SEASONAL ABUNDANCE OF MAJOR SOYBEAN INSECTS AND AN EVALUATION OF SOYBEAN PEST MANAGEMENT FOR EAST CENTRAL OKLAHOMA

By

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CHAPTER I

INTRODUCTION

Soybean acreage has increased in Oklahoma from 149,000 in 1966 to 245,000 in 1975. Considering this increased acreage, it became apparent there was a need to look at the possibilities for developing and initiating management systems which would help increase yields and hold production costs to a minimum. The soybean industry has estimated that the demand for United States soybeans will increase during the next ten years from 1.2 to 2.2 billion bushels. There may never be more than 55 million acres of soybeans harvested in the United States because of competition for acres for planting other basic food and feed crops. Thus, most of the projected increase in production will have to come from planting soybeans in fringe areas where producers convert from other crops to soybeans and in other areas, such as pastureland which could be used for production. Oklahoma has the potential to increase soybean acreage by converting from other crops and pastureland and to increase yields per acre.

Research and extension programs in Oklahoma and other states on crops such as cotton, peanuts and corn have demonstrated the value of controlling plant pathogens, insects, nematodes and weeds. The use of resistant varieties, crop rotation, proper cultural and fertility practices have also shown yield increases. While these research and extension programs have demonstrated yields can be increased

economically, growers many times lack sufficient knowledge of threshold levels and proper biological, cultural or chemical control procedures to make adequate decisions as to the judicious use of pesticides.

The need for the development of improved pest control programs has developed also from the increased restrictions and regulations of pesticides by the Environmental Protection Agency. Hence, came the need for an adaptive research program, one which would encompass a total cropping system for soybeans. Integrated pest management has been just such an approach that has employed a combination of techniques to control the wide variety of potential pests that threaten soybeans. In the past, new technology has usually been in the form of new products, such as chemicals, improved varieties, new equipment, etc. Integrated pest management was not a new product, but a new decision-making process. To develop and utilize effective pest management procedures, information was needed on crop yield reduction relative to pest fluctuations. Thus, this study was undertaken to determine the seasonal abundance of the major soybean insects in east central Oklahoma. Also, an evaluation of the soybean pest management program for east central Oklahoma was made.

CHAPTER II

SEASONAL ABUNDANCE OF MAJOR SOYBEAN INSECTS IN EAST CENTRAL OKLAHOMA

It has been generally recognized that soybeans have no insect pest of economic importance found exclusively on them. However, due to the length of the growing season and the nature of the crop, there have been many insect species associated with soybeans. Kretzschmar (1948) identified more than 80 species of insects collected from soybeans in Minnesota using three collection methods. Balduf (1923) recorded approximately 172 species over a three-year period collected from soybeans in Ohio. The greatest number of species (approximately 540) was collected in Missouri over a three-year period by Blickenstaff and Huggans (1962). Although some of these differences in numbers of species were possibly due to different survey methods, it can be seen that the variety of insects increased from Minnesota southward to Missouri.

General accounts of insects on soybeans in the United States have been published by Morse, et al. (1949), Packard (1951), Anonymous (1953), Anonymous (1957), Metcalf, et al. (1962), Carter and Hartwig (1963), Petty (1967) and Evans (1968). Descriptions of several economic species in the South were provided by Laster (1962). Accounts of pests from a predominantly midwestern viewpoint were published by Piper and Morse (1923), Petty and Wainscott (1961), Daugherty (1967b) and

Jackson (1967). Observations on economically important species have been made for the states of Iowa (Starks, 1954), Delaware (Milliron, 1958), Maryland (Ratcliffe, et al., 1960) and South Carolina (Nettles, et al., 1970).

Compensatory Ability

Reports have indicated soybeans can compensate for losses of and damage to plant parts. Laster (1962) stated that the dilemma concerning control programs for soybean insects has been in determining the point at which populations were high enough to justify an application of insecticide. Defoliation studies of indeterminate northern soybean varieties have been concerned primarily with plant responses to simulated hail injury (Dungan, 1939; Fuelleman, 1944; Kalton, et al., 1945; Camery and Weber, 1953; Weber and Caldwell, 1966; Johnston and Pendleton, 1968). However, Gould (1963) compared artificial with natural defoliations by the Japanese beetle, Popilla japonica (Newman), in Indiana and found that early maturing varieties suffered a yield reduction but late maturing soybeans recovered and did not show a reduction in yield. In Brazil, Rosas (1967) removed 8.3 to 50 percent of soybean foliage at different plant ages to determine effects of defoliating insects. These studies indicated that soybeans generally compensated for rather high percentages of defoliation prior to seed enlargement. Other reports have indicated a general compensatory ability of soybeans to recover from foliage and/or pod losses (Garner, et al., 1914; Gibson, et al., 1943; Sato and Nishikawa, 1955; McAlister and Krober, 1958; Hartwig, 1959).

Most reports on the effects of defoliation by insects originated from southern states and involved determinate varieties of soybeans. Sherman (1920) stated that early August defoliation by the green cloverworm in North Carolina ruined early-maturing varieties, but the late maturing varieties recovered. Nickels (1926) observed that defoliation from the velvetbean caterpillar and the corn earworm in South Carolina caused yield reductions as high as 70 percent in some varieties and as low as five percent in others. In Arkansas, Miner (1963) observed that insecticidal applications, based on light and moderate foliage damage, did not appear to be justified economically. Begum and Eden (1965) indicated that yields in Alabama were not significantly affected by 33 percent foliage removal at blooming, but that the same removal when pods were half-filled caused significant yield reduction. They also reported that 67 or 100 percent defoliations caused significant yield reductions at blooming and when pods were half-filled. However, the effects of defoliation were less important after pods were completely filled. Many other studies have demonstrated that soybeans could withstand 33 to 53 percent defoliation before flowering with little yield loss (Kalton, et al., 1945; Todd and Morgan, 1972). However, many studies have shown that defoliation during pod formation could reduce yields (Kalton, et al., 1945; McAlister and Krober, 1958; Turnipseed, 1972; Todd and Morgan, 1972). Defoliation during the period of time when the beans were filling and maturing was more critical than at any other prior developmental stage (McAlister and Krober, 1958; Kincade, et al., 1971; Smith and Bass, 1972; Turnipseed, 1973).

Stem-Feeding Insects

The threecornered alfalfa hopper, Spissistilus festinus (Say) is a stem-feeding insect of soybeans. Establishment of economic thresholds for stem-feeding insects of soybeans has been difficult because these insects have seldom caused significant economic loss. However, Oklahoma, like most southern soybean growing states, has recommended control of the alfalfa hopper when girdling damage was between ten and 15 percent and nymphs were present. The threecornered alfalfa hopper has exhibited two characteristic methods of feeding. One was the random puncturing of plant stems and the other being the continuous puncturing around the stems causing a girdle (Wildermuth, 1915). Stem girdling may result in the weakening of the plant so that it was easily broken during cultivation or from high winds or rain. Most girdling by threecornered alfalfa hoppers which caused soybean plants to lodge occurred before the plants reached a height of ten inches (Bailey, et al., 1970). A three-year study which simulated threecornered alfalfa hopper feeding damage by stand reduction showed no significant differences in yield when 45 percent of the plants were removed two weeks before bloom, 30 percent at bloom and 15 percent two weeks after bloom (Caviness and Miner, 1962). Tugwell, et al. (1972) found no significant differences in yield between check plots and plots in which the alfalfa hopper was controlled with five insecticide applications. Their treated plot averaged 17 percent plant injury compared to 42 percent plant injury in the untreated check.

Foliage-Feeding Insects

The following represents a review of foliage-feeding insects of soybeans, however, not all species discussed are found in Oklahoma. These insects often feed in mixed populations rather than separately. This makes total defoliation thresholds under various field conditions more meaningful rather than separate thresholds for individual species.

The green cloverworm, Plathypena scabra (Fabricius), has been one of the few insect species that has reached economic injury levels throughout soybean production areas (Sherman, 1920; Balduf, 1923; Stone and Pedigo, 1972). Pedigo, et al. (1972) reported potentially damaging populations of the green cloverworm during late July and early August in Iowa soybeans. Generally, the green cloverworm has been found feeding on soybean foliage in late July, but under normal conditions outbreaks of economic significance have not occurred until mid-August in most southern soybean growing states.

