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Influence of Fertilizers and Wind on Aphid Infestation and Cucumber Yield

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Abstract—The spatial distribution of the melon aphid, *Aphis gossypii* (Homoptera: Aphididae) in a cucumber field was influenced by the direction of wind and the dosages of nitrogen and potassium fertilizer. The leeward side of the field had more aphids than the windward side. In the fertilized plots lower leaves had more aphids than the upper leaves in the vines. Increase in fertilizer application rate increased the aphid population but any adverse impact of this was overshadowed by increased cucumber yield.

Introduction

The melon aphid, *Aphis gossypii* Glover is a common pest of a variety of vegetable and fruit crops on Guam. Heavy infestations of *A. gossypii* on cucumber plants leading to curled and chlorotic leaves and decreased yields are common. This aphid is known to transmit zucchini yellow mosaic virus and papaya ringspot virus watermelon strain in some crops on Guam (G. C. Wall, pers. comm.).

Many studies have shown that fertilization of host plants affects population build up of aphids. An increase in nitrogen fertilization has been reported to increase the population of the aphids, *Brevicoryne brassicae* L. on Brussels sprouts (Koritsas & Garsed 1985), *Myzus persicae* (Sulz.) on sugar beet (Markkula & Tiittanen 1969) and head cabbage (van Emden 1966) and *Lipaphis erysimi* (Davis) on mustard (Rawat et al. 1968). However, Markkula & Tiittanen (1969) reported nitrogen, phosphorus and potassium had no effect on the aphid, *Acyrthosiphon pisum* (Harris) cultured on broad bean. Jayaraj & Venugopal (1964) also did not find any influence of ammonium sulfate application to cotton on *A. gossypii* population. Potassium deficiency promoted reproduction of *A. pisum* on chrysanthemum while application of potassium resulted in a reduction in the reproduction rate of *M. persicae* (Markkula & Tiittanen 1969). Similarly, van Emden (1966) reported a negative effect of potassium application to head cabbage on the reproduction of *M. persicae.* Increased potassium fertilization was reported to reduce the incidence of aphids on *Capsicum annuum* L. (Jeyaraman & Balasubramanian 1988) and to lessen the infestation of barley by *Rhopalosiphum*

padi L. (Havlickova 1993). Most of the above experiments were carried out on potted plants and may not reflect field conditions.

Johnson (1969) reviewed migration and dispersal of insects including aphids by flight. Alate forms are the ones dispersed by wind which start infestations in new localities (Jones et al. 1989). Apterous forms may migrate within a plant. Viviparity and parthenogenesis lead to local overcrowding in settled populations.

This paper presents the effect of application of different levels of nitrogen and potassium fertilizers to cucumber plants and the effect of wind direction on the incidence and population of *A. gossypii* and cucumber yield under field conditions.

Materials and Methods

Cucumber (*Cucumis sativus* L.) cv. Soarer, was planted at the Agricultural Experiment Station, Inarajan, Guam. Cucumber seedlings were transplanted on May 10, 1993 in a soil classified as Guam clay, containing 1.39 to 6.43% organic matter. The pH of soil varied between 7.4 and 8.0 and contained 7.65 to 25.95 ppm phosphorus and 95.0 to 140.0 ppm potassium. The field had a 2% slope and the predominant wind direction was northeast. The field was drip irrigated and controlled by switch tensiometers set at 0.02 megapascal (MPa). Tensiometers were installed 15 cm deep and 15 cm away from a plant hill. The experiment consisted of five replications of five treatments in Latin Square Design. Each treatment plot consisted of four 3.05 m long rows set 1.52 m apart. Seedlings were planted in hills with 2 plants/hill and 6 hills/row. Trellises were installed one week after transplanting. Treatments consisted of varying levels of nitrogen (N) and potassium (K) fertilizers (in kg/ha): A (0 N/0 K), B (56 N/45 K), C (112 N/90 K), D (168 N/135 K), E (224 N/180 K). Insecticide carbaryl was applied at 0.56 kg(AI)/ha by a backpack sprayer twice weekly. For counting aphids, leaves of the main shoot were numbered starting from the bottom to the top. Aphid infestation was estimated and indexed per leaf as 1 (none), 2 (less than 20), 3 (between 20 and 50), 4 (between 50 and 100), 5 (more than 100). Percent Relative Aphid Infestation Index (PRAII) for each treatment plot was obtained by expressing the ratio of the plot Aphid Infestation Index (AII) to its treatment mean as percentage. These PRAIIs were plotted on experimental layout and contour lines were drawn. All the data were entered in a computer (Macintosh, Apple) and analyzed using SuperAnova Latin Square model (Abacus Concepts, 1984 Bonita Ave., Berkely, CA 94704-1038, U.S.A.) statistical software.

