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Life cycle and population growth of the maize aphid on potted finger millet plants

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Abstract

Cage evaluation was made of developmental biology of the maize aphid, *Rhopalosiphum maidis* (Fitch), on finger millet, *Eleusine corocana* L.. The mean developmental period of the aphid was 6.3 days (range 4.8 - 7.2), under 12 hrs, and 5.3 days (range 4.0 - 6.4) under 18 hrs of light, respectively. The aphid's average reproductive life was 24.0 days and each mother aphid produced on average 78.7 nymphs (range 66-94). Two peaks were observed for diurnal nymphal production, the higher being in the afternoon (1400 - 1600 hrs) under normal conditions. Variations in diurnal light intensities affected the occurrence of the peaks.

Key words: Biology, *Rhopalosiphum maidis*, development period, nymphal production, population growth.

Introduction

The maize aphid *Rhopalosiphum maidis* (Fitch) was first reported in Uganda in 1918, when it was recorded as a vector of ten different viral disease in cereals and other crops (Le Pelley, 1959). Main hosts of the aphids are maize and sorghum, and occasionally barley, but seldomly wheat and oats (Hill and Waller, 1988). Although the aphid has not been reported on millet in Uganda, it has been reported elsewhere causing millet red leaf (Blackman and Eastop, 1984).

The maize aphid's large alternative host range (Blackman and Eastop, 1984), coupled with its ability to transmit viruses (Le Pelley, 1959; Starks et al., 1982) and the recent observations of significant infestations of finger millet by the aphid in the country by the second author, indicate that the aphid can be potentially a major pest of finger millet in Uganda. Since the available reports on the aphid are limited to taxonomic descriptions, its host range and distribution(Le Pelley, 1959), the present study was undertaken to evaluate the life cycle and population growth of the aphid on *E. corocana*. This investigation was carried out to establish the relationship between the aphid and the crop that can guide the development of control strategies.

Materials and Methods

Experiments were conducted in cages at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), Uganda, to assess *R. maidis* nymphal development, reproduction and population growth on finger millet *E. corocana*. The aphids used in the experiments were reared on potted finger millet transplanted from the field, each pot contained four plants.

Cultures of test aphids were raised on millet seedlings from field collections. From this culture, freshly moulted apterous adult aphids were transferred onto 2-week-old test potted plants as described by Ogenga-Latigo and Khaemba (1985). They were then left for 2 hr to reproduce and then removed, leaving only the nymphs to develop. This procedure eliminated the use of parasitized and diseased aphids in the study. All experiments were replicated four times, with each replicate consisting of four pots.

Development of nymphal instars

Following the procedure described above, the nymphs produced within a period of 2 hr were left to develop on each plant. On average eight nymphs per plant were left. The nymphs were inspected daily (0600 - 1800 hr) at intervals of 2 hr to record the time of either moulting or start of reproduction. The duration of nymphal instars and the mean developmental period of nymphs from birth to reproductive maturity were then determined. The pots were kept until the last nymph had reproduced.

Fecundity, and longevity of *R. maidis*

Two freshly moulted *R. maids* adults were put on each of 12 plants and left to reproduce. Nymphs produced each day were counted at 0900 hr and removed from the plants. The observations continued until the mother aphids died.

Fecundity, duration of nymphal production and longevity of the aphids were then obtained.

Reproduction pattern of *R. maidis*

Four apterous *R. maidis* adults were left on each potted millet seedling and inspected at 2-hr intervals daily (0600 -1800 hr) to record nymphal production. At the last count for the day, the nymphs were removed so as to determine the number of nymphs produced during the night (1800-0600 hr). All the aphids were removed every four days and the plants reinfested with freshly moulted apterae adults, the experimental days were grouped as follows:

i) Normal day (ND) 12 hr of sunlight.

ii) Dark mornings (DM) 6 hr of sunlight (1200 - 1800 hr), plants kept in a cupboard during the morning hours.

iii) Dark afternoons (DA) 6 hr of sunlight (0600 - 1200 hr), plants kept in a dark cupboard during the afternoon.

iv) Total darkness (TD) plants were kept in a dark cupboard for 24 hr.

Nymphal production by *R. maidis* under the various light conditions were then compared. This was to test the hypothesis that reproduction depends on the physiological and photosynthetic conditions of the host leaves (Kennedy et al., 1950; 1951).

Population growth

Freshly moulted apterous adult aphids were transferred onto uniformly growing millet seedlings as the infestation levels of 1, 2, 3 and 6 aphids per plant. The infested plants were sampled at 2-day interval over a period of 3 wks. Each level of infestation consisted of three pots each with four plants per pot. Three plants were taken at random for each level and all the aphid progeny produced on them counted *in situ*.

