

EFFECTS OF NITROGEN ON MELON APHID
REPRODUCTION AND GROWTH
INTERACTIONS ON
WATERMELON

By

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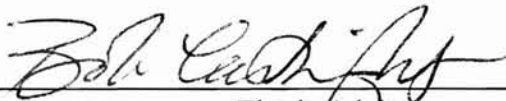
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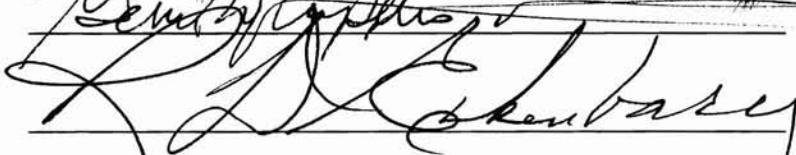
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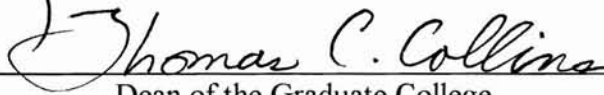


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CHAPTER I

INTRODUCTION

Melon aphids (*Aphis gossypii*) annually infest Oklahoma watermelon fields and producers make decisions to spray and minimize the pest problem. A survey indicated that melon aphids, together with squash bugs and cucumber beetles are the major problems in Oklahoma's watermelon production (Cuperus 1987). Several research studies have been conducted where insecticides were used successfully to manipulate melon aphid densities on watermelon (Cartwright 1989). Melon aphid is a key pest of cucurbits in the Southern United States and is a serious pest of melons. Its biology has been studied (Goff and Tissot, 1932; Isley, 1946), in regard to host plant resistance in *Cucumis melo* (L) (Kennedy and Kishaba 1976), (Kennedy and Kishaba 1977), but little is known of the pest's economic impact on host crops.

Insect population dynamics of insects on different crops have been attributed to soil conditions, particularly to fertility levels, but experimental evidence in support of such conditions is limited (Beckman, 1970). Results by McGarr (1942) showed that use of nitrogen fertilizer increased populations of the cotton aphid (*A. gossypii*). Although most aphid species take up food from the phloem, which contains relatively high amounts of nitrogen compared to other tissues, the development of aphids has been shown to be closely correlated with the nitrogen content of host plants. An adequate nitrogen level is essential for aphid development (Maltais, 1959; Auclair, 1963). Though the importance of

soluble nitrogen in relation to aphid growth and reproduction is well established, a complete understanding of the relationship between aphids and the physiological status of the host plant is lacking.

Soils in Southeastern Oklahoma typically require large amounts of fertilizers for a vegetable crop to have a good yield and a quality product. One of the most essential elements in fertilization is nitrogen. It is important to apply the right amount of nutrients to a vegetable crop in order to have a good yield and a quality product.

Some studies have determined that some nutrients are correlated with the population density of a pest (Scriber, 1984a; Van Emden, 1966). Indeed, some research has been done on *A. gossypii* which has led to conclusions that high applications of nitrogen induce a high population of melon aphids. A good fertilization program could be a valuable tool which would not only increase yield, but also manage pest problems.

Objectives:

The main goal of this research was to characterize the effects and interactions of melon aphid (*Aphis gossypii*) to different rates of nitrogen fertilizer applied to watermelon. A second objective was to examine how the combination of aphid-induced stress and nitrogen rates affect watermelon growth. To achieve these objectives greenhouse experiments were conducted to determine vegetative growth, aphid reproduction and longevity responses in relation to the different nitrogen rates. As part of a greenhouse experiment, a set of trials was established to calculate the interactions of aphid density and nitrogen fertilization rates on plant growth.

In order to determine the effect of varying nitrogen rates on aphid abundance and reproduction, clip cages were used to confine a single aphid. The abundance and reproduction were assessed using the following procedure:

- A.) One aphid was placed within each cage in a manner to maximize their survival. Three to five clip cages per plant were used.
- B.) Cages were checked daily and new nymphs were counted and removed.
- C.) The reproduction and longevity of aphids was determined and assessed.

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CHAPTER II

LITERATURE REVIEW

Descriptions indicate that the early American melon was the citron type and that the true watermelon came originally from Africa (Pierce 1987). The watermelon, *Citrullus lanatus* (L), is considered to be native to Africa, but there is some evidence of American origin. Early French explorers found Indians growing melons in the Mississippi Valley. Melons are also reported as having been a crop in New England in 1629 and in Florida before 1664.

Watermelon is a warm season crop. It is sensitive to frost and is most productive in areas that have a long warm growing season. It belongs to the botanical family Cucurbitaceae, which also includes cucumber, muskmelon, squash, and pumpkin (Johnson 1984). In Oklahoma the growing season for watermelons is typically from early May until mid October, and under favorable conditions watermelon growers may produce up to 15 tons per acre. An expected yield of watermelon under irrigation conditions in Oklahoma would be eight tons per acre (Motes et al. 1986). Watermelon is one of the largest vegetable commodities in Oklahoma which increases in acreage year after year. Watermelon was second in acreage as well as in total value of the reported vegetables in Oklahoma in 1988. For the same year, the total acres of watermelon production was estimated to be 9,000 acres worth \$3,600,000 (Motes 1988). Melons are grown throughout most of the state but acreage is concentrated in the central and south central areas.

Literature Review of The Melon Aphid: *Aphis gossypii*

Melon aphid, *Aphis gossypii* (Glover), is a key pest of cucurbits and cotton which is considered a minor pest of citrus and other crops. Melon aphid can damage watermelon plants, foliage and fruit. In fields heavily damaged by aphids, foliage of plants become curled and fruit is sunburned and damaged; also this aphid is capable of transmitting a virus. Furthermore, the secretions called honeydew and sooty mold often result in the melons unmarketability.

Melon aphid is an important pest of a broad range of crops. Plant resistance may play an important role in management of melon aphids. Melon aphid may attack 23 families within 64 species. Cucurbits, cotton and other vegetable crops are annually attacked (Calilung 1969, Slosser et al. 1989). When *A. gossypii* shifts to a new host, it requires a certain length of time to become adapted. Kishaba and Coudriet (1985) found that field-collected aphids from various cucurbits could adapt to a muskmelon cultivar within 6 months, this conclusion was drawn by an increase in the total number of aphids over five days. They also document an aphid adaptation to pumpkin within 6 months.

In establishing a pest management approach, it is important to make use of resistant germplasm. Plant resistance to *A. gossypii* has been documented in the Cucurbitaceae Family. Kishaba et al. (1971) reported resistance in a plant genotype that led to more detailed studies of resistance mechanisms. Haynes and Jones (1975) conducted experiments on which fecundity studies were performed with melon aphid on greenhouse cucumber. Bohn et al. (1972, 1973), Kennedy et al. (1978), Kishaba et al. (1971, 1976), McCreight et al. (1984) found and released three melon aphid resistant

cultivars. Some research has been to document some resistance to cucumber mosaic virus (CMV) transmission by the melon aphid, Lecoq et al. (1979, 1980), Pitrat and Lecoq (1980), and Kishaba et al. (1992). Nevertheless, efforts to identify resistance in *Citrullus* sp. has been limited. Plant resistance to melon aphid has been reported in various cultivars in the Cucurbitaceae. Ivanoff (1944) found that *Cucumis melo* (L) cultivars of West Indian origin were resistant to melon aphid. MacCarter and Habeck (1966) discovered two *Citrullus* lines of African origin which show resistance characteristics. Allred and Lucier (1990) stated that in the middle 1980's some progress had been made in the development of new, more productive watermelon cultivars, but little has been done regarding the susceptibility of new lines to *A. gossypii*.

Iharco and Horten (1987) reported several common names for *A. gossypii*, but only two have been accepted by the Entomological Society of America. These words of distributions may lead to a difficult task of identifying melon aphid.

