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FOR SUSTAINABLE AGRICULTURE

COMPETITIVE GRANT REPORT
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Use of planting date to avoid injury from soybean insect pests

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Budget
$15,315 for year one
$16,579 for year two
$17,944 for year three

Background

Seedcorn maggots (SCM) and bean leaf beetles (BLB) can substantially reduce soybean grain yield in Iowa and surrounding states. SCM feed on germinating seeds and the growing tips of seedlings, resulting in reduced stands and abnormal plants. Adult bean leaf beetles feed mostly on leaves and pods, with the most serious losses caused by pod feeding. Pod lesions caused by the beetles allow excess moisture and secondary plant disease organisms to enter the pod, causing seed shriveling and discoloration. As a result, seed weight and quality are reduced. The pod feeding problem has increased in severity since the early 1980s, making the bean leaf beetle the most economically important insect pest on soybeans in Iowa.

Modification of planting dates has been widely used to disrupt synchrony between crops and pests. The rate at which BLB develop from eggs to adults is determined principally by temperature. Such insect pests cause the greatest yield reductions when their damaging stages are feeding during the crop's most susceptible stage. If crop phenology (stages such as flowering, fruiting, and seed maturity) can be changed, insect numbers and/or injury per insect can be reduced.

Such a change includes planting alternate varieties, changing planting dates, or both. When planting date is altered, insect management benefits must be weighed against possible yield reduction from direct effects on the crop or other indirect effects—for example, on weeds. If planting is done too early or too late, any economic benefits of reduced damage by insect pests would probably be negated by reduced yields.

In addressing this situation, this project's goal was two-fold:

(1) To *prevent,* at least to a degree, the injury caused by SCM and BLB, by developing recommendations for soybean growers on altering planting date to prevent insect damage—based on the belief that delayed planting would reduce insect damage by upsetting the synchrony between damaging stages of the SCM and susceptible stages of the soybeans, and by reducing colonization of the crop by BLB.

(2) To *improve* curative management of BLB (which involves monitoring of insects and soybean susceptibility) by predicting whether susceptible soybean pod stages will coincide with populations of second-generation beetles.

Specific objectives included determining the effect of early vs. late planting dates on invasion of soybeans, and reproduction, by the BLB; the effect of early vs. late planting date on damage by the SCM; and the effect of soybean pod phenology (growth stages) on consumption by BLB adults. Additional objectives were to validate and refine existing soybean phenology and SCM phenology models, develop and validate a phenology model for the BLB, and determine the effects of BLB fecundity (fertility) when it is confined on a preferred host (soybean), a nonpreferred host (alfalfa), a suspected host (corn), and nonhosts (small grains).

Approach and methods

Planting date experiments were conducted from 1989 through 1993 (the last three years of which were supported by the Leopold Center) at a main site near Ames; supporting studies were carried out at Iowa State University research farms in Castana (1991-1993) and at Chariton (1992).

Field research—early vs. late planting date: To determine whether soybean planting date affects insect populations and resulting damage, the investigators considered the entire insect-pest complex in Iowa soybeans, emphasizing the BLB and SCM. The locations chosen allowed total management control and provided dependable insect populations to ensure test validity. A 130-meter X 30-meter block was replicated four times. Each was divided into two plots that were separated by field corn to minimize BLB movement between plots. Treatments, which consisted of planting soybeans (1) the first week of May and (2) the last week of May, as weather and soil conditions allowed, were randomly assigned to the plots. Specific early and late planting dates for the three years of this study and two previous years were 5/10 and 5/30 (1989); 5/3 and 5/30 (1990); 5/10 and 5/28 (1991); 5/2 and 5/27 (1992); and 5/21 and 6/15 (1993). The late dates for 1993 were attributable to abnormally wet conditions. In all cases, preplant herbicides were applied.

