EFFECTS OF DIFFERENT FERTILIZER AND WATER COMBINATIONS ON PREDATOR POPULATIONS, FLEAHOPPER POPULATION, INSECT DAMAGE, FRUIT PRODUCTION, AND YIELD OF COTTON IN OKLAHOMA

By

SANIT RATANABHUMMA

Bachelor of Science
Kasetsart University
Bangkok, Thailand
1968

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1972

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of the Oklahoma State University
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Thesis Approved:

Jerry H. Young
Thesis Adviser

Richard G. Price

Robert D Morrison

William A. Drew

Don C Peters

D D Durham
Dean of the Graduate College

PREFACE

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CHAPTER I

INTRODUCTION

Cotton is susceptible to severe insect damage at all stages of growth. Cotton insect damage is one of the chief limiting factors in efficient cotton production. As the farmers strive for higher yields, cotton insects become a more important factor. Among the cotton insects, the cotton bollworm, *Heliothis zea* (Boddie); the tobacco budworm, *Heliothis virescens* (Fabricius); the boll weevil, *Anthonomus grandis* (Boheman); the cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter); the pink bollworm, *Pectinophora gossypiella* (Saunders); the cotton aphid, *Aphis gossypii* Glover; and several others are the most serious pests of cotton. Since 1929, cotton growers have lost an average of more than $100 million annually in crop reductions from these insects and the cost of their control. The maximum loss of more than $900 million to cotton insects occurred in 1950 (Young, 1969).

Eichers, et al. (1970), reported that nearly half of all insecticides used in control pests on agricultural crops in the United States are used on cotton. Unfortunately, cotton producers do not realize that these synthetic insecticides have many limitations. Smith (1970) outlined the limitations of pesticides. These include destruction of beneficial insects allowing pest resurgence, the development of insecticide-resistant strains of insect pests, adverse impact on non-target organisms, unleashing of secondary pests, residue hazards on other crops, direct hazards to applicators and farm workers, and simplification of the ecosystem that creates damaging inbalances in food chains, insect-host relationships, etc. Realizing the limitations of pesticides, researchers need to develop alternatives to chemical control.

In recent years, research workers on cotton in Oklahoma have placed emphasis on the factors affecting the predator populations and their roles in regulating cotton insects. Robinson, et al. (1972a, b, c), devoted their two year study to determine the abundance of predatory and injurious insects in relation to damage, yield, and lint quality in cotton as affected by strips of alternate crops adjacent to cotton. Burleigh, et al. (1973), recorded the effect of strip-cropping on beneficial arthropods and parasitism in cotton. Similar studies were conducted by Massey (1973) who in 1971 and 1972 growing seasons determined the effects on predators and insect damage of cotton interplanted with corn or sorghum. Pickle (1973), conducted separate experiments in 1971 and 1972, and attempted to remove the lag between the destructive Heliothis build up and its predators and parasites by seeding lepidopterous larvae and eggs in the cotton field to supply greater sources of food and to provide additional hosts for parasites.

The objectives of this study have been to obtain the following:

1. Determine the effects of different fertilizer and water combinations on the numbers and trends of predators, fleahoppers, insect damage, fruit production, and the yield of cotton.

2. Study the intercorrelation among the populations of predators, fleahoppers, insect damage, fruit production, and the yield of cotton.

Hopefully, this study will aid in contributing significant informations that may be useful in modeling cotton insects in Oklahoma and future non-chemical cotton insect campaigns.

CHAPTER II

DESTRUCTIVE INSECTS AND PREDATORS IN OKLAHOMA COTTON FIELDS

Destructive Insects

The cotton bollworm, *Heliothis zea* (Boddie), and the tobacco budworm, *Heliothis virescens* (Fabricius), are generally the most destructive pests of cotton in Oklahoma. These two species may form a species complex or sometimes occur in pure populations; whereas, the bollworm is usually predominant in mixed population early in the season, with the budworm sometimes being the dominant species later in the season (Bryan, 1961; Kunz, 1966b; Robinson, et al., 1972c; Massey, 1973).

The boll weevil, *Anthonomus grandis* (Boheman), is not considered to be as serious a pest in Oklahoma as *Heliothis*, even though the damage may reach the economic threshold in some years (Robinson, et al., 1972c). In western Oklahoma the severe damage may be avoided by planting cotton as early as is feasible (Massey, 1973).

The cotton fleahopper, *Pseudatomoscelis seriatus* (Reuter), and the black fleahopper complex, *Spanogonicus albofasciatus* (Reuter) and *Rhinacloa forticornis* (Reuter), were found in Oklahoma (Kunz, 1966a; Robinson, et al., 1972c). Fleahopper infestations can be serious enough to cause complete loss of a cotton crop, but usually do not cause economic damage in Oklahoma. This pest is more important to cotton in the drier areas of Oklahoma (Kunz, 1966a).

Thrips, primarily Frankiniella spp., occur on seedling cotton in Oklahoma annually. This insect injures the young seedling by abrading foliage surfaces and sucking juices; thus causing malformed plants (Massey, 1973). Chemical control for thrips is not recommended in Oklahoma for cotton plants will generally overcome early-season thrip damage (Young and Price, 1970).

Other minor pests of cotton in Oklahoma include: the cabbage looper, Trichoplusia ni (Hubner); the cotton leafworm, Alabama argillacea (Hubner); the pink bollworm, Pectinophora gossypiella (Saunders); the lygus bugs, Lygus spp.; the green stink bug, Acrosternum hilare; the conchuela, Chlorochroa ligula (Say); and the Say stink bug, Chlorochroa sayi (Kunz, 1966a, b).

Predators

Several species of arthropod predators are known to attack pests of cotton. More than 600 species of predators have been recorded in Arkansas cotton fields (Whitcomb and Bell, 1964). van den Bosch and Hagen (1966) estimated 350 predators and parasites occur in California cotton fields. Young (1969) reported more than 20 species of primary predators and parasites are common throughout different sections of the Cotton Belt. Ridgway and Lingren (1972) estimated that the most important predators that attack Heliothis may be limited to 10 to 15 families and the parasites probably to not more than 10 or 15 species.

In Oklahoma, the most common predators in cotton fields include: the lady beetles, primarily *Hippodamia* spp.; the green lacewing, *Chrysopa* spp.; the nabids or damsel bugs, *Nabis* spp.; the soft-winged flower beetles, *Collops* spp.; the hooded beetle, *Notoxus monodon* (Fabricius); the flower bug, *Orius insidiosus* (Say); and several species of spiders. The big-eyed bugs, *Geocoris* spp., the ground beetles, and the assassin bugs are less common in Oklahoma cotton fields (Robinson, et al., 1972c; Massey, 1973).

CHAPTER III

ARTHROPOD ABUNDANCE IN COTTON AS AFFECTED BY FERTILITY AND WATER MANAGEMENT

The vegetative and fruiting growth of crops in arid climates are strongly influenced by fertility and water management. This management also affects temperature and humidity within the plant canopy and influences the nutritional aspects of plants as hosts. Variation in the abundance of insects on different crops has been attributed to changes in environmental conditions; these insects respond to conditions in a crop ecosystem modified by application of either water or fertilizer variables.

Unfortunately, the depth of our knowledge of the influence exerted by crop culture variables on cotton insect populations is rather limited. The primary purpose of this research was to determine the affect of fertilizer and water management on the abundance of predators and harmful insects in Oklahoma cotton fields.

The difference in relative abundance of some insect pests between areas within a field or between adjoining fields have been noticed by several investigators. Moderate to major differences in growth of the plants have commonly been associated with such pest population observations. Irrigation and fertilizer have the biggest influence on growth and fruiting characteristics of the cotton plant in the arid southwest. Differences are most obvious in fields where different types of soil occur. Apparently, these growth characteristics appear to relate to nitrogen availability and to soil moisture, though other nutritive factors may be involved (Leigh, et al., 1969).

Investigations of fertility aspects with arthropods are comparatively few. Research is less common on irrigation or water availability as it influences the host or as it may have an indirect influence on the survival or rate of population increase of insects.

More research works have placed emphasis on studying the relationship of nitrogen fertility to abundance of arthropod pests. Only a few also consider the role of potassium and phosphorus or some of the minor elements.

Results by McGarr (1942, 1943) showed that use of nitrogenous fertilizer increased populations of the cotton aphid, *Aphis gossypii* Glover, when the cotton was dusted with calcium arsenate, but no appreciable difference was observed when calcium arsenate was not used. According to Isley (1946) cotton plants growing on soils well supplied with nitrogen are more favorable for development of the cotton aphid than plants grown on soils deficient in nitrogen. van Emden, et al. (1969), have provided a brief review of literature dealing with plant water status and with osmotic pressure effects on aphids.

Robinson and Arant (1929) showed in Alabama that with or without control of the boll weevil, *Anthonomus grandis* (Boheman), the yield of cotton was increased when nitrogen fertilization was increased on Norfolk sandy loam soil, but the percentages of punctured squares were similar at all level of nitrogen. Mistric (1968) reported from work in North Carolina that significant increases in adult weevils, total squares, unpunctured squares, blooms, bolls, and yield were obtained when nitrogen fertilization was increased without boll weevil control.

Several workers have noted the influence of varying soil conditions and plant growth on field populations of the cotton bollworm, Heliothis zea (Boddie). According to Gaines (1933), the rate of bollworm moth oviposition and rate of plant growth were correlated closely and rank, rapidly growing cotton was a preferred site. Fletcher (1941) found that the numbers of bollworm larvae present in different fields were correlated with the moisture content of the growing tips of the cotton plants. Adkisson (1958) obtained significant differences in the bollworm larval counts after mid-August among plots receiving spray treatments and different fertilizer treatments. Yields were increased by both spray and fertilizer treatments.

Beckham (1970) studied the effect of different rates of nitrogen sidedress applications on the abundance of and damage from cotton insects in non-irrigated cotton under a seasonal insecticidal control program in north Georgia, during 1964-66. He found that the significant difference in boll weevil square infestation caused by the different treatments of nitrogen were obtained only from the 1966 data. No significant differences in number of bollworm damaged bolls were due to treatment during any of the three years. Although there was an indication that more cotton aphids occurred on leaves as the rate of nitrogen was increased, significant differences among treatment were obtained only from the 1964 data. The effects of nitrogen sidedress applications on the yield of seed cotton per acre were inconsistent.

Leigh, et al. (1969), recorded differential distribution of several insects among plots under different regimens of irrigation and nitrogen treatment in California cotton fields. They speculated that these differentials may relate, in part, to differences in soil type, especially in their water-holding capacity, level of plant nutrition, and their effect on plant growth.

Spider mite research in this area had been studied by several authors. Andres (1957) compared the net reproduction rate of the pacific mite, Tetranychus pacificus McGregor, under dry versus humid conditions while Nickel (1960) compared the influence of humidity and temperature on two populations of Tetranychus desertorum Banks. Rodriquez (1958) and Watson (1964), in separate experiments, demonstrated that nitrogen, potassium, and phosphorus can influence rate of reproduction in spider mites. Gibbs and Pickett (1966) studied the ability of a capsid pest to survive and develop on cocoa stressed for water as compared to survival and feeding on well watered plants.

CHAPTER IV

EFFECTS OF DIFFERENT FERTILIZER AND WATER COMBINATIONS ON PREDATOR POPULATIONS, FLEAHOPPER POPULATION, INSECT DAMAGE, FRUIT PRODUCTION, AND YIELD ON TAMCOT 788 COTTON

Fertility and moisture levels in the soil have an indirect influence on the variation in the abundance of insects in cotton fields. These cultural practices usually prolong the cotton growing season by maintaining succulent plants and causing the plants to fruit later in the season. The succulent plants then may attract cotton insects from unfertilized and non-irrigated fields in which plants have dried out and have no fruits left. Unfortunately, the experiment evidence in this area in Oklahoma is nonexistent.

The primary objectives of this study were to determine the effects of fertilizer and water combinations on predator populations, fleahopper population, insect damage, fruit production, and yield of cotton in Oklahoma. The intercorrelation among the abundance of predators, fleahopper, insect damage, fruit production, and yield was also investigated.

Materials and Methods

During the 1972 cotton growing season a field test was conducted on leased land southwest of Tipton, Oklahoma. The experiment was arranged in 2 x 3 factorial combination (two fertilizer rates and three water levels). The six treatment combinations were as follows:

Treatment (11)--moderate fertilizer and low water

Treatment (12)--moderate fertilizer and moderate water

Treatment (13)--moderate fertilizer and high water

Treatment (21)--high fertilizer and low water

Treatment (22)--high fertilizer and moderate water

Treatment (23)--high fertilizer and high water

The total study area was 2.013 acres and was divided into twenty-four plots 274 feet long and four-rows wide (40-inch row spacing). Each treatment combination was replicated four times in a randomized-block design (Figure 1).

The cotton variety used was Tamcot 788 which was planted on May 23, 1972 at a rate of 15 pounds per acre on Tipton silt loam soil which has the average water holding capacity of 1.5 inches per foot. A stand of approximately 27,756 plants per acre was obtained.

None of the low-water plots were irrigated during the season due to the heavy and moderate rains that occurred in the early and mid-season. The moderate-water plots were irrigated three times on July 25 and August 3 and 13, while the high-water plots were irrigated five times on July 17 and 25 and August 3, 13, and 21. Approximately three inches of irrigation water was applied for each irrigation. All plots were fertilized with NPK (20-40-0), at 100 pounds per acre on

April 23. In addition, the high-fertilizer plots were sidedressed with NH_4NO_3 (33 percent) at 100 pounds per acre on July 5. No insecticides were applied in the study area at any time during the growing season.

Data were collected ten times by whole plant examination. Sampling was begun on July 13, 1972 and continued on a weekly basis through September 14, 1972. Five plants were selected at random from each of the middle two rows in each plot on each sampling date. The five plants to be sampled were determined by computer generation.

Insect data were collected on the numbers of cotton fleahoppers (Pseudatomoscelis seriatus), green lacewing adults and larvae (Chrysopa spp.), soft-winged flower beetles (Collops spp.), hooded beetles (Notoxus monodon), lady beetles (Hippodamia spp.), nabids (Nabis spp.), and spiders. Damage was recorded as Heliothis damaged fruits and boll weevil damaged fruits. Fruiting characteristics recorded were numbers of squares, blooms, and bolls.

Due to weather conditions the cotton was not harvested until very late in the season on February 16, 1973. Only the middle two rows of each plot were harvested. The data were converted to yield per acre for each treatment combination.

Analysis of variances and correlation coefficients were performed on the data by the Statistics Department of Oklahoma State University utilizing the Statistical Analysis System.[1]

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[1]The system was designed and implemented by Anthony James Barr and James Howard Goodnight, Department of Statistics, North Carolina State University, Raleigh, North Carolina.

Results and Discussion

Nabids (NAB)

The nabid population remained low throughout the growing season, never exceeding 1.16 thousand per acre; the numbers varied from period to period with no set pattern. The population was highest on August 8 with approximately 1.16 thousand per acre present (Figure 2). The numbers decreased from this high during the remaining five sampling dates. The average numbers per acre of nabids in each treatment are given in Table I. The largest numbers occurred in treatment (22) with approximatley 1.11 thousand per acre, averaged over the ten sampling periods. The numbers in the remaining five treatment combinations were less than one thousand per acre. However, it was felt that the population was too low to make an adequate evaluation.

Green Lacewing Larvae (LWL)

The average numbers per acre of lacewing larvae in each treatment are given in Table I. The greatest numbers of lacewing larvae were recorded in treatments (12) and (22) with the identical figure of 0.69 thousand per acre. The population reached an average peak of 1.27 thousand per acre on August 8 (Figure 2). However, the population of this insect was also so low that an adequate evaluation could not be made.

Green Lacewing Adults (LWA)

Lacewing adults had a late season peak from August 8 to August 22 (Figure 3). The average number of lacewing adults at this peak was between 2.54 and 3.82 thousand per acre. The greatest number of this insect was 3.66 thousand per acre which occurred in plots treated with high fertilizer and high water (Table I). Due to relatively low population, this insect was not analyzed individually but collectively in terms of total beneficial arthropods.

Hooded Beetles (HB)

Hooded beetles had three population peaks on July 13 and August 8 and 22. The average numbers during these peaks were 4.17, 3.12, and 5.20 thousand per acre, respectively (Figure 4). The greatest number of hooded beetles was 10.41 thousand per acre which occurred on August 8 in plots treated with moderate fertilizer and high water (Table II). Analysis of variances for hooded beetles indicates no significant difference due to treatment (Table V).

Collops Beetles (COL)

The *Collops* beetle population steadily increased up through August 8, when they reached the first peak with approximately 16.54 thousand per acre (Figure 4). The population declined very sharply one week after reaching its peak. Then, the numbers sharply increased and reached its second peak on August 22 with approximately 7.40 thousand per acre. From this point, the population again declined very sharply and remained low through the last three sampling periods. The average numbers per acre of *Collops* beetles in each treatment are given in Table I. The largest numbers occurred in treatment (11) with approximately 9.30 thousand per acre, averaged over the ten sampling periods. Analysis of the numbers of *Collops* beetles (Table V) indicate one per cent significant difference due to water, period, and water by period interaction. Interestingly, the numbers of this beetle in plots treated with low water was significantly higher than the ones in plots treated either with moderate or high water. This indicated a negative effect of water on the population of Collops beetles.

Lady Beetles (LB)

The lady beetles had three population peaks on July 13 and August 1 and 31. The average numbers at these peaks were 6.59, 7.52, and 8.21 thousand per acre, respectively (Figure 4). The population remained high throughout the first nine sampling periods. The average numbers per acre of lady beetles in each treatment are given in Table IV. The greatest number of this insect (14.57 thousand per acre) was recorded on August 1 in plots treated with moderate fertilizer and moderate water. Analysis of variances for lady beetles indicate no treatment effect (Table V).

Adkisson (1958) reported that significant differences in the numbers of lady beetles, *Hippodamia convergens* (Guerin-Menesville) and *Coleomegilla maculata* Timberlake were affected by fertilizer treatment.

Spiders (SP)

The spider population remained high throughout the ten sampling dates. The population had two peaks on August 8 and 31, with approximately 17.12 and 21.86 thousand per acre, respectively (Figure 3). Analysis of variances for spiders (Table VIII) indicate one per cent significant difference due to water, period, and water by period interaction, and five per cent significant differences due to fertilizer, and fertilizer by period interaction. The average numbers of spiders per acre in each treatment are given in Table VI. The greatest number of spiders (32.61 thousand per acre) was recorded on August 22 in plots treated with high fertilizer and moderate water. Treatment (23) gave the highest average numbers of spiders with approximately 18.24 thousand per acre, averaged over the ten sampling periods (Table I).