Literature Review on Reproduction of *Aphis gossypii*:

Reproduction rate of the melon aphid, *A. gossypii* has been examined in terms of birth rate measured as nymphs per aphid per day and total reproductive rate. The reproduction rate integrate an interaction between both rate and survival rate. This total reproduction rate has been used in predicting life tables and making a future reproduction rate (Wilson and Bossert 1971). This reproduction rate was studied on squash *Cucurbita pepo* L. (Aldyhim Khalil 1993), and in cucumbers *Cucumis sativus* L. (Wyatt and Brown 1977). Reproduction of *A. gossypii* is mostly asexual either by alate or apterous females.

This insect shows an anholocyclic life cycle in high temperatures, but not on low temperatures which present heteroecious holocyclic life cycle (Slosser et al. 1989).

Literature review on Fertilization in Watermelon:

Commercial agriculture depends on the application of fertilizers to achieve high crop productivity. However, such fertilizers may affect not only the plant but also the pests that feed on it. These effects of plant nutrition, directly or indirectly, have been researched and studied by Van Emden et al. (1969). The indirect effects of nitrogen (N) and/or, phosphorous (P) and potassium (K) fertilizers upon plants seem to be important considerations regarding insect responses. Experiments that pinpoint specific plant responses to fertilization regarding pests at specific stages of plant growth under diverse, yet controlled conditions will contribute significantly to our understanding of insect population dynamics. A crop that is fertilized with nitrogen changes physiologically as its insect host. The impact of the effects of nitrogen fertilization upon insect populations vary greatly depending on many factors. Nevertheless, the influence of mineral nutrition on the interactions of the plant to aphid infestation have had little attention (Koritsas and Garsed 1985). Nitrogen, plays an essential role in all biological systems as a component of proteins and nucleic acids. Biochemical interactions between insects and plant chemistry will vary with the degree of stress encountered from soil nitrogen (Bartholomew and Clark 1965) and (McKey et al. 1978). In certain commodities, invasion and damage by some insects may remain largely independent to fertilization. This also suggests that in addition to the limits upon growth performance of insects, N may alter metabolites containing N and allelochemicals (Bernays 1983) and so cause differential acceptability or suitability for

certain potential pests. An extremely strong relation between digestibility and nitrogen concentration of ingested food is also observed for phloem-sucking Hemiptera and many other insects (McNeill and Southwood 1978).

Literature Review on Nutrients and Temperature on Insect Growth and

Reproduction:

Applying nitrogen itself as a fertilizer produces conflicting results concerning insect growth. Populations of insects are recorded as decreasing, increasing or showing no change (van Emden et al. 1969, Mitchell and Paul 1974).

Nitrogen either above or below a certain optimal level in a plant might be detrimental to phytophagous insects (Maxwell and Hardwood 1960). This same pattern is found with other phytophagous insects (Metcalf 1970 and Sharma 1970).

According to Court et al (1972) the concentration of N available in plant cells may go below a point at which insects can survive. Where the application of N to the soil alleviates a deficiency, it might be expected that this would increase the level of N available in soluble form in the plants and decrease the chances of phytophagous feeding on the plant. On the other hand, where the supply of N in the soil is sufficient to increase the general level of N in the plant tissue, an increase in survival and abundance of insect feeding on the plant might be expected. There is strong evidence that this is in fact the case (Archer et al. (1982), and Vince and Valiela (1981)). Increasing the level of N beyond the presumed nutritional optimum of an insect might be expected to show a diminishing rate of increase of that phytophagous insect (Archer et al 1982).

Environmental variables such as how much, when, and what form of N fertilizer was

applied, may have an impact on the abundance of insect feeding on a plant (Stewart et al 1959). Increasing and decreasing temperature has been stated to have an effect in destroying resistance in alfalfa to both the pea aphid and the spotted alfalfa aphid. This lack of resistance has been credited not with the aphids themselves, but with indirect unknown effects in the physiology of the plant (Issak et al. 1965). Isely (1946), as well as Akey and Butler (1993) both studied the effect of temperature on the reproduction rate of *A. gossypii*. They found that temperatures between 27.5°C and 28°C had an effect on *A. gossypii* maturity. At the above temperature, aphids had taken 5.0 and/or 5.18 days for maturity. Temperatures at 25°C versus 20°C showed significant differences (2.85 nymph vs 2.69 nymphs per adult per day, respectively). Llewellyn and Brown (1985) studied the aphid size as an estimated parameter to determine reproduction (birth) rate. Moursi et al. (1985) stated differences in reproduction of *A. gossypii* on watermelon, cotton, and etc. It has been found in plants of certain families that exposure to low temperatures increase tolerance to cold weather and increase the soluble nitrogen to free amino acids in their leaves (Brown and Bixby (1975), Taylor et al. (1972), Alden and Herman (1971). Low summer temperatures supports the hypothesis that cold weather may affect plants and thus increase the survival of insects by increasing the concentration of N in their diets.

Because fertilizers are a major part of modern agriculture, it is logical to question the extent to which increased crop damage due to insects in the last 25 years might be the result of heavy application of N. It seems that fertilizers seldom affect insect population dynamics directly; however, their indirect effects through changes in tolerance can affect plant resistance to insects.

In attempting to understand the role of N as it affects the population dynamics of insects, we must interpret its potential to increase or enhance individual growth rate, survival and reproduction in relation to the plant host. Atsatt and O'Dowd (1976), McClure, (1980), Southwood, (1977) reported that it may be related to their different life styles as well.

Many researchers have found that insect populations can be affected by varying the concentration of macro-nutrient elements available to their host plant. In some cases, plants susceptible to a particular species of insect apparently become resistant when grown in a medium having a deficiency or an excess of a certain element. McGarr et al. (1942) determined the relation of fertilizers to the development of the cotton aphid. He found that N in cotton plants stimulates the reproduction of *A. gossypii*. The higher N rate, the more aphids which cause serious damage to the host. A large part of the confusion in the literature regarding the effects of plant fertilization upon insect dynamics, survival, growth, and reproduction is in direct proportion to our ignorance of the effects of N fertilization on physiology of insects and the plant itself. This critical area needs further studies with respect to the biochemical dynamics involved with this key nutrient (Huber and Watson 1974), (Beevers 1976), (Rosenthal and Jansen 1979) and (Scriber and Slansky 1981).

In order for insects to grow and reproduce, success depends on its ability to efficiently or rapidly ingest and convert plant N. Certain factors affecting this process have been recently reviewed (Scriber and Slansky 1981). While it is generally assumed that increased plant N increases insect damage and populations, there is a considerable

amount of evidence that is inconclusive or indicates the reverse. A search of literature over the past few years (Scriber 1984) illustrates a minimum of 115 different studies in which insect damage, growth, reproduction or population increased with increased plant N. The importance of N in plant-insect interactions has been reviewed by McNeill and Southwood (1978) and Matson (1980). My objective is to point out how insect population growth and reproduction rates are related to N. Fertilization of plants would also affect the host selection, survival and reproduction rates of herbivore insects (Altieri and Whitcomb 1979). As an example, feeding of armyworm *Spodoptera eridania* can affect the N utilization efficiency and reproductive success of the insect in significant ways (Scriber 1981 and 1982).

Insect feeding, growth, and crop damage potential does not seem to be directly related to N fertilization application; the indirect effects upon the plant physiology can drastically affect changes in insects, the potential for invasion, and associated economic losses. Designing research to explain the general governing principles might help clarify current concepts regarding plant fertilization and insect invasion.

