Evaluation of Asparagus for Resistance to *Puccinia asparagi*

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ABSTRACT

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Asparagus officinalis lines from the United States, Canada, and France were evaluated for resistance to *Puccinia asparagi* in naturally infected plots at two Minnesota locations. Several New Jersey selections, including NJ 497, NJ 630, and Rutgers 202, were resistant to both the aecial and uredinial states of the rust fungus. The correlation between the disease ratings based on the frequency of aecia and uredinia among the 45 lines at one location was significant ($r = 0.51$, $P = 0.01$). Disease ratings for uredinial development at the first and second locations were highly correlated ($r = 0.71$, $P = 0.01$) for the 29 lines included at both locations.

Puccinia asparagi DC. is an autoecious, macrocyclic rust that is a serious threat to the asparagus (*Asparagus officinalis* L.) industry. As early as 1902, the rust had spread to every important asparagus-growing region in the United States (6). Even arid areas such as the Imperial Valley of California have reported serious rust damage, with many fields having 100% of the plants infected (4). Rust outbreaks occur in commercial fields after the cutting season when good shoot growth is essential to provide reserves to the crown for the subsequent year's crop. By interfering with carbohydrate synthesis, the rust lowers the amounts of root storage metabolites and reduces plant vigor and yield (3). Plant stress resulting from severe infection can result in death.

Only species of *Asparagus* and *Allium* are susceptible to *P. asparagi* (3). Many commercial cultivars of asparagus—including Mary Washington, which was developed as a rust-resistant line—are severely infected in the field. None of the named cultivars and asparagus selections screened in the greenhouse and field before 1952 by Kahn et al (3) was highly resistant to the rust.

In this study, 45 asparagus lines, including many recently developed hybrids, were screened for resistance to aecial and uredinial development during a natural outbreak of *P. asparagi*.

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MATERIALS AND METHODS

Asparagus field trials containing selections from the United States, Canada, and France were established from seedling transplants. The main planting was located on a silt loam soil at the Horticultural Research Center near Chanhassen, MN (site 1). Forty-five lines of asparagus were planted on 13 May 1980 in a randomized complete block design with four replicates of 25 plants per plot. A second planting containing 29 of the 45 asparagus lines was made on a sandy loam soil at Becker, MN (site 2) on 15 May 1980. This site contained three replicates in a randomized complete block design with 20 plants per plot. At both locations, transplants were spaced 30 cm apart in furrows 20–25 cm deep in single-row plots on 1.5-m centers.

No rust infection was observed during the summer of 1980. A natural outbreak of *P. asparagi* occurred at both sites in 1981. No irrigation was applied at either location during the infection period. At site 1, aecial and uredinial development were scored on 2 June 1981 and 7 July 1981, respectively. Uredinial development was scored on 20 August 1981 at site 2. Two observers evaluated the plants independently. An average disease severity score based on approximate pustule counts per plant was assigned as follows: 0 = none, 1 = 1–5, 2 = 6–100, 3 = 101–300, 4 = 301–1,000, and 5 = more than 1,000.

RESULTS AND DISCUSSION

Infection by *P. asparagi* was first observed at site 1 in early May 1981 on second-year transplants. A month later, pycnial and aecial pustules were present on a majority of the plants. Differences ($P = 0.01$) in disease severity scores, based on the frequency of aecial pustules, were found among the asparagus lines (Table 1). Plant to plant variation within lines was high, and the coefficient of variation for the aecial screening of the 45 lines was 35%. Block differences were also

significant ($P = 0.01$), reflecting an uneven distribution of natural inoculum in the plot.

On most infected plants, aecial densities decreased from the base up, suggesting that telia in prostrate overwintered debris, possibly including dead stems still attached to the crown, were the sources of the primary infection from basidiospores. Also, the absence of established asparagus or onion (*Allium cepa* L.) plants in the immediate vicinity of either trial location supported the contention that telia constituted the inoculum source. Basidiospores of rust fungi are susceptible to drying (7) and are not likely to result in heavy, relatively uniform aecial production if they originate from outside the plots.