Total Beneficial Arthropods (BENIF)

The numbers of all the above mentioned arthropods were pooled and converted to a per acre basis and recorded as beneficial arthropods (Table I). The impact of these predators might be the cause of the low rate of *Heliothis* damaged fruits throughout the growing season. The seasonal trend of all beneficials combined varied between 25.09 and 29.49 thousand per acre on the first three sampling dates (Figure 5). The population increased on August 1 and reached its first peak on August 8 with approximately 49.84 thousand per acre. The population declined sharply one week after reaching its peak. Then the number sharply increased and reached its second peak on August 22 with approximately 38.05 thousand per acre. The population slightly decreased to 36.20 thousand per acre on August 31 then declined to 20.01 and 6.13 thousand per acre on the last two sampling periods. The greatest number of predators was 58.29 thousand per acre recorded on August 8 in plots treated with high fertilizer and high water (Table VII). This treatment combination also produced the highest average number of the beneficials with approximately 35.06 thousand percent, averaged over the ten sampling dates (Table I). Analysis of variances for total beneficial arthropods is given in Table VIII. Overall, the water had significant effect at the one per cent level in the number of beneficials. The sampling period also displayed one per cent significant difference, thus, indicating population cycles. There is no significant difference due to either fertilizer or fertilizer by water interaction. The numbers of beneficials were more numerous in moderate- and high-water plots than in low-water plots, although no significant difference in the numbers of beneficials were found among the moderate- and high-water plots.

Fleahoppers (FH)

No data were taken on fleahopper damage due to the similarities of fleahopper damage, other phytophagous insect damage, and square shedding due to physiological causes. However, numbers of fleahoppers were recorded. The fleahopper population remained high through the first nine sampling dates then sharply declined on the last sampling period (Figure 6). The seasonal trend of fleahoppers varied between 22.21 and 28.80 thousand per acre through the first six sampling periods. The population increased during August 22 and reached a peak of approximately 38.16 thousand per acre on August 31, then declined very sharply during the last two sampling dates. The greatest number of fleahoppers was 84.66 thousand per acre recorded on August 22 in plots treated with high fertilizer and moderate water (Table X). This treatment combination also gave the highest average number of fleahoppers with approximately 33.17 thousand per acre, averaged over the ten sampling dates (Table IX). Fertilizer showed no significant effect on fleahoppers (Table XIII), while water demonstrated significant difference at the one per cent level. The numbers of this insect were significantly higher in plots treated with either moderate or high water than plots treated with low water. Nevertheless, the numbers in moderate- and high-water plots were not significantly different.

Heliothis Damaged Fruits (HDF)

The numbers per acre of *Heliothis* damaged fruit in each treatment are given in Table IX. The *Heliothis* damaged fruits remained low during the first three sampling dates, never exceeding 0.81 thousand per acre. The damaged fruits increased on the following weeks and reached a maximum of approximately 3.35 thousand per acre on August 8. The numbers declined from this high the remainder of the season except for small increases on August 22 and September 7 (Figure 7). The highest number of *Heliothis* damaged fruits (4.86 thousand per acre) was recorded on August 8 in plots treated with high fertilizer and high water. This treatment combination also produced the largest average number of the damaged fruits with approximately 1.80 thousand per acre, averaged over the ten sampling dates (Table IX). The per cent *Heliothis* damaged fruits are given in Table XII. The damaged fruits never reached one per cent of the total fruits at any time, except on August 8 when the damage reached its peak of 1.02 per cent. No analysis of variances for *Heliothis* damaged fruits has been computed due to insufficient population.

Boll Weevil Damaged Fruits (BWDF)

The numbers of boll weevil damaged fruits in each treatment are given in Table IX. The numbers were lowest on the first two sampling dates (average 0.23 thousand per acre at both periods) (Figure 7). From this point, the population began to increase and reached a peak of approximately 17.00 thousand per acre on August 31. The boll weevil damaged fruits declined very sharply from this high the remainder of the season. The greatest numbers of damaged fruits was 33.31 thousand per acre recorded on August 31 in plots treated with high fertilizer and moderate water (Table XI). This treatment combination also produced the highest average number of boll weevil damaged fruits of approximately 8.4 thousand per acre, averaged over the ten sampling dates (Table IX). The per cent boll weevil damaged fruits are given in Table XII. The damaged fruits never reached 0.6 per cent of the total fruits during the first five sampling dates. The per cent damage increased during August 15 and 22 and reached a high of 5.88 per cent on August 31 and sharply declined on the last two periods. Analysis of variances for boll weevil damaged fruits are given in Table XIII. There are no significant effects either due to fertilizer or fertilizer by water interaction on the number of the damaged fruits. However, water demonstrated significant effect at the one per cent level on the numbers of boll weevil damaged fruits. The damaged fruits were significantly higher in plots treated with either moderate or high water than in plots treated with low water; nevertheless, the numbers in moderate- and high-water plots were not significantly different.

Fruit Production

The fruiting pattern of the Tamcot 788 cotton, planted on May 23, 1972 indicated that peak squaring occurred about July 25, with approximately 210.37 thousand squares per acre (Figure 8). The highest number of blooms was recorded on August 8, with approximately 19.08 blooms per acre. Counts of bolls increased from a low of 1.97 thousand per acre on July 13 to a high of 235.69 thousand per acre on August 31. The boll production remained high above 210 thousand per acre on the last two sampling dates.

The average numbers per acre of squares, blooms, and bolls by treatment and sampling date are given in Tables XV, XVI, and XVII, respectively. The numbers of squares, blooms and bolls were highest in plots treated with high fertilizer and high water and lowest in plots treated with high fertilizer and low water (Table XIV).

The analysis of variances for squares, blooms, and bolls are given in Table XVIII. Overall, water demonstrated a significant effect at the one per cent level on the numbers of squares, blooms, and bolls, while fertilizer showed no effect. The numbers of squares, blooms, and bolls were significantly higher in plots treated with either moderate or high water than treated with low water. However, the fruit production in moderate-water plots was not significantly different from that of the high-water plots.

Yield

Pounds of stripper cotton per acre in each treatment are given in Table XIX. Treatments (23), (22), (13), and (12) produced highly significantly greater yield than those of treatments (21) and (11). Treatment (23) was the highest yielding treatment, producing 2,369.05 pounds of stripper cotton per acre. This was approximately 1,400 pounds greater than the yield from treatment (11) (910.71), which was the lowest yielding treatment.

The analysis of variances for yield indicate a one per cent significant difference due to water, while fertilizer showed no effect on yield. There was no significant difference due to fertilizer by water interaction (Table XX).

Relationship Among Arthropod Abundances

Correlation coefficients among beneficial arthropods, fleahopper, cotton production, insect damage, and yield on Tamcot 788 cotton are given in Table XXI. The correlation between beneficials and fleahopper was relatively high (0.44). These predators also showed very high correlation with cotton fruits; the correlation with squares, blooms and bolls was 0.73, 0.69, 0.77, respectively. However, they demonstrated low correlation with yield (0.25).

Fleahopper had relatively the same correlation with either squares (0.38), blooms (0.41), or bolls (0.41), but surprisingly exhibited high correlation with yield (0.54). Blooms (0.56) and bolls (0.56) showed relatively higher correlations with the yield than the squares (0.37). The boll weevil damaged fruits demonstrated relatively high correlation with the squares (0.30), but low with the blooms (0.08) and the bolls (0.11). The correlation between this damaged fruit with fleahopper was relatively high (0.43).

Summary

Fertilizer demonstrated significant differences at five per cent only on the numbers of spiders, while water displayed significant differences at the one per cent level on the numbers of lacewing adults, _Collops_ beetles, and spiders. Overall, fertilizer had no significant effects on the number of predators, but water showed highly significant effect on those predators. The numbers of beneficials were found significantly greater in plots treated with either moderate or high water than low water. _Collops_ beetles was the only predator which was found significantly higher in low-water plots than in either moderate- or high-water plots, hence, indicating a negative effect of the water on the _Collops_ beetle population.

Fertilizer exhibited no significant effects on the numbers of fleahopper and boll weevil damaged fruits. Water, on the other hand, demonstrated highly significantly effects on the fleahopper populations and the boll weevil damaged fruits. Both boll weevil damaged fruits and the fleahopper population were significantly larger in plots treated with either moderate or high water than low water.

Fertilizer displayed no significant effects on the numbers of cotton fruits (squares, blooms, and bolls) and yield, but the water did. Moderate- and high-water plots showed significantly higher both in numbers of the cotton fruits and yields than those of the low-water plots. In addition, plots treated with moderate water displayed no significant differences on the numbers of beneficial arthropods, fleahoppers, insect damaged fruits, cotton fruits, and yield from those treated with high water.

Predators showed relatively high correlation with cotton fruits and with fleahopper but exhibited low correlation with yield. Fleahopper demonstrated relatively the same correlation with either squares, blooms, bolls, or boll weevil damaged fruit, but high with yield. Boll weevil damaged fruit exhibited relatively high correlation with the squares, but low with blooms, bolls and yield.

CHAPTER V

EFFECTS OF DIFFERENT FERTILIZER AND WATER COMBINATIONS ON PREDATOR POPULATIONS, FLEAHOPPER POPULATION, INSECT DAMAGE, FRUIT PRODUCTION, AND YIELD ON WESTBURN 70 COTTON

Based on the obtained informations from the 1972 growing season, the 1973 growing season was devoted to determining the effects of different fertilizer and water combinations on predator populations, fleahopper population, insect damage, fruit production, and yield on Westburn 70 cotton. This cotton variety was developed by the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma, in cooperation with the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland. Foundation seeds of Westburn 70 were released to certified seed growers in Oklahoma in 1970 (Verhalen, et al., 1971). The intercorrelation among the populations of predators, fleahopper, insect damage, fruit production, and yield on Westburn 70 was also studied.

Materials and Methods

During the 1973 cotton growing season, Westburn 70 cotton was planted at the rate of 12 pounds per acre on May 29, 1973, on Tipton silt loam soil which has the average water holding capacity of 1.5

inches per foot, at the Southwest Agronomy Research Station, located three miles south of Tipton, Tillman County, Oklahoma. A stand of approximately 27,225 plants per acre was obtained.

The total study area was 3.67 acres and was divided into twenty four plots, 500 feet long and four rows wide (40-inch row spacing). The experimental design and the applied treatment combinations were similar to those employed in the 1972 growing season. The experiment was arranged in a 2 x 3 factorial combination (two fertilizer rates and three water levels). Each treatment was replicated four times in a randomized-block design. The six treatment combinations were:

Treatment (11)--moderate fertilizer and low water

Treatment (12)--moderate fertilizer and moderate water

Treatment (13)--moderate fertilizer and high water

Treatment (21)--high fertilizer and low water

Treatment (22)--high fertilizer and moderate water

Treatment (23)--high fertilizer and high water (Figure 9).

None of the low-water plots were irrigated during the season due to heavy and moderate rains that occurred in the early and mid-season. The moderate-water plots were irrigated twice on July 12 and August 16, while the high-water plots were irrigated four times on July 12 and 26 and August 9 and 16. Approximately three inches of irrigation water was applied for each irrigation. All plots were fertilized with NPK (18-46-0) at 200 pounds per acre on March 23. In addition, the high-fertilizer plots were sidedressed with NH_4NO_3 (33 per cent) at 100 pounds per acre on July 5. No insecticides were applied in the study area at any time during the growing season.

Data were collected ten times by whole plant examination. Sampling was begun on June 27, 1973 and continued on a weekly basis through August 30, 1973. Five plants were selected at random from each of the middle two rows in each plot on each sampling date. The five plants to be sampled were determined by computer generation.

Insect data were collected on the numbers of cotton fleahopper, *Pseudatomoscelis seriatus*; green lacewing eggs, larvae, and adults, *Chrysopa* spp.; hooded beetle, *Notoxus monodon*; lady beetle, *Hippodamia* spp.; soft-winged flower beetle, *Collops* spp.; big-eyed bug, *Geocoris* spp.; and spiders. Damage was recorded as *Heliothis* damaged fruits and boll weevil damaged fruits. Fruit production recorded were numbers of squares, blooms, and bolls.

The cotton was machine harvested on December 10 and 11. Only the middle two rows of each plot were harvested. The data were converted to yield per acre for each treatment combination.

Analysis of variances and correlation coefficients were performed on the data by the Statistics Department of Oklahoma State University utilizing the Statistical Analysis System.[1]

Results and Discussion

Spiders (SP)

The spider population was lowest on June 27; from this point they steadily increased up through July 31 and then leveled off (Figure 10).

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[1]The system was designed and implemented by Anthony James Barr and James Howard Goodnight, Department of Statistics, North Carolina State University, Raleigh, North Carolina.

The numbers of spiders during this time increased from 1.48 thousand per acre to 21.90 thousand per acre on July 31 when they reached the population peak. The average numbers per acre of spiders in each treatment are given in Table XXII. Treatment (13) produced the largest average number of spiders of 15.11 thousand per acre, averaged over the ten sampling dates. The greatest number of spiders (31.31 thousand per acre) was recorded on July 31 in plots treated with high fertilizer and moderate water (Table XXIII). Analysis of variances for spiders are given in Table XXV. Fertilizer showed no significant effect on spiders, but water demonstrated a significant effect at the one per cent level.

Nabids (NAB)

The nabid population remained low throughout the growing season, never exceeding 2.16 thousand per acre. The population had two peaks on June 18 and August 23, with approximately 2.16 and 1.59 thousand per acre, respectively (Figure 11). Treatment (23) exhibited the highest average numbers of nabids with approximately 1.63 thousand per acre, averaged over the ten sampling periods (Table XXII). The nabid population was too low to be statistically analyzed on an individual basis.

Big-Eyed Bugs (BEB)

The greatest number of big-eyed bugs was recorded in plots treated with moderate fertilizer and low water, with approximately 1.02 thousand per acre (Table XXII). The population of this insect remained low throughout the entire season, never exceeding 1.81

thousand per acre. The population varied from period to period with no set pattern (Figure 11). Due to insufficient population of big-eyed bugs, no analysis of variance had been performed on this insect data.

Leigh, et al. (1974), conducted their experiment in California cotton fields in 1972 in order to determine the effects of water and plant spacing combinations on the abundance of arthropod populations. They found that irrigation had little influence on big-eyed bug population.

Lacewing Eggs (LWE)

The lacewing eggs' first appearance was detected on June 11. The population varied between 0.46 and 13.84 thousand per acre during June 11 through June 31. Lacewing egg population increased steadily from this point and reached a peak of approximately 176.51 thousand per acre on August 23. The population declined sharply one week after reaching its peak (Figure 12). The highest number of lacewing eggs (225.29 thousand per acre) was recorded on August 23 in plots treated with high fertilizer and moderate water (Table XXIV). Treatment (13) exhibited the largest average number of lacewing eggs with approximately 51.80 thousand per acre (Table XXII). Analysis of variances for lacewing eggs indicates no treatment effect (Table XXV).

Lacewing Larvae (LWL)

The population of lacewing larvae remained low during the first six sampling dates, then increased sharply and reached a maximum of 5.1 thousand per acre on August 23. The population declined very sharply on the last sampling date (Figure 13). Treatments (11) and (23) displayed the largest average number of lacewing larvae (averaged 1.29 thousand per acre for both treatments) (Table XXII). However, it was felt the population was too low to make an adequate evaluation.

Lacewing Adults (LWA)

The lacewing adults, likewise, exhibited a similar pattern of population to lacewing larvae (Figure 13). The population reached its peak of approximately 2.95 thousand per acre on August 23. The average number per acre of lacewing adults (1.23 thousand per acre) was recorded in plots treated with moderate fertilizer and moderate water. No analysis of variances for this insect is given due to the insufficient population.

Hooded Beetles (HB)

The hooded beetle population had two peaks on July 11 and August 23, with approximately 5.90 and 7.94 thousand per acre, respectively (Figure 14). The highest number of hooded beetles (17.70 thousand per acre) was observed on August 23 in plots treated with moderate fertilizer and moderate water (Table XXVI). This treatment combination also produced the highest average number of hooded beetle with approximately 5.99 thousand per acre (Table XXII). Neither fertilizer nor water displayed significant effect on the number of hooded beetles (Table XXIX).

Collops Beetles (COL)

The pattern of *Collops* beetle population is shown in Figure 14. The population remained low throughout the growing season. A peak of approximately 2.50 thousand per acre was recorded on August 23. The average numbers per acre of *Collops* beetles in each treatment are given in Table XXII. The largest number occurred in plots treated with moderate fertilizer and low water, with approximately 1.91 thousand per acre. Although the number of this insect in plots treated with low water was higher than the ones treated either with moderate or high water (similar to what we found in the 1972 growing season), it was felt the population was too low to make an adequate evaluation.

Lady Beetles (LB)

The population of lady beetles varied between 1.02 and 3.06 thousand per acre during the first three sampling dates (Figure 14). The population increased on June 11 and reached its peak of approximately 6.01 thousand per acre on June 18. The population declined from this high the remainder of the season except for a small increase on August 23. Treatment (12) produced the highest average number of lady beetles with approximately 4.42 thousand per acre, averaged over the ten sampling dates (Table XXII). Neither fertilizer nor water exhibited a significant effect on numbers of this beetle (Table XXIX). However, fertilizer by water interaction demonstrated a significant difference at the five per cent level, indicating these two factors were not additive effects on the population of lady beetles.

Total Beneficial Arthropods (BENIF)

The numbers of all the above mentioned arthropods, except lacewing eggs, were pooled and converted to a per acre basis and recorded as beneficial arthropods (Table XXII). The numbers of these predators were lowest on the first sampling dates with averages of 0.23 thousand per acre (Figure 15). From this point, the population began to increase and reached its first peak during June 18 and 31. The population varied between 31.08 and 33.47 thousand per acre during these periods. The population declined sharply one week after reaching its peak and then steadily increased and reached a second peak of approximately 36.98 thousand per acre on August 23. The greatest number of predators (54.46 thousand per acre) was recorded on August 23 in plots treated with moderate fertilizer and moderate water (Table XXVIII). This treatment combination also produced the highest average number of total beneficials with approximately 29.33 thousand per acre, averaged over the ten sampling periods (Table XXII). Fertilizer exhibited no significant effect on predators, but water demonstrated significant difference at the five per cent level (Table XXIX). The numbers of beneficials were more numerous in plots treated with either moderate or high water than low water. Nevertheless, the numbers in moderate- and high-water plots were not significantly different.