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CHAPTER III
REPRODUCTION RATE OF *Aphis gossypii* (Glover)
(Homoptera: Aphididae) IN RELATION
TO DIFFERENT NITROGEN LEVELS.
AMMONIUM NITRATE

INTRODUCTION

Aphis gossypii (Glover) is an important pest of melons worldwide. It attacks a diversity of crops including cucurbits and cotton crops. It also serves as a vector of several viruses economically important to cucurbits. *A. gossypii* may also result in yield losses by curling leaves and contaminating harvest products with honeydew.

Due to its significance as a major pest of cucurbits, a number of studies has been conducted to determine the reproductive potential of melon aphid, but little has been done to address the interaction of melon aphid with plant fertilization. Nitrogen fertilization has been shown to encourage aphid populations (Dixon 1987). Lack of plant N might limit crop growth more than any other macro-element (Black 1968). Lack of fertilization with this essential element may interfere with the physiology, morphology and nutritional aspects of plants and as a result it might affect insect growth, survival, and reproduction rates (Scriber 1984b). The prominence of plant N in insect reproduction has been stated by McNeill & Southwood (1978) and Mattson (1980). Scriber (1984a) found that of 179 studies 144 reported a significant correlation of plant nitrogen with aphid growth, reproduction, and fecundity. Dixon (1970) stated that aphid size shall not be ignored

since it may influence aphid fecundity. In some instances, Dixon (1970) showed that large aphids start reproduction earlier than small ones. Consequently, large aphids produce more offspring and experience less mortality in early life stages. Reduction in N application to the crop may decrease the reproduction rate of aphid population as studied in previous research on *Myzus persicae* (Van Emden 1966; Van Emden and Bashford 1969; Jansson and Smilowitz 1986). Providing a crop with the optimal amount of N required to reach good profit may help to manage this pest and reduce costs of environmental hazards associated with leaching of excess nitrates to the ground water.

To determine optimal N levels relative to melon aphid management, a set of greenhouse experiments were initiated to evaluate different rates of N on *A. gossypii* to assess aphid reproduction and development. Aphid growth is known to be linked with both total and soluble nitrogen (Klingauf 1987), and the reproductive potential of *A. gossypii* is affected by N availability and moisture in the soil; a lack of either may reduce reproduction (Isley 1946). The importance of N fertilization has also been studied by Beckham (1970), and Banerjee & Kaychaudhuri (1987). Isley (1946) found that aphids on host plants under stress lack essential nutrients. *Aphis gossypii* had a low birth rate on stressed plants, but N did have a significant decrease in offspring and reproduction. This present study was conducted to assess the outcome of N (ammonium-nitrate) on the reproduction and development of *A. gossypii* in watermelons.

MATERIALS AND METHODS

This experiment was conducted for 2 years under greenhouse conditions at the Wes Watkins Agricultural Research and Extension Station Center at Lane, OK. The

effects of N (ammonium nitrate) on nutrient availability and aphid reproduction rate (AOPC) was assessed using a randomized complete block design with four replications. Five different levels of N were used. Nitrogen treatments were spaced as follows: 0, 60, 120, 240, and 480 lbs N/Acre and were applied in the form of ammonium nitrate sidedress. Treatments were split as follow: 60 in 2/applications, 120 in 4/applications, 240 in 6/applications, and 480 in 8/applications.

Plant Production and Aphid Rearing:

Watermelon seedlings were planted and grown in a greenhouse using 25 cm diameter plastic pots. Two cultivars '*Allsweet*' and '*Jubilee*' were used to rear aphids. Plants of these two cultivars were seeded and grown in a mixture of vermiculite and peat. Each plant was potted and fertilized using soluble Peter's solution (20-20-20) with 4 g per liter of water weekly.

After plants were potted for 2-3 wks, they were transferred to a 1 m² cloth sealed cage in a greenhouse room. Once these plants were transferred, the greenhouse room was covered with a shade cloth which was used to restrict temperatures during the summer season.

Watering and Temperature Control:

A recording thermometer was used to keep temperature records and a thermostat was used to regulate temperature inside the greenhouse. To keep temperature within 26.6°C and 29.4°C was imperative to manipulate aphid colonies. In addition, a max-min thermometer was used to verify recorded temperatures.

In 1993, a greenhouse experiment gave us some factors that needed to be controlled more accurately such as temperature and moisture. By the use of shade cloth and air fans temperatures were maintained in the range of 26.6°C to 29.4°C for the experiment. Soil moisture in pots was maintained by watering pots with approximately 900-1000 ml of water every other day. Watering was done using a mini-computerized Rainmatic® 2500 electronic water timer programming system to control the flow of water. The system was programmed to deliver the prescribed in two minutes with constant pressure. To connect the system the following materials were used: emitters, PVC pipe for headers, small diameter tubing to connect emitters to PVC pipes, and connectors. Emitters were placed in each pot close to each plant which ensured proper delivery of the water to a single pot. Flow rates of water were regulated so that fertilizer was not leached from the pot. Clip cages (10 mm diam) were used to confine aphids individually. Five cages were attached to each plant. The number of *A. gossypii* nymphs per clip cage were counted, recorded, and removed daily. At least twenty aphids per nitrogen treatment were monitored daily for nymph production. A single aphid (<2 d old) was placed inside each clip cage and a piece of cotton was used to secure the aphid in place. Dead adults were removed and replaced as needed.

Data were analyzed using Microsoft Excel and SAS. Excel was used as a database which was infilled into SAS. Calculations were made in SAS using procedure ANOVA for analysis of variance and Least Significance Difference (LSD) was used to separate treatment means together with the General Linear Model (GLM). The reproduction rate

of aphids exposed to each N treatment was calculated by linear regression model using SAS (SAS Institute 1990).

RESULTS AND CONCLUSIONS

The results of these experiments did not show dramatic differences between aphid reproduction on different levels of nitrogen. The melon aphid reproduction growth rate on watermelon plants slightly increased linearly within increasing levels of N fertilization.

To determine if any differences in survival days (S Days) and offspring (AOPC) were attributable to nitrogen rate (N Rate), regression lines were fitted for each data set using the model given below:

$$Y = B_0 + B_1 X;$$

Where;

Y= Survival days or AOPC

X= Nitrogen rate (N Rate)

Reproduction (AOPC):

The estimated parameters for the model were $\hat{Y} = 0.002(\text{Nrate}) + 3.00$ (Fig. 1) for 1993, $\hat{Y} = 0.002(\text{Nrate}) + 2.86$ (Fig. 4) for 1994.

The level of N applied had hardly any influence on reproduction of *A. gossypii*. Few differences were found among N treatments in the numbers of nymphs per life cycle during the life stage. Cumulative mean numbers of nymphs were similar among N treatments. Regardless, more nymphs of *Aphis gossypii* were found in the higher nitrogen rates than the lower rates throughout the entire experiment. These differences in means were not significant at $\alpha 0.05$ level in 1993 (Table. 1) but were in 1994 (Table. 2). Aphid reproduction growth (AOPC) was slightly higher at nitrogen treatment 480 kg/ha N than in the other N levels, so that the amount of soluble N in plants is believed to be critical for

aphid development (van Emden 1966). According to Harrewijn's (1970) findings high levels of soluble N increased reproduction of aphids on potato plants. We did not measure total and soluble N contents in the watermelon leaves in our experiment and could not determine if the larger watermelon created more favorable conditions for aphids or if the aphid reproduction rates were directly related to the availability of increased N in the plant sap. The study showed that increase in aphid population was directly related to increase in N fertilizer dosage.

In general, trends in the data showed more nymphs with higher treatment levels of N but they were not significantly different from the lower levels of N. Nevertheless, more offspring were found as the N was increased, but these differences were quite small and did not show significance at $\alpha = 0.05$. Offspring (AOPC) was regressed in relation to N and a conclusion could be drawn that N had little effect on *A. gossypii* (Fig 1). Aphid reproduction rate was influenced significantly in 1994 (Table. 2), but was not influenced significantly in 1993 (Table. 1).

