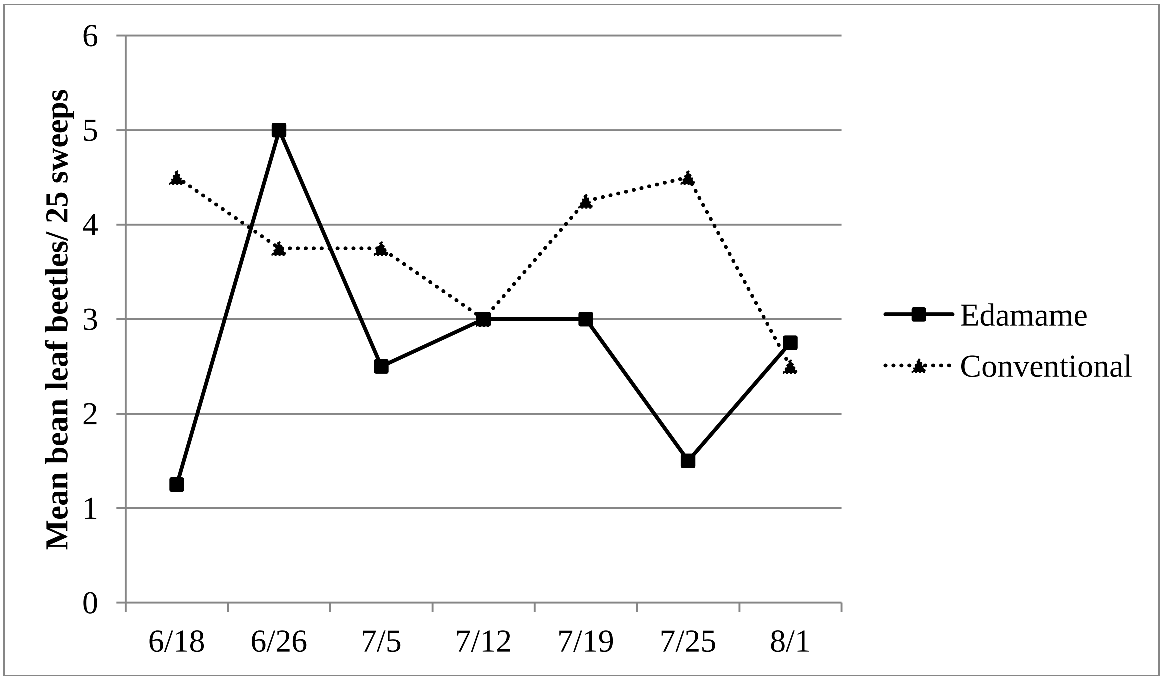


Figure 2. Mean numbers of grape colaspis per 25 sweeps, at seven sample dates on edamame (JYC2 cultivar) or conventional (Asgrow 4832 cultivar) soybean (*Glycine max* (L.) Merrill). Plots were planted on 18 May 2012 at the Lon Mann Cotton Branch Experiment Station, Marianna, AR. Each mean consisted of four replications.