Fleahoppers (FH)

The maximum number of fleahoppers (25.18 thousand per acre) was recorded in plots treated with high fertilizer and low water on

August 23 (Table XXXI). Treatment (23) produced the highest average number of fleahoppers with approximately 13.88 thousand per acre, averaged over the entire season (Table XXX). The population had two peaks on June 18 and August 23, with approximately 17.47 and 18.15 thousand per acre, respectively (Figure 15). Analysis of variances for fleahoppers (Table XXXIV) indicate no significant differences due to treatment. The plots treated with either moderate or high water produced larger number of fleahoppers than the ones treated with low water; however, about the same numbers were obtained in both moderate- and high-water plots.

Heliothis Damaged Fruits (HDF)

The number of *Heliothis* damaged fruit was first recorded on June 18. The population remained low through June 31, then increased very sharply on the following weeks and reached its peak of 45.83 thousand per acre on August 15. The population declined very sharply after reaching this high during the last two sampling dates (Figure 16). Treatment (23) produced the highest average number damaged fruits with approximately 12.93 thousand per acre, averaged over the entire growing season (Table XXX). The maximum number of *Heliothis* damaged fruits (64.66 thousand per acre) was observed on August 15 in plots treated with moderate fertilizer and high water (Table XXXII). The percentage of *Heliothis* damaged fruits is given in Table XXXIII. The damaged fruits reached its peak of 7.43 per cent of the total fruits on August 15. Neither fertilizer nor water demonstrated significant effect on the bollworm damaged fruits (Table XXXIV).

Boll Weevil Damaged Fruits (BWDF)

The boll weevil damaged fruits did not reach high levels until after data collecting ceased and was not a significant factor in this study.

Fruit Production

Figure 17 depicts the fruiting pattern of the Westburn 70 cotton planted on May 29, 1973. The peak squaring occurred on August 15 with approximately 529.19 thousand squares per acre. The bolls and blooms were first recorded on June 25. Both populations increased steadily and reached highs of 200.10 and 39.93 thousand per acre, respectively, on August 30. Bloom and boll counts more than likely continued to increase after the last sampling date, August 30.

The average numbers per acre of squares, blooms, and bolls by treatment and sampling date are given in Tables XXXVI, XXXVII, and XXXVIII, respectively. The maximum number of squares (303.22 thousand per acre) was recorded in plots treated with moderate fertilizer and high water. Treatment (12) exhibited the highest numbers of both blooms and bolls of approximately 11.57 and 60.44 thousand per acre, respectively (Table XXXV). Water demonstrated significant effect at the one per cent level on the numbers of squares and bolls but showed no effect on blooms. Fertilizer, on the other hand, had no significant effect on any of the cotton fruits. There was a significant difference at the five per cent level due to fertilizer and water interaction on bolls, indicating these two variables were not additive factors on bolls (Table XXXIX). In general the cotton fruits were more numerous in plots treated with either moderate or high water than the ones treated with low water.

Yield

Pounds of stripper cotton per acre in each treatment are given in Table XL. Treatments (23), (13), (12) and (22) produced significant higher yield, at the one per cent level, than those of treatments (21) and (11). Treatment (11) was the lowest yielding treatment producing approximately 1,960.78 pounds of stripper cotton per acre. This was approximately 1,300 pounds less than the yield produced by treatment (23) (3,300.60 pounds), which was the highest yielding treatment. The analysis of variances for yield (Table XLI) indicated a one per cent significant difference due to water, but fertilizer demonstrated no significant effect on yield.

Relationship Among Arthropod Abundances

Correlation coefficients among beneficial arthropods, fleahopper, cotton fruits, insect damage, and yield on Westburn 70 cotton are given in Table XLII. The spiders exhibited relatively high correlation with fleahoppers (0.48), lacewing eggs (0.52), and squares (0.71), but showed low correlation with lady beetle (0.28), hooded beetle (0.31), bollworm damaged fruit (0.30), blooms (0.43), and bolls (0.38), and no correlation with yield (0.12). Lacewing eggs demonstrated relatively high correlations with squares (0.68), blooms (0.57), and *Heliothis* damaged fruit (0.41), but showed relatively low correlation with hooded beetle (0.35), lady beetle (0.33), and bolls (0.38), and exhibited no correlation with either fleahoppers (0.08) or yield (0.04). The correlation between hooded beetle and blooms was relatively high (0.41). Lady beetle displayed relatively high correlation with both squares (0.54) and bollworm damaged fruit (0.67), but exhibited low correlation with bolls and other predators. They also showed no correlation with either fleahopper (0.09) or yield (-0.02).

Overall, beneficial arthropods demonstrated high correlation with fleahoppers (0.45), squares (0.76), blooms (0.50), bolls (0.54), and Heliothis damaged fruit (0.52), but displayed no correlation with yield (-0.10). Fleahoppers showed no correlation with either blooms (-0.01), yield (-0.16), or any of the individual predator, but displayed relatively high correlation with squares (0.48) and bolls (0.54). Only squares exhibited low correlation with yield (0.22). Other variables showed no correlation with yield. In addition, Heliothis damaged fruit was the only variable which demonstrated low negative correlation with yield (-0.31).

Summary

Overall, water showed significant difference at the five per cent level on the numbers of predators but fertilizer displayed no effect on these predators. There were no treatment effects on the numbers of fleahoppers and Heliothis damaged fruits.

Fertilizer exhibited no significant effects on the number of cotton fruits (squares, blooms, and bolls), but water, in contrast, displayed significant differences at the one per cent level on the numbers of squares and bolls. In general, significantly greater amounts of cotton fruits and yield were obtained from plots treated with either moderate or high water than those from plots treated with low water.

Overall, predators showed high correlation with fleahoppers and cotton fruits but exhibited no correlation with yield. Fleahoppers displayed no correlation with either blooms or yield, but demonstrated relatively high correlation with squares and bolls. Squares were the only variable which showed low correlation with yield. The other variables exhibited no correlation with yield. In addition, Heliothis damaged fruit was the only variable which displayed low negative correlation with yield.

CHAPTER VI

SUMMARY AND CONCLUSIONS

There were several agreements in the results from the experiments in both years. In general, plots treated with either moderate or high water demonstrated a superior attractiveness to both predators and harmful insects of cotton than the ones receiving no additional irrigation water (low-water plots). The predators probably helped regulate the cotton pests. The fertility and water management increased the productivity of the cotton plants, thus enabling them to withstand heavy insect infestation without reducing the final yield.

Water exhibited significant effect on fruit production and yield of cotton, hence significantly higher cotton fruits and yield were obtained from plots treated either with moderate or high water than low water. Overall, plots treated with either moderate or high fertilizer exhibited no significant differences on the numbers of either predators, fleahoppers, insect damage, cotton fruits, or yield.

Predators showed relatively high correlation with fleahoppers and cotton fruits but exhibited low or no correlation with yield. Fleahopper displayed high correlation with predators and moderate to high correlation with cotton fruits. The high correlation between fleahoppers and yield was obtained in the 1972 growing season;

however, this relationship was low for the 1973 growing season. In general, boll weevil damaged fruit demonstrated high correlation with fleahoppers and squares but low with bolls, blooms, and yield. Heliothis damaged fruit showed high correlation with beneficial arthropods but low correlation with cotton fruits. There was no correlation between bollworm damaged fruit and fleahoppers. In addition, bollworm damaged fruit displayed low negative correlation with yield.

The annual average rainfall in southwest Oklahoma was approximately 24 inches. During the year 1972 only 22.74 inches of rain were received in the study area. This was a little over an inch below normal. Heavy and moderate rains occurred throughout the year 1973; the rainfall amount received in the study area in that year was way above normal (approximately 14 inches greater) (Table XLIII).

Fertility and water management is certainly one of the best tools in efficient cotton production in Oklahoma. Oklahoma cotton growers cannot afford to rely on natural water alone if they want to obtain higher yields from their crops. This two year experiment has demonstrated clearly that additional amounts of three to five irrigations during the growing season help increase the final yield at least 80 per cent. No insecticide was applied in the study areas at any time during the two growing seasons; thus, beneficial arthropods were able to increase tremendously and keep harmful insects under control. This study has shown that the vegetative and fruiting growth of cotton are strongly influenced by cultural practices.

I agree with Longeneker and Erie (1968) who stated that in order to determine the amount of water cotton needs there are several factors involved, including the environmental factors, length of growing season, variety used, depth and texture of soil, water-holding capacity, fertility, leaching requirements, quality of water, and the efficiency of scheduling and applying irrigation water.

More research still needs to be done in order to obtain more information concerning the above factors before definite information dealing with fertility and water management of cotton can be fully released.

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APPENDIX

TABLE I

AVERAGE NUMBERS IN THOUSANDS OF BENEFICIAL ARTHROPODS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT, TIPTON, OKLAHOMA, 1972

TREATMENT	NAB	LWL	LWA	HB	COL	LB	SP	BENIF
(11)	0.33*	0.42	0.07	1.25	9.30	5.13	8.24	24.79
(12)	0.42	0.69	2.00	2.41	3.94	5.88	13.32	28.73
(13)	0.33	0.42	2.64	3.89	3.39	5.69	14.21	30.61
(21)	0.28	0.47	0.28	1.94	8.33	3.05	9.58	23.87
(22)	1.11	0.69	1.86	2.50	4.08	5.13	16.65	32.06
(23)	0.89	0.56	3.66	2.69	3.47	5.47	18.24	35.06

*Each figure is an average of 400 observations.

TABLE II

AVERAGE NUMBERS IN THOUSANDS OF HOODED BEETLES PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	3.47*	0.69	0.69	1.39	2.08	2.08	0.00	0.00	2.08	0.00
(12)	6.94	1.39	0.69	0.69	6.94	3.47	2.08	1.39	0.69	0.00
(13)	4.86	1.39	9.02	3.47	10.41	2.78	4.86	2.08	0.00	0.00
(21)	4.86	1.39	0.00	0.00	4.16	6.25	0.69	1.39	0.69	0.00
(22)	2.78	3.47	1.39	0.69	3.47	2.08	6.94	2.78	0.69	0.69
(23)	2.08	0.69	6.94	2.78	4.16	3.47	6.94	0.00	0.00	0.00

*Each figure is an average of 40 observations.

TABLE III

AVERAGE NUMBERS IN THOUSANDS OF COLLOPS BEETLES PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	0.69*	9.02	11.80	18.74	30.53	2.08	18.74	1.39	0.00	0.00
(12)	0.69	4.16	3.47	12.49	11.80	2.78	4.16	0.00	0.00	0.00
(13)	4.86	4.16	3.47	5.55	9.71	2.08	3.47	0.69	0.00	0.00
(21)	1.39	6.25	11.80	22.20	23.59	4.16	12.49	0.69	0.00	0.69
(22)	2.78	4.16	9.02	5.55	9.71	3.47	4.16	0.69	0.69	0.69
(23)	2.78	9.02	2.78	3.47	13.88	1.39	1.39	0.00	0.00	0.00

*Each figure is an average of 40 observations.

TABLE IV

AVERAGE NUBMERS IN THOUSANDS OF LADY BEETLES PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	7.63*	9.02	4.86	5.55	1.39	1.39	6.25	6.94	8.33	0.00
(12)	6.25	2.08	3.47	14.57	7.63	6.94	7.63	7.63	2.78	0.00
(13)	5.55	4.16	4.16	6.25	4.16	4.86	6.94	10.41	9.71	0.69
(21)	4.86	2.78	2.78	6.25	4.16	0.69	1.39	5.55	1.39	0.69
(22)	4.86	4.16	2.78	6.94	10.41	6.25	4.16	9.71	0.69	1.39
(23)	10.41	3.47	4.16	5.55	4.16	4.86	7.63	9.02	4.86	0.69

*Each figure is an average of 40 observations.

TABLE V

ANALYSES OF VARIANCES FOR HOODED BEETLES, COLLOPS BEETLES, AND LADY BEETLES COLLECTED FROM TAMCOT 788 COTTON, TIPTON, OKLAHOMA, 1972

Source	DF	MS		
		HB	COL	LB
TOTAL (CORRECTED)	2399			
REP	3	0.2800	0.7794	0.8938
FERT	1	0.0150	0.0417	0.7704
WATER	2	0.7504	8.9617**	0.7204
FERT*WATER	2	0.2363	0.1067	0.2454
ROW (REP FERT WATER)	24	0.1625	0.2883	0.2354
ERROR A (R*F/W)	15	0.2657	0.4481	0.2198
PERIOD	9	0.8581**	9.1231**	1.4621**
FERT*PERIOD	9	0.1669	0.1417	0.2862
WATER*PERIOD	18	0.3222**	1.6056**	0.4204*
FERT*WATER*PERIOD	18	0.1117	0.2831	0.1973
PERIOD*ROW (REP FERT WATER)	216	0.1523	0.2976	0.2391
ERROR B (R*P*F/W)	162	0.1421	0.3836	0.2259
RESIDUAL	1920	0.1142	0.2625	0.2177

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE VI

AVERAGE NUMBERS IN THOUSANDS OF SPIDERS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	13.18*	10.41	9.02	13.88	11.10	4.16	2.78	9.71	4.86	3.47
(12)	11.80	11.80	15.96	10.41	24.29	6.94	11.10	23.59	12.49	4.86
(13)	9.71	11.80	23.59	14.57	24.29	9.71	15.27	21.51	8.33	3.47
(21)	11.10	6.94	9.71	17.35	6.94	2.78	7.63	15.27	15.96	2.08
(22)	13.18	16.65	7.63	15.96	13.18	14.57	32.61	29.84	15.27	7.63
(23)	9.02	11.10	15.27	27.06	22.90	18.74	28.45	31.23	15.96	2.78

*Each figure is an average of 40 observations.

TABLE VII

AVERAGE NUMBERS IN THOUSANDS OF TOTAL BENEFICIAL ARTHROPODS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	25.67*	29.14	30.53	39.55	45.10	10.41	28.45	19.43	15.96	3.47
(12)	27.06	20.82	24.29	40.94	57.59	22.20	31.23	37.47	18.74	6.94
(13)	24.98	22.20	43.02	32.61	54.12	25.67	37.47	39.55	22.20	4.16
(21)	23.59	18.04	24.98	46.49	40.94	15.27	22.90	24.98	18.04	3.47
(22)	23.59	29.84	22.90	34.70	43.02	31.23	56.21	46.99	18.74	13.89
(23)	25.67	24.98	31.23	42.33	58.29	35.39	52.04	49.27	26.37	4.86

*Each figure is an average of 40 observations.

TABLE VIII

ANALYSES OF VARIANCES FOR SPIDERS AND TOTAL BENEFICIAL ARTHROPODS COLLECTED FROM TAMCOT 788 COTTON, TIPTON, OKLAHOMA, 1972

Source	DF	MS	
		SP	BENIF
TOTAL (CORRECTED)	2399		
REP	3	5.5949	30.4367
FERT	1	6.3038*	4.0017
WATER	2	15.8679**	20.1279**
FERT*WATER	2	0.5213	2.1679
ROW (REP FERT WATER)	24	1.1429	2.7808
ERROR A (R*F/W)	15	0.8602	2.1407
PERIOD	9	7.5745**	46.8650**
FERT*PERIOD	9	2.8204**	2.4156
WATER*PERIOD	18	1.7545*	3.4446
FERT*WATER*PERIOD	18	0.5921	1.3901
PERIOD*ROW (REP FERT WATER)	216	0.6133	1.5595
ERROR B (R*P*F/W)	162	0.9632	2.4730
RESIDUAL	1920	0.5577	1.3848

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE IX

AVERAGE NUMBERS IN THOUSANDS OF FLEAHOPPERS, *HELIOTHIS* DAMAGED FRUITS, AND BOLL WEEVIL DAMAGED FRUITS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT, TIPTON, OKLAHOMA, 1972

Treatment	Fleahoppers	Damaged Fruits	
		Heliothis	Boll Weevil
(11)	15.40*	0.90	0.83
(12)	26.92	0.83	5.07
(13)	32.53	1.11	6.73
(21)	15.82	0.35	0.76
(22)	33.17	1.53	8.40
(23)	33.03	1.80	7.15

*Each figure is an average of 400 observations.

TABLE X

AVERAGE NUMBERS IN THOUSANDS OF FLEAHOPPERS, PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	22.90*	22.90	23.59	29.84	17.35	9.02	5.55	15.27	7.63	0.00
(12)	28.45	28.45	29.14	18.74	28.45	4.86	43.02	57.59	27.06	3.47
(13)	34.70	18.04	39.55	34.70	49.27	20.82	47.19	48.57	31.23	1.39
(21)	28.45	15.96	29.14	18.04	9.71	10.41	14.57	9.71	21.51	0.69
(22)	21.51	23.59	28.45	20.12	24.98	38.61	84.66	52.74	34.70	2.78
(23)	24.29	25.67	22.90	25.67	36.78	49.96	64.53	45.10	34.70	0.69

*Each figure is an average of 40 observations.

TABLE XI

AVERAGE NUMBERS IN THOUSANDS OF BOLL WEEVIL DAMAGED FRUITS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	0.00*	0.69	0.69	2.08	0.69	0.00	0.00	2.78	0.69	0.69
(12)	0.00	0.00	2.78	1.39	1.39	1.39	6.94	13.18	15.96	7.63
(13)	0.00	0.00	2.78	2.08	1.39	2.08	17.35	29.84	6.94	4.86
(21)	0.00	0.00	0.69	2.08	0.00	0.00	0.00	2.08	1.39	1.39
(22)	0.69	0.00	0.69	1.39	2.78	2.78	27.06	33.31	9.02	6.25
(23)	0.69	0.69	2.08	2.78	3.47	13.18	11.10	20.82	13.18	3.47

*Each figure is an average of 40 observations.

TABLE XII

PER CENT HELIOTHIS AND BOLL WEEVIL DAMAGED FRUITS ON TAMCOT 788 COTTON BY SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Sampling Date	% Damaged Fruits	
	Heliothis	Boll Weevil
7-13	0.25	0.17
7-18	0.38	0.11
7-25	0.21	0.58
8- 1	0.45	0.59
8- 8	1.02	0.49
8-15	0.27	1.08
8-22	0.33	3.33
8-31	0.28	5.88
9- 7	0.36	3.07
9-14	0.30	1.74

TABLE XIII

ANALYSES OF VARIANCES FOR FLEAHOPPERS AND BOLL WEEVIL DAMAGED FRUITS COLLECTED FROM TAMCOT 788 COTTON, TIPTON, OKLAHOMA, 1972

Source	DF	MS	
		FH	BWDF
TOTAL (CORRECTED)	2399		
REP	3	13.4438	0.9394
FERT	1	4.4204	1.0417
WATER	2	88.1617**	12.8413**
FERT*WATER	2	2.8017	0.9404
ROW (REP FERT WATER)	24	2.0821	0.4000
ERROR A (R*F/W)	15	2.6554	0.7521
PERIOD	9	37.4075**	8.9233**
FERT*PERIOD	9	9.8482**	0.3185
WATER*PERIOD	18	11.9376**	2.2274**
FERT*WATER*PERIOD	18	2.4138	1.3589**
PERIOD*ROW (REP FERT WATER)	216	1.8812	0.4759
ERROR B (R*P*F/W)	162	3.4584	0.3022
RESIDUAL	1920	1.3690	0.3775

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE XIV

AVERAGE NUMBERS IN THOUSANDS OF SQUARES, BLOOMS, AND BOLLS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT, TIPTON, OKLAHOMA, 1972

Treatment	Squares	Blooms	Bolls
(11)	82.92*	6.52	107.14
(12)	99.78	7.56	131.15
(13)	150.58	11.17	157.38
(21)	65.92	5.41	101.45
(22)	146.76	9.37	163.76
(23)	163.14	11.59	189.02

*Each figure is an average of 400 observations.