Survival days (Sdays):

The estimated parameters for the model were $\check{Y} = 0.002(\text{Nrate}) + 7.19$ (Fig. 2) for 1993 data, $\check{Y} = 0.003(\text{Nrate}) + 7.02$ (Fig. 3) for 1994 data. The level of N applied had hardly any influence on survival days (Sdays) reproduction of *A. gossypii*. The differences in means were not significant at $\alpha 0.05$ level. In conclusion survival days were not influenced by increased N rate (Tables. 1 and 2). Survival days was regressed against N rates. The potential survival of *A. gossypii* was slightly correlated with nitrogen applications (Fig. 2) and (Fig. 3). Results from this research were not as dramatic as has

been observed in some studies (e.g. Scriber 1984a) involving the influence of N on insect population dynamics.

Certain hypothesis can be used to explain my findings. First, it is possible that some entities in the high nitrogen rates have grown faster and emigrated to the adjacent part of the leaf or to another part of the plant outside the clip cage before samples were taken. This would affect the aphid reproduction rate in the high nitrogen treatments. In spite of that, it seems that nitrogen supplied to watermelon influenced the plant nutrition more than that of the aphids. These studies have provided variable conclusions about the effects of N on aphid reproduction. Most experiments demonstrated that N can play an important role in increasing aphid reproduction rate. It is important to mention that my findings were subject to environmental factors such as temperature and moisture which interfere with the mobility and assimilation of N of plants (Beevers 1976).

More research should be done regarding the effects of nitrogen interactions, nutrition, and assimilation of nitrogen in watermelon, as well as their aside effects on nutritional impact on *A. gossypii*.

Melon Aphid Nitrogen Response 1993

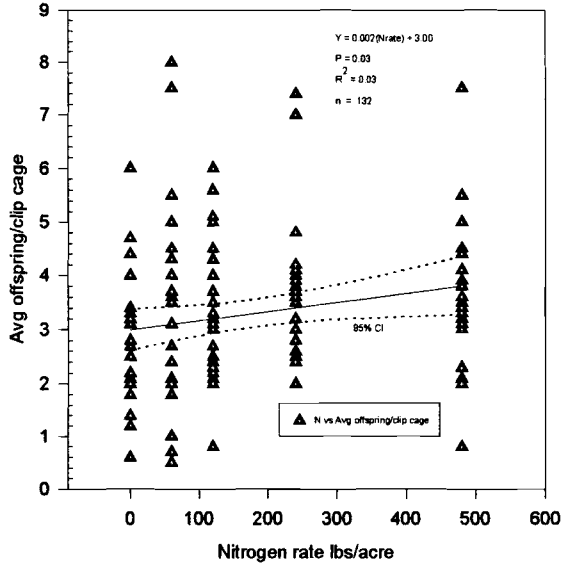


Fig. 1. Relationship between melon aphid reproduction (offspring) and nitrogen rate

Melon Aphid Nitrogen Response 1993

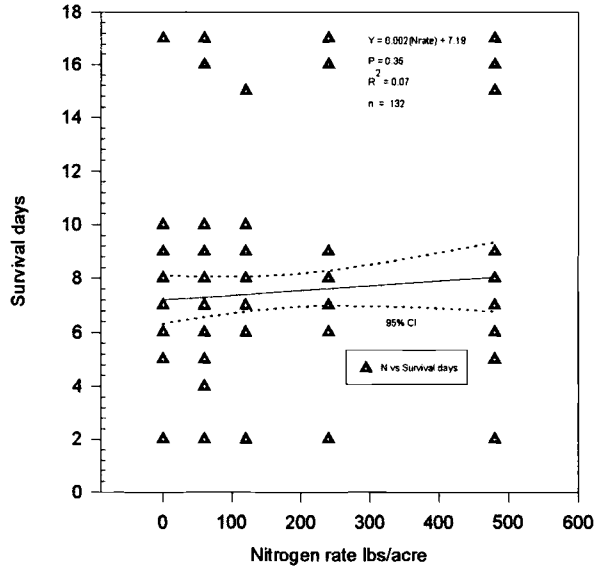


Fig. 2. Relationship between survival days and nitrogen rate

Melon Aphid Nitrogen Response 1994

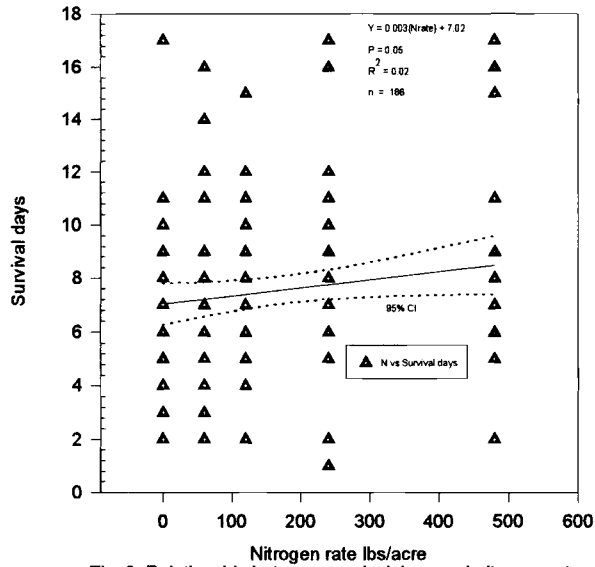


Fig. 3. Relationship between survival days and nitrogen rate

Melon Aphid Nitrogen Response 1994

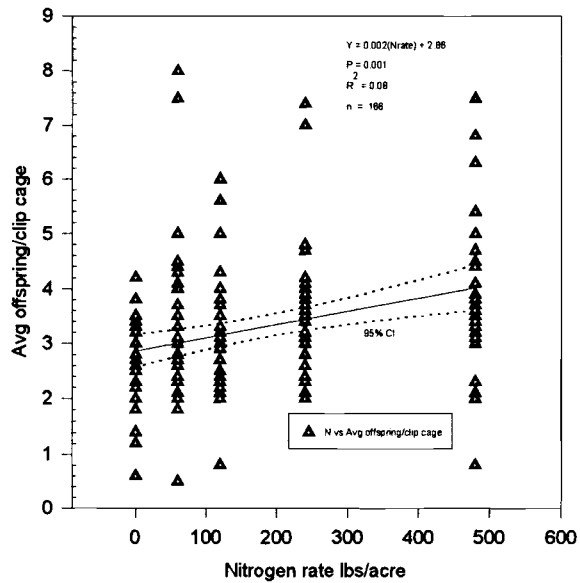


Fig. 4. Relationship between melon aphid reproduction (offspring) and nitrogen rate

Table 1. ANOVA for the survival days and average of offspring per clip cage on watermelon 1993

Source of variance	df	F Value		Pr > F	
		Sdays ¹	AOPC ²	Sdays ¹	AOPC ²
Rep	3	7.98	0.73	0.0034 *	0.5549 NS
Nrate	4	2.27	2.36	0.1224 NS	0.1119 NS
Rep*Nrate**	12				

NS Not significantly different at $\alpha = 0.05$ Level.

* Significantly different at $\alpha = 0.05$ Level

** Rep*Nrate used as error term for rep and for Nrate

Sdays¹ = Survival days

AOPC² = Average offspring per clip cage

Table 2. ANOVA for the survival days and average of offspring per clip cage on watermelon 1994

Source of variance	df	F Value		Pr > F	
		Sdays ¹	AOPC ²	Sdays ¹	AOPC ²
Rep	3	3.12	0.49	0.0661 NS	0.6989 NS
Nrate	4	1.60	13.97	0.2363 NS	0.0002 *
Rep*Nrate**	12				

NS Not significantly different at $\alpha = 0.05$ Level.