As with other species of soybean foliage-feeders, the majority of the economic-injury levels for P. scabra have been based on insufficient information. Recommended treatment levels range from 2-5/row foot (Harding and Bissell, 1966) to 5-10/row foot (Anonymous, 1968). The treatments levels were not based on experimental data. However, Stone and Pedigo (1972) suggested, based on theoretical economic-injury levels for P. scabra, thresholds should be revised upward. Results of studies on foliage removal have varied with the stage of growth affected. Prior to blooming, soybeans may sustain 33 percent foliage removal while the same percentage of removal during pod filling may result in a yield reduction (Turnipseed, 1972a; Todd, 1972). The

effects of defoliation were less important after pods were completely filled (Pedigo and Stone, 1972). Based on the above findings and the fact that foliage-feeding insects generally occurred as a mixture of species, many states have adopted an economic threshold for foliage-feeding insects on soybeans that corresponds to the percentage of defoliation at different plant growth stages.

There have been several species of loopers which may infest soybeans. However, Hensley, et al. (1964) and Canerday and Arant (1966) identified well over 90 percent of the total larval numbers as the soybean looper, Pseudoplusia includens (Walker). Loopers have often caused extensive foliage loss and occasional pod damage in southern states, but have seldom reached economic levels north of Arkansas, Tennessee or North Carolina. Work on the soybean looper in Louisiana showed populations were highest during late August and September (Burleigh, 1972) and in Alabama during mid-August and early September (Harper and Carner, 1973).

The velvetbean caterpillar, Anticarsia gemmatalis (Huber) has been a pest in southern states. Field infestations have caused serious defoliation in mid-August in 1929 in Louisiana and Texas (Hinds, 1930; Douglas, 1930). Strayer and Greene (1974) reported population peaks in Florida in late July, mid-August and early September. Infestations of velvetbean caterpillars, which occurred in mid-August and September, were reported capable of causing economic damage. Velvetbean caterpillars have rarely been collected on soybeans in Oklahoma.

A representative of the armyworms which attack soybeans has been the beet armyworm, Spodoptera exigua (Huber). This insect was more prevalent on beans in the southern Mississippi Delta than in other

soybean growing areas. Other members of the armyworm group which have caused occasional damage are the fall armyworm, Spodoptera frugiperda (J.E. Smith) and the yellow-striped armyworm, Spodoptera ornithogalli (Guenee).

The garden webworm, Loxostege rantalis (Guenee), has been the primary webworm found feeding on soybean foliage. In Oklahoma it has ocurred as an occasional pest on late planted soybeans. However, in the northern U.S., reports have indicated the alfalfa webworm, Loxostege commixtalis (Walker), may be more prevalent (Petty, 1967).

The saltmarsh caterpillar, Estigmene acrea (Drury), has been found on soybeans but has seldom reached economic levels. A related species, the yellow woolybear, Diacrisia virginica (Fabricius) damaged some fields in Nebraska in 1969, with 65 percent defoliation in one field (U.S. Department of Agriculture, 1970).

Some leaf-feeding coleptera have caused significant economic loss to soybeans. The Mexican bean beetle, Epilachna varivestis (Mulsant) has been one of these. They have occurred on soybean foliage as far north as southern Indiana or Illinois, but feeding was seldom severe enough to have caused yield losses except in the Coastal Plain from Delaware to northern Florida and has been reported into southern Alabama. Chemical control of Mexican bean beetles have resulted in increased yields in Maryland (Ratcliffe, et al., 1960) and in South Carolina (Turnipseed, 1967).

The bean leaf beetle, Cerotoma trifurcata (Foster) has fed on all parts of the soybean plant and although some damage has occurred on seedling beans, infestations of economic importance have not usually occurred until last August or September. This insect seems to have

been most destructive to soybeans from Louisiana north into Missouri and in Tennessee and North Carolina. From South Carolina south and west into Mississippi, the bean leaf beetle has only occasionally caused economic damage. Development of the bean leaf beetle on crops including soybeans has been studied in South Carolina (Eddy and Nettles, 1930) and in Arkansas (Isley, 1930).

The Japanese beetle, Popilla japonica (Newman) has not been a serious problem of soybeans in southeastern states, but adults have been reported feeding on foliage in north central states (Packard, 1951; Starks, 1954). They skeletonized bean leaves in late July and early August. Coon (1946) reported late maturing varieties produced new foliage to replace the beetle-damaged foliage and consequently produced higher yields than earlier maturing varieties.

The feeding of the adult blister beetle, Epicauta spp. has occasionally resulted in severe defoliation of border areas of soybean fields in the south, but some damage has also been reported in the midwest (Anonymous, 1957).

Cucumber beetles have often been found in soybean fields (Kretzschmar, 1948; Nettles, et al., 1970) but seldom have they contributed to foliage losses of economic significance.

Thrips have probably been more numerous on soybeans than any other insect group, with the most prevalent species having been Sericothrips variabilis (Beach), (Blickenstaff and Huggans, 1962). There have been numerous reports of thrips on soybeans causing damage (Ratcliffe, et al., 1960; Petty, 1967), but in most areas it was doubtful that thrips damage caused any economic loss. However, Bergeson, et al. (1964)

found that it was possible for thrips to transmit tobacco ringspot virus to soybeans.

The potato leafhopper, Empoasca fabae (Harris) has been one of the most common insects on soybeans in Iowa (Pedigo, 1972), Ohio (Balduf, 1923), Minnesota (Kretzschmar, 1948) and Missouri (Blickenstaff and Huggans, 1962). Most studies of potato leafhopper damage to soybeans have dealt with relative tolerance of various pubescent varieties to leafhopper attack as compared with glabrous varieties (Poos, 1929; Poos and Smith, 1931; Hollowell and Johnson, 1934; Johnson and Hollowell, 1935).

Grasshoppers have not been generally considered serious pests of soybeans, but they have been reported to strip fields of their foliage (Anonymous, 1953). Packard (1951) listed the following species as possible soybean pests: differential grasshopper, Melanoplus differentialis (Thomas); migratory grasshopper, Melanoplus sanquinipes (Fabricius); red-legged grasshopper, Melanoplus femmurrubrum (DeGreer) and two-striped grasshopper, Melanoplus bivittatus (Say). Grasshoppers have also been implicated as vectors of tobacco ringspot virus in soybeans (Dunleavy, 1957).

The tarnished plant bug, Lygus lineolaris (Palisto de Beauvois), has often been found in high numbers in soybeans in the midwest (Balduf, 1923). Economic importance of field populations of this insect have been questioned. However, Blickenstaff and Huggans (1962) observed in laboratory tests that terminal buds were killed by the feeding of L. lineolaris. Broersma and Luckman (1970) demonstrated by caging adults on fruiting structures that their feeding caused some deleterious affects on buds, blossoms and pods. Tarnished plant bugs have been

found to feed and reproduce on a great variety of plants and large populations have been found in soybeans during flowering and pod development (Broersma and Luckman, 1970).

Pod-Feeding Insects

Pod-feeding insects of soybeans have had the greatest potential for decreased soybean quality and quantity. The two major pod-feeding insects of soybeans in the U.S. have been Heliothis spp. and stink bugs, Nezara, Acrosternum and Euschistus spp.

Miner (1960) attempted to determine the economic injury threshold of corn earworms, Heliothis zea. on soybeans by using artificial infestations but was unable to do so. Conflicting reports as to the number of corn earworms needed to cause economic damage have been presented by Barnes and Roberts (1967), Boyer (1955) and Nettles and Thomas (1968). These conflicting reports have been due partially to the soybean plant's capacity to compensate for pod loss. This compensation was influenced by environmental factors such as moisture conditions. Another important factor involved the extent to which a soybean plant compensated for a poor pod set by an increased seed size or weight. This consideration has not been adequately researched so one can only speculate with respect to the relative importance of this factor. Populations of Heliothis spp. have been shown to increase sharply in Alabama between August 27 and September 3 in most fields (Smith and Bass, 1971). Boyer (1965) indicated that crop loss and application of control measures cost Arkansas soybean growers $8,500,000. Severe outbreaks were noted by Haseman (1931) in Missouri and by Isely (1930) in Arkansas. Arkansas's first economic threshold

level for corn earworms was established at 1 worm/3 row feet but as further studies were made, the level was raised to 2 worms/row foot. Work done in South Carolina suggested that treatment was only needed if corn earworm infestations averaged 3 worms/row foot. Smith and Bass (1971) established that 3 worms/row foot was the economic threshold for corn earworms in Alabama soybeans.