TABLE XV

AVERAGE NUMBERS IN THOUSANDS OF SQUARES PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	147.11*	190.13	219.97	186.66	56.90	20.12	3.47	1.39	0.69	2.78
(12)	118.66	149.88	142.94	117.96	120.74	70.78	110.33	70.78	56.21	39.55
(13)	127.68	165.84	251.19	248.42	268.54	202.62	136.00	46.49	41.63	17.35
(21)	119.35	173.48	178.33	111.72	29.84	18.04	15.96	3.47	6.25	2.78
(22)	154.74	283.81	244.25	178.33	124.90	124.21	122.82	129.76	70.08	34.70
(23)	136.00	166.54	225.52	321.97	308.79	213.72	115.88	47.88	81.88	13.18

*Each figure is an average of 40 observations.

TABLE XVI

AVERAGE NUMBERS IN THOUSANDS OF BLOOMS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	1.39*	9.71	20.12	9.71	16.65	6.25	0.69	0.69	0.00	0.00
(12)	2.78	13.18	11.80	15.96	13.88	3.47	9.02	4.86	0.00	0.69
(13)	6.25	6.94	13.88	10.41	24.29	16.65	22.20	8.33	0.69	2.08
(21)	2.78	2.78	9.02	17.35	11.80	6.25	3.47	0.69	0.00	0.00
(22)	2.08	9.02	13.18	13.18	22.90	6.25	12.49	5.55	6.94	2.08
(23)	4.16	6.25	11.10	10.41	24.98	20.12	31.92	2.08	4.16	0.69

*Each figure is an average of 40 observations.

TABLE XVII

AVERAGE NUMBERS IN THOUSANDS OF BOLLS PER ACRE ON TAMCOT 788 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1972

Treatment	Sampling Date									
	7-13	7-18	7-25	8-1	8-8	8-15	8-22	8-31	9-7	9-14
(11)	1.39*	12.49	69.39	146.41	164.45	138.78	138.78	138.78	120.74	140.17
(12)	2.08	11.10	60.37	136.00	130.45	179.72	199.15	194.99	219.27	178.33
(13)	4.16	10.41	45.80	111.72	151.27	170.70	281.72	292.83	269.93	235.23
(21)	0.69	21.51	58.98	136.00	132.54	123.51	125.60	145.72	132.54	137.39
(22)	1.39	20.82	62.45	133.23	201.23	207.48	197.76	297.68	237.31	278.25
(23)	2.08	10.41	46.49	100.62	173.48	267.15	351.11	344.17	285.89	308.79

*Each figure is an average of 40 observations.

TABLE XVIII

ANALYSES OF VARIANCES FOR SQUARES, BLOOMS, AND BOLLS ON TAMCOT 788 COTTON, TIPTON, OKLAHOMA, 1972

Source	DF	MS Squares	MS Blooms	MS Bolls
TOTAL (CORRECTED)	2399			
REP	3	1013.6571	6.0615	1648.3961
FERT	1	151.5038	0.0204	309.6017
WATER	2	1848.3238**	7.6117**	1257.2788**
FERT*WATER	2	267.3263	0.3817	135.6829
ROW (REP FERT WATER)	24	25.5754	0.3321	21.8592
ERROR A (R*F/W)	15	103.2961	0.7799	135.5768
PERIOD	9	1488.6578**	10.7865**	2398.5646**
FERT*PERIOD	9	12.1704	0.7825	39.5739
WATER*PERIOD	18	270.5728**	2.3394**	199.5834**
FERT*WATER*PERIOD	18	41.0540	0.4687	23.3246
PERIOD*ROW (REP FERT WATER)	216	17.7828	0.4117	12.8981
ERROR B (R*P*F/W)	162	52.6242	0.5787	43.3229
RESIDUAL	1920	16.4513	0.3963	15.2063

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE XIX

POUNDS OF STRIPPER TAMCOT 788 COTTON HARVESTED PER PLOT AND CALCULATIONS TO CONVERT THE YIELD TO POUND PER ACRE, TIPTON, OKLAHOMA, 1972

Treatment	Plot No.	Lbs.	Total Lbs/Trt		Acreage	Yield[1] Lbs/Acre
	4	24				
(11)	10	77	153	÷	0.168	910.71[b]
	13	37				
	21	15				
	5	74				
(12)	7	82	339	÷	0.168	2017.86[a]
	15	99				
	22	84				
	6	117				
(13)	8	86	388	÷	0.168	2309.52[a]
	14	106				
	23	79				
	3	37				
(21)	9	94	186	÷	0.168	1107.14[b]
	16	27				
	24	28				
	1	96				
(22)	12	125	396	÷	0.168	2357.14[a]
	18	93				
	19	82				
	2	101				
(23)	11	123	398	÷	0.168	2369.05[a]
	17	107				
	20	67				

[1]Entries with any of the same letters have no significant difference (1% level of probability) measured by Duncan's new multiple range test.

TABLE XX

ANALYSIS OF VARIANCES FOR YIELDS OF TAMCOT 788
COTTON, TIPTON, OKLAHOMA, 1972

Source	DF	MS
TOTAL (CORRECTED)	23	
REP	3	1514.223
FERT	1	416.670
WATER	2	7483.875**
FERT*WATER	2	69.040
ERROR	15	313.522

**Significant at the 0.01 level

TABLE XXI

CORRELATION COEFFICIENTS ADJUSTED FOR REPLICATION AND TREATMENT AMONG BENEFICIAL ARTHROPODS, FLEAHOPPERS, COTTON PRODUCTION, INSECT DAMAGE, AND YIELD ON TAMCOT 788 COTTON, TIPTON, OKLAHOMA, 1972

Variables	Fleahopper	Beneficials	Square	Bloom	Boll	Boll Weevil Damaged Fruit
BENEFICIALS	0.44					
SQUARE	0.38	0.73				
BLOOM	0.42	0.69	0.83			
BOLL	0.41	0.77	0.89	0.88		
BOLL WEEVIL DAMAGED FRUIT	0.43	0.17	0.30	0.08	0.11	
YIELD	0.54	0.25	0.37	0.56	0.56	0.35

TABLE XXII

AVERAGE NUMBERS IN THOUSANDS OF BENEFICIAL ARTHROPODS
PER ACRE ON WESTBURN 70 COTTON BY TREATMENT,
TIPTON, OKLAHOMA, 1973

Treatment	SP	NAB	BEB	LWE	LWL	LWA	HB	COL	LB	BENIF
(11)	11.91*	1.36	1.02	40.50	1.29	0.20	3.95	1.91	2.38	24.03
(12)	14.09	1.57	0.34	50.50	0.95	1.23	5.99	0.75	4.42	29.33
(13)	15.11	1.02	0.61	51.80	1.70	0.75	3.68	0.41	3.13	25.93
(21)	9.26	1.36	0.68	36.96	0.61	0.00	3.68	1.02	2.93	19.53
(22)	13.95	1.29	0.68	49.48	1.16	0.48	4.42	0.61	2.31	24.91
(23)	14.84	1.63	0.54	39.75	1.29	1.16	3.88	0.34	3.20	27.50

*Each figure is an average of 400 observations.

TABLE XXIII

AVERAGE NUMBERS IN THOUSANDS OF SPIDERS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	2.04*	8.17	6.13	16.34	11.57	18.38	19.06	14.29	14.29	8.85
(12)	0.68	8.85	12.93	14.29	17.70	18.38	16.34	13.61	13.61	24.50
(13)	1.36	6.13	10.89	19.74	19.74	23.82	11.57	22.46	16.34	14.29
(21)	0.00	6.81	5.45	16.34	11.57	13.61	12.93	5.45	10.89	9.53
(22)	0.68	5.45	10.21	17.70	24.50	31.31	12.25	11.57	12.25	13.61
(23)	4.08	8.85	11.57	17.70	16.34	25.86	18.38	18.38	12.93	14.29

*Each figure is an average of 40 observations.

TABLE XXIV

AVERAGE NUMBERS IN THOUSANDS OF LACEWING EGGS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	0.00*	0.00	0.00	4.08	19.06	6.81	58.53	100.05	149.74	66.70
(12)	0.00	0.00	1.36	4.76	12.93	6.13	69.42	117.75	166.07	126.60
(13)	0.00	0.00	0.00	2.72	15.65	12.93	43.56	157.22	234.14	51.73
(21)	0.00	0.00	0.68	2.72	14.97	12.93	46.96	91.20	126.60	73.51
(22)	0.00	0.00	0.68	5.45	13.61	12.93	31.31	104.14	225.29	101.41
(23)	0.00	0.00	0.00	3.40	6.81	13.61	61.26	92.57	157.22	62.62

*Each figure is an average of 40 observations.

TABLE XXV

ANALYSES OF VARIANCES FOR SPIDERS AND LACEWING EGGS COLLECTED FROM WESTBURN 70 COTTON, TIPTON, OKLAHOMA, 1973

Source	DF	MS	
		SP	LWE
TOTAL (CORRECTED)	2399		
REP	3	0.7528	105.9438
FERT	1	0.8817	43.4704
WATER	2	5.3829**	33.6679
FERT*WATER	2	0.6379	24.1904
ROW (REP FERT WATER)	24	0.7692	1.8513
ERROR A (R*F/W)	15	0.4291	13.0948
PERIOD	9	10.8048**	1206.1477**
FERT*PERIOD	9	0.4937	10.0528
WATER*PERIOD	18	0.8047	14.3485
FERT*WATER*PERIOD	18	0.6236	17.8478
PERIOD*ROW (REP FERT WATER)	216	0.4775	2.1605
ERROR B (R*P*F/W)	162	0.6229	16.3998
RESIDUAL	1920	0.5521	1.5233

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE XXVI

AVERAGE NUMBERS IN THOUSANDS OF HOODED BEETLES PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	1.36*	8.85	6.13	4.76	4.08	4.08	0.68	2.72	6.13	0.68
(12)	3.40	2.72	6.13	9.53	8.17	4.76	2.04	3.40	17.70	2.04
(13)	1.36	3.40	6.13	4.76	2.72	3.40	4.76	2.04	4.76	3.40
(21)	2.72	2.72	6.13	4.08	5.45	2.04	2.72	4.08	3.40	3.40
(22)	2.72	4.76	4.76	4.08	2.72	2.72	2.04	8.85	6.13	5.45
(23)	5.45	5.45	6.13	6.81	2.72	3.40	1.36	2.72	9.53	1.36

*Each figure is an average of 40 observations.

TABLE XXVII

AVERAGE NUMBERS IN THOUSANDS OF LADY BEETLES PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-14	7-31	8-8	8-15	8-23	8-30
(11)	1.36*	0.68	2.04	6.13	4.76	1.36	2.72	2.04	1.36	1.36
(12)	0.00	0.00	6.13	8.85	8.85	5.45	2.04	1.36	4.76	6.81
(13)	0.00	1.36	4.76	6.81	2.04	8.17	1.36	2.72	2.72	1.36
(21)	0.00	2.72	2.04	2.72	7.49	6.81	0.68	0.68	2.72	3.40
(22)	0.00	1.36	0.68	4.08	2.72	3.40	2.72	2.04	4.76	1.36
(23)	0.00	0.00	2.72	7.49	8.84	5.45	2.72	1.36	3.40	0.00

*Each figure is an average of 40 observations.

TABLE XXVIII

AVERAGE NUMBERS IN THOUSANDS OF TOTAL BENEFICIAL ARTHROPODS
PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND
SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	5.45*	22.46	17.02	28.59	26.54	29.27	23.82	31.31	36.75	19.06
(12)	4.08	12.25	29.95	36.07	39.48	30.63	23.14	23.82	54.46	39.48
(13)	2.72	12.93	23.82	36.75	27.23	39.48	20.42	35.39	35.39	25.18
(21)	2.72	14.97	19.74	29.95	28.59	23.14	19.06	16.34	21.10	19.74
(22)	4.08	14.97	17.70	31.99	34.03	39.48	19.74	31.99	31.31	23.82
(23)	9.53	17.02	23.14	36.07	30.63	38.80	25.86	26.54	48.88	24.50

*Each figure is an average of 40 observations.

TABLE XXIX

ANALYSES OF VARIANCES FOR HOODED BEETLES, LADY BEETLES, AND TOTAL BENEFICIAL ARTHROPODS COLLECTED FROM WESTBURN 70 COTTON, TIPTON, OKLAHOMA, 1973

Source	DF	MS		
		HB	LB	BENIF
TOTAL (CORRECTED)	2399			
REP	3	1.3828	0.0006	4.1493
FERT	1	0.0417	0.3267	5.9004
WATER	2	0.5938	0.1738	9.1267*
FERT*WATER	2	0.3454	0.6779*	4.2917
ROW (REP FERT WATER)	24	0.2450	0.1900	1.8220
ERROR A (R*F/W)	15	0.1758	0.1542	2.2383
PERIOD	9	0.9648**	1.2083**	30.7076**
FERT*PERIOD	9	0.2037	0.1341	0.9754
WATER*PERIOD	18	0.2530	0.1196	1.2350
FERT*WATER*PERIOD	18	0.3741	0.2284	1.8111
PERIOD*ROW (REP FERT WATER)	216	0.1876	1.1252	1.1850
ERROR B (R*P*F/W)	162	0.3340	0.1416	2.0355
RESIDUAL	1920	0.2196	0.1231	1.2629

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE XXX

AVERAGE NUMBERS IN THOUSANDS OF FLEAHOPPERS AND *HELIOTHIS* DAMAGED FRUITS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT, TIPTON, OKLAHOMA, 1973

Treatment	Fleahoppers	*Heliothis* Damaged Fruits
(11)	12.46*	11.91
(12)	13.41	12.39
(13)	12.25	11.09
(21)	11.98	7.90
(22)	11.77	10.82
(23)	13.88	12.93

*Each figure is an average of 400 observations.

TABLE XXXI

AVERAGE NUMBERS IN THOUSANDS OF FLEAHOPPERS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	3.40*	17.70	11.57	11.57	13.61	11.57	9.53	14.97	19.74	10.89
(12)	6.13	8.85	13.61	22.46	11.57	7.49	16.34	10.89	19.74	17.01
(13)	2.04	8.84	21.10	16.34	10.89	10.89	9.53	15.65	14.97	12.25
(21)	1.36	10.20	18.38	21.78	7.49	5.45	9.53	8.85	25.18	11.57
(22)	2.04	14.29	17.02	12.25	13.61	10.89	7.49	16.34	12.25	11.57
(23)	2.04	9.53	14.97	20.42	22.46	9.53	13.61	16.34	17.02	12.93

*Each figure is an average of 40 observations.

TABLE XXXII

AVERAGE NUMBERS IN THOUSANDS OF HELIOTHIS DAMAGED FRUITS PER ACRE ON WESTBURN 70 BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	0.00*	0.00	0.00	0.00	0.68	4.76	17.70	39.48	44.92	11.57
(12)	0.00	0.00	0.00	0.68	2.04	0.68	12.25	52.41	34.03	21.78
(13)	0.00	0.00	0.00	0.00	4.08	1.36	19.06	64.66	16.34	5.45
(21)	0.00	0.00	0.00	0.68	0.00	1.36	12.25	33.35	13.61	17.70
(22)	0.00	0.00	0.00	0.00	1.36	0.68	23.82	39.48	31.99	10.89
(23)	0.00	0.00	0.00	0.68	1.36	2.04	21.78	45.60	49.01	8.85

*Each figure is an average of 40 observations.

TABLE XXXIII

PER CENT *HELIOTHIS* DAMAGED FRUITS ON WESTBURN 70
COTTON BY SAMPLING DATE, TIPTON,
OKLAHOMA, 1973

Sampling Date	Per Cent *Heliothis* Damaged Fruits
6 - 27	0.00
7 - 5	0.00
7 - 11	0.00
7 - 18	0.31
7 - 25	0.81
7 - 31	0.57
8 - 8	3.36
8 - 15	7.43
8 - 23	5.29
8 - 30	2.64

TABLE XXXIV

ANALYSES OF VARIANCES FOR FLEAHOPPERS AND HELIOTHIS DAMAGED FRUITS COLLECTED FROM WESTBURN 70 COTTON, TIPTON, OKLAHOMA, 1973

Source	DF	MS	
		FH	HDF
TOTAL (CORRECTED)	2399		
REP	3	4.1904	10.3311
FERT	1	0.0104	1.1267
WATER	2	0.2929	1.2829
FERT*WATER	2	0.6254	2.4204
ROW (REP FERT WATER)	24	0.7496	1.6267
ERROR A (R*F/W)	15	0.9374	2.2764
PERIOD	9	6.0474**	82.7111**
FERT*PERIOD	9	0.1252	1.1878
WATER*PERIOD	18	0.4216	1.3788
FERT*WATER*PERIOD	18	1.2958	3.5579
PERIOD*ROW (REP FERT WATER)	216	0.7653	1.1081
ERROR B (R*P*F/W)	162	0.9484	2.2186
RESIDUAL	1920	0.5342	0.7533

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE XXXV

AVERAGE NUMBERS IN THOUSANDS OF SQUARES, BLOOMS, AND BOLLS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT, TIPTON, OKLAHOMA, 1973

Treatment	Squares	Blooms	Bolls
(11)	187.10*	8.37	39.75
(12)	285.59	11.57	60.44
(13)	303.22	8.17	34.71
(21)	116.89	6.87	33.90
(22)	233.45	9.46	45.46
(23)	266.67	10.01	43.42

*Each figure is an average of 400 observations.