Emergence traps were located in each plot and inspected weekly for emerging seedcorn maggot adults until the soybean plants reached growth stage V1 (three to five inches in height). SCM injury was evaluated at this time. Because alfalfa is an alternate feeding source for BLB, investigators sampled it with sweep nets to detect any early activity and subsequent movement into the soybeans. Direct counts of BLB were taken until soybeans reached stage V3, after which samples were taken with a sweep net.

Soybean plant stage was recorded twice weekly, along with air temperature, rainfall, solar radiation, and soil temperature. Together, these data permitted the development of cultivar-specific parameters needed to develop the soybean phenology model. At maturity, number of pods and BLB-damaged pods were enumerated from representative soybean plants removed from the harvest samples. These plants were returned intact to their respective harvest samples, then threshed to obtain seed weights for all plots. While the plots at the two outlying research farms were not replicated, they provided data for validation of the Ames results.

Laboratory research—development of a degree-day model for the BLB: From 1990 to 1993, female adults were collected via sweepnet to serve as sources of eggs. Eggs were used regardless of county of origin or generation (overwintered vs. first generation). Larvae were reared in near-optimal conditions, allowing the durations of four life stages to be measured: (1) egg stage (oviposition through egg hatch), (2) combined first and second larval stages, (3) feeding portion of the third larval stage (formation of pupal cell by late-third instar through adult emergence), and (4) beginning of pupation cell stage to adulthood. In each replicated incubator, rearing was continued until at least 40 larvae had reached adult stage.

Larvae were transferred to prepared soybean root surfaces in the greenhouse; roots were recovered with soil and the infested pots placed in incubators. Moisture was regulated and plants were monitored daily for beetle emergence.

A computer program developed by ISU statisticians aided in estimating developmental rates. This program was validated by manual calculation of median developmental rates. Rearing temperatures were correlated with developmental rates of each life stage.

A degree-day model was developed from a base temperature (cardinal temperature) of 11.6 °C established from incubator rearing. The model predicts time of egg hatch, third larval stage, pupation, and adult emergence from the soil. This model was validated with data on BLB phenology from field sweep net sampling.

Greenhouse research—timing of food plant availability and its effects on BLB survival and oviposition: Preliminary experiments in 1990 showed that mated females caged on field alfafa fed on foliage and laid some eggs in the soil (precluding quantitative study).

Investigators collected overwintered BLB via sweepnet and divided them among greenhouse cages on several crop species. Numbers of eggs produced were enumerated until all females died. Data were used to calculate mean female lifespan, mean oviposition rate of females that had been transferred to soybean, and mean lifetime egg production per female. Data were analyzed separately for each year via the Statistical Application System.

Greenhouse research—seasonal changes in feeding by ***BLB:*** Beetle consumption was measured via free-choice feeding tests in a series of experiments using soybeans at all growth stages. Three plant part categories were tested: pods, including green immature pods, green small seed early pods, and green small seed late pods; leaves; and stems. Experiments varied by year. Care was taken so that feeding would not be constrained by plant-part availability. Injured plant parts were videotaped and then digitized for analysis. Total surface area eaten in each category of plant was divided by beetle feeding days to give consumption rates, which were converted to units of volume that could then be translated into gram per beetle per day. In 1992 and 1993, the quantity and quality of the soybean plant parts as BLB food were analyzed as well.

Findings

Field research showed that planting date had a strong influence on BLB colonization and SCM injury. Analysis of the data showed that soybeans planted toward the end of May seemingly germinated after most of the SCM larvae completed development, resulting in fewer plants with SCM damage (Fig. 1). Although not reflected in numbers of emerging flies, numbers of injured plants were reduced and plant-stand densities were generally greater in the late plantings. More significantly, late planting reduced invasions and egg laying by overwintering BLB, resulting in lower beetle numbers and significantly fewer BLB feeding days. With this reduced feeding exposure, late-planted soybeans usually suffered fewer injured pods (Fig. 2) and showed a seed-yield increase over early planted soybeans (Fig. 3).

