Attraction of Twospotted Spider Mite to Bean Rust Uredinia

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ABSTRACT

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Adults of the twospotted spider mite, *Tetranychus urticae,* were two- to sixfold greater on bean leaves, *Phaseolus vulgaris,* containing multiple uredinia of the rust fungus, *Uromyces appendiculatus,* than on rust-free bean leaves. On rust-free plants, freshly released mites went to the young trifoliolate leaves; but on rust-infected plants, they initially migrated to uredinia on older leaves. Mites became covered with echinulate urediniospores and vectored them to rust-free plants. The smooth-walled teliospores seldom adhered to the mites.

The twospotted spider mite, *Tetranychus urticae* Koch, is well-known, cosmopolitan, and an important phytophagous agricultural pest (Fig. 1B). It is common on fruit trees, vegetables, and field crops. Worldwide, it is known from over 200 hosts, including common bean (1,2). Usually, it initially infests young leaves; but as populations increase, mites move onto older leaves. They produce a beige silk webbing along which they move. This mite causes severe chlorosis on beans, followed by bronzing (Fig. 1C). The mites overwinter as diapausing orange females. During summer, many generations may develop (1,3,8). The summer females are green to dark greenish and up to 300 μm long and 200 μm wide; the males are pale yellow to pale brown and much smaller.

The bean rust fungus, *Uromyces appendiculatus* (Pers.:Pers.) Unger, is also cosmopolitan, and it is a major pathogen of beans (*Phaseolus vulgaris* L.) throughout most of the world (7). It is a macrocyclic and autoecious rust (Fig. 1A and D). A review of the literature revealed no studies on the attraction of mites by *U. appendiculatus.* Our objectives were to determine if 1) bean rust uredinia preferentially attract mites, 2) spores fortuitously adhere to mites or mite behavior during their ontogeny elicits spore adherence, and 3) mites vector rust spores within the bean canopy.

The use of trade, firm, or cultivar names in this article is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

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MATERIALS AND METHODS

Location. In spring 1991, the twospotted spider mite was abundant on the leaves of rust-infected bean cv. Kentucky Wonder 780 planted in a domestic garden in Greenbelt, Maryland. During the previous 8 yr, beans were not grown in this plot, nor did it receive any pesticides. Daughters of this brood were parents of progenies used in our experiments (unfertilized eggs become males, fertilized ones, females). Experimental mites were raised on caged plants in the domestic garden.

Host plants and inoculation. Greenhouse-germinated plants were kept rust free by isolation or inoculated as seedlings with race 41 of the rust fungus following published procedures (5). On 1 May 1991 and 23 May 1992, 2-wk-old pot-grown pairs of bush snap bean cv. Slenderette and indeterminate short vine dry bean cvs. Pinto U.I. 111 and Pinto U.I. 114 were transplanted outdoors. These three cultivars are very susceptible to bean rust (6), and inoculated plants produced abundant large uredinia of *U. appendiculatus* with intensity in proportion to concentration of urediniospore inoculum. When necessary, experimental plants were grown in rain-, rust-, and mite-proof cages of plexiglass containing 9 × 18 cm openings covered with nylon netting. Sufficient aeration occurred through the netting so that the temperature within the cages was never more than 3 C above ambient. The rust-free plants remained rust free.

Mite populations caged with rusted and rust-free plants. During June and July 1991, four 4-wk-old potted bean plants, one per pot, two each of cvs. Slenderette and Pinto 111, were placed in each cage to confirm field observations on aggregation behavior of adult mites. One set of artificially inoculated greenhouse-grown plants bore mature uredinia of race 41, and the other similar set was rust free. A colony of 100 females reared on rust-free plants in separate cages was used for infestation, with 50 adults placed on one plant per pot. On a sunny day, the greenish adult females were carefully removed with a camel hair brush and placed on a clean host leaflet. This leaflet was then placed at the edge of each pot in each cage. The experiment was repeated twice.

RESULTS AND DISCUSSION

Throughout the growing season, the numbers of both uredinia and mites varied considerably from leaf to leaf of all cultivars. Mites and rust generally decreased apically on cv. Kentucky Wonder 780, a climber. Mite populations were consistently much higher on rust-infected than on rust-free leaves.