TABLE XXXVI

AVERAGE NUMBERS IN THOUSANDS OF SQUARES PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	0.00*	2.04	71.47	106.86	199.42	302.88	312.41	408.38	283.14	184.45
(12)	0.00	0.68	51.05	119.11	249.11	345.08	611.88	479.84	593.51	405.65
(13)	0.00	0.68	61.26	103.46	193.98	337.59	550.63	825.60	668.37	290.63
(21)	0.00	0.00	68.74	92.57	161.31	278.38	331.46	387.28	211.67	112.98
(22)	0.00	0.00	68.06	105.50	181.73	279.06	511.15	444.45	528.17	216.44
(23)	0.00	0.68	68.06	127.28	195.34	283.82	593.51	629.58	528.85	239.58

*Each figure is an average of 40 observations.

TABLE XXXVII

AVERAGE NUMBERS IN THOUSANDS OF BLOOMS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	0.00*	0.00	0.00	0.00	0.68	12.93	11.57	8.85	20.42	29.27
(12)	0.00	0.00	0.00	0.00	0.00	7.49	11.57	12.93	25.86	57.85
(13)	0.00	0.00	0.00	0.00	0.00	7.49	8.17	11.57	17.02	37.43
(21)	0.00	0.00	0.00	0.00	0.68	4.76	8.17	8.17	19.06	27.91
(22)	0.00	0.00	0.00	0.00	0.00	4.76	6.13	17.02	23.82	42.88
(23)	0.00	0.00	0.00	0.00	0.00	6.81	8.17	12.25	28.59	44.24

*Each figure is an average of 40 observations.

TABLE XXXVIII

AVERAGE NUMBERS IN THOUSANDS ON BOLLS PER ACRE ON WESTBURN 70 COTTON BY TREATMENT AND SAMPLING DATE, TIPTON, OKLAHOMA, 1973

Treatment	Sampling Date									
	6-27	7-5	7-11	7-18	7-25	7-31	8-8	8-15	8-23	8-30
(11)	0.00*	0.00	0.00	0.00	0.68	10.21	41.52	77.59	90.52	176.96
(12)	0.00	0.00	0.00	0.00	0.00	3.40	42.88	78.27	181.17	292.67
(13)	0.00	0.00	0.00	0.00	0.00	4.08	24.50	66.02	79.63	172.88
(21)	0.00	0.00	0.00	0.00	0.00	7.49	25.86	61.94	65.34	178.32
(22)	0.00	0.00	0.00	0.00	0.00	4.08	31.99	109.58	119.79	188.53
(23)	0.00	0.00	0.00	0.00	0.00	8.17	45.60	63.30	125.92	191.26

*Each figure is an average of 40 observations.

TABLE XXXIX

ANALYSES OF VARIANCES FOR SQUARES, BLOOMS, AND BOLLS COLLECTED FROM WESTBURN 70 COTTON, TIPTON, OKLAHOMA, 1973

Source	DF	MS		
		Squares	Blooms	Bolls
TOTAL (CORRECTED)	2399			
REP	3	539.1526	2.0093	2.8406
FERT	1	971.5537	0.2604	7.4817
WATER	2	3480.1667**	2.3129	73.0129**
FERT* WATER	2	42.1350	1.3379	33.2004*
ROW (REP FERT WATER)	24	61.4587	0.4988	6.8608
ERROR A (R*F/W)	15	220.8816	0.8366	7.4206
PERIOD	9	13403.5250**	56.0121**	1488.7909**
FERT* PERIOD	9	130.8991	0.3632	4.3020
WATER* PERIOD	18	684.6671**	1.4157*	22.9013**
FERT *WATER *PERIOD	18	68.3429	0.5018	16.4500**
PERIOD *ROW (REP FERT WATER)	216	46.1560	0.5645	5.5840
ERROR B (R* P* F/W)	162	100.9549	0.7086	6.3989
RESIDUAL	1920	47.9394	0.4706	4.6196

*Significant at the 0.05 level

**Significant at the 0.01 level

TABLE XL

POUNDS OF STRIPPER WESTBURN 70 COTTON HARVESTED PER PLOT AND CALCULATIONS TO CONVERT THE YIELD TO POUNDS PER ACRE, TIPTON, OKLAHOMA, 1973

Treatment	Plot No.	Lbs.	Total Lbs/Trt		Acreage	Yield[1] Lbs/Acre
(11)	4	120	600	÷	0.306	1960.78[c]
	10	130				
	18	160				
	24	190				
(12)	2	240	910	÷	0.306	2973.86[ab]
	12	220				
	13	230				
	23	220				
(13)	1	270	960	÷	0.306	3137.25[ab]
	7	220				
	15	240				
	19	230				
(21)	5	160	630	÷	0.306	2058.82[c]
	8	140				
	14	170				
	21	160				
(22)	3	180	830	÷	0.306	2712.42[b]
	9	210				
	16	220				
	20	220				
(23)	6	260	1010	÷	0.306	3300.65[a]
	11	250				
	17	250				
	22	250				

[1]Entries with any of the same letters have no significant difference (1% level of probability) measured by Duncan's new multiple range test.

TABLE XLI

ANALYSIS OF VARIANCES FOR YIELD OF WESTBURN 70 COTTON, TIPTON, OKLAHOMA, 1973

Source	DF	MS
TOTAL (CORRECTED)	23	
REP	3	372.22
FERT	1	0.00
WATER	2	17929.165**
FERT*WATER	2	612.500
ERROR	15	345.556

**Significant at the 0.01 level

TABLE XLII

CORRELATION COEFFICIENTS ADJUSTED FOR REPLICATION AND TREATMENT AMONG BENEFICIAL ARTHROPODS, FLEAHOPPERS, COTTON PRODUCTION, INSECT DAMAGE, AND YIELD ON WESTBURN 70 COTTON, TIPTON, OKLAHOMA, 1973

Variables	Fleahopper	Spider	Lacewing Eggs	Hooded Beetle	Lady Beetle	Beneficials	Square	Bloom	Boll	*Heliothis* Damaged Fruit
SPIDER	0.48									
LACEWING EGG	0.08	0.52								
HOODED BEETLE	0.08	0.31	0.35							
LADY BEETLE	0.09	0.28	0.33	0.26						
BENEFICIALS	0.45	0.84	0.59	0.61	0.54					
SQUARE	0.48	0.71	0.68	0.29	0.54	0.76				
BLOOM	-0.01	0.43	0.57	0.41	-0.07	0.50	0.53			
BOLL	0.54	0.38	0.38	0.34	0.20	0.54	0.47	0.30		
HELIOTHIS DAMAGED FRUIT	0.02	0.30	0.41	0.18	0.67	0.52	0.37	-0.07	0.05	
YIELD	-0.16	0.12	0.04	-0.13	-0.02	-0.10	0.22	0.08	-0.04	-0.31

TABLE XLIII

THE MONTHLY RAINFALL TOTALS IN INCHES OF THE YEARS 1972 AND 1973 AT SOUTHWESTERN AGRONOMY RESEARCH STATION, TIPTON, OKLAHOMA

Month	1972	1973	Norms
	(Inches)	(Inches)	(Inches)
JAN	0.02	4.13	0.86
FEB	0.23	1.17	1.78
MAR	0.25	4.06	1.35
APR	2.20	3.06	2.57
MAY	2.63	4.47	3.34
JUN	3.01	3.69	1.06
JUL	1.78	3.22	2.13
AUG	2.15	0.29	2.74
SEP	3.65	10.63	3.35
OCT	4.11	2.52	2.57
NOV	2.46	1.12	1.49
DEC	0.25	0.29	0.68
TOTAL	22.74	38.65	23.92

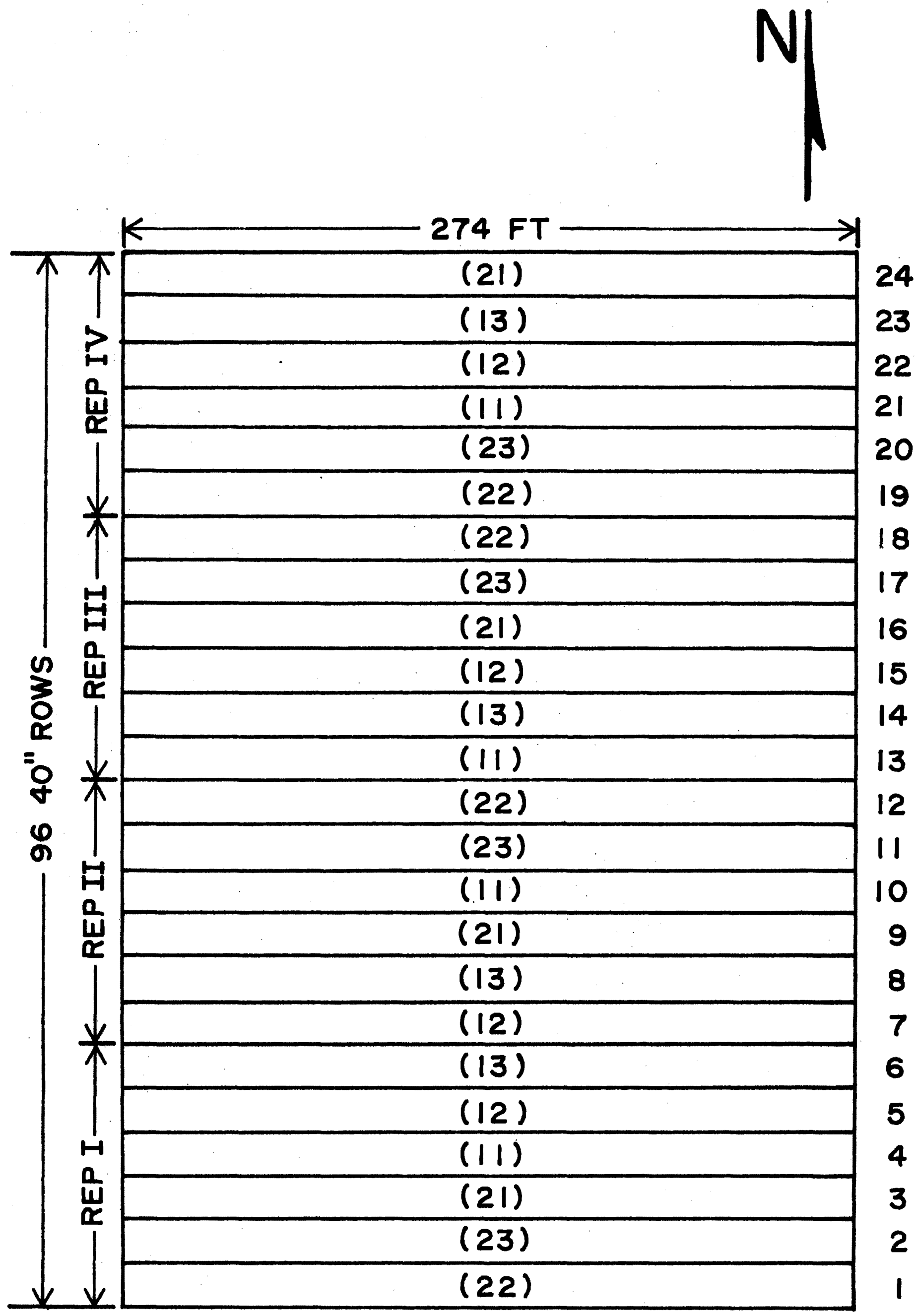
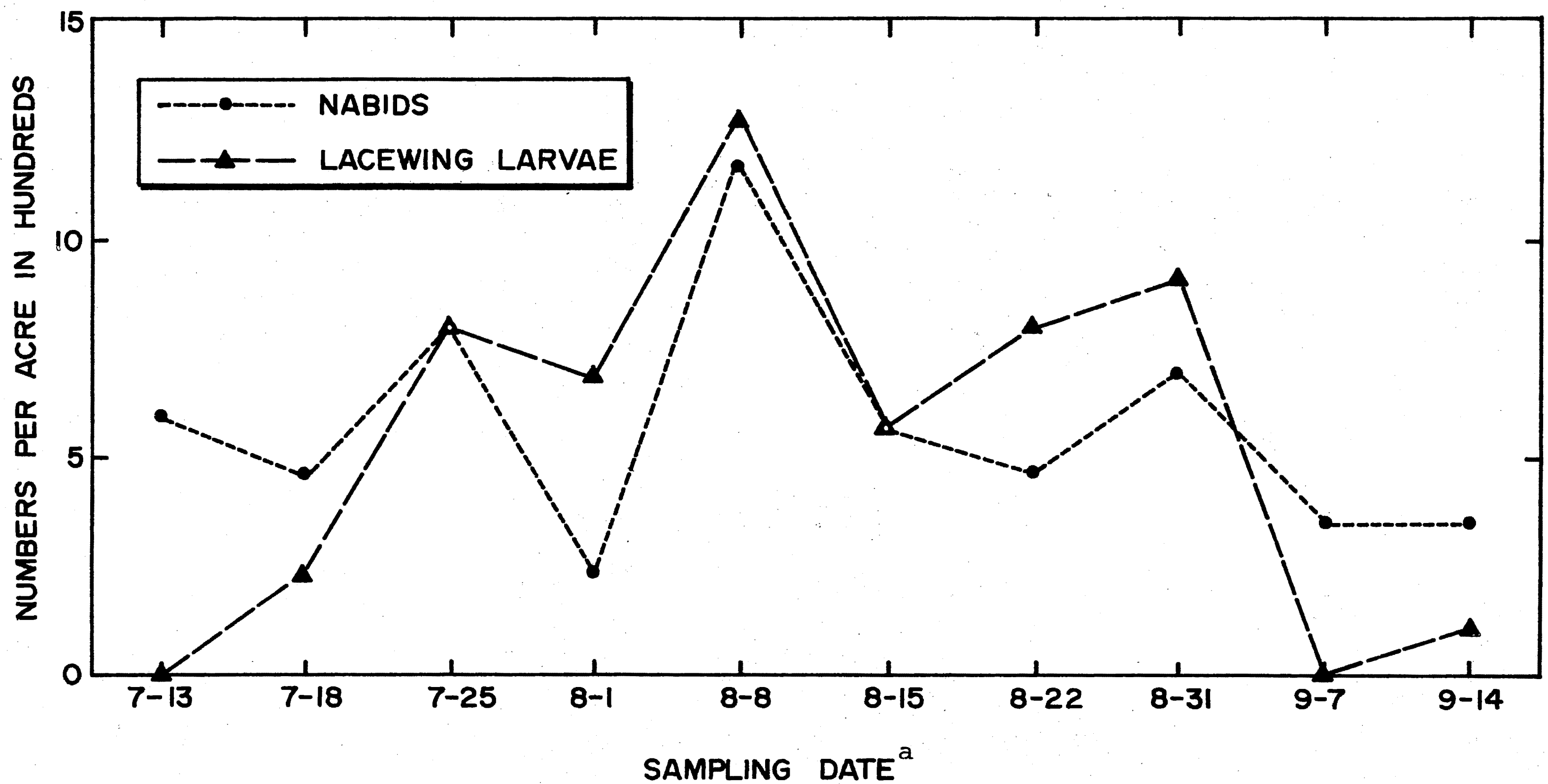
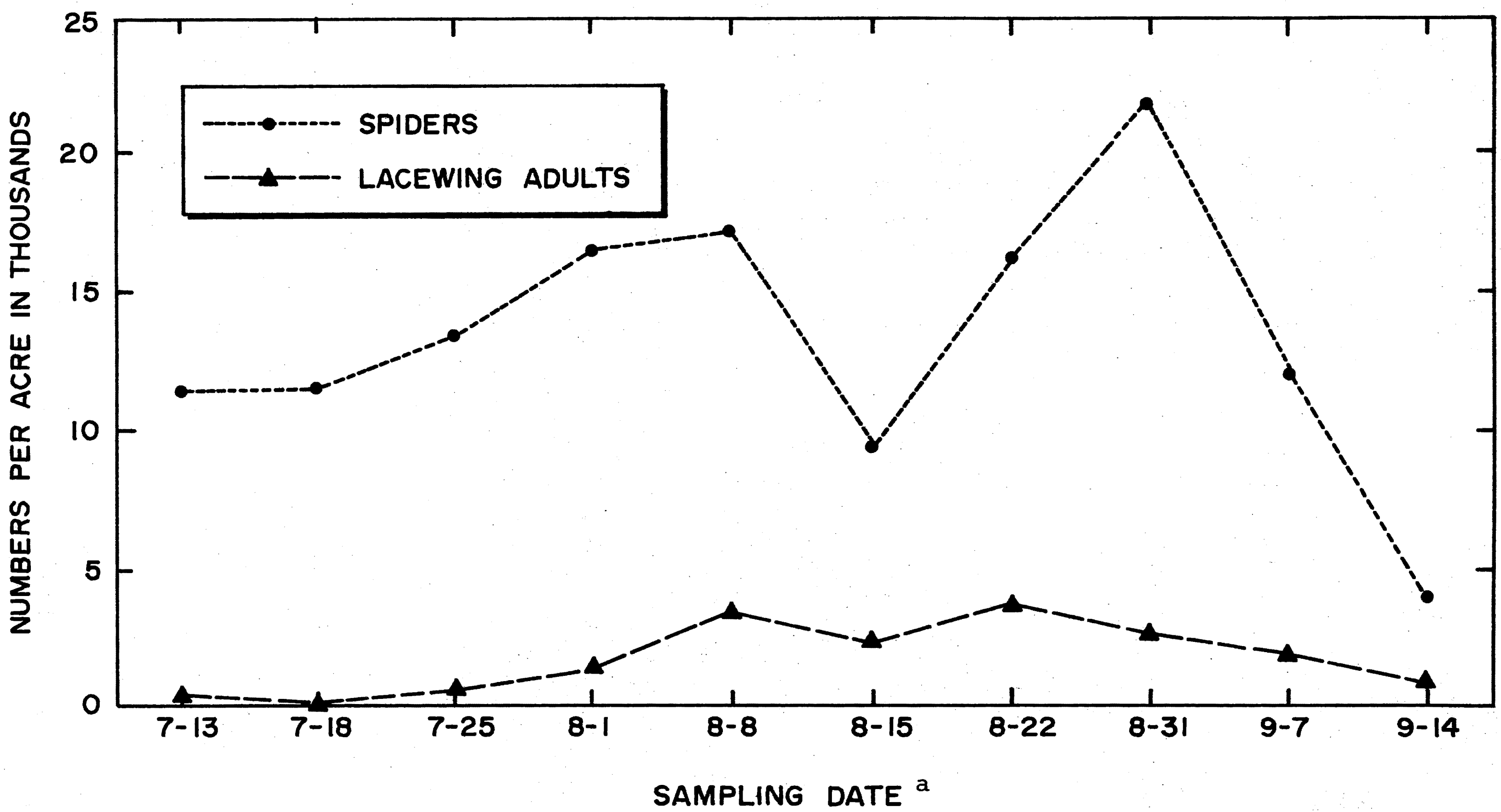