At least four species of stink bugs, the southern green stink bug, Nezara viridula (L.), the green stink bug, Acrosternum hilare (Say), the brown stink bug, Euschistus servus (Say) and the one spot stink bug, E. variolarius (Palisot de Veavois) have caused severe damage to soybeans grown in the United States (Miner, 1961; Blickenstaff and Huggans, 1962; Daugherty, et al., 1964; Duncan and Walker, 1968; Jensen and Newsom, 1972). The losses from stink bug infestations have resulted from reduction in seed yield and in seed quality. Miner (1961 and 1966) and Daugherty, et al. (1964) have found that an increased level of stink bug (N. viridula, A. hilare or E. servus) feeding on soybean seed pods significantly decreased the oil content and also slightly increased protein content of soybean seeds. Also, Blickenstaff and Huggans (1962) used caged infestations of A. hilare and Euschistus spp. at levels of 1, 2.5 and 5/plant and found they reduced the number of seeds produced and significantly decreased soybean yields. However, progressively less stink bug damage occurred as the plants matured (Blickenstaff and Huggans, 1962; Daugherty, et al., 1964). Conversely, Jensen and Newsom (1972) showed that with regard to viability, the location of a stink bug puncture has probably more importance than the number of punctures. This research demonstrated that one puncture in

the radicle-hypocotyl axis of the seed could prevent germination and that several punctures in the cotyledons effected the vigor of the plant that did not prevent germination.

The infestation level of stink bugs which justified control measures has been investigated by several researchers. The brown stink bug in Missouri caused characteristic seed damage and reduced yields at an intitial infestation rate of 1 adult/plant (Blickenstaff and Huggans, 1962). Miner (1966) concluded that an infestation of approximately 1 stink bug/6 row feet when pods were small was a threat to yield. He found that 1 stink bug/3 row feet caused sufficient damage to justify control measures.

Sampling

No generalized sampling procedure has been prescribed to survey the soybean insect fauna as a whole. Survey methods have been designed to take advantage of the behavioral characteristics of a target species and are adjusted to the stage of plant development.

To develop and utilize effective pest management procedures, information has been needed on crop yield reduction relative to pest density. The ability to determine an economic threshold of an insect pest on a crop has been dependent on distinguishing the different infestation levels and the degree to which each level influences the harvested crop (Stern, 1973). The first step to obtain this information has been to establish an accurate, efficient sampling technique to be used on a wide range of insects. Hillhouse and Pitre (1974) compared four sweep-net techniques to the groundcloth-shake sampling method. Their relative estimates, when compared to absolute populations, showed

the groundcloth-shake method to be the most efficient method for sampling lepidopterous larvae. Hillhouse and Pitre (1974) also showed this method had a low relative variation and a high fidelity to population changes but consumed too much time. Their work with sweep nets showed sweeping upwards against the foliage of one row was the most efficient method for sampling adult Cerotoma trifurcata (Forster) and adults and nymphs of Spissistilus festinus (Say). Turnipseed, et al. (1974) compared the sweep-net, D-Vac®, and groundcloth-plant shake methods for sampling insect pests and beneficial arthropods associated with soybeans. They found the sweep-net technique gave a greater relative net precision (based on precision and cost). The groundcloth-shake method produced higher means for most of the beneficials and large lepidopterous larvae collected in the study, while the D-Vac gave very low population estimates of all lepidopterous species. Pedigo, et al. (1971) used two sampling techniques for population estimates of green cloverworms in Iowa soybeans. They found the cage technique was most precise, but the sweep-net method gave greater relative net precision.

Methods and Materials

Weekly samples of the major soybean insects were taken from 15 fields in four east central Oklahoma counties from June 15 to September 21, 1976. The 15 fields sampled were part of a multi-crop, multi-discipline pest management program, which was provided in this area in 1975 and 1976. Fields sampled in the pest management program are listed by county and are as follows: Muskogee (3), LeFlore (3), Haskell (4) and Sequoyah (5). Fields surveyed represented 510 acres, with a county breakdown of 75, 140, 165, 130 acres, respectively

(Table I). To supplement this study, a comparison of species diversity was made with two independent insect scouting programs in Wagoner and McCurtain counties, where 1,800 and 2,400 acres, respectively, were scounted in 1975.

To survey for threecornered alfalfa hoppers, a standard 15-inch sweep net was used. The surveyor entered the field and selected a site at random. By walking fast between rows and parallel with the rows, the surveyor reached forward as far as possible and swept the top of one row of soybeans pulling the net toward the surveyor in the manner as rowing a boat with a single oar (Boyer, 1963). This method was employed since the adult, an extremely active insect, hops or flies when disturbed. Using ten sweeps, approximately 30 row feet were sampled and this was repeated in five randomly selected locations of each field. This technique was used until the soybeans reached a height of 12 inches. This corresponded to the emergence of the fifth or sixth trifoliate leaf (Bailey, et al., 1968), after which time sampling for alfalfa hoppers was discontinued.

The plant-shaking method, developed by Boyer and Dumas (1963), was used to sample for lepidopterous insects. This method involved the use of a drop cloth which consisted of a piece of heavy white or off-white cloth. The ends of the cloth were folded over a thin piece of wood, one inch by 24 inches long and stapled. The drop cloths were made to adapt to a row spacing of 42 inches.

To sample for lepidopterous larvae, the surveyor entered the field and selected a site at random. While standing parallel to two rows, the drop cloth was unrolled and slid forward at ground level beneath undisturbed plants. The surveyor then knelt down and vigorously shook

the vines from each row over the cloth. Approximately one and one half row feet of plants from each row were shaken to give a sample of three row feet. The plants were then pushed back from over the cloth and the dislodged insects were counted and recorded. Ten randomly selected sites were checked in each field to give a total sample of 30 row feet.

To determine the major soybean insects in Oklahoma, a review of the Cooperative Extension Service Annual Summary of Insect Conditions in Oklahoma for the past ten years was made. This along with personal correspondence with the Arkansas survey entomologist, W.P. Boyer, gave an indication of what insects would be of major concern in east central Oklahoma. This review resulted in determining the following potential pests in Oklahoma soybeans:

1. Threecornered Alfalfa Hopper, Spissistilus festinus (Say)
2. Green Cloverworm, Plathypena scabra (Fabricius)
3. Loopers complex, Pseudoplusia and Trichoplusia spp.
4. Heliothis spp.
5. Green Stink Bug, Acrosternum hilare (Say)
6. Brown Stink Bug, Euschistus servus (Say)

*7. Bean Leaf Beetles, Cerotoma trifurcata (Forster)

*8. Blister Beetles, Epicauta spp.

*9. Garden Webworm, Loxostege rantalis (Guenee)

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*These last three insects were recorded by presence only because their occurrence has been sporadic in the past.

Results and Discussion

The most abundant insect pests of east central Oklahoma soybeans were the threecornered alfalfa hopper, Spissistilus festinus (Say), green cloverworm, Plathypena scabra (Fabricius) and corn earworm, Heliothis zea.(Boddie). The looper complex, Pseudoplusia spp., green stink bug, Acrosternum hilare (Say) and the brown stink bug, Euschistus servus (Say) were observed in many of the samples but numbers were too low to determine seasonal abundance. However, it was interesting to note that from the results of two years experience in the scouting program and from review of the Cooperative Extensive Service Annual Summary of Insect Conditions in Oklahoma, the cabbage looper was found to be the predominate looper species. This was contrary to the findings of Hensley, et al. (1964) and Canerday and Arant (1966), who reported the soybean looper as the prevalent species.