Results

Development of nymphal instars

Results of nymphal duration and mean developmental period of *R. maidis* are presented in Table 1. The developmental period was short and differed with the period of plant exposure to light. Under normal light conditions (12 hr of light), nymphal development took on average 6.3 days with a range of 4.8 to 7.2 days. Under 18 hr of light the developmental period was reduced to 5.3 days, with a range of 4.0 to 6.4 days.

Table 1. Duration of instar stages and the development period of *R. maidis* on finger millet *E. corocana* under normal day and 18 hrs of light.

Instar stage	Duration (days) of the instar stages[a]	
	Normal light	18 hrs of light
1st	1.99 ± 0.04	1.39 ± 0.04
2nd	2.03 ± 0.01	1.88 ± 0.04
3rd	1.19 ± 0.01	0.93 ± 0.01
4th	0.78 ± 0.04	0.81 ± 0.05
Pre-reproduction period	0.35 ± 0.02	0.26 ± 0.01
Total Development period	6.33 ± 0.08	5.28 ± 0.04

[a]Mean of four replicates, each replicate consisting of eight aphids

Fecundity and longevity

On finger millet, each *R. maidis* produced an average of 78.7 nymphs during a mean reproductive life of 24.0 days (range 20 - 26 (Figure 1). Baker and Turker (1916), working on *Dysaphis crataegi,* obtained 71 nymphs per female, Hussey et al. (1969), put the number at 50 . During the first week, an average of 4.73 nymphs day^{-1} (range 3 - 8) were produced by each mother aphid. Reproduction during the period accounted for 41.9% of the total progeny produced. In the second and third weeks, on average 4.3 nymphs (range 4 - 6) and 2.44 nymphs (range 1 - 4) day^{-1} were produced, representing 35.72% and 21.66% of total progeny, respectively. The mother aphids lived for 23 to 27 days. Hussey et al. (1969) similarly recorded 5-6 nymphs per female *Aphis fabae* scop. per day during its first two weeks of reproductive life, with the number falling to two larvae per day the following week.

Reproduction pattern of *R. maidis*

Daily variation in the reproduction pattern of the aphid under different light conditions is presented in Table 2. Nymphs were produced both during the day and night, a larger proportion being produced during day (Table 2). Daytime reproductive rhythm of the aphid was characterized by two peaks, one in the morning and the other in the afternoon. Under normal day, the first peak occurred during the early morning (800 - 1000 hr) during which 10.56% of the nymphs were produced, while a slightly higher peak was recorded in the afternoon (1400 - 1600 hr), during which 12.66% of the day's progeny was produced. This pattern also occurred when the plants were subjected to 24 hrs of total darkness. Under the other variable conditions, peak reproduction coincided with the periods of maximum light availability (Figure 2). This was probably due to difference in availability of the food for the aphid; maximum food being present during periods of maximum light availability. Apart from food, temperature is likely to have played a part. During maximum light intensity, temperatures rise making the

Table 2. Diurnal reproduction pattern of the aphid *R.maidis* on finger millet (*Eleusine corocana*) under different light conditions.

Light condition	% nymphs produced in a day	
	Day	Night
Normal day	54.5 ± 5.1	45.5 ± 5.1
Dark Morning	64.3 ± 4.1	35.8 ± 3.9
Dark Afternonn	57.1 ± 6.6	43.0 ± 6.6
Total Darkness	54.0 ± 9.9	46.0 ± 9.9

aphids more physiologically active. For example, Imms (1947) calculated that at 22 °C, 1300 individuals could arise from a single female in 14 days, meanwhile at 14° C less than 500 individuals could arise.

Population growth

Development of *R. maidis* populations on finger millet from initial levels of infestation is shown in (Figure 2). From initial levels of 1, 2, 3 and 6 adults aphid per plant, mean number of aphids found per plant after three weeks were 1061.0, 1583.0, 1645.7 and 1898.0, respectively.

Discussion

It has been shown by the study reported here that the mean developmental period of *R. maidis* is very short. Ogenga-Latigo and Lamo-Ayo (1993), obtained a similar developmental period for the carrot aphid (*Chomaphis (Dysaphis) foeniculus*) at Kabanyolo under normal day conditions. The short nymphal development observed for the aphids was similar to those known for many aphid species (Kennedy and Stroyan, 1959). The developmental period was further shortened by increased light duration (18 hr) by an average of 1.05 days. The quicker development was probably due to prolonged photosynthetic activity of host plants (Ogenga-Latigo and Khaemba, 1985). Kennedy et al. (1950; 1951) state that the rate of feeding, influenced by the age, physiological and photosynthetic conditions of the leaves influence the physiological conditions of the aphid; the greater the rate of feeding the faster the aphids physiological conditions.

