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FIELD RESPONSE OF SOME ASPARAGUS VARIETIES TO RUST, FUSARIUM CROWN ROOT ROT, AND VIOLET ROOT ROT

F. FIUME & G. FIUME
Sezione di Biologia, Fisiologia e Difesa
Istituto Sperimentale per l'Orticoltura (MiPAF)
via Cavalleggeri 25, I-84098 Pontecagnano (Salerno), Italy

ABSTRACT

Research was carried out to evaluate the behaviour of some asparagus genotypes against three most important fungal diseases: 1) asparagus rust caused by *Puccinia asparagi* D.C.; 2) *Fusarium* crown and root rot caused by *Fusarium oxysporum* (Schlecht.) f.sp. *asparagi* (Cohen & Heald) and *Fusarium proliferatum* (Matsush.) Nirenberg; 3) violet root rot caused by *Rhizoctonia violacea* Tul. The object of this research was also to found an eventual correlation between the plant susceptibility to asparagus rust and the sensibility to *Fusarium* crown root rot and violet root rot attacks. Resistant genotypes to rust should be less susceptible to attacks from *F. oxysporum* f.sp. *asparagi*, *F. proliferatum* and *R. violacea*, a fungal complex causing the plant decline.
Asparagus genotypes were compared in a randomized complete block experiment design, replicated four times, in order to search that ones showing the best behaviour to escape the diseases. Phytopatological observations were carried out on November when the control plots showed 100% infected plants. The pathogens were isolated and identified. The diseased plants were registered. According to symptom evaluation scales, all the plants were grouped into infection classes, calculating frequency and McKinney index. Wishing to learn something about the infection trend of *F. oxysporum* f.sp. *asparagi* or *R. violacea* in relation to *P. asparagi* attack, the relative curvilinear regressions were calculated.
The Italian cultivars "Marte" and "Grande" showed significantly the best behaviour in terms of resistance to asparagus rust, exhibiting 37% and 42% of diseased plants. The McKinney index was 9.1% and 15.6%, respectively. The susceptible plots showed 100% of infected plants and different McKinney index: 46% for "Eros", about 60% for "H 519", "Atlas" and "Golia", over 70% for the remainder. "Marte" and "Grande" showed good tolerance to *F. oxysporum* f.sp. *asparagi* and to *R. violacea* exhibiting up to 100% of healthy plants. The regression between plants affected by asparagus rust and those diseased by *Fusarium* crown root rot showed a linear equation with a regression coefficient b = 1.186 and a correlation coefficient R^2 = 0.98. The regression between infection caused by rust and that caused by violet root rot exhibited a regression coefficient b = 1.03 and a coefficient of correlation R^2 = 0.9. "Marte" and "Grande" exhibited the best behaviour against the rust attacks. Plants without rust were tolerant to pathogens causing plant decline.

INTRODUCTION

Asparagus (*Asparagus officinalis* L.) is a member of the lily family grown as a perennial crop. A planting may remain productive for 6 to 10 years, although to allow establishment time, returns are not high in the first few years. Asparagus has potential both in the domestic and export markets. It is highly nutritious, flavorful, and has medicinal properties such as the improvement of the digestive qualities, a strong diuretic and benefits people with heart problems (Schofield, 1946).

In Italy, the cultivation surface of asparagus increased, during 2000 to 2001, from 5516 Ha to 6211 Ha and the yield ranged from 56.6 q/Ha up to 62.6 q/Ha. Turions harvested and marketable were 304916 q in the first year (2000) and 380733 q in the second (2001).

Asparagus diseases studied in this work were asparagus rust, *Fusarium* crown and root rot, violet root rot that were among them correlated in relation to variety susceptibility and symptom severity in open field.