Threecornered alfalfa hopper, Spissistilus festinus (Say)

Adult hopper numbers peaked the last week in June and the first week of July in eight of the 15 fields sampled in 1976 (Table II). This corresponded to the peak alfalfa hopper populations in the 1975 Wagoner County scouting program. The alfalfa hoppers did not peak at the same time in McCurtain County but did peak at the equivalent growth stage or before the soybeans reached ten inches in height. The next peak in 1976 occurred the second week in August and was attributed to two factors: (1) late planting of soybeans (after July 5th) and (2) lack of adequate moisture for growth. In the seven fields in which the alfalfa hopper build-up occurred, the soybeans were less than 12 inches tall and were

beginning to bloom but they were not lapping the middle of the rows. None of these fields sustained girdling damage of greater than five percent. This was ten percent below the girdling damage that is suggested as an economic threshold for alfalfa hopper control in Oklahoma. During the two years the pest management program has been conducted, none of the fields in the program have reached the economic threshold for the three-cornered alfalfa hopper in Oklahoma. This corresponds to what has happened in the private insect scouting programs in Wagoner and McCurtain Counties. However, in 1974, several fields in Wagoner County, the leading soybean producing county in Oklahoma, received extensive damage from early infestations of threecornered alfalfa hoppers.

The damage from threecornered alfalfa hoppers in 1974 prompted a study in conjunction with the pest management program to evaluate the validity of the economic threshold for threecornered alfalfa hoppers in Oklahoma. This randomized, replicated study was conducted for two years in LeFlore County. Soybeans were planted at a reduced rate, approximately 8 seeds/foot, simulating a poor stand of soybeans which might result from low seed germination, low seeding rate or low emergence due to soil crusting. After two years of study, no definite conclusions as to the validity of the economic threshold for threecornered alfalfa hoppers in Oklahoma could be drawn due to the lack of a sufficient infestation.

Green cloverworm, Plathypena scabra (Fabricius)

As presented in Table III, early season population levels peaked the third week in July and caused very little defoliation (less than two percent). This was significantly below the 35 percent pre-bloom

economic threshold suggested in Oklahoma. The largest and potentially most damaging populations occurred the third week in August. This occurrence corresponded with blooming and early pod-set. Even with these high populations present at a critical growth stage, defoliation was still 17 percent below the suggested economic threshold for soybeans at pod-fill in Oklahoma.

The green cloverworm population peaks corresponded to peaks reported by a privately employed individual who monitored soybeans for insects in 1975 in Wagoner County. Although green cloverworm populations were higher, the percent defoliation differed very little. Appearance of cloverworms were reported approximately two weeks earlier by another private scout in McCurtain County in 1975, but, again defoliation was minimal and did not reach the economic threshold during the growing season. Although some fields have been sprayed for control of foliage-feeders in Oklahoma, no reports exist where the currently recommended economic thresholds have been reached.

Corn earworms, Heliothis zea. (Boddie)

Corn earworm populations also peaked the third week in August which corresponded to blooming and early pod setting (Table IV). During this study the closest a field came to the Oklahoma recommended economic threshold of 1 corn earworm/row foot was an infestation of slightly over 0.5 earworms/row foot. However, conditions existed in a majority of the fields sampled which favored an earworm infestation, i.e., reduced and open canopy. Boyer (1970) observed that beans with an open canopy (not lapping the middle) had higher bollworm populations than those with a closed canopy.

Bean leaf beetles, Cerotoma trifurcata (Forster)

Bean leaf beetles were observed in all fields checked throughout the growing season, but they did not cause economic damage to the soybeans. A review of the Annual Summary of Insect Conditions in Oklahoma for the past ten years showed that economic damage by bean leaf beetles has never been recorded.

Blister beetles, Epicauta spp. and garden webworms, Loxostege rantalis (Guenee)

These insects were observed in fields in east central Oklahoma but they were not present in the 15 fields sampled weekly. Some spot treatments of blister beetles did occur in two fields in the pest management program.

Conclusions

Each of the insects, which displayed a seasonal fluctuation, attack a different part of the soybean plant. To date, research in Oklahoma has not shown that threecornered alfalfa hoppers can reduce soybean yields, but such reductions have been witnessed by farmers. If such infestations do occur in east central Oklahoma, farmers must be prepared to make well-timed applications of insecticides to control this pest.

When insects, such as green cloverworms caused indirect damage to soybeans, such as reduced yield through defoliation, it has been difficult to correlate populations with damage. This has also been complicated by the soybeans ability to compensate for such damage and

the occurrence of mixed populations of foliage feeding insects. But if their populations peak at a critical soybean growth stage, such as pod-set, they cause economic damage. Blooming and pod-set in east central Oklahoma did correspond to peak populations of green cloverworms and could in the future present a problem if populations increased tremendously over what they have been.

When green cloverworm populations were present in early season, such as July, it would not be likely they would constitute a serious threat. Research has shown that soybeans can withstand 50 percent defoliation without a yield reduction in early growth stages.

East central Oklahoma experienced a dry summer in 1976. Since soybeans were under a drought stress and an open canopy existed in 12 of the 15 fields checked, corn earworm infestations were expected but did not materialize. Corn earworms could have developed into a serious threat if their population peaks continue to correspond with the peak green cloverworm populations and if both populations increase significantly.

CHAPTER III

AN EVALUATION OF SOYBEAN PEST MANAGEMENT FOR EAST CENTRAL OKLAHOMA

Insect scouting, as known today, seems to have appeared in the second decade of the 1900's. Its beginning in Arkansas has been well documented (Boyer, et al., 1962). Scouting as the basis for cotton insect control in Arkansas began in research conducted by Dwight Isley in the 1920's. The first commercial scout in Arkansas was hired in 1925 and worked under Isley's direction.

This initial scouting was done to determine insect population levels prior to the application of insecticides, so that differences in efficiency among various materials could be determined. Isley's work in this area lead to his insistence that insect infestations varied from field to field and from week to week, to the extent that insect scouting was needed on a weekly basis in all fields in order to use insecticides in a biologically and economically sound manner. As the need was established, cotton insect scouting in Arkansas grew and has since spread to other parts of the cotton growing regions of the United States. Oklahoma has employed continuous cotton insect scouting since 1972, although some cotton insect scouting was done in the state as early as 1950.

Until about the mid 1950's, cotton insect scouting usually resulted in the use of more insecticides as growers realized the limiting

influence of insects on crop production. Over the years, however, boll weevils became resistant to an increasing number of insecticides. Entomologists also became aware that insecticides used for boll weevil control were creating outbreaks of other insects by destroying their natural enemies. As a result, additional control strategies were developed against the boll weevil. The diapause control concept (Brazzel, et al., 1961), which lessened the adverse impact of pesticides on natural populations of beneficial arthropods was one such strategy.

In the last 15 years, the direction of cotton insect scouting has been toward its employment as a monitoring tool in a more complete management system. The development of alternate strategies, when successfully implemented, has resulted in optimizing insect control while often reducing the frequency and the amount of insecticide used.

The use of chemicals for control of other pests has developed on various crops where the need for strategic timing was also essential. Peanuts grown in Oklahoma were just one example of where chemicals were widely used to control weeds, nematodes and plant pathogens. Cultural and biological methods aimed at management of pests have also continued to develop in crops such as soybeans. Along with this evolution, scouting and consulting have developed into viable enterprises in certain areas of the country. These areas usually are regions where a combination of available technology, dedicated people and economic feasibility coexists. For example, the number of consultants in California and the Mississippi River flood plain in the midsouth has rapidly increased in the last eight to ten years and some have been in business for nearly 25 years (Reese and Brazzel, 1974).

Integrated Pest Management Defined

Glass (1975) defined integrated pest management as:

> ... a pest management system that in the context of the associated environment and population dynamics of the pest species utilizes all suitable techniques and methods in a compatible manner as possible, and maintains the pest population at levels below those causing economic injury.

Hepp (1976) implied in the above definition of integrated pest management these components:

1. Population assessment through a regular field checking procedure and recording of the number of beneficials and pests. This has been commonly referred to as scouting or field checking.
2. Pesticide applications take place only when pest populations reach the economic threshold level. The economic threshold was the point in pest population density below which the cost of applying controlled measures exceeds the losses caused by the pest.
3. Decisions about pest control were repetitive during the growing season and were made in dynamic environment. At the point in which decisions were made, changes were occurring in the plant, weather, pest populations, cost of control, prices for the products, etc.
4. Prevention and/or suppression of the pest by the most appropriate tools available. Community or group means to manage the pests were sometimes needed.