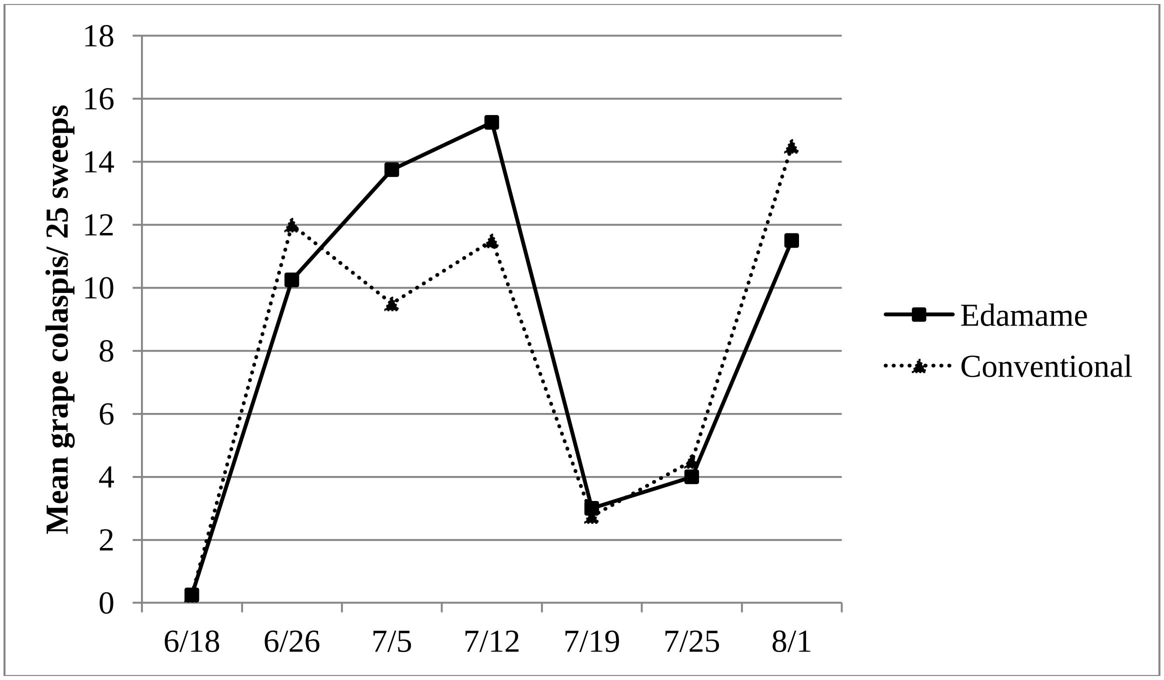


Figure 3. Mean numbers of three-cornered alfalfa hoppers per 25 sweeps, at seven sample dates on edamame (JYC2 cultivar) or conventional (Asgrow 4832 cultivar) soybean (*Glycine max* (L.) Merrill). Plots were planted on 18 May 2012 at the Lon Mann Cotton Branch Experiment Station, Marianna, AR. Each mean consisted of four replications.

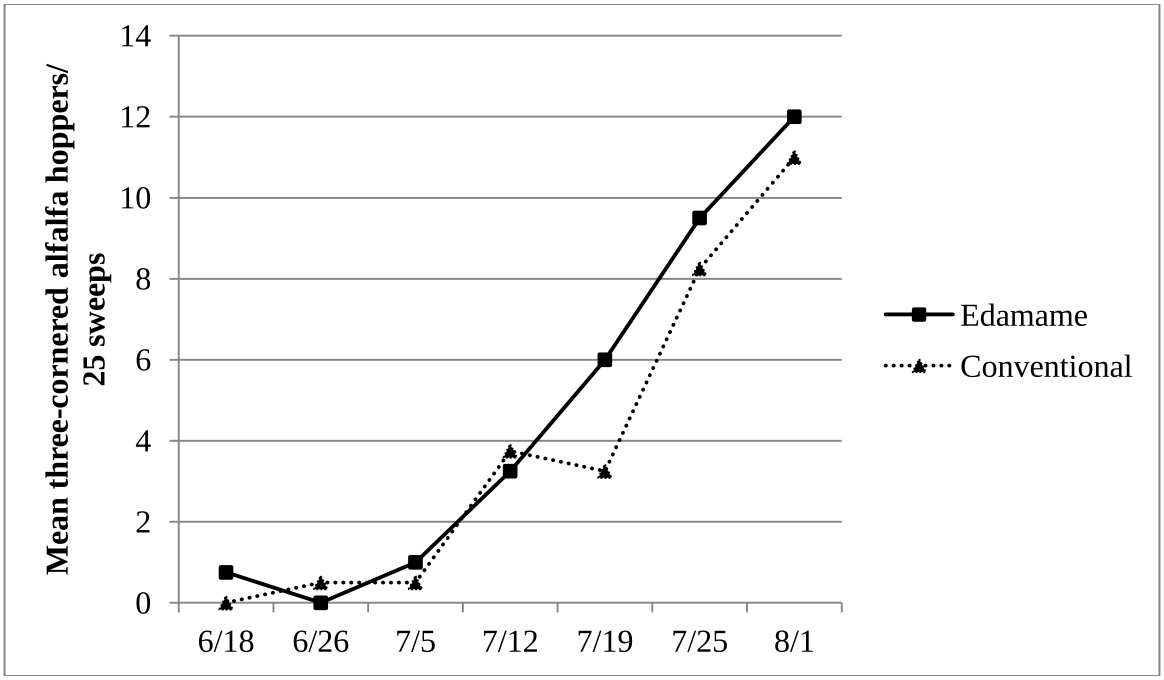


Figure 4. Mean numbers of bean leaf beetles per 25 sweeps, at seven sample dates on edamame (JYC2 cultivar) or conventional (Asgrow 4832 cultivar) soybean (*Glycine max* (L.) Merrill). Plots were planted on 27 May 2013 at the Lon Mann Cotton Branch Experiment Station, Marianna, AR. Each mean consisted of four replications.