Although the unreplicated studies at the outlying research farms generally agreed with results from the Ames locations, in 1992 more than double the numbers of BLB adults were captured in the late planting than in the early planting at Castana. This factor seemed to relate to increased pod injury and reduced yield in the late planting. This was a reversal from 1991 and opposite to results obtained at Ames and Chariton. The fact that the late planting was surrounded by alfalfa suggests that late planting may not be effective if large BLB populations have built up in adjacent alfalfa.

Laboratory research showed that although the degree-day model based on near-natural rearing used less than a tenth as many individuals as the near-optimal model, the two

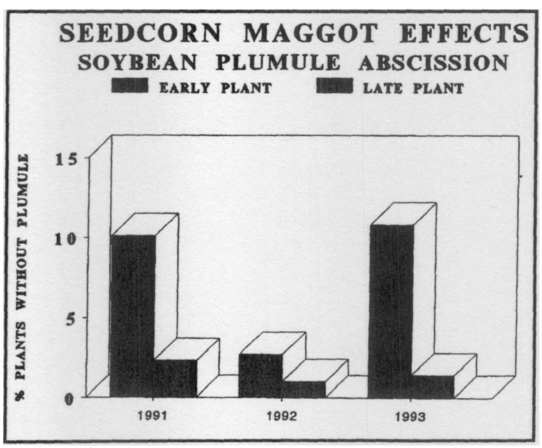

Fig. 1. Soybeans planted toward the end of May seemingly germinated after most of the SCM larvae completed development, resulting in fewer plants with SCM damage.

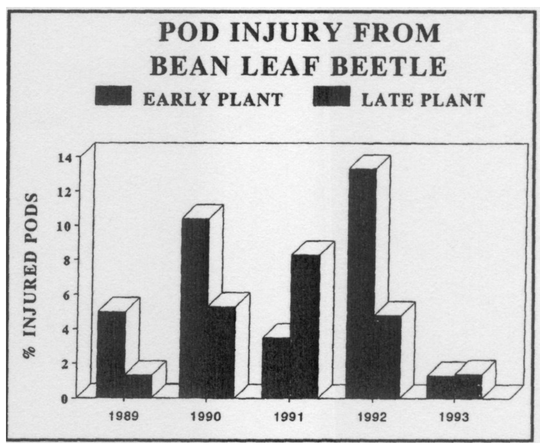

Fig. 2. With reduced feeding exposure, late-planted soybeans usually suffered fewer injured pods.

models were almost identical in precision. But because the near-natural minimal temperature for rearing is closer to field conditions, its degree-day model is probably the one that should be used for predicting developing field populations. Degree-day variability was twice as high for second generations relative to first.

Greenhouse findings indicate that delaying soybean planting by 14 days would reduce the abundance and fecundity of beetles that colonize, even if carried out by all producers in a region. Further delay not only offers no additional benefit; it can result in additional delays due to wet fields, which ultimately result in yield declines. BLB were found to prefer leaves to pods, yet among pod classes, consumption was higher on the younger pods. The quality of the leaves (as food) declined as plants matured, and BLB preference for leaves is lower then, but changes in the relative abundance of pods and leaves did not signficantly affect beetle preference. Increased pod consumption later in the season apparently is not due to changes in the relative nitrogen or moisture contents of pods and leaves.

Corn and wheat will not support development of BLB. Alfalfa serves to maintain beetles until soybeans emerge, but it is a poor quality food plant for BLB. Finally, there are differences between first- and second-generation beetles in total daily consumption and in preference for pods.

SOYBEAN SEED YIELD
PLANTING EXPERIMENT
EARLY PLANT LATE PLANT

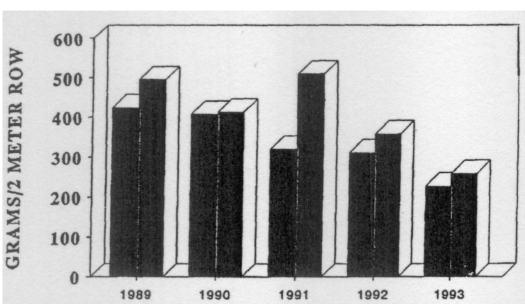

Fig. 3. With reduced feeding exposures, soybeans showed a seed-yield increase over early planted soybeans.

