# Influence of Temperature on Population Development of Two Color Morphs of the Tobacco Aphid (Homoptera: Aphididae) on Flue-Cured Tobacco[1]

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**ABSTRACT** Tests were conducted at seven constant temperature regimes in controlled environmental chambers to compare population growth parameters of red and green morphs of the tobacco aphid, *Myzus nicotianae* Blackman. The optimal temperature for population development of both color morphs was 25°C. At 25°C and above, the red morph had three advantages over the green; most striking was the ability to survive to reproductive age. The red morph also developed faster and was more fecund than the green. Although neither morph reproduced at 32°C, longevity of the red morph was 120% greater. Results of this study may help to explain the disproportionate development of populations of the red morph in the field.

**KEY WORDS** Tobacco aphid, *Myzus nicotianae,* population growth, development, fecundity, longevity.

The green peach aphid, *Myzus persicae* (Sulzer), has been an economic pest of tobacco, *Nicotiana tabacum* L., in North America since the mid-1940's (Dominick 1949, Chamberlin 1958, Cheng and Hanlon 1985). Blackman (1987) demonstrated that this tobacco-feeding aphid is morphologically distinct and reproductively isolated from *M. persicae* and described it as *M. nicotianae.* Before 1986, aphids on tobacco in North America were reportedly green or yellow-green (Chamberlin 1958). Since 1986, a red morph has replaced the green as the predominant morph on tobacco (Lampert & Dennis 1987).

Based on the morphometric similarities of the two color morphs, Blackman (1987) hypothesized that the red morph of the tobacco aphid resulted from a mutation within the existing green morph populations in North America. Detailed comparisons of the biology and life history of the two color morphs are limited. Before the red morph was known on tobacco and before *M. nicotianae* was separated taxonomically from *M. persicae,* Harrison (1969) reported on the temperature-dependent growth of aphids on tobacco under outdoor insectary conditions. Lampert and Dennis (1987) showed that the red morph exhibited a higher reproductive rate under ambient laboratory conditions. McPherson (1989) investigated the seasonal abundance of both morphs on tobacco in Georgia and found daily high temperatures exceeding 35°C not to be detrimental to the red morph.

This study was conducted to compare the influence of constant temperatures on the developmental time, fecundity, and longevity of red and green morphs of the tobacco aphid on flue-cured tobacco.

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## Materials and Methods

Research was conducted at the VPI and SU Southern Piedmont Agricultural Experiment Station near Blackstone, VA during the summer and fall of 1986. Colonies of two color morphs of the tobacco aphid were started from individuals collected from field tobacco and maintained on potted flue-cured tobacco plants ('Coker 319') in cheesecloth covered cages in an outdoor insectary.

Tobacco aphid population growth was observed on excised tobacco leaves ('Coker 319') grown in an insecticide-free greenhouse. Twelve hours before the beginning of each test, adult apterous virginoparae were allowed to deposit nymphs on tobacco leaf discs (85 mm diameter) placed in petri dishes lined with moistened filter paper. From these individuals, four first-instar aphids (one cohort) were transferred to each leaf using moistened camel's brushes. Mortality associated with handling of the aphids was minimal; although, individuals that suffered such mortality were not included in the determination of longevity. The number of cohorts tested varied between temperatures and for the two color morphs, depending upon the availability of suitable first-instar nymphs. The petioles of the leaves were inserted into 2 cm of water agar (10 g agar/liter of water) in the bottom of 470 ml styrofoam cups (one leaf per cup). Cups were covered with translucent plastic lids and placed in controlled environmental chambers (Nor-Lake Scientific, Hudson, WI and Percival, Boone, IA). Tests were conducted under a 16:18 (L:D) photophase and constant temperature of 8, 12, 16, 20, 25, 30 and 32° C. These temperatures represent a sufficient range to provide a description of the temperatures that would impact field populations of the tobacco aphid. Aphids were transferred to fresh leaves and new cups of agar every 7 to 10 days. The number of live and dead aphids, exuviae, and nymphs were observed and recorded daily. All nymphs, exuviae, and dead aphids were removed during these observations.

Developmental time was determined for the first reproducing aphid in each cohort. Fecundity was calculated for individual cohorts and expressed as nymphs/4 females and was corrected for mortality of adults within a cohort. Longevity was determined for individual aphids. Differences between the two color morphs for the three population growth parameters were evaluated using a $t$-test (SAS 1985).