Although each element was not new or innovative, taken as a whole, integrated pest management has been a new technical development. In the past, most new technology usually has been in the form of new products, such as a chemical, seed variety, machine, equipment, etc. Integrated pest management was not a new product but a new decision-making process for the production of crops such as soybeans.

Methods and Materials

In 1975 and 1976, a pilot multi-discipline, multi-crop pest management program principally funded by the Cooperative Extension Service was conducted in four east central Oklahoma counties; Muskogee, Haskell, LeFlore and Sequoyah (Table V). Field size in the 1975 pest management program ranged from five to 300 acres. This included 60 fields totalling 2,095 acres. During 1976, 43 fields totalling 1,560 acres and ranging in size from ten to 90 acres were monitored in the east central Oklahoma soybean pest management program. As mentioned, this was a multi-crop program, but since the other crops monitored equalled less than ten percent of the total acreage scouted, this evaluation will be concerned only with the soybean portion of the pest management program.

Each field was sampled weekly or as weather permitted from emergence to near soybean maturity for weeds, insects and plant pathogens. In 1975 a preseason soil fertility analysis was taken. Fertility recommendations for each field were sent to the grower by the Oklahoma State University Soil Testing Laboratory. The soil testing service was not included in 1976 to help reduce the cost of the program and because most participants had already applied fertilizer. Preseason nematode samples were taken and farmers were advised by the Oklahoma State

University Diagnostic Laboratory as to whether or not control was needed. Each time his field was scouted, the farmer received a scouting report informing him as to the pest conditions and soybean growth stage of each of his fields in the program. Weeds and plant pathogens were rated on their severity in each field on a scale of zero to nine (zero being no infestation and nine being very severe). Insects were scouted by methods outlined in Chapter II and recorded by percent defoliation or number per row foot. The scouting report was mailed to the farmer the day the scouting occurred unless an economic threshold for insects was reached and the farmer was then contacted immediately. Control decisions for the various disciplines were made by using Oklahoma State University Extension Control Recommendations.

Toward the end of each growing season, a field day was held on a test plot area donated by one of the participants. At this time, the farmers were exposed to field applications of various pest management techniques. The test plot included herbicide, insecticide, fungicide and variety tests.

A questionnaire (Appendix B) was formulated and sent to participants and non-participants in 1975 and 1976, in order to obtain field history information concerning soybean farming practices.

A second questionnaire (Appendix C) was developed to sample opinions of participants which could be used to determine the benefits growers received from participating in the soybean pest management program. Question 4 was deleted from the 1976 questionnaire (Appendix D) since the soil fertility service was withdrawn from the soybean pest management program. The second questionnaire was developed for use

by the soybean pest management participants only. This provided them an opportunity to evaluate the benefits of the pest management program.

The questionnaires used were designed by the writer with assistance of staff members in the Entomology and Agronomy Departments.

There were 16 soybean pest management participants surveyed in 1975 and 17 in 1976. Corresponding numbers of non-participants were surveyed each year. These non-participants were selected from lists of soybean growers provided by extension agents in Haskell and Sequoyah counties. All those surveyed received the appropriate questionnaires explaining the purpose of the study and were asked to respond by returning the self-addressed stamped envelopes. Within two weeks, if questionnaires were not returned, personal contact was made encouraging the growers to complete and return the questionnaire.

Results and Discussion

There were 11 of 16 participants from the 1975 program which chose to repeat in the soybean pest management program the second year it was offered. Two of the participants which did not repeat are no longer farming and two stated the cost of the program prohibited them from participating again. The remaining participant stated that he was not satisfied with the program.

In two years only three participants did not or would not return their questionnaires. This resulted in a 91 percent response to the questionnaire. Fifty-one percent of those participants returned their questionnaires voluntarily, while 40 percent had to be contacted and asked to complete and return their questionnaire. The non-participants

rate of return was 76 percent and only 20 percent returned questionnaires voluntarily (Table VI).

Weeds and insects which were found in weekly scouting of east central Oklahoma soybean fields in the pest management programs are included in Table VII. The causes for pest fluctuations between years was attributed in part to different fields being involved in the two years the study was conducted and because insect populations are dynamic.

Results dealing with yield and crop histories varied according to the pest management participants and non-participants (Questionnaire I-Category I). All four counties reported cotton as the predominate previous crop followed by watermelons, spinach, summer fallow or pastureland. Soybean varieties varied with the type of cropping system used. A late maturing variety, such as Bragg, was used if the soybeans followed wheat. Medium maturing varieties, such as Lee 68 and Dare, were used where a normal or one crop system was employed. As new varieties were developed and released, they were tried with Forrest being the most widely used. Seeding rates where soybeans were planted with a planter ranged from 28 pounds/acre to 75 pounds/acre on row beans with an average of 42 pounds/acre, while the seeding rate of soybeans planted with a grain drill averaged 60 pounds/acre.

Category II of Questionnaire I was designed to determine the pesticide usage trends by soybean growers sampled (Table VIII). Herbicide usage was divided into three categories: preplant, pre-emergence and post-emergence. The significant difference seen was that the pre-emergence and post-emergence herbicide usage has increased, basically because there has been an increase in the number of products available

to the soybean grower. Foliar fungicide usage has increased because of the same reason. The questionnaires revealed that both the participants and non-participants are both trying foliar fungicides to determine if they are cost-effective in their programs. The history of insecticide usage was reported as very slight by participants and non-participants and this was attributed to extremely light insect populations. In two years only one entire field in the scouting program was treated for insect damage. This was for control of corn earworms feeding on soybean pods in 1976. Also, 160 acres of soybeans were sprayed for corn earworms in Wagoner County in 1976. Two of the pest management fields were spot treated for blister beetles and fall armyworms in 1976. In 1975, blister beetles were found and spot treated in one field. The responses to the questionnaires showed nematodes were relatively new to the growers and none of the growers contacted had used nematicides in their soybeans.

Fertilizer usage by soybean pest management participants was higher than by non-participants and this could partially account for the differences in yields; 33.4 bushels/acre in 1976 for participants and 23.9 bushels/acre for non-participants and 26.3 bushels/acre and 20.1 bushels/acre, respectively in 1976 (Table IX).

Pesticide application methods varied very little between participants and non-participants (Table X). Post-emergence herbicides are easier and quicker to apply by airplane and can be applied with an airplane when ground application is not feasible, for example when the field is wet. Foliar fungicides and post-emergence herbicides are often applied at a time when most soybeans have lapped the rows

and damage to the plant would result if ground application were used to apply these pesticides.

While most non-participants used personal judgement when determining the desired pesticide, chemical dealers or chemical company representatives were also contacted. Some non-participants used the extension personnel or extension fact sheet to make their determination (Table XI). This could be attributed to the fact that farmers go to a local chemical dealer to purchase chemicals and ask what to use instead of going to the extension office. They will sometimes just call the aerial applicator and use whatever the applicator suggests. Pest management participants used the extension service more, mainly because of their direct contact with the scouting program and the information received from state specialists connected with the program.

The second questionnaire was developed for use by the soybean pest management participants only. This provided participants an opportunity to evaluate the benefits of the pest management program. One participant in two years believed the weekly scouting for plant pathogens, insects and weeds was not of benefit to him. Most thought the scouts were able to identify problems which they, personally, could not. They also believed the scout could get to the field when they were not able to allocate time. Thus, some insurance was provided the grower from the weekly scouting service. Participants admitted they would eventually find the problem, but it would probably be too late and when they did, they would not be able to identify the cause. Again, all but one, felt the weekly report on each of these pests was beneficial and kept them

informed of pest conditions and growth stages of their soybeans. Growers were very receptive to the written information from state specialists and all believed the scouting report was understandable and none of the participants made suggestions for changes or improvements. The test plot information met with varied reaction. Some growers were more interested in their own fields, rather than a test plot area or were unable to attend the field day and they thought they did not receive the full benefit of a test plot. The best received portion of the test plot was the variety test which demonstrated the varieties which performed best in their area. As to whether or not the program was cost-effective in their operation, most said the scouting service was a form of insurance, that is, a negative report which indicated there was not a problem, was a benefit which did not have a dollar value.