Conclusions—*Preventive tactics:* ***delayed*** *soybean* ***planting:*** The field study at Ames showed that BLB was reduced in late plantings, which in turn reduced pod feeding and damage and resulted in higher yields. These findings were generally corroborated at the other locations, although BLB in the small-plot situation confounded results at Castana. SCM populations were also reduced in two of the three years at Ames, and in all years, numbers of abcised plumules in seedlings were reduced over early plantings. These findings, which were corroborated at the other locations, ultimately indicate that planting soybeans near the end of the recommended planting date will reduce BLB colonization and subsequent injury, as well as SCM plumule abscission.

Thus, soybean producers should plant as late in the recommended planting period as their production schedule allows to help prevent pest problems. There is little need for concern over frost susceptibility of late plantings, because early planting run a risk just as great and because late plantings display accelerated growth rates. In three of the study's five years, both early- and late-planted soybeans reached maturity at approximately the same time; in the other two years, the late-planted soybeans were delayed seven days at most.

Another concern of planting late is the harvest delay and BLB migration from early to late plantings. Although this phenomenon was observed in two of the study's five years, the close proximity of the plots probably intensified this migration. In field situations, the migration would be less likely, in part because all the fields on a farm would be planted late. In instances where migration is a major concern, scouting, use of economic thresholds (the density at which pesticides are recommended), and timely insecticide use can reduce the risk.

Greenhouse studies showed that even if all growers in a region adopted delayed planting, BLB survival and reproduction would still be reduced, with reductions being greatest in regions without alfalfa. This is because BLB use alfalfa as an alternate food while waiting for late-planted soybeans to emerge.

Curative tactics: The degree-day model developed from laboratory research gives reasonably precise predictions of the date of second-generation BLB emergence (its most damaging stage). Use of the model should reduce sampling frequency for growers and encourage sampling acceptance. Considerable progress on predicting the susceptibility of soybeans to pod injury has also been made. This project has provided information on pod feeding habits by BLB, and these observations have been incorporated into the pod phenology model—which, when combined with the degree-day model, can make simultaneous predictions of second-generation beetle emergence and pod phenology, in turn increasing sampling efficiency.

Integrating preventive and curative tactics: This research has provided soybean growers with an integrated approach for managing soybean pests. *Early in the season, growers should plant their soybeans as late within the recommended planting period as their production schedule will allow to help prevent pest problems. In mid-season, growers or pest management advisors should use models of beetle and soybean development to predict pod damage and then monitor beetle abundance and if indicated, make decisions about curative insecticide use based on economic thresholds.* While additional research can fine-tune this system, these approaches form the backbone of practical, sustainable management of soybean insect pests.

Implications

This research shows that significant reductions in injury can be obtained by planting late in the recommended planting period. If this IPM strategy is adopted by Iowa farmers, they will obtain a three-fold benefit: production costs lowered in the short term and net profits increased by eliminating or at least reducing frequency of insecticide applications; gains in environmental quality over the long term as unnecessary pesticide residues are reduced; and, assuming acceptance is widespread, a reduction in bean leaf beetle population densities across the state—another long-term solution.

In years or regions in which delayed planting fails to hold beetle populations below economic levels, growers will need to monitor beetle abundance to make rational decisions about insecticide use. Models for predicting beetle emergence and soybean susceptibility will greatly increase the efficiency of sampling. Improved sampling efficiency should increase grower acceptance of sampling, leading to increased use of economic thresholds and reduction of unnecessary insecticide applications. The success of this project shows the value of further investigation into manipulations of plant culture and insect ecology.

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