* Significantly different at $\alpha = 0.05$ Level

** Rep*Nrate used as error term for rep and for Nrate

Sdays¹ = Survival days

AOPC² = Average offspring per clip cage

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CHAPTER IV

EFFECTS OF NITROGEN AND MELON APHIDS ON WATERMELON PLANT GROWTH

INTRODUCTION

The melon aphid, *A. gossypii* (Glover) is a potential pest of cucurbits in the Southern United States and is a key pest of watermelons. Heavy infestations of *A. gossypii* on watermelon plants leads to chlorotic and curling leaves and decreased yields (Cartwright 1992). Its biology has been stated on several hosts (Goff and Tissot 1932, Isley 1946). *A. gossypii* induces plant stress through feeding injury to host phloem tissue. Consequently it reduces levels of photosynthate available for plant growth. Wood et al. (1985) reported that pecan aphids reduced the chlorophyll content of pecan leaves. Since aphids are phloem feeders, aphids have been stated to increase with increasing levels of foliar N (Van Emden and Bashford 1969). Little research has been done on the effects of soil nutrient fertility on *A. gossypii*, though studies by Beckham (1970) and McGarr (1942, 1943) have indicated that increasing N level induced a greater *A. gossypii* reproduction rate on cotton. Varn (1987) found that aphids in apple leaves may reduce the chlorophyll content of apple leaves.

A. gossypii is a stress inducing insect in Oklahoma watermelon production. Plant stress caused by this pest may decrease watermelon foliage. In watermelon fields heavily infested with this aphid, vine growth, chlorophyll content of leaves, number of leaves per plant and N content may be affected. The nutritional state of the host plant photosynthetic

activity has been studied by DeJong (1983) and Syvertsen (1987). Some studies have proved that fertilization of host plants affects population dynamics of aphids. An increase in nitrogen application has been stated to build up aphids in *Brevicoryne brassicae* L. on Brussels sprouts (Koritsas and Garsed 1985), on cabbage (Van Emden 1966), *Myzus persicae* on sugar beet (Markkula and Tiittanen 1969), and *Ripaphis erysimi* (Davis) on mustard (Rawat et al. 1968).

The effects of *A. gossypii* and ammonium nitrate as a source of N on plant vegetative growth have not been studied. The purpose of this study was to determine the complex influence of *A. gossypii* with N (ammonium nitrate) on various parameters of plant growth in Southeastern Oklahoma in greenhouse conditions.

MATERIALS AND METHODS

These studies were conducted under greenhouse conditions in both 1993 and 1994 at the Wes Watkins Agricultural Research and Extension Center in Lane, Oklahoma. Watermelon seedlings of '*Allsweet*' were transplanted into 30.48 cm diameter pots on July 10, 1993 and on August 13, 1994. Soil samples were taken from each pot in 1993 and 1994 to be analyzed for pH, N, P, and K availability. These soil samples were analyzed by the Soil, Water, and Forage Analytical Laboratory of Oklahoma State University, Stillwater, Oklahoma. Soil each year was classified as sandy loam. In 1993 it contained 160 pounds of P, 111 pounds of K and 2 pounds of N per acre with a pH 6.0 and a buffer index of 7.3. In 1994, results were 43 pounds of P, 111 pounds of K, and 2 pounds of N per acre with a pH of 5.6 and a buffer index of 7.2. This soil was used to provide an extremely low amount of N, so that responses to applied N could be obtained by both plants and aphids.

The effects of N (ammonium nitrate) on nutrient availability and watermelon growth were assessed using a randomized complete block design with three replications. Five different levels of N were used with two aphid densities (0 as low and 20 aphids per plant as high). Nitrogen treatments were equally spaced as follows: 0, 60, 120, 240, and 480 lbs N/Acre and were applied in the form of ammonium nitrate sidedress. Every pot was sprayed weekly with a rotation of chlorothalonil (Bravo) and Dithane to control foliar diseases.

Aphid populations, leaf area, number of leaves, vine length, and chlorophyll estimates were taken daily during the entire experiment. Aphid counts were made on the

whole plant. Winged and non-winged aphids were counted from the bottom to the top of the plant. Leaf area was calculated with a method developed by King and Cartwright, (1990), using leaf length and width to obtain an index of area. $Area = 2.577 + 0.6785X$, where X is equal to the product of width in cm and length in cm at the widest point. Vine length was measured in inches. Number of leaves per plant were counted daily as well. Chlorophyll concentration was estimated with a portable chlorophyll meter (SPAD 501) (Minolta Corp., Ramsey, NJ) for a rapid and nondestructive estimate of leaf greenness as an index of leaf chlorophyll. Three measurements were made on each leaf, then the three values were averaged. These readings were taken after the aphid infestation took place until the end of the experiment.

These sampling techniques for different measurements throughout the entire experiment were employed as uniformly as possible. Data were taken by the same individuals and an efficient routine was established. These sampling techniques were used in both 1993 and 1994. M-PEDE® was applied to foliage at the rate of 120 ml/pot for thrips control. At the beginning of the experiment imidacloprid was used as a soil drench in each pot to insure plants were free of thrips and aphids. Plants were infested with aphids between 1st and 2nd week after being transplanted. This window of time was given so as to not stress the watermelon plants, and let them become established in the pot. Watermelon plants were infested with 20 aphids per plant (high treatment) or 0 aphids as (low treatment) a control.

RESULTS AND CONCLUSIONS

Nitrogen treatment influences were similar in both seasons; therefore, all data were analyzed using the same procedures. Means of each N rate was input in Excel and analyzed in SAS for separated years. Nitrogen affected watermelon vegetative growth (Table 3 and Table 4). All levels of nitrogen consistently increased growth. The effects of varying levels of N with two levels of aphids were measured on watermelon growth responses such as chlorophyll, number of leaves, vine length and leaf area. The N rate was significant in a linear manner. The main effect of aphids was significantly different for vine length response in 1993, but was not significantly different for chlorophyll, number of leaves and leaf area (Table. 3). Plants receiving low aphid grew larger vine length than plants with high aphid, but the interaction between N rate and aphid level was not significant differently at $\alpha = 0.05$ level for any of the plant growth response.

In 1994, the N main effect was significant for each plant growth response at the level $\alpha 0.05$. The aphid main effect was significant for number of leaves and vine length but not for chlorophyll and leaf area at the $\alpha = 0.05$ level. The interaction between N rate and aphid level was not significantly different at $\alpha = 0.05$ level for any plant growth response (Table. 4).

Total chlorophyll content (leaf greenness) using the SPAD meter was linearly correlated with N whether infested or non-infested. Linear regression equations and R^2 values are as follow: $R^2 = 0.37$, $Y = 0.010(\text{nrate}) + 30.04$, (Fig. 5), $R^2 = 0.82$, $Y = 0.016(\text{nrate}) + 28.27$, (Fig. 6) for 1993 and $R^2 = 0.06$, $Y = 7.25(\text{nrate}) + 31.34$, (Fig. 13), $R^2 = 0.50$, $Y = 0.023 + 25.97$, (Fig. 14) for 1994.

The number of leaves was significantly related to nitrogen rates at $\alpha = 0.05$ level. Linear equations and R^2 are as follow: $R^2 = 0.13$, $Y = 5.175(\text{nrate}) + 14.12$ (Fig. 7), $R^2 = 0.36$, $Y = 0.011(\text{nrate}) + 10.74$ (Fig. 8) for 1993 and $R^2 = 0.37$, $Y = 9.12(\text{nrate}) + 13.17$ (Fig. 15), $R^2 = 0.63$, $Y = 0.02(\text{nrate}) + 10.17$ (Fig. 16) for 1994.