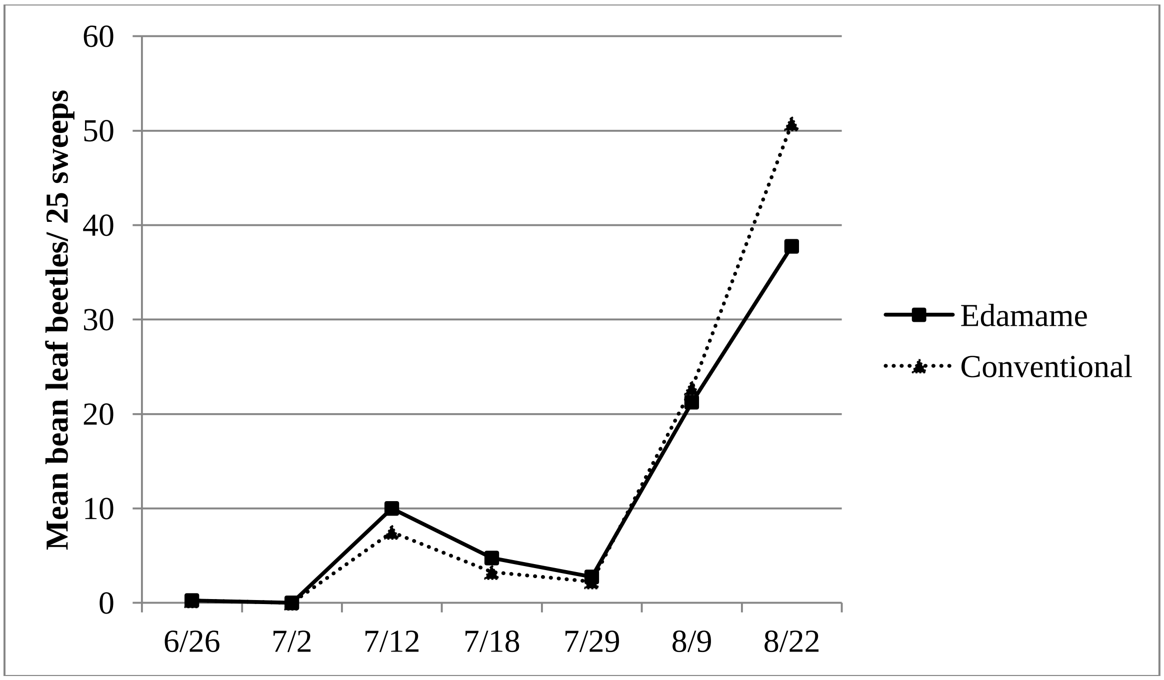
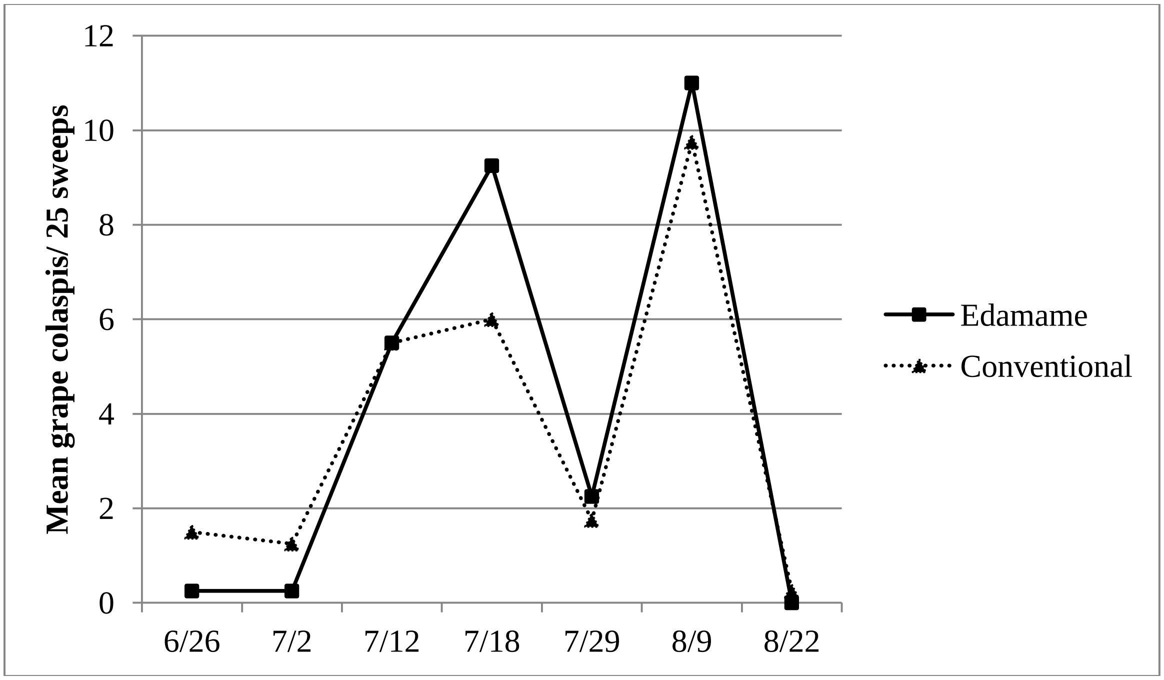