Puccinia asparagi D.C. (*Basidiomycotina*, *Uredinales*, *Pucciniaceae*) is responsible for asparagus rust, one the most important fungal disease attacking asparagus plants where the liliaceous is grown. Asparagus rust was originally described in France in 1805 and within a few years had spread to every region where asparagus was grown (Halsteated, 1898; Norton, 1913; Kahn *et al.*, 1952). In Italy, rust is diffused in almost all the asparagus cultivation regions (Matta and Garibaldi, 1969; Messiaen and Lafon, 1970; Brunelli *et al.*, 1989). Symptoms are first noticeable on the growing shoots in early summer as light green, oval lesions, followed by tan blister spots and black, protruding blisters later in the season. The lesions are symptoms of *Puccinia asparagi* during early spring, mid-summer and later summer to fall, respectively. Severe rust infections stunt or kill young asparagus shoots, causing foliage to fall prematurely, and reduce the ability of the plant to store food reserves in the crown. The asparagus plants can parch, the below spears are suffering and the cultivations became more susceptible to attacks of root pathogens. *P. asparagi* is an autoecious (single host) complete-cycle rust, pathogen which produces four spore types (basidiospores, aeciospores, urediniospores, and teliospores) in succession. Early spring infections of young spears occur with basidiospores. These infections, in turn, produce oval, light-green lesions about 6 x 19 mm in size. One to 2-weeks later, cream coloured aecia are produced. The windblown aeciospores initiate early rust epidemics and then give rise to the brownish-red uredinia stage. The uredinial cycle repeats every 10 to 14 days during summer and autumn. The urediospores are wind-borne to plants where new generations are formed causing the majority of fern damage. In early fall, completing the life cycle, blackish telia, at first subepidermic and then dehiscent, replace uredinia and serve as the overwintering stage. The aecia stage is the focal point for disease spread and the field cut can reduce the disease epidemic. If the first year field is not harvested, the aecia stage on the spear is not removed, develops and leads to greater severity the two-year-old field. If the field is harvested preventing the aecia stage from developing, the rust will show low severity. The difference in rust severity between a 2-year-old uncut field and a 3-year-old harvested field can be striking.

Management of rust can be achieved by using an integrated approach of resistant cultivars, fungicides, and sanitation practices. Breeders have since made great improvements in incorporating stable quantitatively inherited resistance into commercial lines (Blanchette *et al.*, 1982; Johnson, 1990; Johnson and Lunden, 1992; Johnson and Peaden, 1993). However, the current level of resistance is insufficient to completely control severe outbreaks (Johnson, 1989). The control of asparagus rust is possible by using chemicals such as zineb, mancozeb, maneb, bitertanole, alone or in combination with captan and EBI cyproconazole and tebuconazole (Brunelli *et al.*, 1989). However, cultivar improvements are needed because damage thresholds have been determined, fungicide applications could be timed to suppress outbreaks during conducive periods. The current dilemma in rust management is the loss of registered products and the processors refusal to accept asparagus treated with EBDC fungicides. Fungicide treatments are costly inputs that could be reduced with improved genetic resistance to rust.

Fusarium crown and root rot, caused by *Fusarium oxysporum* (Schlecht.) f.sp. *asparagi* (Cohen and Heald) and *Fusarium proliferatum* (Matsushima T.) Nirenberg, is a disease of worldwide economic importance wherever asparagus is grown and the major cause of early plant decline. Disease symptoms are characterized by the production of weak, spindly spears in the spring. As the season progresses, shoots from severely infected crowns may exhibit brilliant yellow coloration and they may exhibit a limited amount of vascular discoloration. Feeder roots are frequently rotted and discolored, with the discoloration extending into the storage roots. Stems infected with the stem miner frequently exhibit extensive lesions near the soil line. Affected crowns are found to have a low number of shoot buds and a reddish-brown discoloration of tissue when cut in cross section. Plants weakened by adverse growing conditions and by extending harvest too long are most severely affected by Fusarium wilt and crown rot. *F. oxysporum* produces long-lived chlamydospores that can infest soil for many years.

Pathogens are seedborne (Inglis, 1980; Damicone *et al.*, 1981) and carried on transplants. Seed disinfection by using a solution of benomyl in acetone eradicates the *Fusarium* pathogens from asparagus seed.