There was no strong correlation between vine length and nitrogen for low aphid in either year. Linear equations and R^2 : $Y = 0.012(\text{nrate}) + 37.4$, $R^2 = 0.08$ (Fig. 9), $Y = 0.020(\text{nrate}) + 34.35$, $R^2 = 0.22$ (Fig. 17). The R^2 for high aphid densities were found as follow: $R^2 = 0.54$ and 0.72 , (Fig. 10 and 18). Both N rate and aphid level were significantly different as main effects, but the data did show significant differences for the interaction effect.

To determine the effect of N on leaf area, all infested and uninfested plants were sampled for leaf growth measurements with a method of estimation developed by King and Cartwright (1992). Changes in leaf area values were best described by the following equation where leaf area increased linearly for each level of N. $R^2 = 0.28$, $Y = 0.033(\text{nrate}) + 55.69$ (Fig. 11), $R^2 = 0.37$, $Y = 0.0048(\text{nrate}) + 45.25$ (Fig. 12) for 1993 and $R^2 = 0.76$, $Y = 0.06(\text{nrate}) + 45.80$ (Fig. 19), $R^2 = 0.83$, $Y = 0.08(\text{nrate}) + 39.71$ (Fig. 20) for 1994 respectively.

The environmental conditions inside the greenhouse were monitored. Shade cloth was used over the greenhouse to control temperature in hot summer days which may affect plant and aphid growth. Temperature may affect the individual organisms directly, but other factors, such as light intensity or mineral nutrition (N), may act indirectly on aphids by altering the chemical composition and plant watermelon growth. Whether both

aphid and plant respond in a similar manner over a wide range of temperatures was not examined, but it is known that aphid growth increases with temperature up to 25°C (Huges 1963). In the present study, the five levels of N nutrition resulted not only in differences in plant growth, but also differences in the number of aphids proportional to the differences in plant size. Consequently more aphids were found in taller plants, but interaction between aphid level and N rate was not significantly different at the $\alpha = 0.05$ level.

Table 3. Effect of nitrogen and aphids on watermelon plant response in 1993

Plant response	Source of variance	df	F Value	Pr > F ³
Chlorophyll	Nrate ¹	4	12.1	0.0001 *
	Aphlvl ²	1	0.82	0.3788 NS
	Rep	2	1.80	0.1970 NS
	Nrate*aphlvl	4	1.78	0.1826 NS
Leaves	Nrate	4	3.24	0.0397 *
	Aphlvl	1	3.12	0.2891 NS
	Rep	2	1.34	0.2891 NS
	Nrate*aphlvl	4	0.76	0.5667 NS
Vine length	Nrate	4	3.37	0.0350 *
	Aphlvl	1	12.92	0.0024 *
	Rep	2	1.46	0.2616 NS
	Nrate*aphlvl	4	0.81	0.5388 NS
Leaf area	Nrate	4	4.38	0.0139 *
	Aphlvl	1	2.09	0.1680 NS
	Rep	2	2.05	0.1618 NS
	Nrate*aphlvl	4	0.33	0.8516 NS

¹Nrate = Nitrogen rate

²Aphlvl = Aphid level

³Significant at 0.05, (*) and nonsignificant (NS)

⁴Error term was pooled as Rep*Nrate, Rep*Aphlvl, and Rep*Nrate*Aphlvl

Table 4. Effect of nitrogen and aphids on watermelon plant response in 1994

Plant response	Source of variance	df	F Value	Pr > F ³
Chlorophyll	Nrate ¹	4	3.97	0.0175 *
	Aphlvl ²	1	2.41	0.1377 NS
	Rep	2	0.20	0.8218 NS
	Nrate*aphlvl	4	1.75	0.1836 NS
Leaves	Nrate	4	10.47	0.0001 *
	Aphlvl	1	7.81	0.0120 *
	Rep	2	3.06	0.0715 NS
	Nrate*aphlvl	4	1.01	0.4269 NS
Vine length	Nrate	4	7.34	0.0011 *
	Aphlvl	1	16.20	0.0008 *
	Rep	2	1.41	0.2707 NS
	Nrate*aphlvl	4	0.55	0.7033 NS
Leaf area	Nrate	4	20.18	0.0001 *
	Aphlvl	1	0.81	0.3811 NS
	Rep	2	0.71	0.5044 NS
	Nrate*aphlvl	4	1.65	0.2064 NS

¹Nrate = Nitrogen rate

²Aphlvl = Aphid level

³Significant at 0.05, (*) and nonsignificant (NS)

⁴Error term was pooled as Rep*Nrate, Rep*Aphlvl, and Rep*Nrate*Aphlvl

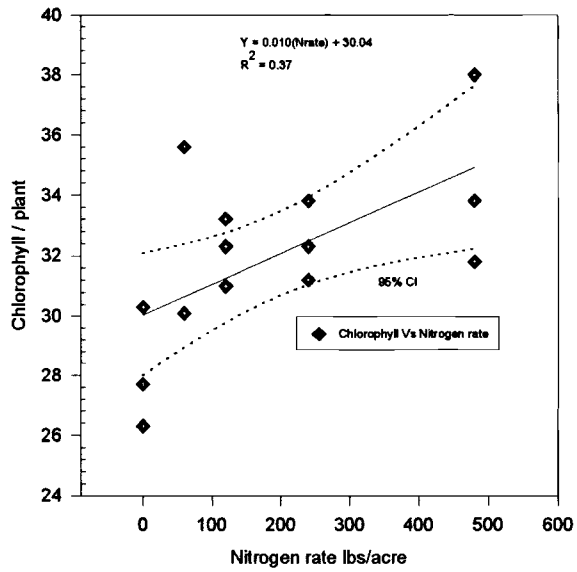


Fig. 5. Relationship between nitrogen rate and chlorophyll for low aphid in 1993

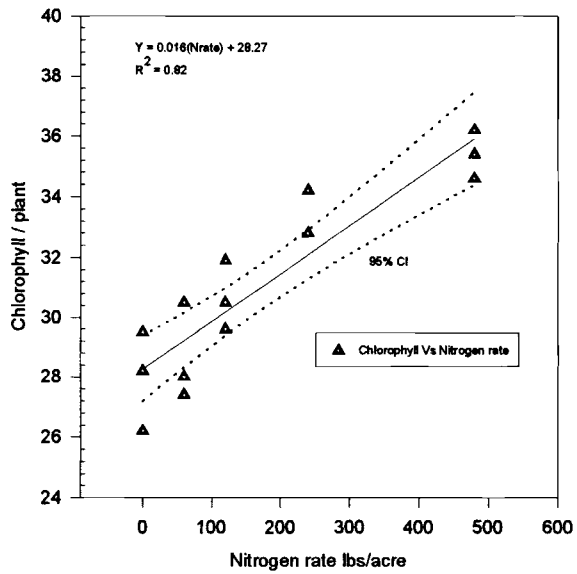


Fig. 6. Relationship between nitrogen rate and chlorophyll for high aphid in 1993