Results

Aphid infestation took place at the beginning of the fruiting period. Other insect pests that occurred in the field were thrips, *Thrips palmi* (Karny), and whitefly, *Bemesia tabasi* (Gennadius), melon worm, *Diphania indica* (Saunders), pumpkin beetle, *Aulacophora similis* (Olivier) and melon fly, *Bactrocera cucurbitae* (Coquillett). All plants in the field were infested by *A. gossypii.* The mean

aphid infestation index of plants with no fertilizer treatment was 1.53 and it increased significantly between treatment groups B, C and D. No difference in aphid infestation was found between treatments D and E (Table 1). Figure 1 shows the mean aphid infestation index found on each leaf of plants in each treatment group. The main difference in aphid infestation between treatment groups was on the lower leaves from 1 through 12. There was no significant difference between treatment groups D and E. The highest aphid infestation index in treatment group A was found in the fifth leaf, whereas in all other treatments the highest number of aphids was on leaf one. The spatial distribution of Percent

Table 1. Mean Aphid Index and cucumber yield (week of June 15, 1993) in each treatment group.

Group	Treatment kg/ha	Aphid Index mean	SE	Cucumber yield mean (kg)
A	0 N + 0 K	1.53	± 0.03	8.3
B	56 N + 45 K	1.69	± 0.03	38.2
C	112 N + 90 K	1.93	± 0.04	85.4
D	168 N + 135 K	2.14	± 0.05	103.0
E	224 N + 180 K	2.14	± 0.04	136.7

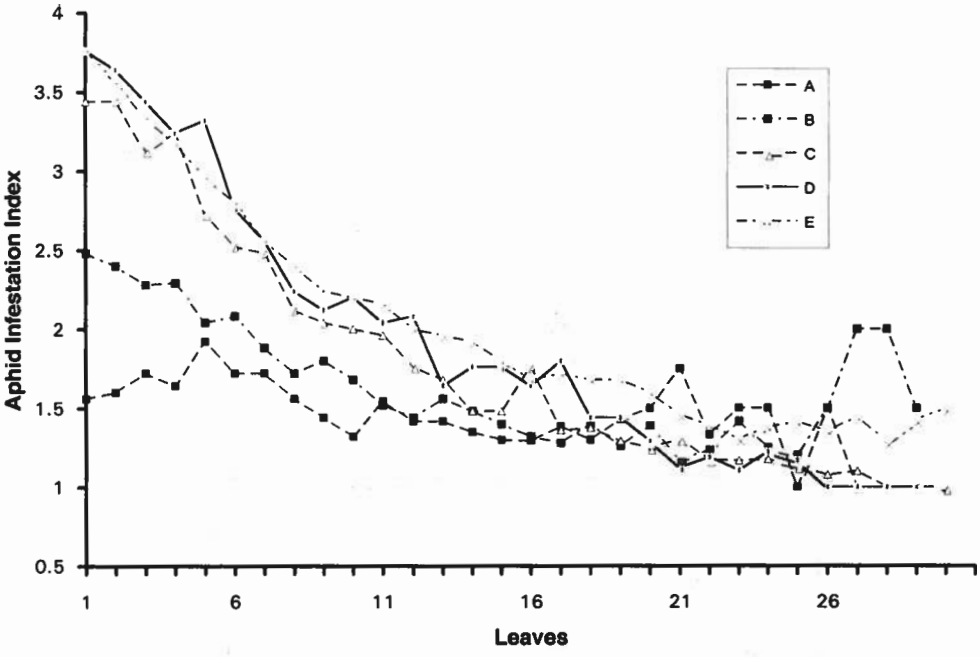

Figure 1. Mean aphid indices on individual leaves of cucumber plants fertilized with varying amounts of nitrogen and potassium in kg/ha [A (0 N/0 K), B (56 N/45 K), C (112 N/90 K), D (168 N/135 K), E (224 N/180 K)].

Relative Aphid Infestation Index (PRAII) of cucumber plants in the field was approximated by the contour lines as shown in Figure 2. The PRAII varies between 80 to 120. Higher aphid indices were found in the leeward portion of the field. The yield of cucumber in different treatments during the week of June 15, 1993 is given in Table 1.