Mite population density. Between the beginning of observations (5 May 1991 and 23 May 1992) and the termination (23 July 1991 and 23 July 1992), the male and female adults of *T. urticae* were two to six times more numerous on rust-infected unifoliolate (first nodal) and trifoliolate (secondary nodal) leaves than on similar rust-free leaves of cv. Slenderette (Fig. 2). No comparable data on larvae, protonymphs, and deutonymphs were taken. However, all of these stages were abundant on young succulent leaves, on both rust-infected and rust-free plants in the domestic garden.

Mite behavior and webbing. Between dusk and about 9 a.m., mites were more abundant on abaxial than on adaxial leaf surfaces of all four bean cultivars. This confirms the abaxial/adaxial relationship reported earlier (1). The mites were often covered with urediniospores. This is the first report of the adherence of echinulate urediniospores to mites. The smooth-walled teliospores rarely adhered to mites. Many urediniospores remained caught between mite hairs and leg joints, even after mites had crawled for 24 hr on 2% water agar in petri dishes. On days when leaf surface moisture was heavy, such as during cool rainy periods, most mites did not appear on the adaxial leaf surface until moisture on the adaxial surface had evaporated. This was observed both on uncaged and caged plants. Adult mites (12 and 7 observations in 1991 and 1992, respectively) spent considerable time exploring the pale yellow pearllike exudate that usually accumulates on top of mature uredinia under near-saturated moisture regimens. In two such cases, an adult remained nearly motionless for 30 min and apparently imbibed exudate, because it became

considerably swollen.

The rust-colored webbing made by the mites often permeated and enclosed uredinia. Instead of being well-organized discrete structures, they appeared as amorphous powdery masses of urediniospores. Usually an amorphous 1–3 mm area of dislodged urediniospores surrounded the original uredinium (Fig. 1E). On 23 July 1991, 83% of 2,523 rust pustules that were examined stereoscopically (120×) were primarily uredinial; those remaining were primarily telial. Whereas 63% of uredinia had an amorphous-webbed appearance, there were no signs that mites disturbed the telia. The mite webbing on all rust-infected leaves was ornamented with rows of the echinulate *U. appendiculatus* urediniospores, giving individual threads the appearance of strings of beads. Many observations indicated that uredinia served as mite nurseries. Many urediniospores became lodged between their leg joints and hair during ontogeny of the young mites.

Six hours after infestation of the caged plants, the mite colony had dispersed from the initial source leaflet, which was then discarded. At 24 hr, 36% of the mites

