Reaction of Downy Mildew-Resistant Lettuce Cultivars to Infection by Turnip Mosaic Virus

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ABSTRACT

Lettuce cultivars resistant to one or more Bremia lactucae races in Israel or The Netherlands were assayed for reaction to the California race of B. lactucae and to turnip mosaic virus (TuMV). Forty-three cultivars resistant to one or more Israeli or Netherlands races were resistant to U.S. race 5 which is prevalent in California. By using the world lettuce cultivar differentials for identifying races of B. lactucae, we found U.S. race 5 to be different from British races W1, W2, and W3; Israeli races 1, 2, and 4; and Netherlands races 1, 2, 3, and 4. Israeli race 3 and U.S. race 5 appear to be similar. Downy mildew-resistant, TuMV-susceptible cultivars were restricted to the crisphead type. Cultivars Calice, Calmar, Calmaria, E-4, Imperial 410, Imperial Triumph, Montemar, Monterey, Valrio, Valtemp, and Valverde were mildew-resistant and TuMV-susceptible. The crisphead cultivar Avoncrisp was resistant to both mildew and TuMV. Twenty-seven butterhead type cultivars, two leaf types, one cos type, and one Latin type were resistant, both to U.S. race 5 of B. lactucae and to TuMV. The genetic relationships of mildew-resistant and TuMV-susceptible cultivars are discussed.

Additional key words: races, linkage.

Downy mildew (incited by Bremia lactucae Reg.)-resistant crisphead lettuce cultivars Lactuca sativa L. grown in the United States are susceptible to turnip mosaic virus (TuMV) (16, 17, 18, 19). These cultivars are derived from crosses of Imperial D × Lactuca serriola L. (P.I. 91532), reported in the early literature as P.I. 104854 (8, 14). Resistance to B. lactucae, U.S. race 5, is conferred by a single dominant allele, designated Dm, in cultivars with the L. serriola (P.I. 91532) source of resistance (8, 17). Susceptibility to TuMV is conferred by a recessive allele, designated ts; the TuMV allele, Ts, is linked with the mildew allele, Dm dm (17, 18).

Cultivars with P.I. 91532 source of resistance to B. lactucae are susceptible to U.S. race 6 in Texas, a new race in California, British race W3, Israeli races 1 and 4, and Netherlands races 3 and 4 (3, 4, 9, 10). There is need, therefore, for additional mildew-resistant alleles, free of the linkage to the TuMV-susceptible allele, to broaden the genetic base for resistance to races of B. lactucae.

The purposes of this article are: (i) to report the identity of the prevalent race of B. lactucae in California, and to compare its identity with races in England, The Netherlands, and Israel; (ii) to list cultivars resistant to U.S. race 5 of B. lactucae; (iii) to list cultivars that are TuMV resistant and carry allele(s) that confer resistance to one or more British, Israeli, The Netherlands, and U.S. races of B. lactucae; and (iv) to report information concerning the inheritance of resistance to races of B. lactucae in relationship to TuMV susceptibility.

MATERIALS AND METHODS.—Forty-three lettuce cultivars resistant to one or more B. lactucae races in Israel or The Netherlands were assayed for reaction to U.S. race 5 of B. lactucae and to TuMV. Approximately 70 seedlings of each cultivar were assayed for mildew reaction, and about 40 for TuMV reaction.

Downy mildew inoculum was collected from commercial lettuce fields in the central coastal districts of California. Cultures of mildew were maintained continuously on Great Lakes 118 to provide a readily available supply of inoculum. The mildew race or races prevalent in this area were determined by use of the world lettuce cultivar differentials for identifying races of B. lactucae (11).

Seeds for plants to be assayed for mildew reaction were placed on moist blotter paper in 11.5 × 10.5 × 3 cm plastic “sandwich boxes,” 35 seeds per box. The boxes were placed on slant trays at a 45-degree angle, and a well of one-quarter strength Hoagland’s solution (5) was maintained at the base of each box during germination and incubation. The seeds were germinated at 20-22 C under continuous light. On the seventh day, the young seedlings with expanded cotyledons were inoculated with a water suspension of spores. The plastic boxes containing the seedlings were then placed in a growth chamber similar to that described by Huyskes (6). A second inoculation of mildew was made two days after the first inoculation. A photoperiod of 14 hours of light and 10 hours dark was used. During the ‘day’ the temp was 15 C, with a relative air humidity of 95%, while at ‘night’ it was 5 C, with 100% relative humidity. An incubation period of 14 days after the second inoculation was allowed before the seedlings were scored for mildew reaction. By misting the seedlings, and then placing lids on the “sandwich boxes” for 10 hours in the dark, conidiophores and conidia were formed on the surfaces of the cotyledons of susceptible cultivars. A cultivar was susceptible if 100% of the plants became infected, and resistant if none were attacked. In each test, mildew-resistant Calamar and mildew-susceptible Great Lakes 118 were included.