Discussion

The infestation index system used to evaluate aphid populations on individual leaves allowed visual estimation of aphid infestation in the field in timely fashion and without undue disturbance of the leaves. The results show clear differences between aphid populations on cucumber plants grown on different levels of nitrogen and potassium fertilization. The melon aphid population on cucumber plants increased with increased levels of nitrogen and potassium fertilization. This finding is consistent with results of studies with varying levels of nitrogen in potted plants under laboratory conditions done elsewhere. Markkula & Tiittanen (1969) reported increase in populations of peach aphid, *M. persicae*

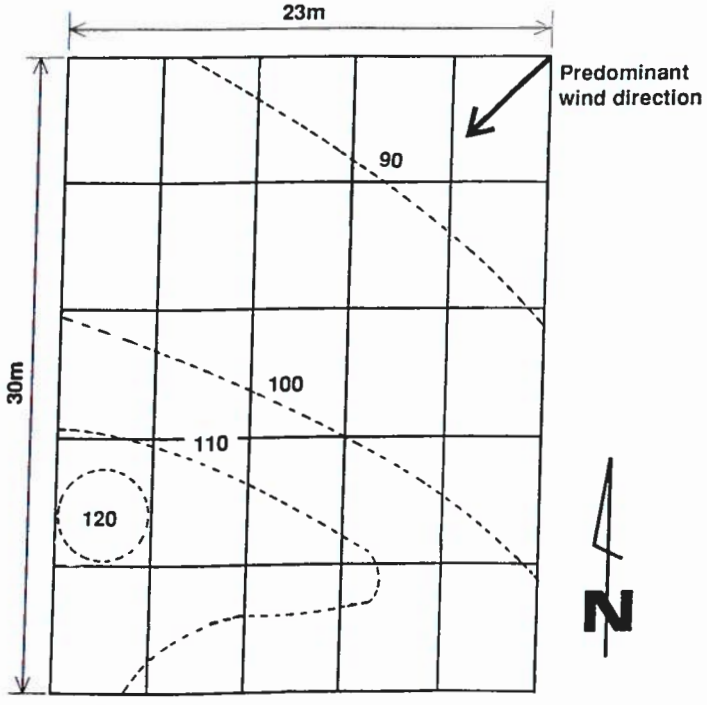

Figure 2. Spatial distribution of Percent Relative Aphid Infestation Index (PRAII) as approximated by the contour lines. Each contour line passes through points having the same level of PRAIIs. The arrow indicates the prominent wind direction at the experimental site.

on sugar beet plants that received more nitrogen and on potted chrysanthemum plants with less potassium application. However, the same authors reported peach aphid populations not to show any difference with different levels of nitrogen and potassium fertilization of cucumber plants. Pot experiments with spring barley grown in soils with various potassium levels showed reduced bird cherry oat aphid infestations on plants with a high level (424 ppm) of available potassium (Havlickova 1993). We were unable to separate the effects of potassium and nitrogen in this study, because their levels varied directly together in the experimental design.

Several factors seem to have influenced the aphid population on cucumber plants in the field. The leeward side of the field generally had a higher aphid population than the windward side. The initial winged aphids that started the population in the field also probably settled on the cucumber plants in the leeward side that provided shelter from the direct wind. The gradually increasing population level of the aphid towards the leeward area of the field (Fig. 2) indicates that protection from wind is congenial for population build up. The direction of wind also influenced the spatial distribution. Increased nitrogen and potassium fertilization resulted in increased aphid populations in all areas of the field. Cucumber plants grown on soil with higher fertilization had more leaves than plants grown with lower levels of fertilization. The leaves of highly fertilized plants were larger, more succulent and lush and provided more shade. These factors were probably favorable for the aphid multiplication and build up of larger populations as noted in the treatments C, D and E.

The amount of soluble nitrogen in plants is believed to be critical for aphid development (van Emden 1966). Pirson (1955) mentioned that high concentrations of potassium may reduce the soluble nitrogen level in plants and thus have a negative effect on aphid populations. According to Harrewijn (1970) high levels of soluble nitrogen increased reproduction rate of peach aphids on potato plants. We did not measure total and soluble nitrogen contents in the cucumber leaves in our experiment and could not determine if the larger cucumber plants created more favorable conditions for aphids or if aphid populations were directly related to the availability of increased nitrogen in the plant sap. The study did show that increase in aphid population was directly related to increase in fertilizer application. The cucumber yield also increased with an increase in fertilizer dosage. The increase in cucumber yield due to fertilizer application overshadowed the possible adverse impact of the aphids. However, the results of the spatial and vertical distribution of the aphids indicate that it is advisable to sample basal leaves in the leeward side of the field for early detection of aphid infestation as well as for scouting in an integrated pest management program.

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