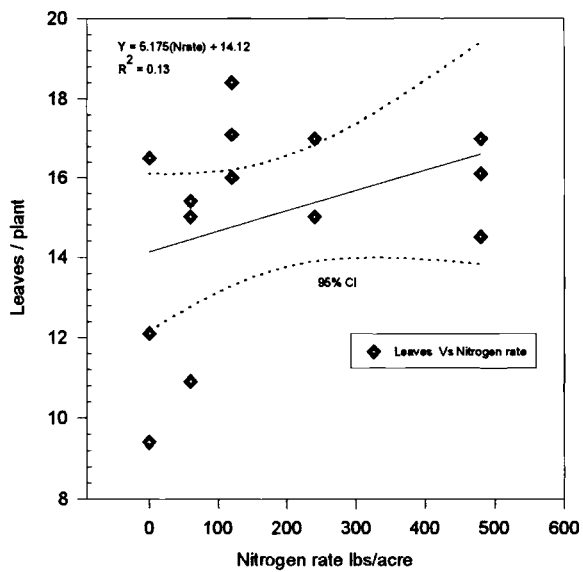


Fig. 7. Relationship between nitrogen rate and leaves for low aphid in 1993

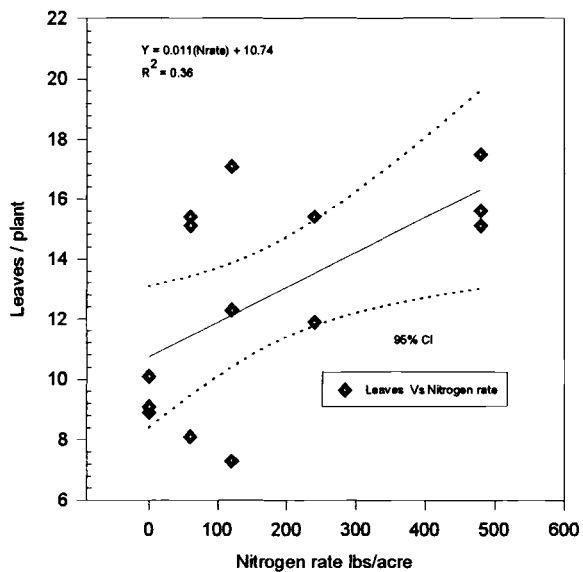


Fig. 8. Relationship between nitrogen rate and leaves for high aphid in 1993

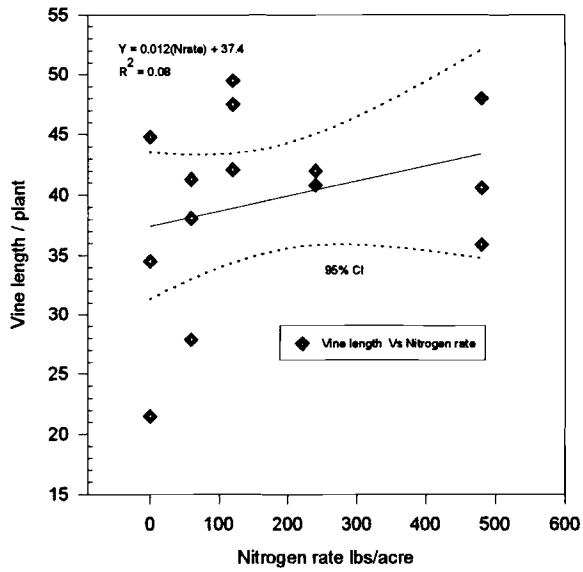


Fig. 9. Relationship between nitrogen rate and vine length for low aphid in 1993

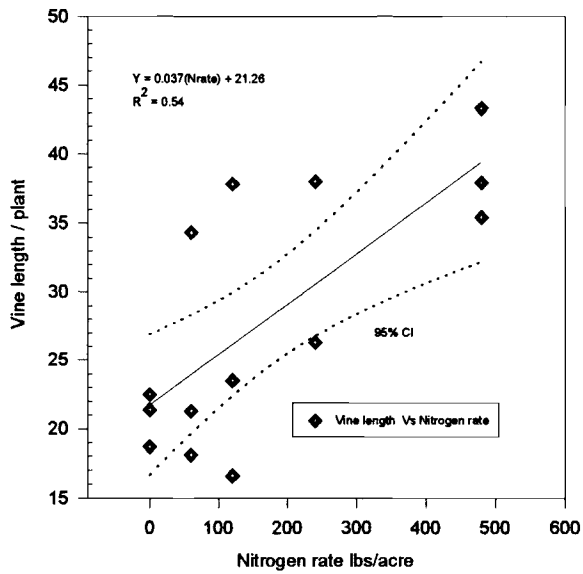


Fig. 10. Relationship between nitrogen rate and vine length for high aphid in 1993

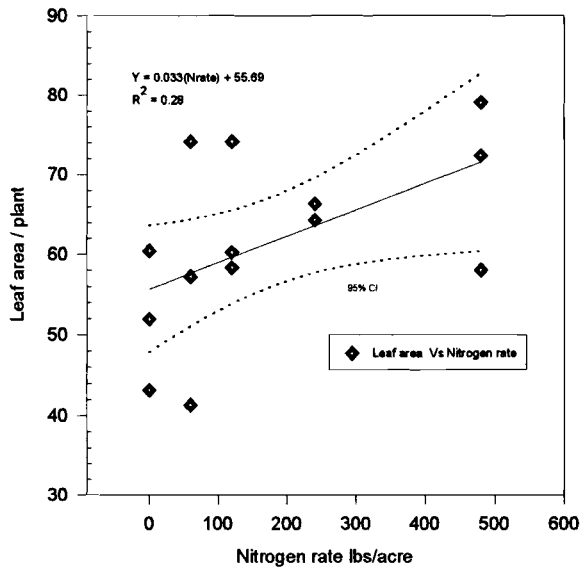


Fig. 11. Relationship between nitrogen rate and leaf area for low aphid in 1993

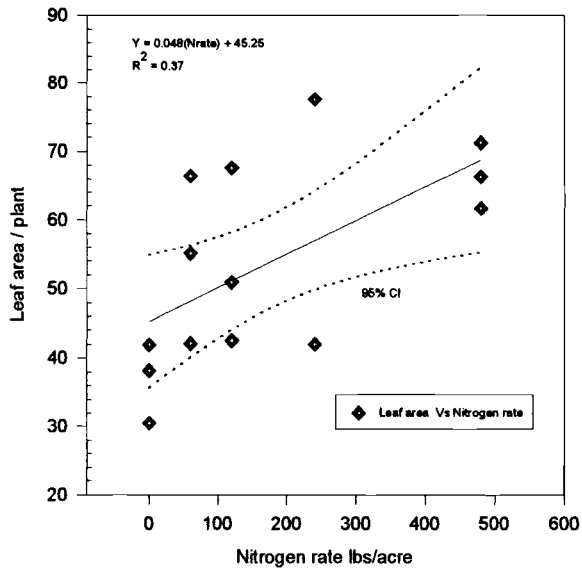


Fig. 12. Relationship between nitrogen rate and leaf area for high aphid in 1993

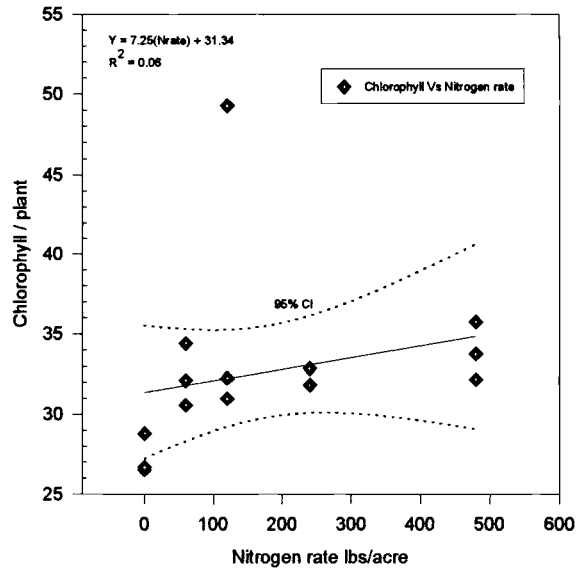


Fig. 13. Relationship between nitrogen rate and chlorophyll for low aphid in 1994