Figure 1. Field Plot Diagram, Tipton, Oklahoma, 1972



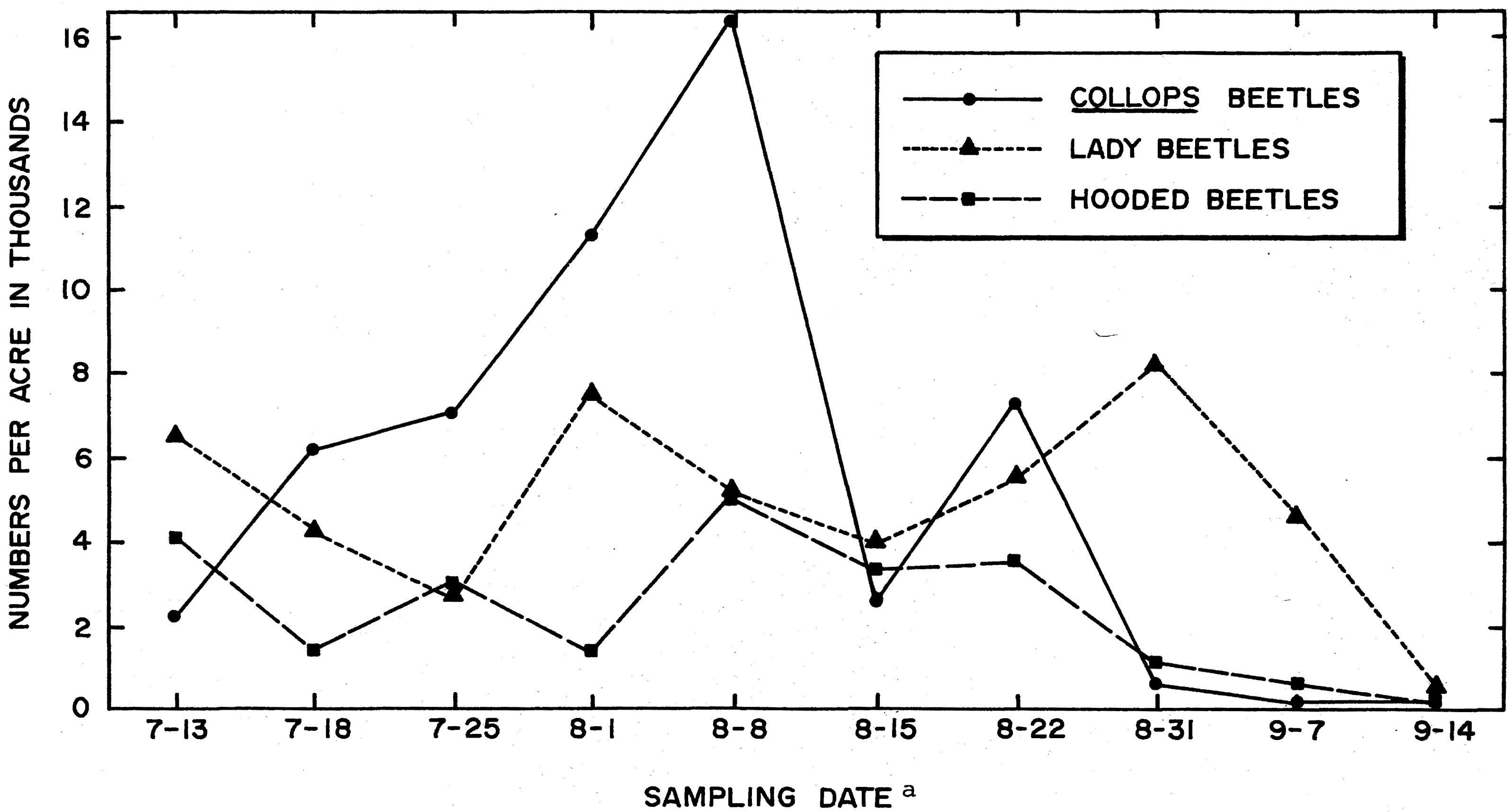
[a]Each point is based on 240 observations.

Figure 2. Average Numbers in Hundreds of Nabids and Lacewing Larvae Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972



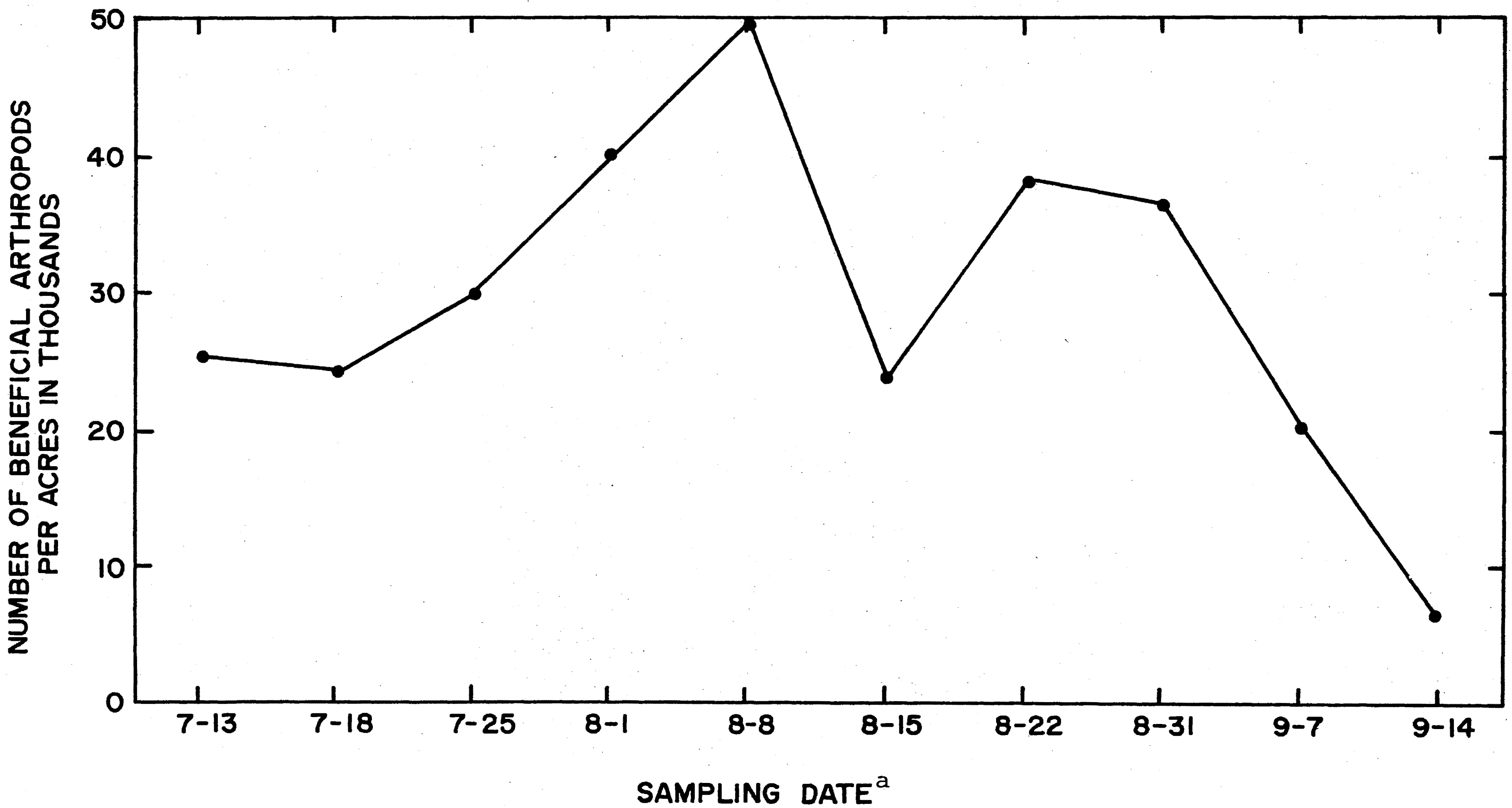
[a]Each point is based on 240 observations.

Figure 3. Average Numbers in Thousands of Spiders and Lacewing Adults Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972



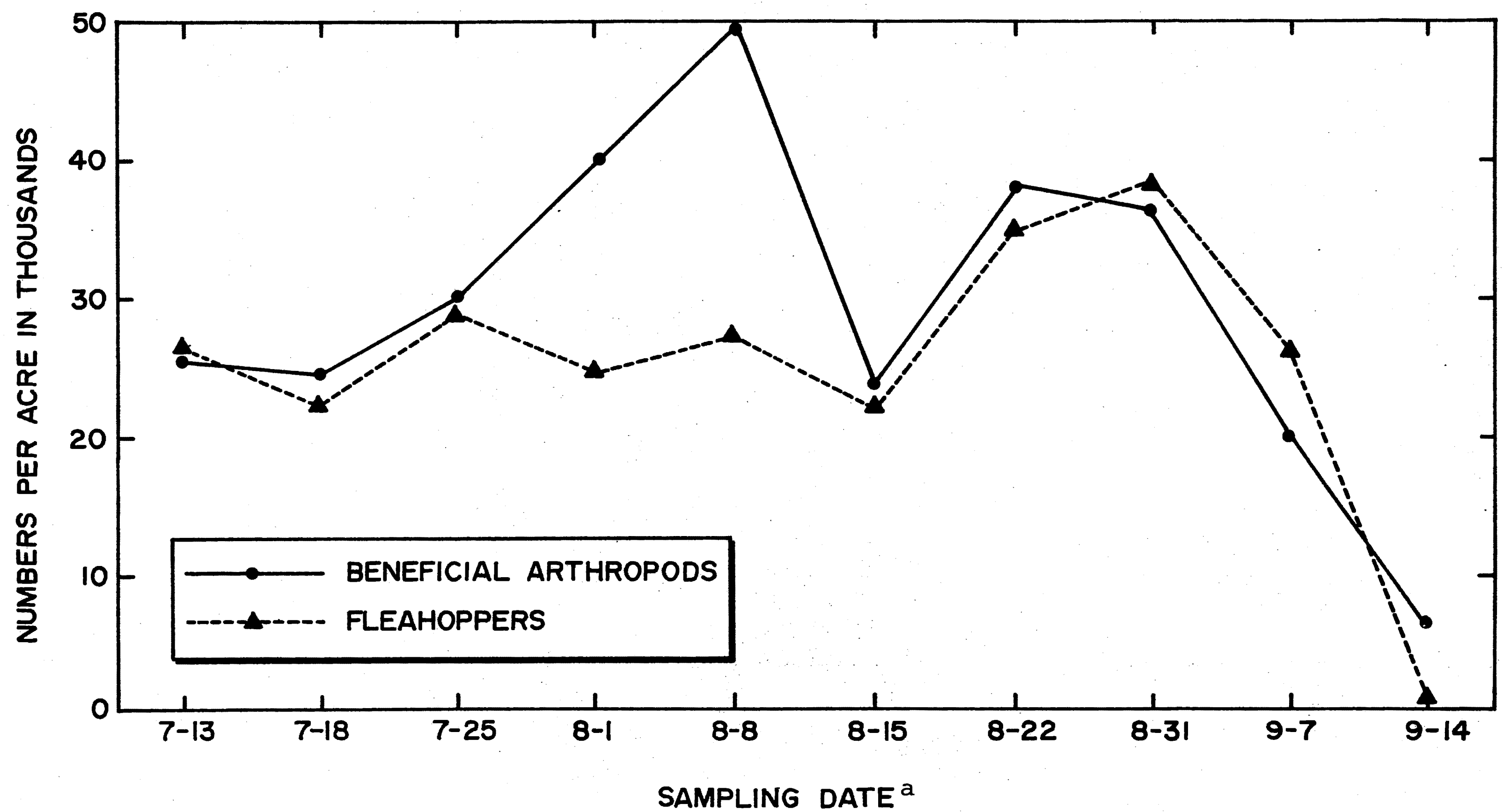
[a]Each point is based on 240 observations.

Figure 4. Average Numbers in Thousands of <u>Collops</u> Beetles, Lady Beetles, and Hooded Beetles Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972



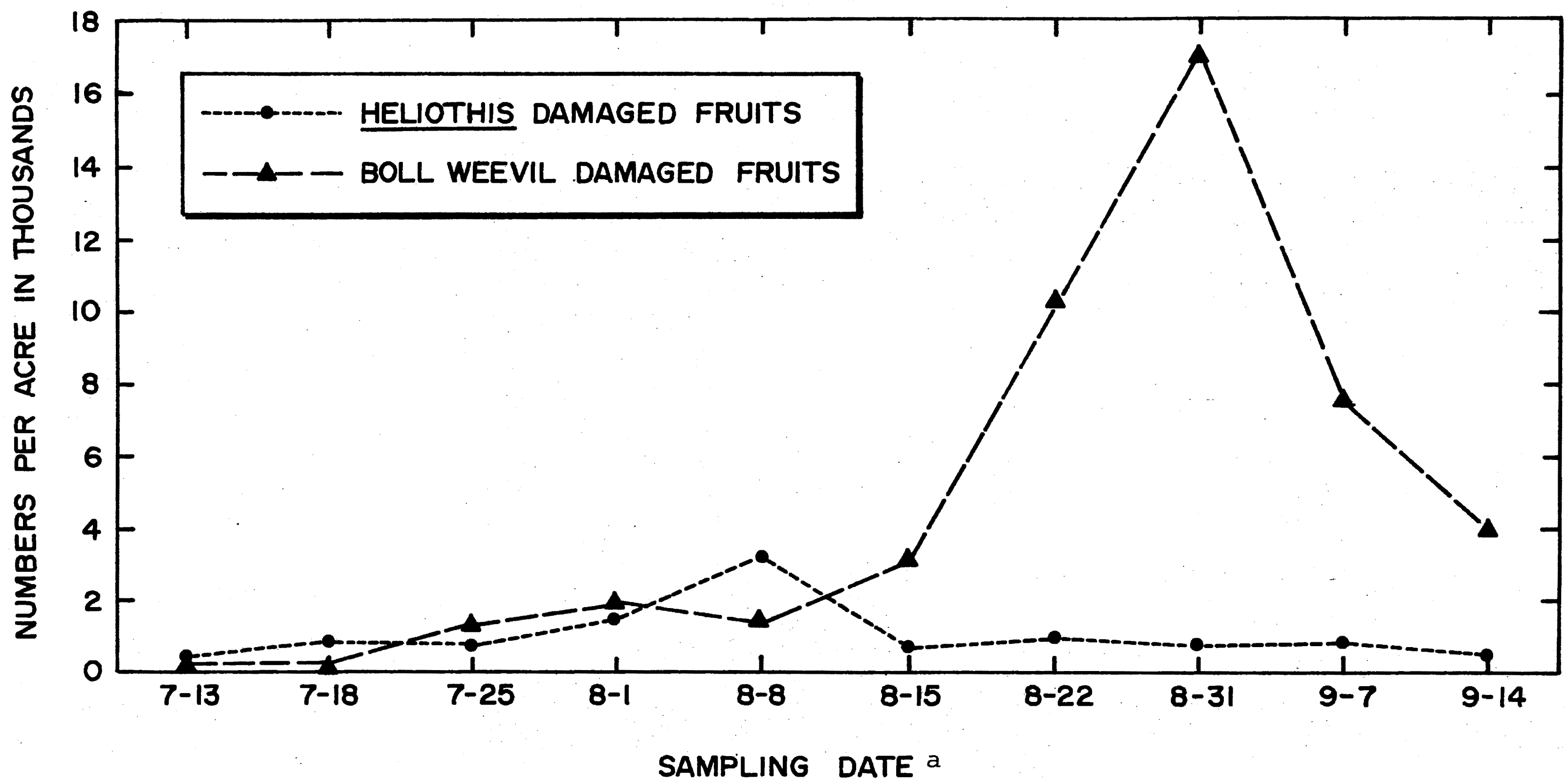
[a]Each point is based on 240 observations.

Figure 5. Total Numbers in Thousands of Beneficial Arthropods Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972



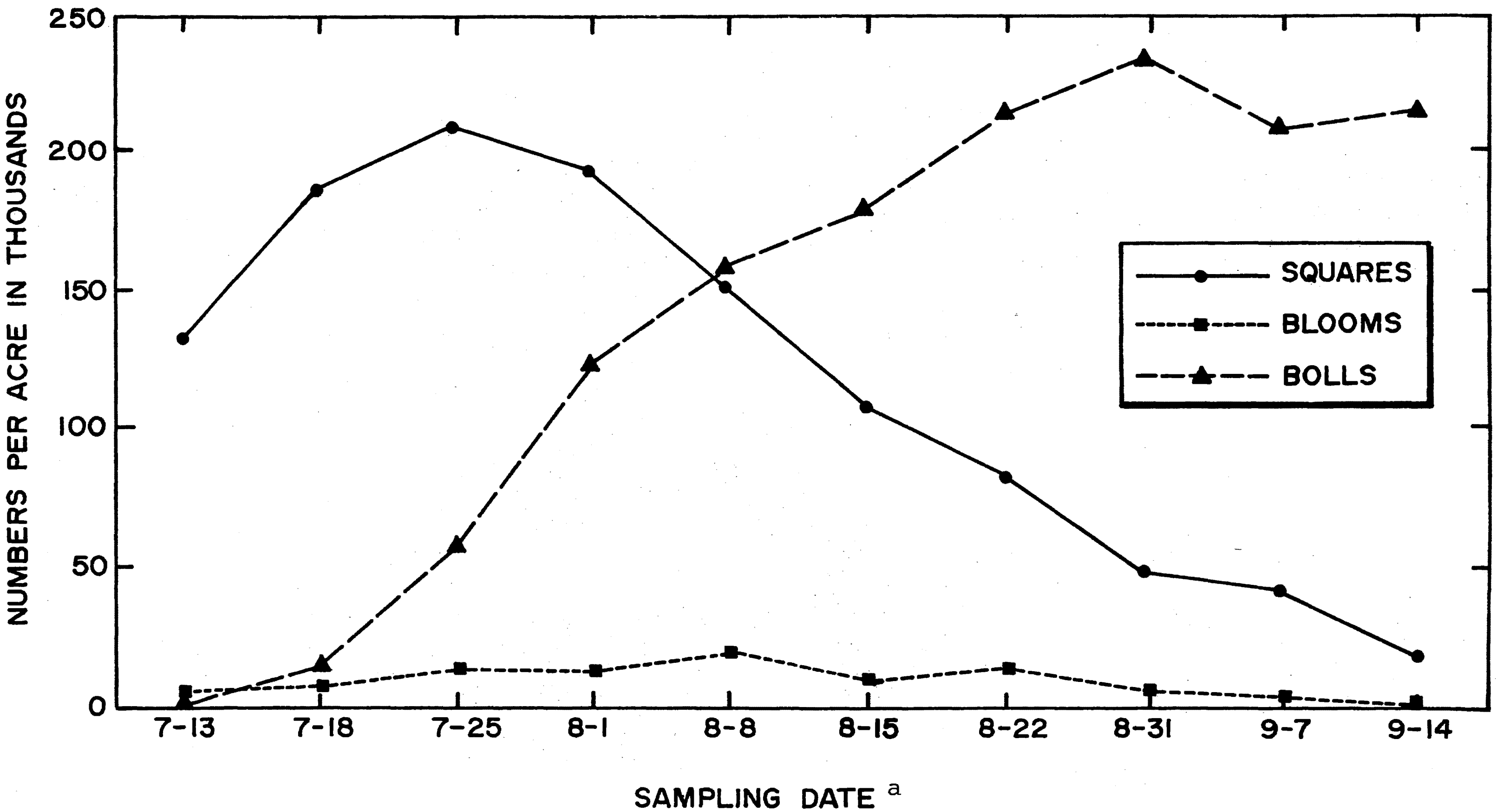
[a]Each point is based on 240 observations.