Figure 5. Mean numbers of grape colaspis per 25 sweeps, at seven sample dates on edamame (JYC2 cultivar) or conventional (Asgrow 4832 cultivar) soybean (*Glycine max* (L.) Merrill). Plots were planted on 27 May 2013 at the Lon Mann Cotton Branch Experiment Station, Marianna, AR. Each mean consisted of four replications.



Conclusion

When commercial production of edamame in Arkansas began several years ago, questions were raised about how insect pests will need to be managed. The studies presented here attempted to answer some of these questions by evaluating insect pest abundance in edamame and how green stink bugs damage edamame.

Another study undertaken was evaluating insect pest abundance in edamame compared to conventional soybeans. In the 2012 and 2013 field seasons, only three insects -- bean leaf beetle, grape colaspis, and threecornered alfalfa hopper were found in great enough numbers to be analyzed. However, no differences were found in comparing the numbers of these species in conventional soybeans and edamame. Several other insects considered to be pests of conventional soybean occurred in this study, but only a few of each were found. The insects that were found in small numbers still provided important information because their presence means that they were likely feeding on the edamame, meaning the potential is there to cause damage to edamame if they are more numerous.

The original intention was to establish a green stink bug economic threshold on edamame. This pest was chosen because of its important pest status in closely related conventional soybeans. The models used for this study were based on those evaluating stink bug injury in conventional soybean. Edamame were exposed to green stink bugs at densities of up to 12 per cage but no differences were found in terms of the numbers of damaged pods, average pod weights, or yields when compared to cages containing zero stink bugs. After this study there was a realization that a true comparison cannot be made between the previous studies evaluating stink bug injury on conventional soybean and this one evaluating edamame. This is because the parameters establishing a quality conventional soybean crop are not the same as those found in a quality edamame crop. No other studies were found evaluating the effects of stink bug feeding on pod quality instead of seed quality, average pod weights instead of seed weight, or yield as a result of weighing green pods and seeds instead of dry seed alone.

From the tests presented here, I believe that insect management of edamame will most likely be akin to growing an early-maturing variety of conventional soybean. If edamame are able to be planted early in the season, they will likely avoid much of the insect pressure associated with growing later maturing cultivars. However, with pod appearance being such an important factor in determining edamame value even small numbers of pod-feeding insect pests may still require management once economic thresholds are established.

Although the stink bug cage studies did not allow for determining of an economic threshold, the studies still provided valuable information how to improve future research. Information on how pod quality is affected by stink bug feeding will provide valuable in future edamame research. Further research should also be conducted evaluating economic thresholds for other potential pests of this crop such as corn earworm and bean leaf beetles. Very low numbers of lepidopteran pests were found in the insect abundance trials. Lepidopteran insects frequently cause significant amounts of damage to conventional soybeans, so future studies should include oviposition preference in conventional soybean and edamame, which may prove useful when developing management guidelines.