## Results and Discussion

Populations of both morphs reproduced at all temperatures tested except 32° C where neither morph reproduced. Developmental time (days to first reproduction) is presented in Table 1. The green morph developed significantly faster than the red at 12°C ($t$ = 3.301; df = 51; $P$ = 0.0002). The red morph developed faster than the green at the three highest temperatures at which reproduction occurred. The optimal temperature for both morphs was 25°C and developmental time for the red morph was 0.5 days shorter ($t$ = 1.564; df = 75; $P$ = 0.122). Differences in developmental time were significant at 20°C ($t$ = 2.030; df = 35.4; $P$ = 0.050) and 30°C ($t$ = 1.888; df = 16; $P$ = 0.077).

Peak fecundity (nymphs /4 females) occurred at 25°C for both morphs and there was a sharp decrease in fecundity at 30°C (Fig. 1). At 25°C, the fecundity of the red morph was 42.3 nymphs/4 females greater than the green (t = 2.576; df = 75; $P$ = 0.012).

**Table 1. Mean developmental time to reproductive maturity and the percentage reaching maturity for cohorts of two color morphs of the tobacco aphid on excised flue-cured tobacco leaves held at seven constant temperatures.**

| Temp (°C) | Morph | Number of Cohorts tested | Number of Cohorts reproducing | Developmental time (mean ± SEM) (days) | % of cohorts reproducing |
|---|---|---|---|---|---|
| 8 | Green | 32 | 21 | 49.9 ± 1.56 | 66 |
| 8 | Red | 32 | 21 | 48.1 ± 1.93 | 66 |
| 12 | Green | 32 | 28 | 29.9 ± 0.94 | 88 |
| 12 | Red | 32 | 25 | 35.2 ± 1.36 | 78 |
| 16 | Green | 32 | 23 | 14.2 ± 0.40 | 72 |
| 16 | Red | 18 | 12 | 14.7 ± 0.58 | 67 |
| 20 | Green | 24 | 24 | 8.7 ± 0.13 | 100 |
| 20 | Red | 18 | 14 | 8.4 ± 0.08 | 78 |
| 25 | Green | 48 | 45 | 8.0 ± 0.19 | 93 |
| 25 | Red | 36 | 32 | 7.5 ± 0.25 | 89 |
| 30 | Green | 32 | 6 | 12.1 ± 0.95 | 19 |
| 30 | Red | 18 | 12 | 10.4 ± 0.41 | 67 |
| 32 | Green | 18 | 0 | - | 0 |
| 32 | Red | 18 | 0 | - | 0 |

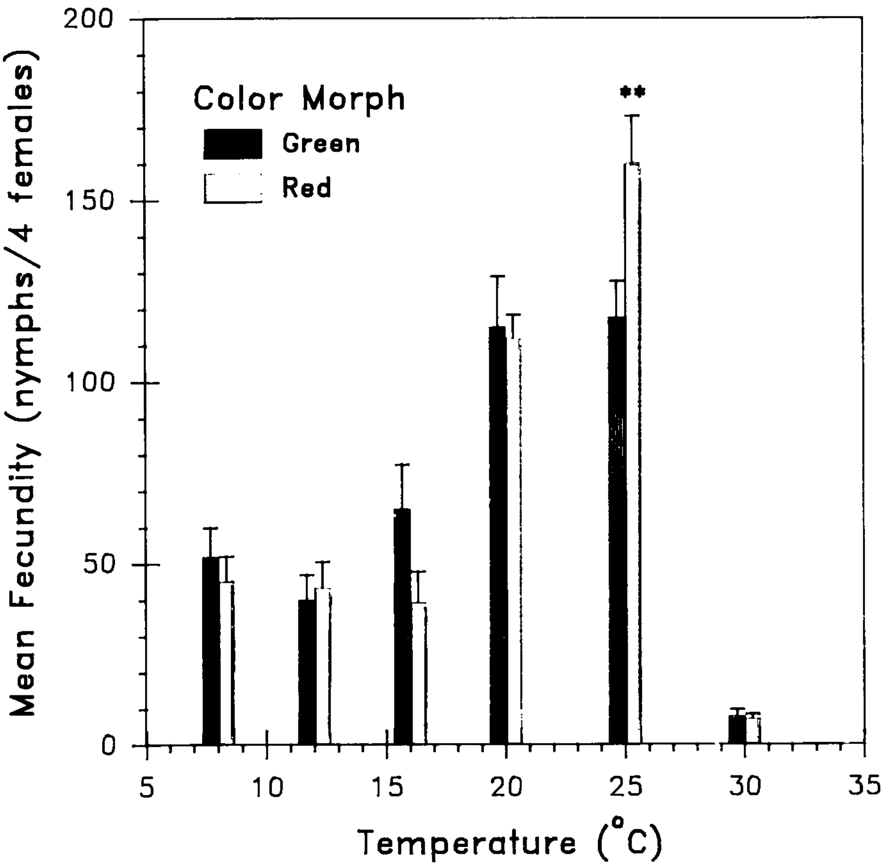


Fig. 1. Mean fecundity of two color morphs of the tobacco aphid tested under constant temperature regimes. Standard error of the means are indicated and bars marked with '**' are significant at $P < 0.05$ ($t$-test).