Figure 6. Comparison of the Average Numbers in Thousands of Beneficial Arthropods and Fleahoppers Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972



[a]Each point is based on 240 observations.

Figure 7. Average Numbers in Thousands of *Heliothis* Damaged Fruits and Boll Weevil Damaged Fruits Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972



[a]Each point is based on 240 observations.

Figure 8. Average Numbers in Thousands of Squares, Blooms, and Bolls Per Acre on Tamcot 788 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1972

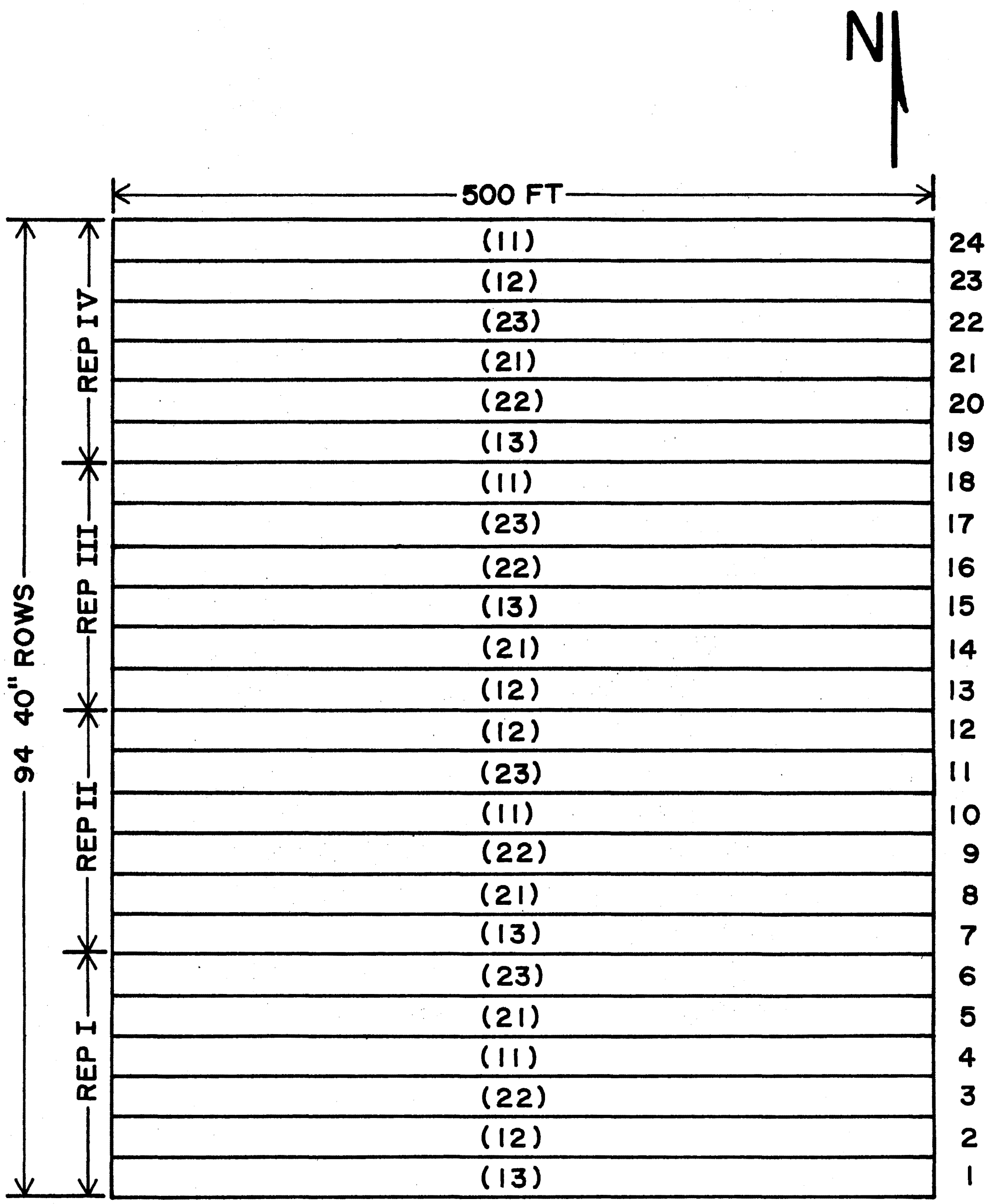
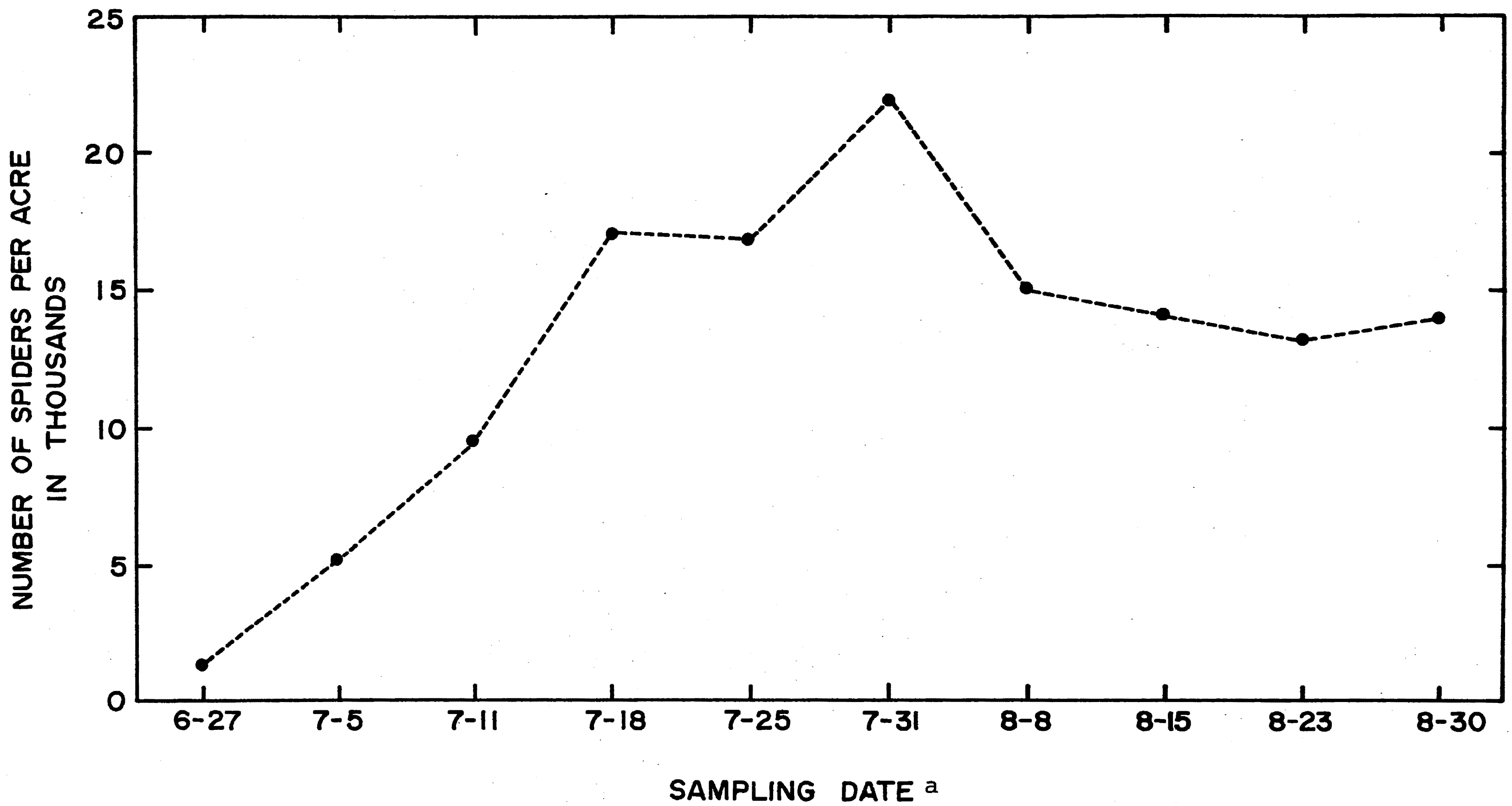
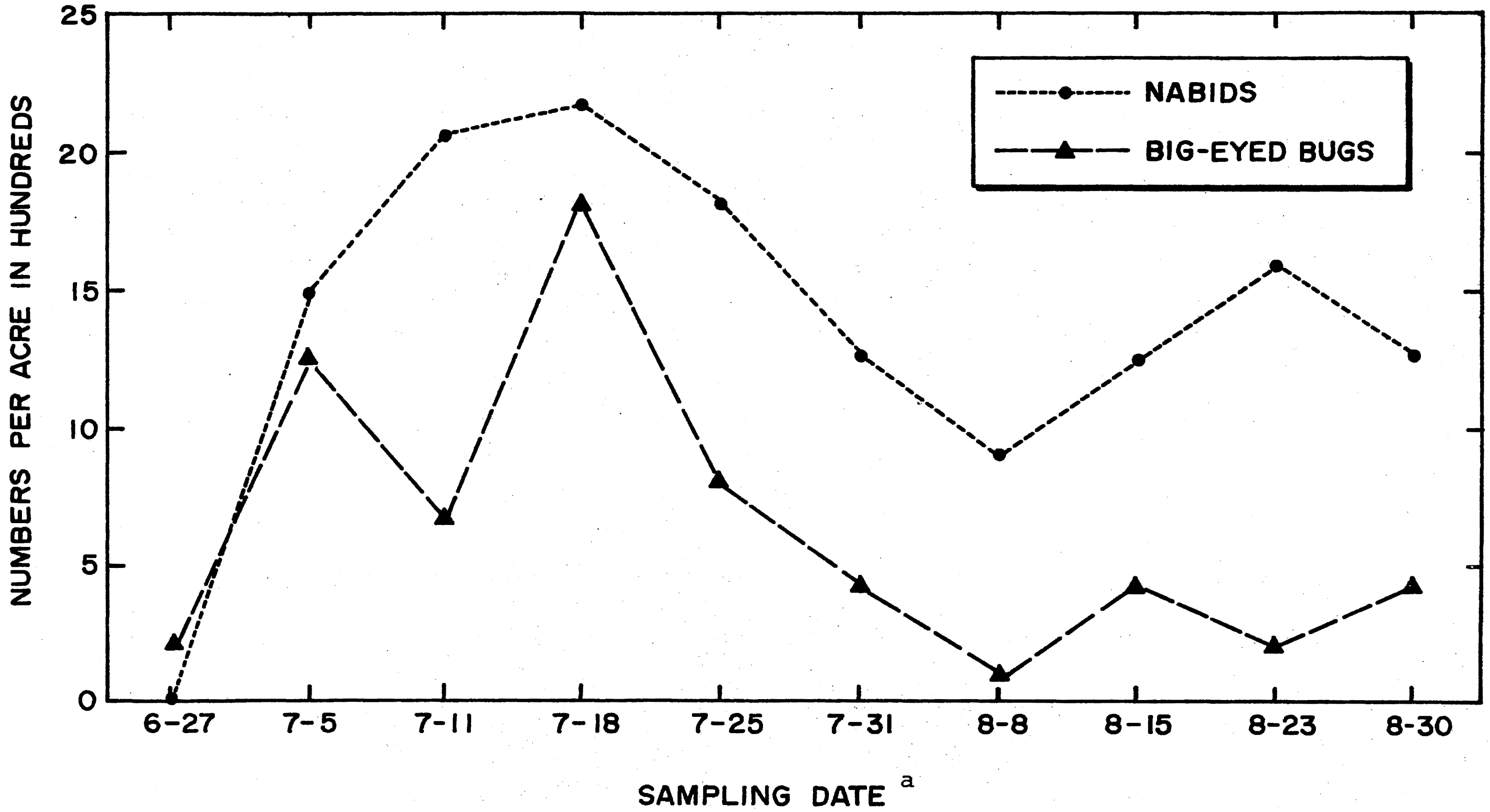


Figure 9. Field Plot Diagram, Tipton, Oklahoma, 1973



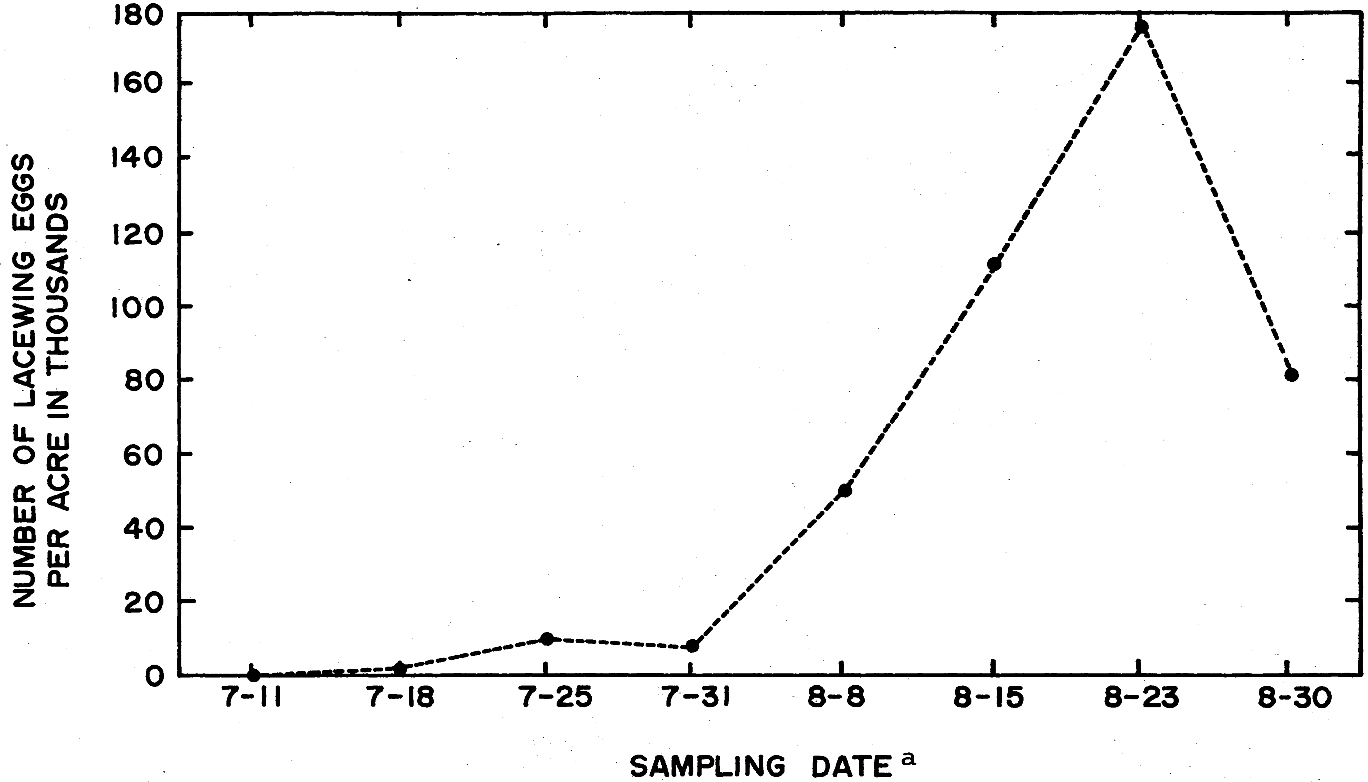
[a]Each point is based on 240 observations.

Figure 10. Average Number in Thousands of Spiders Per Acre on Westburn 70 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1973



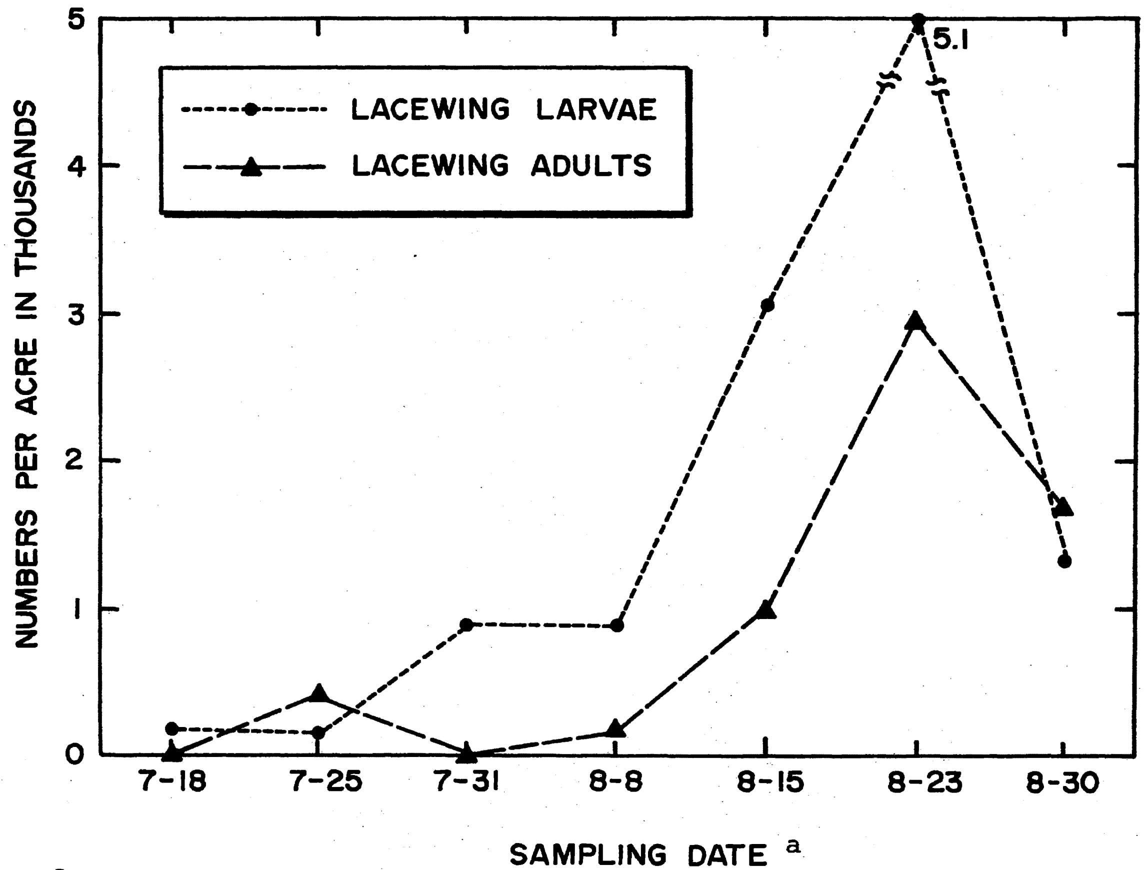
[a]Each point is based on 240 observations.