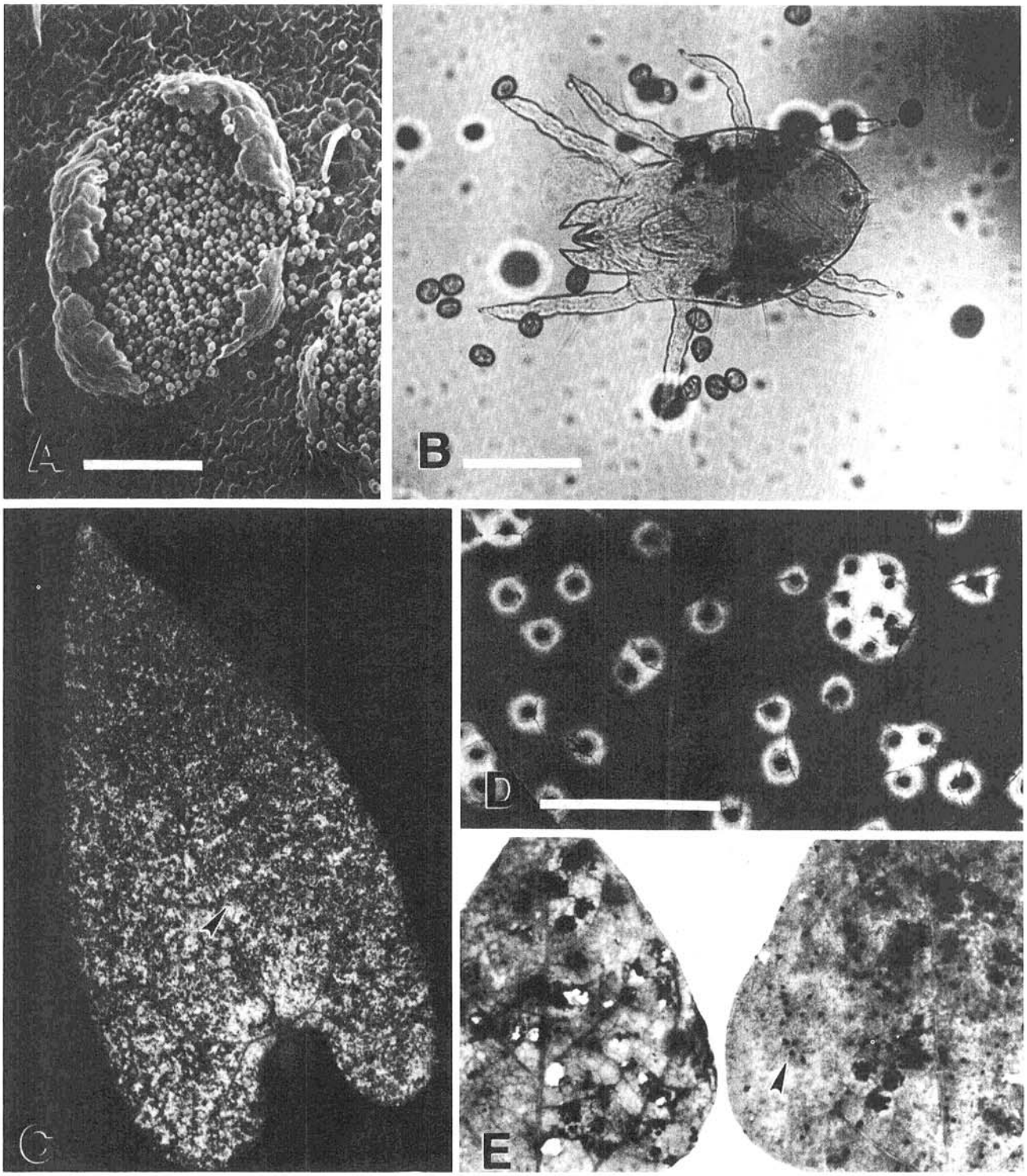

Fig. 1. (A) Uredinium of *Uromyces appendiculatus*. Scale bar equals 200 μm. **(B)** Adult *Tetranychus urticae* mite with bean rust urediniospores. Scale bar equals 100 μm. **(C)** Bean leaf, cv. Slenderette, with heavy mite infestation (black objects, arrow) and symptoms of mite injury (numerous light colored spots), about natural size. **(D)** Rust uredinia undisturbed by mites. Scale bar equals 10 mm. **(E)** Similar uredinia damaged by mite activity (discrete black bodies are telia, arrow), about natural size.

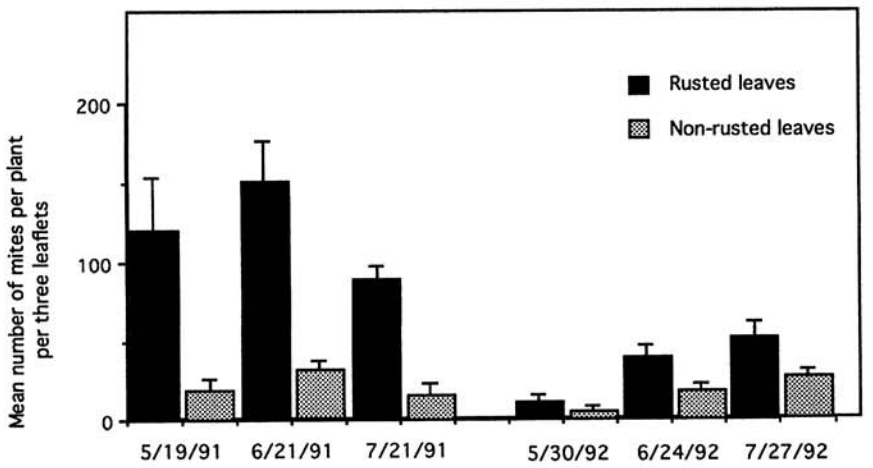

Fig. 2. Mean number of adults of *Tetranychus urticae* mites counted per plant on rust-infected and rust-free bean cv. Slenderette at Greenbelt, Maryland. In all cases, rusted leaves had significantly ($P < 0.001$) greater numbers of mites than did healthy leaves. Numbers of mites counted were from eight plants (two trifoliolate leaflets and one unifoliolate leaf per plant in May and June, and three trifoliolate leaflets per plant in July). Bar length above each mean represents one standard deviation.

in the rust-free plants of cv. Slenderette were lodged on the two youngest, fully expanded trifoliolate 11th or 12th leaves; and the remaining mites were randomly scattered on the second through 10th nodal leaves. The same distribution pattern occurred on cv. Pinto U.I. 111. Abundant mite-feeding marks were observed on both cultivars, which were equally susceptible to mite damage. In contrast, no mites were present on the equivalent youngest, rust-free leaves on rust-infected plants. They remained confined to uredinia-bearing second through sixth nodal leaves.