Conclusions

It was found that types of pesticides and methods of application of these chemicals varied little between pest management participants and non-participants. Thus, yield differences can be attributed to quality of the land or fertilizer practices and the degree of professionalism displayed by each farmer. When a program of this nature is initiated in an area, the most informed and usually the best farmers participate, thus, assuring field averages above the norm.

Ninety-seven percent of the soybean pest management participants who returned their questionnaires were satisfied with the service and felt the information received in the form of weekly reports and extension information was beneficial. The cost-effectiveness of the program did not necessarily result from the detection of an unknown problem or

the reduction of an unnecessary pesticide application, but from the assurance that the fields were being monitored weekly by informed individuals.

CHAPTER IV

SUMMARY

To develop and utilize effective pest management procedures, information is needed on crop yield reduction relative to pest density. First, most efficient and accurate sampling techniques must be determined and second, develop seasonal abundance population curves of potential soybean pest species. This study dealt with population fluctuations, but for more precise information, the seasonal abundance study should be carried on for several growing seasons to determine the fluctuation of soybean insect species in east central Oklahoma.

It is difficult to evaluate a program of this nature. The benefits received were of an intangible nature since problems encountered and dealt with did not significantly increase yields. Even though yields of participants were higher than non-participants, no significant differences were seen in pesticide usage. Therefore, higher yields were attributed to fertilizer practices and the quality of farming involved.

Glass (1975) made some interesting comments concerning pest management educational needs which after two years of involvement with a pest management program, I feel are valid suggestions for future consideration.

> The technology to alter present pest control practices in soybean production systems is available. If farmers are to benefit from this new technology, careful consideration

must be given to the available mechanisms for pest management implementation. At present there are two principal mechanisms which will most likely dictate the rate of change in pest control practices. These are the private consultant and the Extension Service. Both of these outlets for new technology will require some adjustment, if the delivery of technical assistance to the agricultural producer and others is to function effectively. Since technical assistance is commonly provided for a limited number of larger producers, the private consultant has generally limited influence on total agricultural practices in a given area. The remaining producers in the area must make specific organizational changes to meet the demanding requirements of modern pest management systems.

The Land Grant University system is uniquely structured to develop and implement changes in pest control. Integrated pest management systems will likely be characterized by their complexity and the constant adjustment required to rapidly incorporate new technology into existing production systems. The rapid flow of communications and the broad, interdisciplinary expertise provided by the Land Grant System is extremely important in designing and obtaining wide adoption of practical pest control practices.

The importance of the 'systems approach' to integrated pest management extends beyond the crop plants. It includes the total agricultural, industrial and social spheres, necessitates that pest management personnel receive training in a wide range of subjects. The extent of training necessary will depend upon the positions in question. Clearly, research personnel will require more extensive training than will field survey personnel.

Present training of students in the crop protection fields (plant pathology, entomology, nematology and weed science) typically leads to a specialization even within a field. New programs specifically designed to train pest management personnel should be initiated, but the training of specialists in the traditional sense would not be abandoned. Additionally, it is essential to recognize that at the present time, integrated pest management systems have not generally reached the implementation stage. Thus, the demands for pest management specialists are, as yet, limited. Any training of new personnel should, in addition to rendering them competent in the area of pest management, prepare them to fill existing positions within one of the fields of specialization.

The goal of any pest management training program should be to prepare new and returning students to assume responsibilities for developing, teaching and applying

the concepts, strategies and tactics of pest management in a manner that is both effective and economically feasible. Training at all levels should be both practical and realistic.

In order to bring the promise of pest management to all persons connected with a program, either directly or indirectly, it must be cognizant of the concepts, philosophies and goals of pest management. A number of different levels of training will be required to provide the personnel needed for the development and operation of successful pest management systems. What follows is an outline of the various types of training suggested for persons likely to be involved in pest management. Only general areas of learning have been considered; specific curricula will vary with the educational institution involved.

The objectives of a Master of Science program in pest management should be the training of persons to make intelligent, informed decisions. Resulting from the optimum economically feasible combination of minimal pest damage and maximal environmental safety. They should have sufficient theoretical knowledge and practical experience to qualify for positions as private pest management consultants, extension personnel, agri-industry employees for various types and as assistants to research personnel.

Programs leading to a Master's degree in integrated pest management should be designed for students planning to terminate their formal training at the Master's level. Since practical experience will be of greater value to such persons than research experience, these programs should not require a dissertation based on original research. A period of internship in pest management should be required for all persons receiving a Master's degree in integrated pest management. Training at the Master's level should include:

1. strategies, methods and philosophies of pest management;

2. concepts and practices of entomology, plant pathology, weed science and nematology;

3. plant pest diagnosis;

4. methods of statistics and population sampling; and concepts of systems and analysis.

Internship in pest management for Master's degree candidates could be obtained by participating in the development, operation and continued improvement of pest management programs. Initially this experience would be

available only in pilot programs established primarily for research purposes. Due to the expenses involved in the establishment of such pilot programs, duplication of such efforts should be avoided. This may be accomplished by establishing pest management centers at a limited number of leading universities equipped to undertake such vast endeavors (Glass, 1975).

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APPENDIXES

APPENDIX A

TABLES

TABLE I

DISTRIBUTION OF FIELDS USED IN SEASONAL ABUNDANCE STUDY. 1976

County	No. Fields Sampled/County	No. Acres Sampled/County
Muskogee	3	75
LeFlore	3	140
Haskell	4	165
Sequoyah	5	130
Total	15	510

TABLE II

THREECORNERED ALFALFA HOPPER ABUNDANCE
IN SOYBEANS OVER 11 SAMPLING DATES
IN EAST CENTRAL OKLAHOMA. 1976

Sampling Week	No. Fields Sampled	Mean No. Hoppers/10 Sweeps
6/15	5	0.36
6/24	8	0.53
7/6	8	0.53
7/13	7	0.31
7/21	7	0.17
7/27	7	0.29
8/5	6	0.23
8/11	6	0.60
8/18	3	0.20
8/25	2	0.90
8/30	1	1.20

TABLE III

GREEN CLOVERWORM ABUNDANCE IN SOYBEANS OVER 11 SAMPLING DATES IN EAST CENTRAL OKLAHOMA. 1976

Sampling Week	% Defoliation	No. Fields Sampled	Mean No. Cloverworms/Row Foot
7/13	<1	1	0.13
7/21	<1	8	0.29
7/27	<1	8	0.13
8/5	<1	9	0.03
8/11	<1	9	0.17
8/18	1	13	0.65
8/25[1]	2	13	1.02
8/30	1	14	0.62
9/6	<1	15	0.27
9/14	<1	15	0.17
9/21	<1	15	0.10

[1]Corresponded with blooming and early pod set in fields sampled.

TABLE IV

CORN EARWORM ABUNDANCE IN SOYBEANS OVER EIGHT SAMPLING DATES IN EAST CENTRAL OKLAHOMA. 1976

Week	No. Fields Sampled	Mean No. Earworms/Row Foot	Max. No. Earworms/Row Foot
8/5	9	0.02	0.02
8/11	9	0.05	0.27
8/18	13	0.10	0.47
8/25	13	0.13	0.34
8/30	14	0.11	0.54
9/6	15	0.04	0.17
9/14	15	0.01	0.06
9/21	15	0.009	0.06

TABLE V

DISTRIBUTION OF ACREAGE AND PARTICIPANTS IN EAST CENTRAL OKLAHOMA PEST MANAGEMENT PROGRAM. 1975-1976 (SOYBEANS ONLY)

County	Number of Acres/County	Number of Fields/County	Number of Growers/County
		1975	
Muskogee	345	13	3
Haskell	200	9	4
LeFlore	400	13	2
Sequoyah	1150	25	7
Total	2095	60	16
		1976	
Muskogee	100	4	2
Haskell	475	10	3
LeFlore	175	4	3
Sequoyah	810	25	9
Total	1560	43	17

TABLE VI

DISTRIBUTION OF QUESTIONNAIRE RETURNS BY PEST MANAGEMENT PARTICIPANTS AND NON-PARTICIPANTS 1975 - 1976

County	No. Growers/County		No. Voluntary Returns		No. Contact Returns[1]	
	P[2]	N-P[3]	P[2]	N-P[3]	P[2]	N-P[3]
1975						
Muskogee	3	0	2	0	1[4]	0
Haskell	4	7	3	1	1[5]	4[4]
LeFlore	2	1	0	0	2	1
Sequoyah	7	8	5	1	2	6[2]
Total	16	16	10	2	6	11
1976						
Muskogee	2	0	0	0	2[6]	0
Haskell	3	7	2	1	1	4
LeFlore	3	1	0	1	3	0
Sequoyah	9	9	5	1	4	6
Total	17	17	7	3	9	10

[1]These growers were contacted and asked to return questionnaires.