Figure 11. Average Numbers in Hundreds of Nabids and Big-Eyed Bugs Per Acre on Westburn 70 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1973



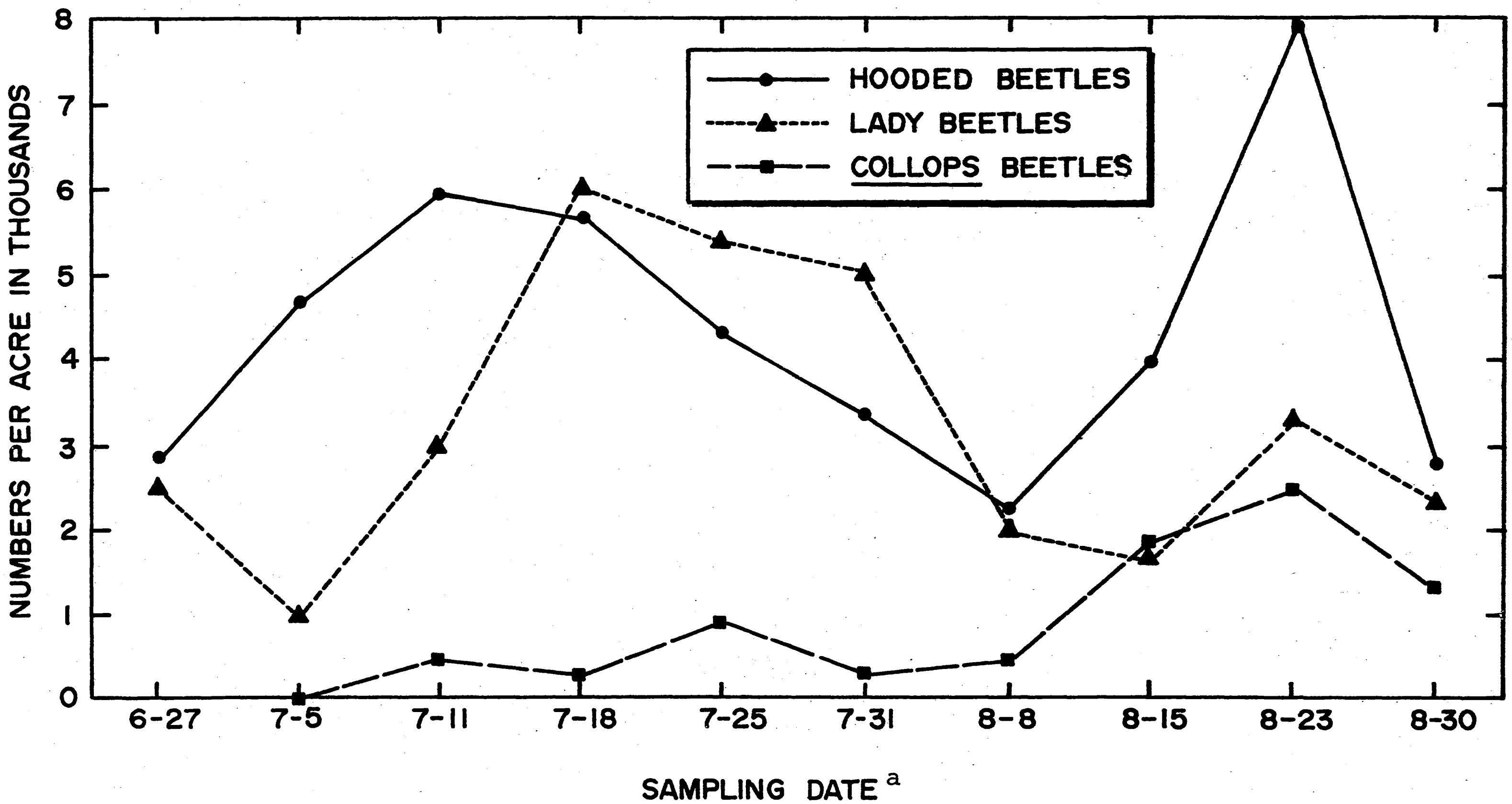
[a]Each point is based on 240 observations.

Figure 12. Average Number in Thousands of Lacewing Eggs Per Acre on Westburn 70 Cotton by Sampling Dates, Tipton, Oklahoma, 1973



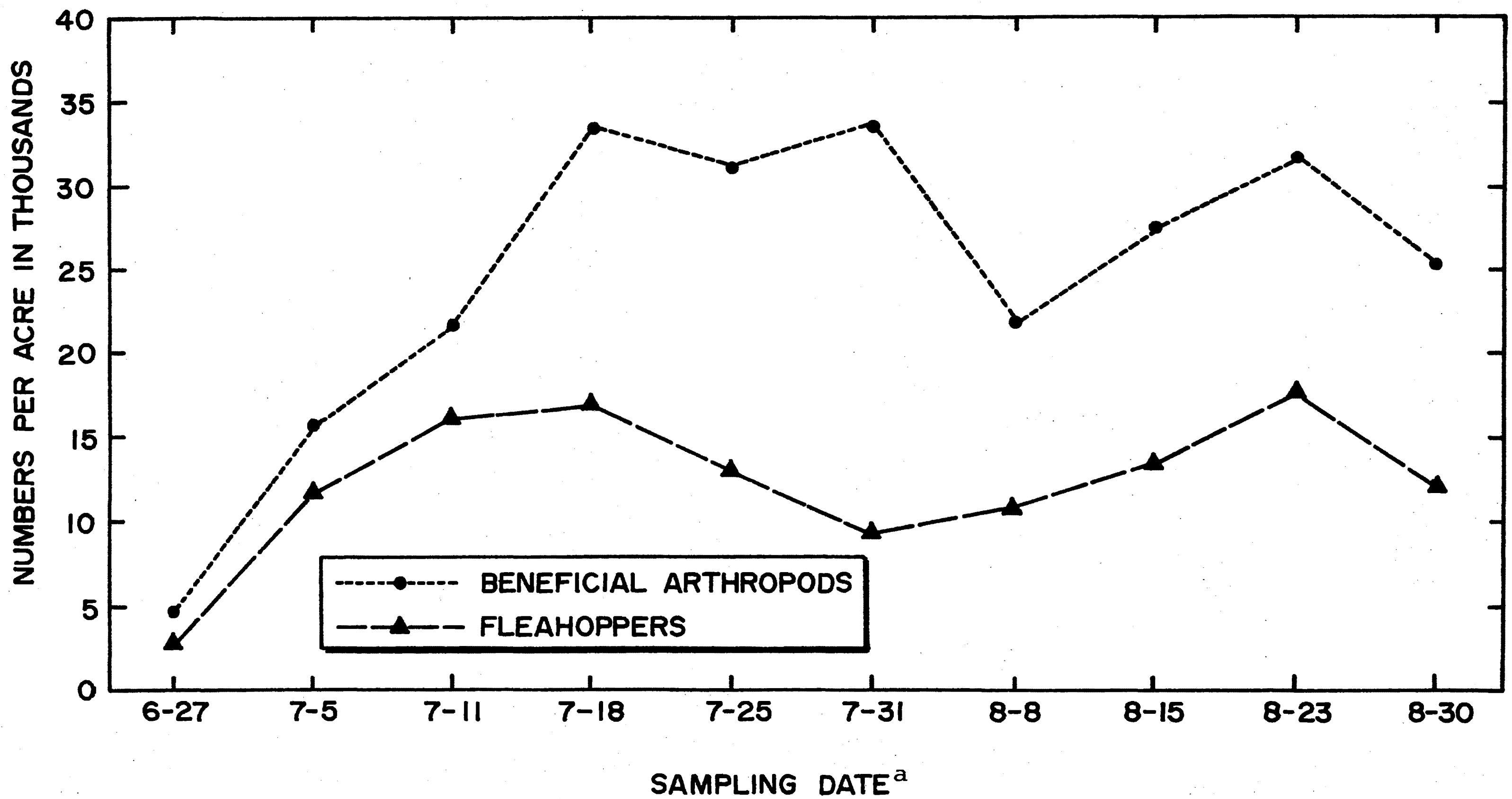
[a]Each point is based on 240 observations.

Figure 13. Average Numbers in Thousands of Lacewing Larvae and Lacewing Adults Per Acre on Westburn 70 Cotton by Sampling Dates, Tipton, Oklahoma, 1973



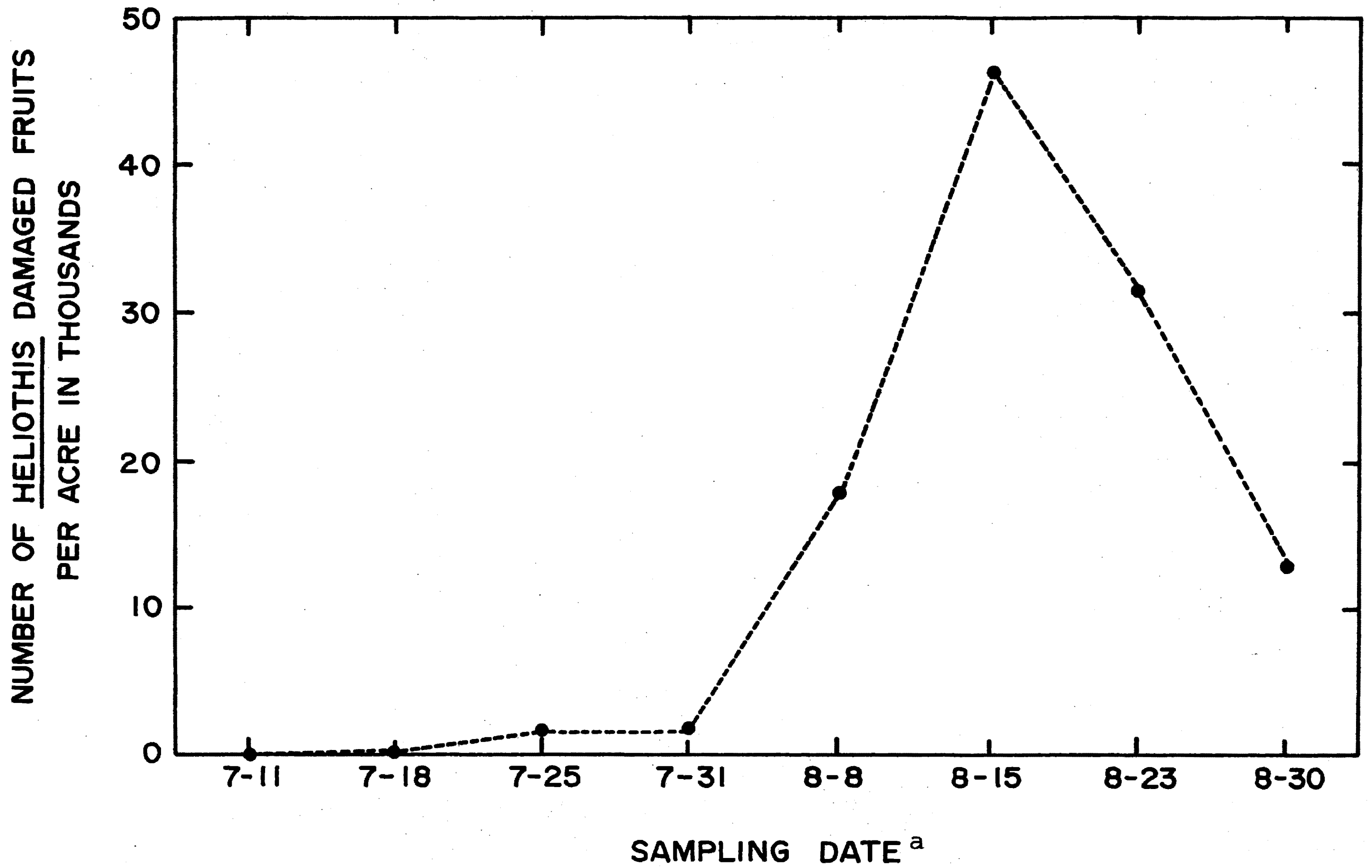
[a]Each point is based on 240 observations.

Figure 14. Average Numbers in Thousands of Hooded Beetles, Lady Beetles, and *Collops* Beetles Per Acre on Westburn 70 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1973



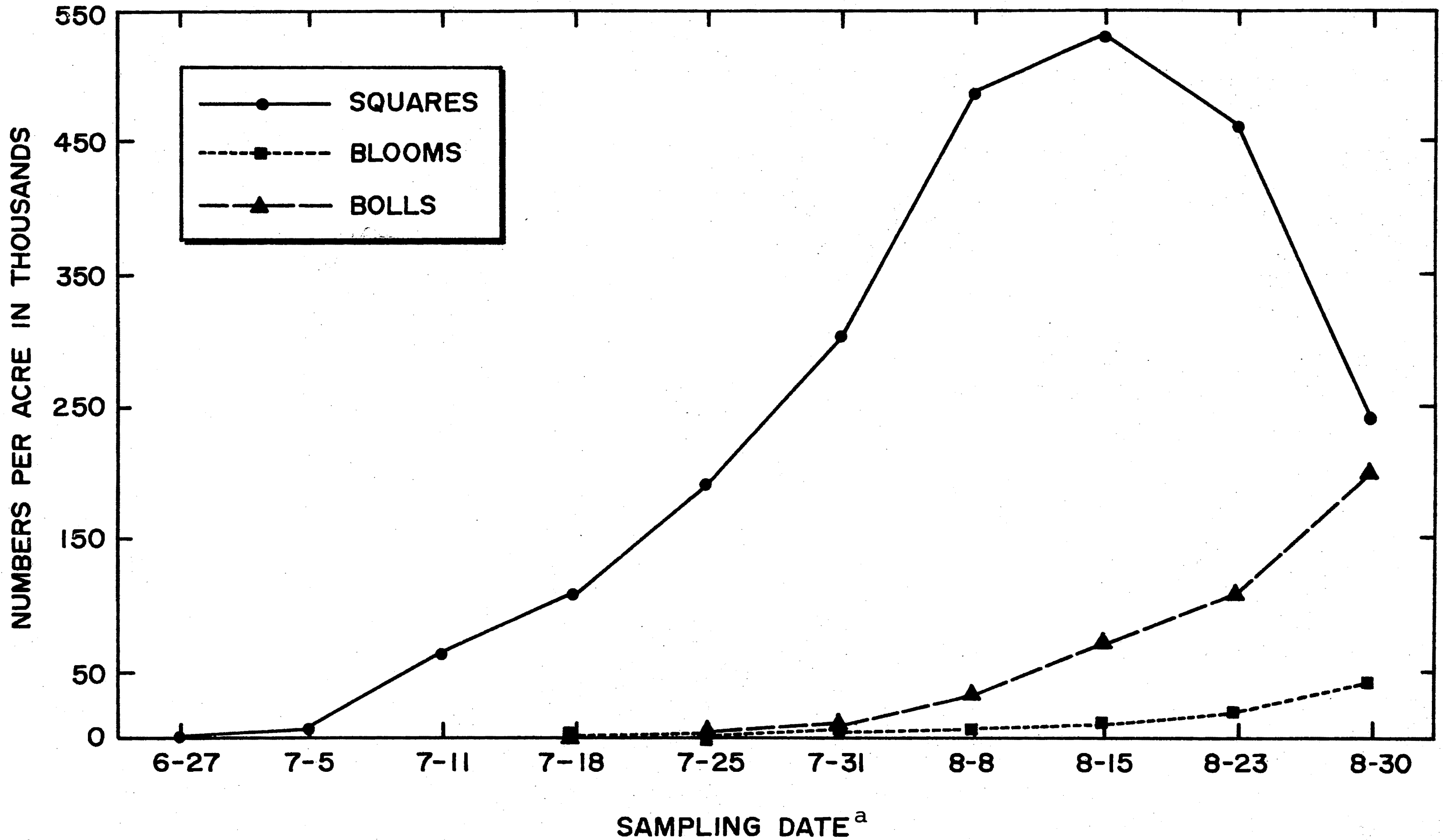
[a]Each point is based on 240 observations.

Figure 15. Comparison of the Average Numbers in Thousands of Beneficial Arthropods and Fleahoppers Per Acre on Westburn 70 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1973



[a]Each point is based on 240 observations.

Figure 16. Average Number in Thousands of Heliothis Damaged Fruits Per Acre on Westburn 70 Cotton by Sampling Dates, Tipton, Oklahoma, 1973



[a]Each point is based on 240 observations.

Figure 17. Average Numbers in Thousands of Squares, Blooms, and Bolls Per Acre on Westburn 70 Cotton on Ten Weekly Sampling Dates, Tipton, Oklahoma, 1973

VITA

Sanit Ratanabhumma

Candidate for the Degree of

Doctor of Philosophy

Thesis: EFFECTS OF DIFFERENT FERTILIZER AND WATER COMBINATIONS ON PREDATOR POPULATIONS, FLEAHOPPER POPULATION, INSECT DAMAGE, FRUIT PRODUCTION, AND YIELD OF COTTON IN OKLAHOMA

Major Field: Entomology

Biographical:

Personal Data: Born in Bangkok, Thailand, February 17, 1945, the son of Varee and Chaleo Ratanabhumma.

Education: Received the Bachelor of Science degree (Honor) from Kasetsart University, Bangkok, Thailand, in June, 1968, with a major in Entomology; received the Master of Science degree from Oklahoma State University, in July, 1972, with a major in Entomology; completed requirements for the Doctor of Philosophy degree at Oklahoma State University, in July, 1975.

Professional Experience: Employed as a Laboratory Assistant, Department of Entomology, Kasetsart University, from November, 1968 to May, 1970; Graduate Research Assistant, Department of Entomology, Oklahoma State University, 1970-1974.