Differences ($P = 0.01$) in resistance to development of uredinia (Table 2) were found among the plants that had been evaluated for aecial production at site 1. A block effect was observed, with uredinial frequencies heaviest in the replicates that previously had higher levels of aecia. The correlation between aecial and uredinial scores for the 45 asparagus lines was significant ($r = 0.51$, $P = 0.01$). Several lines, including NJ 497, NJ 630, and Rutgers 202, were resistant to both the aecial and uredinial states of the rust. However, other lines, including Mn 4X2, NJ 663, NJ 647, and Wash T2, appeared to have differential response to the rust states. While breeding for resistance to the rust, Norton (5) noted high density of aecia on some selections of asparagus resistant to the uredinial state. Differential resistance to the pycnial (and aecial) vs. the uredinial state of an autoecious rust has been shown in flax to flax rust (2,8).

No aecia were observed in the plots at site 2, and uredinial production did not occur until mid-July. Although the planting at site 2 contained only three replicates of the asparagus lines, the rust was uniformly distributed across the plots, resulting in no significant block effects. The coefficient of variation for the uredinial screening of the 29 lines at site 2 was 15%, compared with 25% at site 1. Plant growth on the sandy soil at site 2 was less vigorous than on the heavier silt loam soil at site 1. Asparagus grown on sandy loam averaged 15% fewer stems and a reduction of 30% in height compared with those on the silt loam (*unpublished data*). Although plant growth was influenced by the environment, host response to uredinial production by *P. asparagi* apparently was not. Significant differences in the response of the asparagus cultivars to uredinial production were again observed (Table 2). The disease ratings for uredinial development at site 2 correlated well ($r = 0.71$, $P = 0.01$) with those obtained from evaluation of uredinia at site 1.

The genetics of the host-pathogen relationship between asparagus and *P. asparagi* has not been elucidated, nor is much known about the relationship between resistance to the pathogen and plant characteristics. Norton (5) reported a positive correlation between seedling height and resistance to the rust fungus in his crosses. The low correlations between uredinial resistance and height ($r = 0.13$ at site 1 and $r = 0.16$ at site 2) were not significant in our study and do not support such an association between these factors.

High levels of resistance to *P. asparagi* exist within the present germ plasm of *A. officinalis*. Rutgers 202, a line resistant to development of both aecia and uredinia in our study, will be available in 1982 as the cultivar Jersey Centennial (1). The variability in disease reaction to the rust and the development of pure lines of asparagus through production of male hybrids and cloning techniques will aid in future studies of the genetics of resistance to *P. asparagi* and the variability of the pathogen.

Table 1. Mean aecial ratings of 45 asparagus lines and hybrids infected with *Puccinia asparagi* at Chanhassen, MN

Asparagus line or hybrid	Disease severity rating[a]
NJ 467	0.8 a
NJ 497	1.0 ab
Rutgers 202	1.0 ab
NJ 630	1.1 ab
Mn 4X2	1.1 ab
NJ 528	1.3 abc
NJ 529	1.3 abc
NJ 647	1.3 abc
NJ 663	1.3 abc
Mn 6X4	1.3 abc
Mn 6X2	1.3 abc
Wash T2	1.3 abc
Rutgers Beacon	1.4 abc
Green Giant Selection	1.4 abc
Mn 6X5	1.4 abc
Mn 4X3	1.4 abc
Wash T1	1.4 abc
Wash C1	1.4 abc
NJ 532	1.5 abcde
NJ 565	1.5 abcde
NJ 643	1.5 abcde
Viking 2K	1.5 abcde
Bruneto	1.5 abcde
NJ 534	1.6 abcdef
NJ 545	1.6 abcdef
NJ 581	1.6 abcdef
Mn 6X3	1.6 abcdef
Wash C2	1.6 abcdef
NJ 589	1.8 abcdef
MN 4-5X3-9	1.8 abcdef
Aneto	1.8 abcdef
NJ 582	1.9 bcdef
NJ 639	1.9 bcdef
MN 3X1	1.9 bcdef
Larac	1.9 bcdef
NJ 547	2.0 bcdef
Faribo F-1	2.0 bcdef
NJ 533	2.3 cdef
NJ 566	2.3 cdef
NJ 640	2.3 cdef
NJ 652	2.4 cdef
WSU 1	2.4 cdef
NJ 590	2.5 ef
Cito	2.5 ef
NJ 569	2.6 f