Populations of both color morphs exhibited similar longevity at the five lowest temperatures tested (Table 2). However at temperatures above 20°C, the longevity of the red morph increased over the green morph at each increment. At 32°C, the red morph survived more than twice as long as the green. The difference between the morphs was significant at 25°C ($t = 1.827$; df = 292; $P = 0.069$), and was highly significant at 30° C($t = 3.603$; df = 172; $P = 0.004$) and 32°C ($t = 8.106$; df = 103.8; $P = 0.001$).

Tobacco aphids have the capacity to develop large populations in the field. However, high temperatures of mid-summer in combination with changes in the host plant often serve to reduce tobacco aphid populations. Changes in population density at a given temperature is a result of the fecundity of individual aphids and their ability to survive to reproduce. Survival to reproductive maturity for the populations tested was calculated as the percentage of the total number of cohorts

**Table 2. Mean longevity of two color morphs of the tobacco aphid on excised flue-cured tobacco leaves held at seven constant temperatures.***

| Temp (°C) | Morph | N | Longevity (mean ± SEM) (days) |
|---|---|---|---|
| 8 | Green | 119 | 41.3 ± 3.04 |
| 8 | Red | 121 | 44.5 ± 3.18 |
| 12 | Green | 122 | 30.0 ± 1.61 |
| 12 | Red | 126 | 30.7 ± 2.17 |
| 16 | Green | 113 | 15.3 ± 0.95 |
| 16 | Red | 61 | 15.9 ± 0.95 |
| 20 | Green | 81 | 16.3 ± 0.67 |
| 20 | Red | 59 | 15.2 ± 0.78 |
| 25 | Green | 174 | 12.7 ± 0.54 |
| 25 | Red | 120 | 14.3 ± 0.70 |
| 30 | Green | 117 | 9.5 ± 0.57 |
| 30 | Red | 57 | 13.2 ± 0.83 |
| 32 | Green | 48 | 2.5 ± 0.19 |
| 32 | Red | 67 | 5.5 ± 0.32 |

* = total number of aphids observed to mortality.

tested and listed in Table 1. Maximum values occurred at 20 and 25°C for the green and red morphs, respectively. The depression observed at 16°C is unexplained and is perhaps aberrant. The most important difference responsible for explaining differential population growth occurred at the higher temperatures. At 30°C, 67% of the red and only 19% of the green morphs reproduced. Populations of the green morph decreased at 30°C since the net reproductive rate was only 0.57 nymphs per female (12.1 nymphs/4 females times 0.19 survival to reproduction). The net reproductive rate for the red morph at 30°C was 1.74 nymphs per female (10.4 nymphs/4 females times 0.67 survival).

This study indicates that the temperature-dependent population development for both color morphs of the tobacco aphid is similar to that of the closely related *M. persicae* (once considered the primary aphid species on tobacco). The optimal temperature for population growth (25°C) is the same for both species (Deloach 1974). In addition, the upper developmental threshold of 30°C for *M. persicae* (Whalon and Smilowitz 1979) is the same as found in this study.

Results of this study are similar to those reported by Lampert and Dennis (1987) in a less controlled environment. At the optimal temperature of 25°C, the red morph reproduced 0.5 days sooner and gave birth to significantly more nymphs than the green. As temperature increased above the optimum, the response of populations of the two color morphs became increasingly divergent. Longevity was 40 and 120% greater for the red morph at 30 and 32°C, respectively.

This study was conducted under constant temperature regimes and thus caution is in order when applying the results to the variable environment that exists in the field. However, the advantage of the red morph over the green at high temperatures (ca. 28°C and above) is supported by field observation. The proportion of red tobacco aphids to green has been observed to increase over the course of the flue-cured tobacco season (McPherson 1989; Semtner, unpublished data). The greater potential of populations of the red morph to increase at high temperatures in this study is one explanation for why the red morph has replaced the green on tobacco in North America.

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