Walter and Dowd (9) recently reported that several species of mites, including *Tetranychus* species, are attracted to crevices or hollows (domatia) in angiosperm leaves, which serve as a lodging for them. Although domatia comprised only a small fraction of total leaf area, they contained most of the inactive stages (eggs and quiescent, molting mites) and a large fraction of active stages (larvae, nymphs, and adults). It appears that rust uredinia mimic domatia and provide suitable nesting places for them. Four days after infestation, uredinia appeared amorphous and disorganized, as described above; and mite eggs were found among them. At this time some adults moved to younger 10th or 11th nodal leaves and also deposited eggs there. Five weeks after infestation, the experiment was terminated. At this time, a mean of 26.7 adults, males and females, per leaflet were recovered from rust-free plants (n = 641; SD = 6.81) vs. 24.3 from rust-infected ones (n = 583; SD = 7.73) (average of 24 randomly removed leaflets, 12 per bean cultivar, i.e., six per plant). These data indicate that mite colonies on the rust-infected and rust-free plants multiplied equally well. During the cool wet May and June of 1992, a lower experimental mite population developed than in 1991. Thus, comparable investigations were not undertaken on caged rust-infected and rust-free plants in 1992.

Mites as vectors of urediniospores. In a separate experiment, rust-infested adult females were placed on six rust-free caged plants of cv. Pinto U.I. 111, and similar uninfested plants were kept as controls. Natural dew deposition was prolonged and heavy for the next several night–morning periods. Uredinia of *U. appendiculatus* appeared about 1 wk later on mite-infested plants, whereas controls remained rust free, indicating that the fungus can be transmitted by the twospotted spider mite. Although this indicates that rust urediniospores can be mite disseminated, the rust fungus is well known to be wind-disseminated. It is doubtful that mites are major vectors because of their limited capacity to migrate, as compared with readily wind-borne urediniospores. Uredinial webbing produced by the mites and their debilitating effect on the plants seem likely to reduce urediniospore production and dispersal below the levels on mite-free plants. However, attractiveness of the rust fungus to the mites suggests that rusted beans are likely to be more severely debilitated by mites, and thus overall damage to the crop could be enhanced. Perhaps mites could accomplish spermatization in *U. appendiculatus,* as many insects do for other rusts (4).

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LITERATURE CITED

1. Cagle, L. R. 1949. Life history of the twospotted spider mite. Va. Agric. Exp. Stn. Tech. Bull. 113:1-31.
2. Cardona, C. 1989. Insects and other invertebrate bean pests in Latin America. Pages 505-570 in: Bean Production Problems in the Tropics. H. F. Schwartz and M. A. Pastor-Corrales, eds. Centro Internacional de Agricultura Tropical, Cali, Colombia.
3. Herbert, H. J. 1981. Biology, life tables and innate capacity for increase of the twospotted spider mite, *Tetranychus urticae* (Acarina:Tetranychidae). Can. Entomol. 113:371-378.
4. Roy, B. A. 1993. Floral mimicry induced by a plant pathogen. Nature 362:56-58.
5. Stavely, J. R. 1983. A rapid technique for inoculation of *Phaseolus vulgaris* with multiple pathotypes of *Uromyces phaseoli.* Phytopathology 73:676-679.
6. Stavely, J. R. 1984. Pathogenic specialization in *Uromyces phaseoli* in the United States and rust resistance in beans. Plant Dis. 68:95-99.
7. Stavely, J. R., and Pastor-Corrales, M. A. 1989. Rust. Pages 159-194 in: Bean Production Problems in the Tropics. H. F. Schwartz and M. S. Pastor-Corrales, eds. Centro Internacional de Agricultura Tropical, Cali, Colombia.
8. van de Vrie, M., McMurtry, J. A., and Huffaker, C. B. 1972. Ecology of tetranychid mites and their natural enemies. A review. III. Biology, ecology and pest status, and host-plant relations of tetranychids. Hilgardia 41:343-432.
9. Walter, D. E., and Dowd, D. J. 1992. Leaves with domatia have more mites. Ecology 73:1514-1518.