[a] Each rating is the mean of four replicates (two independent evaluations of 25 plants per replicate), using a disease severity index based on approximate numbers of aecia per plant: 0 = none, 1 = 1–5, 2 = 6–100, 3 = 101–300, 4 = 301–1,000, and 5 = more than 1,000. Means not followed by the same letter differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 2. Uredinial ratings of asparagus lines and hybrids infected with *Puccinia asparagi* at Chanhassen and Becker, MN

Asparagus line or hybrid	Disease severity rating[a]	
	Chanhassen[b]	Becker[c]
NJ 467	1.1 a	3.2 cdef
Bruneto	1.1 a	2.0 a
NJ 497	1.3 ab	2.0 a
Rutgers 202	1.3 ab	···
NJ 529	1.4 abc	3.2 cdef
NJ 630	1.4 abc	···
MN 6X4	1.4 abc	···
MN 4X3	1.4 abc	3.0 bcde
NJ 528	1.5 abcd	2.3 ab
NJ 581	1.5 abcd	···
NJ 532	1.6 abcde	3.2 cdef
NJ 547	1.6 abcde	2.5 abc
Rutgers Beacon	1.6 abcde	···
Aneto	1.6 abcde	2.8 abcd
MN 6X3	1.8 abcdef	3.3 cdefg
Viking 2K	1.8 abcdef	2.8 abcd
NJ 534	1.9 abcdefg	2.8 abcd
NJ 565	1.9 abcdefg	···
Green Giant Selection	1.9 abcdefg	3.3 cdefg
Faribo F-1	1.9 abcdefg	···
MN 6X2	1.9 abcdefg	···
CITO	1.9 abcdefg	3.8 efgh
NJ 589	2.1 bcdefgh	···
NJ 643	2.1 bcdefgh	2.3 ab
MN 3X1	2.1 bcdefgh	3.2 cdef
Larac	2.1 bcdefgh	3.2 cdef
NJ 582	2.3 defghi	4.0 fgh
MN 6X5	2.3 defghi	4.2 gh
MN 4-5X3-9	2.3 defghi	3.8 efgh
Wash T1	2.3 defghi	4.3 h
NJ 590	2.4 efghi	···
NJ 640	2.4 efghi	···
NJ 647	2.4 efghi	2.3 ab
NJ 663	2.4 efghi	···
MN 4X2	2.4 efghi	3.8 efgh
WSU 1	2.4 efghi	···
NJ 566	2.5 fghi	3.7 defgh
Wash T2	2.5 fghi	4.2 gh
Wash C1	2.5 fghi	4.2 gh
NJ 569	2.6 fghi	···
NJ 652	2.6 fghi	···
NJ 545	2.8 ghi	···
NJ 639	2.8 ghi	3.8 efgh
NJ 533	2.9 hi	4.0 fgh
Wash C2	3.0 i	4.5 h

[a] Disease ratings are based on approximate numbers of uredinia per plant: 0 = none, 1 = 1–5, 2 = 6–100, 3 = 101–300, 4 = 301–1,000, and 5 = more than 1,000. Means within a column not followed by the same letter differ significantly ($P = 0.05$) according to Duncan's multiple range test.

[b] Each rating is the mean of four replicates, with two independent evaluations of 25 plants per replicate.

[c] Each rating is the mean of three replicates, with two independent evaluations of 20 plants per replicate.

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