Low temperature decreases CUF 101 alfalfa resistance to blue alfalfa aphid

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The blue alfalfa aphid.

Host-plant resistance can be divided into three basic mechanisms: nonpreference (antixenosis), antibiosis, and tolerance. Antixenosis is a property making the plant an unacceptable host so that it is avoided by a potential pest. Antibiosis refers to an adverse effect of the host on pest biology, reducing survival or reproductive success of the pest. Tolerance is the ability of the plant to withstand pest infestation levels that would significantly decrease yield or quality in a susceptible plant. These mechanisms may act singly or together to produce the observed resistance.

While probably of little importance in the short-term, commercial use of resistant cultivars, knowledge of the biological mechanisms has both biological and practical significance. The stability and effectiveness of resistance may well depend on the mechanisms involved. Spotted alfalfa aphid, *Theroaphis maculata*, has developed eight biotypes, so that researchers have had to reintroduce resistance into commercial alfalfa cultivars several times. Tolerance, depending on its level, may be overwhelmed by unusually large pest populations, resulting in unanticipated losses.

Perhaps of equal importance to knowledge of the mechanisms is knowledge of the stability of resistance over a range of climatic conditions. Temperature is known to bias the expression of alfalfa resistance to aphids. Researchers in California, Arizona, and elsewhere have found a decrease in the expression of resistance to spotted alfalfa aphid with decreasing temperatures. Aphid fecundity and survival were both greater at lower temperatures. In the 'Lahontan' clone C-902, resistance was completely lost at 60°F. In this report, we explore the possible contributions of antibiosis and examine the effect of temperature on CUF 101 resistance to the blue alfalfa aphid.

Methods

We started the first generation of aphids, hereafter referred to as the parental generation (P), by selecting four-hour-old nymphs from stock colony stem mothers. The next (F₁) generation was initiated...
by selecting four-hour-old nymphs produced by the parental stem mothers. F₂ and F₃ generations were likewise started from F₁ and F₂ stem mothers, respectively. In each case, nymphs were selected from aphids in their second and third day of reproduction.

Nymphs were placed singly on each of 10 plants of CUF 101 and the susceptible Moapa 69 for comparison. Mature (about six months old), vigorously growing plants were used in the tests. Before each experiment began, plants were conditioned for six days at the temperature at which the test would be conducted. Before infestation, plants were trimmed to a single stem and, following infestation, were enclosed in a plastic frame and nylon-organ- 
dy cage. Plants were then placed in a 2-inch-thick Styrofoam board drilled to accommodate the vials. Each plant was randomly positioned on the board, and a new location was assigned daily. Plants were replaced if they became too large for the cage or showed signs of deterioration, such as yellowing or spindly growth. Replacement plants were also conditioned at the appropriate temperature for six days before use.

Studies took place at 68°F and 59°F (20°C and 15°C) in growth chambers with a 12-hour light (fluorescent and incandescent lamps), 12-hour dark cycle. During the developmental period, cages were checked twice daily for cast skins to determine when molting occurred. After reproduction began, mortality and fecundity were recorded daily and all young removed. Cohorts in each generation were followed until the last member died.

Developmental times

At 68°F, total aphid developmental time was significantly longer (P < 0.01) in all four generations reared on CUF 101 than in those reared on Moapa 69 (fig. 1). Prolonged developmental times on CUF 101 resulted from extended third and/or fourth nymphal stages. At 59°F, only the first generation had a significantly longer total developmental time (P = 0.01) on CUF 101 than on Moapa 69. While the fourth nymphal stage in the third generation was significantly longer (P < 0.05) on CUF 101, total developmental time was not affected.

Survival and reproduction

At 68°F, aphid survival was as much as 280 day-degrees shorter on CUF 101 than on Moapa 69. In addition to a shorter survival time, mortality on CUF 101 began earlier and progressed at a much more rapid rate. At 59°F, however, survival rates were nearly identical on both cultivars.

Reproductive patterns on the two cultivars were distinctly different at 68°F. Fecundity curves on Moapa 69 were typical for aphids, with the reproductive maximum occurring early (within two to three days of reaching adulthood) followed by a gradual decline. Aphids reared on CUF 101 exhibited a less normal fecundity pattern. Peak reproduction was delayed until shortly before the midpoint of the reproductive cycle. Once reproduction on CUF 101 began, it appeared to remain at a more or less consistent level, followed by a precipitous decline and abrupt cessation. At 59°F, however, reproductive patterns on both cultivars were similar.

At 68°F, total progeny production was significantly higher (P < 0.05) in all four generations on Moapa 69 than on CUF 101 (fig. 2). At 59°F, however, total progeny production, except in the parental generation, was statistically identical on the two cultivars.

Discussion and conclusions

CUF 101, growing at 68°F, had an adverse effect on blue alfalfa aphid biology that was consistent with accepted definitions of antibiosis. Developmental times on CUF 101 were increased by as much as 24 percent (third generation) with a protracted third or fourth nymphal stage as the principal contributor to this increase. At 59°F, only the first generation had a significantly increased time to adulthood when reared on CUF 101_t0.05). Reduced fecundity, another indication of antibiosis, was also apparent at 68°F. Rearing on CUF 101 significantly depressed reproduciveness in all four generations when compared with that on Moapa 69. Although reproduction varied somewhat between the various generations, it was relatively consistent within individual cultivars. Such results suggest a relatively stable relationship between aphid and host over an extended period. Longevity on CUF 101 was also markedly reduced at 68°F. Such depressions in fecundity and survival have been documented in relationships between other aphids and resistant cultivars.

At 59°F, cultivar-mediated differences in survival and fecundity were virtually eliminated in all but the parental generation. Such temperature-induced loss of resistance is consistent with the findings of other researchers working with the spotted alfalfa aphid. CUF 101 appears to have moderate resistance to the blue alfalfa aphid when compared with a susceptible cultivar such as Moapa 69. While tolerance contributes somewhat to the success of CUF 101, antibiosis also plays a role. The loss of resistance at low temperatures could create some problems. Blue alfalfa aphid is an early-season, cool-weather pest and, in unusually cool springs, alfalfa resistance might be sufficiently suppressed to permit the development of economically injurious population levels. Frequent monitoring during such situations is advised.

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