The TuMV isolate was obtained from a commercial planting of Calmar in the Salinas Valley of California. All isolates of TuMV thus far collected are capable of infecting susceptible lettuce cultivars (16). To provide a readily available supply of inoculum, the virus was maintained continuously in turnip plants, Brassica campestris L. (Raphiara group).

Nonviruliferous green peach aphids, Myzus persicae (Sulz.), were reared on radish, Raphanus sativus L. The nonviruliferous aphids were transferred to TuMV-
infected turnip plants for about 24 hours; then approximately 20 aphids were transferred to each lettuce seedling for an infection feeding period of about 24 hours. After inoculation with aphids, all plants were sprayed with nicotine sulfate and placed in greenhouses, which were fumigated at weekly intervals with nicotine sulfate. An incubation period of 21 days after inoculation was allowed before the seedlings were scored for TuMV reaction. A clear distinction between susceptible and resistant cultivars was observed. A cultivar was susceptible if 100% of the plants became infected, and resistant if none were infected. Resistant cultivars have extremely high resistance ("immunity") to TuMV (16).

RESULTS.—Identification of mildew race.—The following cultivars were susceptible to the mildew collection from the central coast of California: Caravan, Climax, Delta, Francisco, Grand Rapids, Great Lakes 65, Great Lakes 118, Grosos, Hilde, Imperial D, Imperial F, Imperial 615, Resistant, Suzan, and Wonder van Voorburg. The cultivar Bourguignon from the world collection was susceptible, but our stock of Bourguignon was resistant to the California race.

Cultivars resistant to the prevalent race in California are as follows: Crisphead type — Avonc ISBN, Calicel, Calmar, Calmaria, E-4, Imperial 410, Imperial Triumph, Montemar, Monterey, Valrio, Valtem, Valverde. Butterhead type — Agilo, Amplus, Arlon, Avondefiance, Briosso, Bourguignonne, Interrex, Klock, Knap, Kordaat, Korrekt, Kwick, Larganda, Liba, Magiola, Meikoningin, Noran, Proeftuinn's Blackpool, Portato, Rapide, Regina, Secura, Solito, Tinto, Tonika, Valore, Ventura. Leaf type — Red Salad Bowl, Salad Trim. Cos type — Valmaine. Latin type — Sucrine. The reaction of these cultivars indicates that U.S. race 5 was present since cultivars Imperial F, Imperial D, and Imperial 615 resistant to U.S. race 4 were susceptible (7, 8). The cultivars Calmar, Valverde, and Valmaine were resistant; therefore, U.S. race 6 was not present (10). With the use of the system suggested by Tjallingii and Rodenburg (11), we determined that U.S. race 5, the prevalent race in California, is different from Netherlands (NL) races 1, 2, 3, and 4. Based on the results of Neter (9) on the reaction of cultivars to the four Israeli races, it is apparent that U.S. race 5 is different from Israeli races 1, 2, and 4. Forty-eight cultivars, used for identifying races, inoculated with U.S. race 5 gave identical reactions as those reported by Globerson et al. (4) for Israeli race 3. United States races 5 and Israeli race 3 appear to be similar. The reaction of test cultivars indicates that the British races W1, W2, and W3 differ from U.S. race 5 (2).

Resistance to TuMV and Bremia lactucae.—To determine how widespread susceptibility to TuMV is in mildew-resistant cultivars of L. sativa, the world cultivar differentials for identifying races of B. lactucae also were surveyed for TuMV resistance.

The cultivars tested were either susceptible or resistant to TuMV, with no segregation within the population of a given cultivar. TuMV-susceptible, downy mildew-resistant cultivars were all of the crisphead type: Calicel, Calmar, Calmaria, E-4, Imperial 410, Imperial Triumph, Montemar, Monterey, Valrio, Valtem, and Valverde. Cultivars resistant to TuMV and to U.S. race 5 as well as to one or more Israeli and Netherlands races of B. lactucae are as follows: Crisphead type — Avonc ISBN.
Calmar also carries two dominant complementary alleles, which confer resistance to NL2 and NL1 (4). The inheritance of resistance to the British races has not been reported. It is not known whether the single dominant allele that confers resistance to U.S. race 5 is the same as one of the alleles that confers resistance to one or more of the Israeli, Netherlands, or British races. The similarity of U.S. race 5 and I1.3 suggest that the single dominant allele which confers resistance to U.S. 5 is the same allele which confers resistance to I1.3.

Lettuce cultivars Calmar, Calmaria, and Montemar were found seriously affected with *B. lactucae* in commercial plantings in the Santa Maria Valley of California in the spring of 1974. This is the first observation of a race attacking cultivars with P.I. 91532 source of resistance in California. A new physiologic race is believed to be the cause of the recent outbreak of downy mildew in these previously resistant cultivars. At least it is a new race in California. It is not known if this is an introduced race, or one which developed as a mutant in California.

LITERATURE CITED