[2]Pest management participants

[3]Non-participants of pest management program

[4]Would not cooperate or return questionnaire

[5]No longer farming in Haskell County and could not be reached

[6]One grower from Muskogee County could not be contacted and did not return questionnaire

TABLE VII

WEEDS AND INSECTS FOUND IN WEEKLY SCOUTING OF EAST CENTRAL OKLAHOMA SOYBEAN PEST MANAGEMENT PROGRAM

	1975	1976
Weed	Percent Infested[1]	Percent Infested[2]
Cocklebur	71	63
Morninglory	52	74
Johnsongrass	36	72
Pigweed	36	70
Nutsedge	16	33
Copperleaf	9	9
Crabgrass	7	44
Bullnettle	2	0
Teaweed	0	9
Smartweed	0	5
Insect		
Green Clover-worms	100	100
Corn Earworms	18	93[3]
Blister Beetles	4	12
Garden Webworms	2	16
Stinkbugs	30	49
Bean leaf Beetles	100	100
Alfalfa hopper	52	100

[1]56 fields monitored

[2]43 fields monitored

[3]Two percent of the fields monitored in 1976 sustained an economic infestation of corn earworms.

TABLE VIII

PESTICIDE USAGE BY SOYBEAN PEST MANAGEMENT PARTICIPANTS AND NON-PARTICIPANTS

	1973[1]		1974[1]		1975[1]		1976[2]	
	P[3]	N-P[4]	P[3]	N-P[4]	P[3]	N-P[4]	P[3]	N-P[4]
Herbicides								
Pre-plant	12	12	13	12	13	15	16	16
Pre-emergence	2	0	4	2	5	3	5	4
Post-emergence	0	2	2	2	8	16	13	16
Foliar Fungicides	0	0	0	0	3	5	3	4
Insecticides	1	1	1	2	1	3	1	2
Nematicides	0	0	0	0	0	0	0	0
Fertilizer	7	2	8	3	7	4	9	2

[1]16 growers sampled

[2]17 growers sampled

[3]Pest management participants

[4]Non-participants of pest management program

TABLE IX

SOYBEAN YIELDS FOR SOYBEAN PEST MANAGEMENT PARTICIPANTS AND NON-PARTICIPANTS

	Yields	
	1975	1976
Participants	33.4	26.3
Non-Participants	23.9	20.1

TABLE IX

SUMMARY OF RECOMMENDATIONS OF PESTICIDE USAGE FOR PEST MANAGEMENT PARTICIPANTS AND NON-PARTICIPANTS

	Herbicides				Foliar Fungicides				Insecticides				Nematicides				Fertilizer			
	1975		1976		1975		1976		1975		1976		1975		1976		1975		1976	
	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]	P[1]	N-P[2]
County Agent	1	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	4	1
Other Extension Personnel	0	0	0	4	0	0	1	2	0	0	0	0	0	0	0	0	1	0	2	1
OSU Fact Sheet	1	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	1
Pest Management Program	3	0	7	1	0	1	0	1	0	1	0	0	0	0	0	0	4	0	1	0
Personal Judgement	0	3	0	4	0	0	0	3	1	0	1	1	0	0	0	0	0	3	1	1
Advice of Friend	1	2	2	1	1	0	0	1	0	0	0	0	0	0	0	0	1	2	0	1
Chemical Representative or Salesman	2	3	4	2	1	1	1	2	0	0	0	1	0	0	0	0	0	0	0	2
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1

[1]Pest management participants

[2]Non-participants of pest management program

TABLE X

PESTICIDE APPLICATION METHODS OF PEST MANAGEMENT
PARTICIPANTS AND NON-PARTICIPANTS

	1973				1974				1975				1976			
	G[1]		A[2]		G[1]		A[2]		G[1]		A[2]		G[1]		A[2]	
	P[3]	N-P[4]	P	N-P	P[3]	N-P[4]	P[3]	N-P[4]	P[3]	N-P[4]	P[3]	N-P[4]	P[3]	N-P[4]	P[3]	N-P[4]
Herbicides																
Pre-plant	12	12	0	0	13	12	0	0	13	15	0	0	16	16	1	0
Pre-emerge	2	0	0	0	4	2	0	0	5	3	0	0	5	4	1	0
Post-emerge	0	0	0	2	0	0	2	2	3	0	6	16	4	0	10	16
Foliar																
Fungicides	0	0	0	0	0	0	0	0	0	0	3	5	0	0	3	4
Insecticides	0	0	1	1	0	0	1	2	1	0	0	3	1	0	2	2
Nematicides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fertilizer	7	2	0	0	8	3	0	0	7	4	0	0	8	2	1	0

[1]Ground application

[2]Aerial application

[3]Pest management participants

[4]Non-participants of pest management program

APPENDIX B

1975 and 1976 CORRESPONDENCE TO PARTICIPANTS AND NON-PARTICIPANTS REGARDING FARMING PRACTICES

Oklahoma State University

DEPARTMENT OF ENTOMOLOGY

STILLWATER, OKLAHOMA, 74074
501 LIFE SCIENCES WEST
(405) 372-6211, EXT. 7055

March 9, 1976

To: Soybean Pest Management Cooperators

From: Ron Blythe

Dear Cooperators:

Enclosed you will find a field history form partially completed on one of your fields which was in the pest management propram this past summer. I would appreciate your completing this field history and also answering the questionnaire which is also enclosed. I will contact you by phone in the near future to answer any questions you might have.

This information will be used to determine the benefits of the pest management program in eastern Oklahoma; your names will not, in any way, be connected to the findings. I am compiling this information as a part of my education requirements and your cooperation would be greatly appreciated.

Sincerely,

Ron Blythe

Oklahoma State University

DEPARTMENT OF ENTOMOLOGY

STILLWATER, OKLAHOMA, 74074
501 LIFE SCIENCES WEST
(405) 372-6211, EXT. 7055

March 18, 1976

TO: Soybean Growers

FROM: Ron Blythe

Dear Growers:

In talking with your county extension agent, Phil Nowlin, he suggested you might help me.

As you might know, there is an effort in your area by Oklahoma State University to help you improve your soybean yields in the form of a pest management program. I am connected to this program as field supervisor which means I am in charge of seeing that the fields are scouted. I am also going to school at OSU and as part of my training I am trying to determine many of the practices used by you as soybean growers. Enclosed you will find a field history form which I hope you will complete and return to me. I will be in touch with you by phone in the near future if you have any questions. Any help you might give me would be greatly appreciated.