The reproductive duration for *R. maidis* of about 3 weeks is substantially longer than those reported for other aphids under screen house conditions. Ogenga-Latigo and Lamo-Ayo, (1993) recorded a reproductive life of 5 - 6 days for the aphid *C. (Dysaphis) foeniculus* T. on carrots during which the aphids produced an average of 20 nymphs each. Ogenga-Latigo and Khaemba, (1985) reported a shorter reproductive period of 15.3 days for *Aphids fabae* with about 55 nymphs being produced by each mother aphid. Ogenga-Latigo (1993) urgued that the relatively high temperatures in the glasshouse should have shortened the physiological duration. Hussey et al. (1969), however also obtained three weeks of reproductive life, under normal temperatures. The long reproductive life and high fecundity of *R. maidis* means that its infestation on finger millet can develop to severe levels after a short period of time.

Two peaks of diurnal reproduction recorded for *R. maidis* compare with those of other aphids as reported by several workers (Eastop, 1957; Johnson et al., 1957, Taylor, 1957, Ogenga-Latigo and Lamo-Ayo, 1993). For this aphid however, under normal light conditions, peak reproduction occurred in the afternoon (1400-1600 hr) rather than in the morning as observed for the carrot aphid. It is probable that there are major differences in photosynthetic activity and assimilate build-up, between finger millet and other test crops. This would influence availability of food for the aphids, which would in turn affect their developmental rhythm (Johnson et al., 1957).

The build-up of *R. maidis* population was also greater than those reported for the other aphids (Ogenga-Latigo and Khaemba, 1985; Ogenga-Latigo and Lamo-Ayo, 1993). This seems to be due to the long reproductive period and higher fecundity of *R.maidis* on finger millet. It was also shown that at low levels of initial infestation, the aphid has a high rate of population build-up. Rapid population build-up from the lower initial infestation

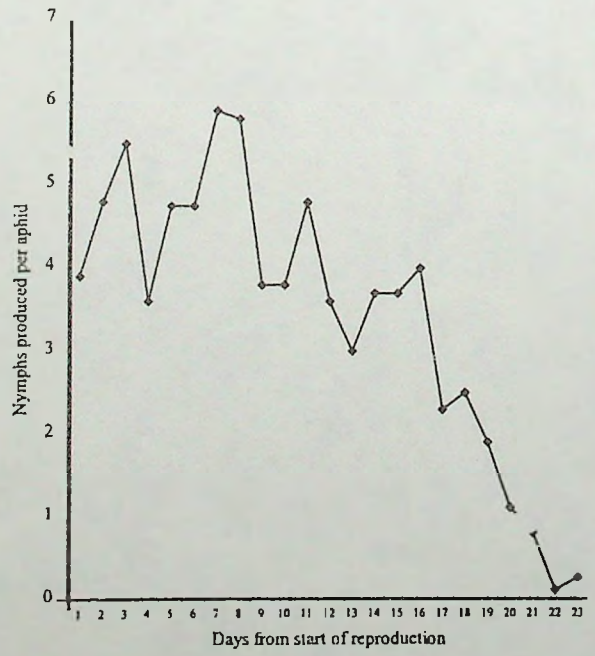


Fig. 1: Reproduction pattern of Rhopalosiphum maidis on finger millet

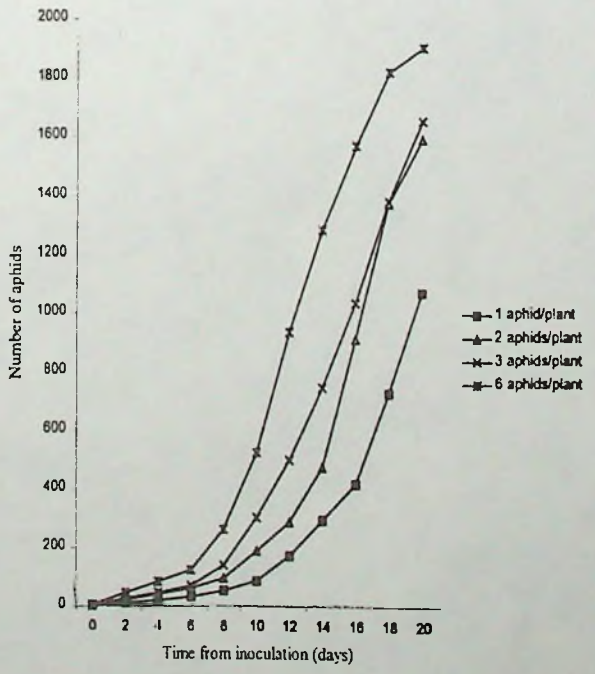


Fig. 2: Build-up of *Rhopalosiphum maidis* population on finger millet seedlings from four levels of inoculation

probably leads to serious intra-specific competition and to suppressed reproductive rates.

The study showed that under favourable conditions, *R. maidis* is capable of developing high populations from very low initial levels of infestations. The aphid is therefore potentially a very serious pest of millet, particularly when negative population factors such as climate and biotic mortality factors are not operative.

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