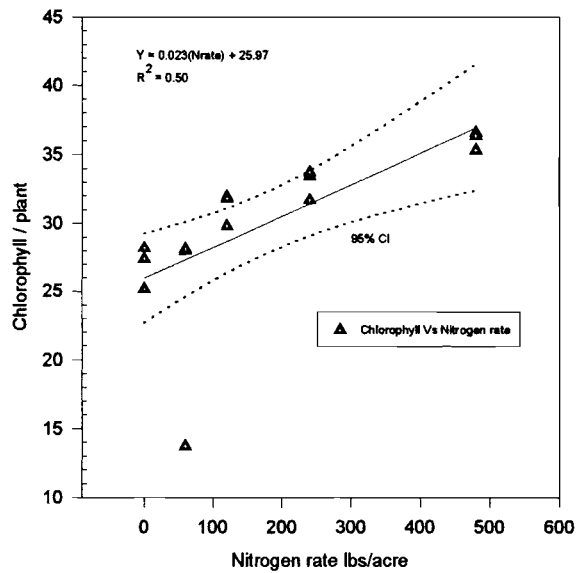


Fig. 14. Relationship between nitrogen rate and chlorophyll for high aphid in 1994

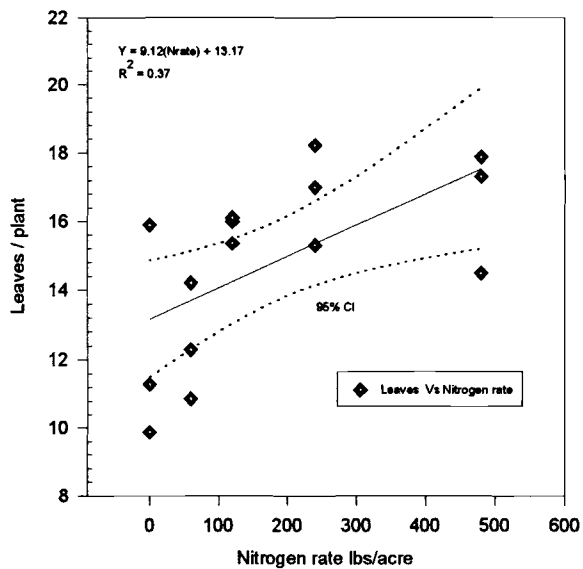


Fig. 15. Relationship between nitrogen rate and leaves for low aphid in 1994

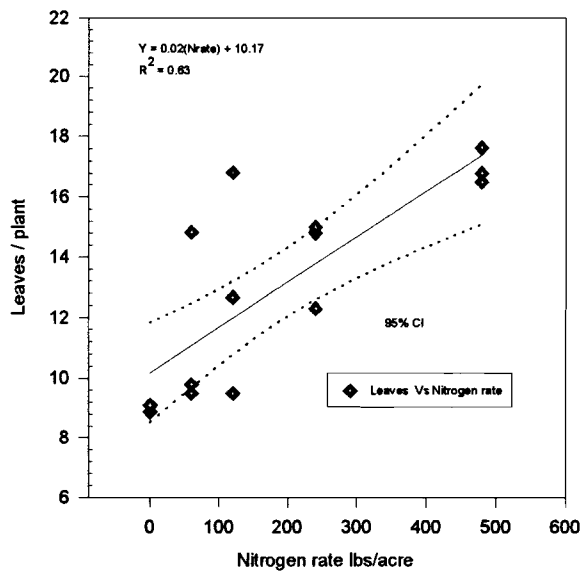


Fig. 16. Relationship between nitrogen rate and leaves for high aphid in 1994

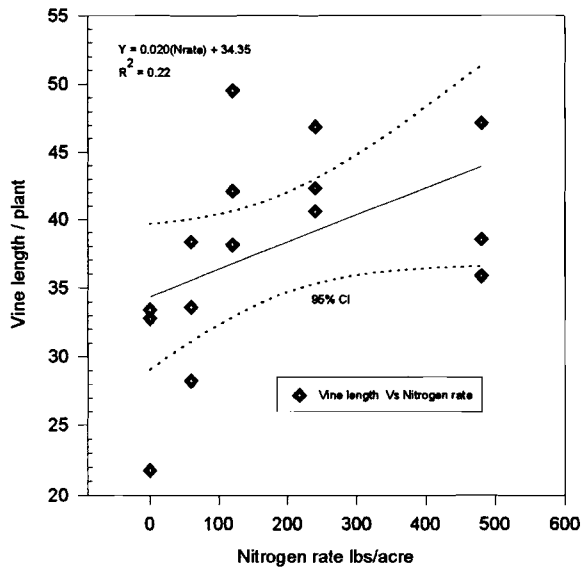


Fig. 17. Relationship between nitrogen rate and vine length for low aphid in 1994

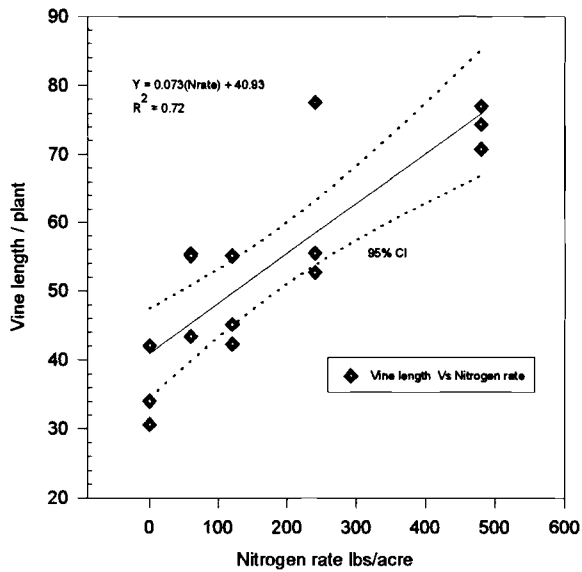


Fig. 18. Relationship between nitrogen rate and vine length for high aphid in 1994

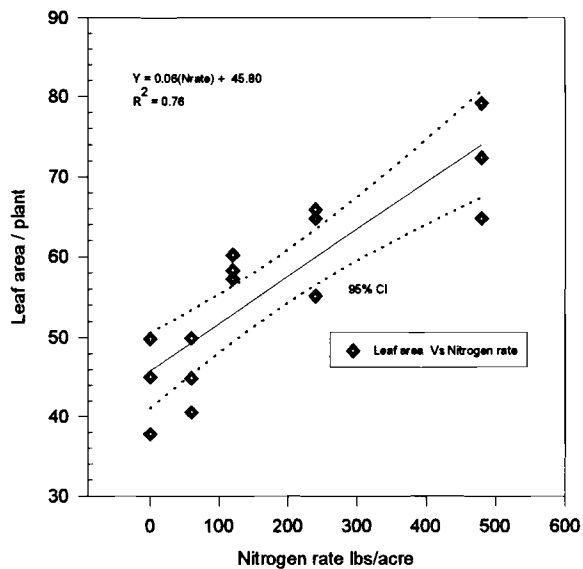


Fig. 19. Relationship between nitrogen rate and leaf area for low aphid in 1994

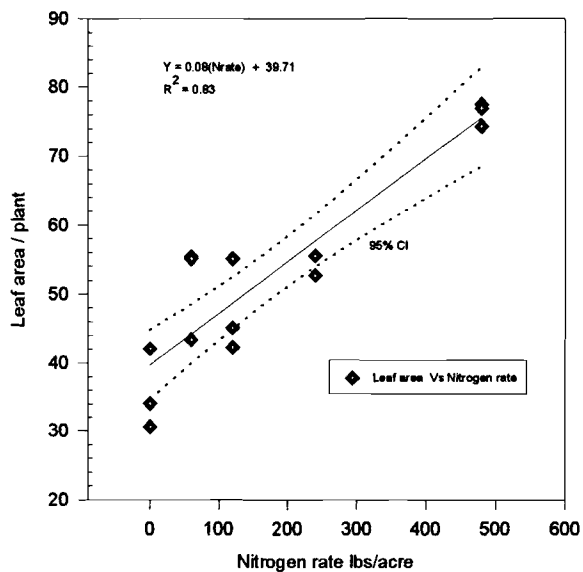


Fig. 20. Relationship between nitrogen rate and leaf area for high aphid in 1994

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