Sincerely,

Ron Blythe

RB:jm

Enclosure

Oklahoma State University

DEPARTMENT OF ENTOMOLOGY

STILLWATER, OKLAHOMA, 74074
501 LIFE SCIENCES WEST
(405) 372-6211, EXT. 7055

March 18, 1976

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Sincerely,

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Enclosure

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STILLWATER, OKLAHOMA, 74074
501 LIFE SCIENCES WEST
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Sincerely,

Ron Blythe

RB:vg

Enclosure

Oklahoma State University

DEPARTMENT OF ENTOMOLOGY

STILLWATER, OKLAHOMA, 74074
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Sincerely,

Ron Blythe

RB:vg

Enclosure

SOYBEAN GROWER QUESTIONNAIRE

Grower: _____ County: _____

1. Total number of acres of soybeans _____

2. Number of acres in pest management program _____

3. Yield from acres in program by field or farm (Circle One)

	YIELD	VARIETY	SEEDING RATE
73	_____	_____	_____
74	_____	_____	_____
75	_____	_____	_____
76	_____	_____	_____

Yield from acres not in program by field or farm (Circle One)

73	_____	_____	_____
74	_____	_____	_____
75	_____	_____	_____
76	_____	_____	_____

4. Field History

a. Pesticides used: (use pattern for years noted)

1. Herbicides

YEAR	CHEMICAL	RATE	DATE(S) APPLIED	METHOD/FORM OF APPLICATION	PEST PROBLEM	WHO RECMD*
73	_____	_____	_____	_____	_____	_____
74	_____	_____	_____	_____	_____	_____
75	_____	_____	_____	_____	_____	_____
76	_____	_____	_____	_____	_____	_____

2. Insecticides

73	_____	_____	_____	_____	_____	_____
74	_____	_____	_____	_____	_____	_____
75	_____	_____	_____	_____	_____	_____
76	_____	_____	_____	_____	_____	_____

YEAR	CHEMICAL	RATE	DATE(S) APPLIED	METHOD/FORM OF APPLICATION	PEST PROBLEM	WHO RECMD*
3. Foliar Fungicides						
73						
74						
75						
76						
4. Nematicides						
73						
74						
75						
76						

5. Fertilizer used (Formulation)	Rate (#/ac)	Who Recommended*
73		
74		
75		
76		

* Recommendations made by -

a. County Agent
b. Other Extension Personnel
c. OSU Fact Sheet
d. Pest Management Program
e. Personal Judgement
f. Advice of Friend
g. Chemical Representative or Salesman
h. Other

APPENDIX C

1975 CORRESPONDENCE TO PARTICIPANTS REGARDING PROGRAM BENEFITS

Oklahoma State University

DEPARTMENT OF ENTOMOLOGY

STILLWATER, OKLAHOMA, 74074
501 LIFE SCIENCES WEST
(405) 372-6211, EXT. 7055

March 9, 1976

To: Soybean Pest Management Cooperators

From: Ron Blythe

Dear Cooperators:

Enclosed you will find a field history form partially completed on one of your fields which was in the pest management propram this past summer. I would appreciate your completing this field history and also answering the questionnaire which is also enclosed. I will contact you by phone in the near future to answer any questions you might have.

This information will be used to determine the benefits of the pest management program in eastern Oklahoma; your names will not, in any way, be connected to the findings. I am compiling this information as a part of my education requirements and your cooperation would be greatly appreciated.

Sincerely,

Ron Blythe

SOYBEAN PEST MANAGEMENT EVALUATION

1. Was the soybean disease scouting of benefit to you? Yes _____ No _____
   Please explain _____

2. Was the soybean weed scouting of benefit to you? Yes _____ No _____
   Please explain _____

3. Was the soybean insect scouting of benefit to you? Yes _____ No _____
   Please explain _____

4. Was the soil fertilizer analysis of benefit to you? Yes _____ No _____
   Please explain _____

5. Was the nematode report of benefit to you? Yes _____ No _____
   Please explain _____

6. Were the written materials from the state specialist of benefit to you?
   Yes _____ No _____ Please explain _____

7. Were the weekly scouting reports of benefit to you? Yes _____ No _____
   Please explain _____

8. Did the weekly scouting reports alert you to any problems which would have gone undetected otherwise? Yes _____ No _____ Please list _____

9. What suggestions would you make to change the scouting report, that is to make it easier to understand or changes that would better serve your needs?

10. Was the test plot information of benefit to you? Yes _____ No _____
    Please explain _____

11. Is the soybean pest management cost effective for your farming operation?
    Please comment* _____

*Considering the cost of the program to you, did any part of the program benefit you such that the program participation was paid for or result in more than paying for itself?

APPENDIX D

1976 REVISED CORRESPONDENCE TO PARTICIPANTS

REGARDING PROGRAM BENEFITS

OKLAHOMA STATE UNIVERSITY

MEMORANDUM

DATE November 5, 1976

TO Soybean Pest Management Cooperators

FROM Ron Blythe, Scout Supervisor

SUBJECT Soybean Pest Management Program

Enclosed you will find a questionnaire concerning the soybean pest management program which you participated in this past summer. I would appreciate your completing this questionnaire, and returning it to me in the self-addressed stamped envelope which is provided.

This information will be used to determine the benefits of the pest management program in east central Oklahoma; your names will not, in any way, be connected to the findings. I am compiling this information as a part of my educational requirements at Oklahoma State University, and your cooperation would be greatly appreciated.

Sincerely,

Ron Blythe
501 Life Science West
OSU - Stillwater, OK 74074

SOYBEAN PEST MANAGEMENT EVALUATION

1. Was the soybean disease scouting of benefit to you? Yes_____ No_____
   Please explain _____

2. Was the soybean weed scouting of benefit to you? Yes_____ No_____
   Please explain _____

3. Was the soybean insect scouting of benefit to you? Yes_____ No_____
   Please explain _____

4. Was the nematode report of benefit to you? Yes_____ No_____
   Please explain _____

5. Were the written materials from the state specialist of benefit to you?
   Yes_____ No_____ Please explain _____

6. Were the weekly scouting reports of benefit to you? Yes_____ No_____
   Please explain _____

7. Did the weekly scouting reports alert you to any problems which would have gone undetected otherwise? Yes_____ No_____ Please list the problems____

8. What suggestions would you make to changing the scouting report, that is to make it easier to understand or changes that would better serve your needs? _____

9. Was the test plot information of benefit to you? Yes_____ No_____
   Please explain _____

10. Is the soybean pest management cost effective for your farming operation?
    Please comment* _____

*Considering the cost of the program to you, did any part of the program benefit you such that the program participation was paid for or result in more than paying for itself?

SOYBEAN GROWER QUESTIONNAIRE

Grower: _____ County: _____

1. Total number of acres of soybeans _____

2. Number of acres in pest management program _____

3. Yield from acres in program by field or farm (Circle One)

	YIELD	VARIETY	SEEDING RATE
73	_____	_____	_____
74	_____	_____	_____
75	_____	_____	_____
76	_____	_____	_____

Yield from acres not in program by field or farm (Circle One)

73	_____	_____	_____
74	_____	_____	_____
75	_____	_____	_____
76	_____	_____	_____

4. Field History

a. Pesticides used: (use pattern for years noted)

1. Herbicides

YEAR	CHEMICAL	RATE	DATE(S) APPLIED	METHOD/FORM OF APPLICATION	PEST PROBLEM	WHO RECMD*
73	_____	_____	_____	_____	_____	_____
74	_____	_____	_____	_____	_____	_____
75	_____	_____	_____	_____	_____	_____
76	_____	_____	_____	_____	_____	_____

2. Insecticides

73	_____	_____	_____	_____	_____	_____
74	_____	_____	_____	_____	_____	_____
75	_____	_____	_____	_____	_____	_____
76	_____	_____	_____	_____	_____	_____

YEAR	CHEMICAL	RATE	DATE(S) APPLIED	METHOD/FORM OF APPLICATION	PEST PROBLEM	WHO RECMD*
3. Foliar Fungicides						
73						
74						
75						
76						
4. Nematicides						
73						
74						
75						
76						

5. Fertilizer used (Formulation)	Rate (#/ac)	Who Recommended*
73		
74		
75		
76		

* Recommendations made by -

a. County Agent
b. Other Extension Personnel
c. OSU Fact Sheet
d. Pest Management Program
e. Personal Judgement
f. Advice of Friend
g. Chemical Representative or Salesman
h. Other

VITA

Ronald E. Blythe

Candidate for the Degree of

Master of Science

Thesis: SEASONAL ABUNDANCE OF MAJOR SOYBEAN INSECTS AND AN EVALUATION OF SOYBEAN PEST MANAGEMENT FOR EAST CENTRAL OKLAHOMA

Major Field: Entomology

Biographical:

Personal Data: Born in Nowata, Oklahoma, July 25, 1951, the son of Robert S. and Mary R. Blythe.

Education: Graduated from Nowata Senior High School, Nowata, Oklahoma, 1969; received Bachelor of Science degree, Oklahoma State University, July, 1974; completed requirements for the Master of Science degree in the Department of Entomology at Oklahoma State University in May, 1977.

Professional Experience: Field supervisor, Multi-crop Multi-discipline Pest Management Program, 1975 to present.

Organizations: Entomological Society of America, American Soybean Association, Southern Weed Science Society, National High School Athletic Coaches Association, Oklahoma Secondary Coaches Association.