Management of Fusarium crown and root rot is difficult because pathogens are ubiquitous (Damicone and Manning, 1985; LaMondia and Elmer, 1989). Preventive measures, such as choosing sandy, well-drained soils, increasing soil pH up to 7.5 (Hodupp, 1983), using fertilizers and organic amendant (Huber, 1990) and selecting the best cultivars for the area, are very important, but growers need strategies in place when established plantings show signs of decline. Limited success has been made by broadcasting NaCl onto older, declining fields (Elmer, 1992; 1995; Elmer *et al.*, 1996; Elmer and LaMondia, 1998; Reid *et al.*, 2001). Research has found that rates between 560-1120 kg NaCl/Ha will boost vigor, slow the rate of decline (Elmer, 1992), and may allow growers to recoup some profits for a negligible cost. The mechanism of NaCl on Fusarium crown and root rot is unclear. It does not affect soil pathogens, and may improve host defence (Elmer, 1995). The resistance in the all-male hybrids has helped to reduce the financial losses due to this disease, but improvements are still needed that will ensure plantings' greater longevity. Fungicide applications have traditionally been ineffective or impractical (Manning and Vardaro, 1977; Lacy, 1979). Some stress factors, such as drought, weeds, rust or insects, will increase the incidence and severity of Fusarium crown and root rot (Nigh, 1990). As a result, management programs that control insects, rust and weeds will reduce damage from Fusarium crown and root rot (Damicone *et al.*, 1987). Although asparagus is drought-tolerant, small deficits in soil moisture can result in large reductions in growth and increases in infection (Wilcox-Lee, 1987). Cutting pressure can also exert stress on a production field; consequently, extending the harvest season weakens the plant's ability to regenerate the stems and ferns that produce the carbohydrates for next year's yield (Shelton and Lacy, 1980) and should be avoided.

Violet root rot is one of the most serious diseases of asparagus caused by the fungus *Rhizoctonia violacea* Tul. Its own teleomorph is *Helicobasidium purpureum* Pat. [synamorph, *Helicobasidium brebissonii* (Desm.) Donk] a *Basidiomycotina*, *Auriculariales*, *Auriculariaceae*. The disease is less common in cooler areas than in warm districts. In Italy, violet root rot and Fusarium crown and root rot together are the most destructive diseases of asparagus (Matta and Garibaldi, 1969; Messiaen and Lafon, 1970). The asparagus fields affected by violet root rot show circular patches of yellowing fronds and dead plants. The increase in damage is usually seen in late summer and autumn. Older plants are the usual victims, but young plants are occasionally affected.

The pathogen fungus attacks roots, rootstalks and the basal portion of the stem. These vegetative organs show reddish, purple, brown filaments of mycelium spreading across and rich in brown-spheroidal lumps (0.5÷3.0 mm in diameter) on mycelium strands (0.10÷0.15 mm in diameter). The hyphae of fungus radiate from these bodies spreading along the soil surface and in depth causing the pathogen development. The young hyphae are uncoloured and then become violet. Violet and flat sclerotia (up to 5.0 mm in diameter) appear later, and serve as the overwintering vegetative forms of the fungus. *H. purpureum* produces basidia 4÷5 μ in diameter, containing hyaline and ellipsoidal basidiospores 9÷12 x 5÷8 μ. Predisposing causes to disease are a low soil pH, high soil moisture, excess of organic substance into soil, infestations of insects and weeds. Eliminating these predisposing causes can result in large reductions in growth and increase in violet root rot infection. Disease chemical control is based on preventive criteria such as asparagus crown disinfection (by using a 2% solution of NaClO) and soil disinfection (by using CH_3Br at 120 g m^{-2}). Soil fumigation is very expensive and unacceptable with environmental safeguard systems.

The genetic improvement for resistance to diseases also has given good results for *P. asparagi* control, incorporating stable quantitatively inherited resistance into commercial lines (Blanchette *et al.*, 1982; Johnson, 1990; Johnson and Lunden, 1992; Johnson and Peaden, 1993). Therefore, in relation to biological control programs on resistant variety studies carried out at our Institute, asparagus varieties, hybrids and lines have been compared to analyse their behaviour against asparagus rust. In this work, the levels of resistance or susceptibility to asparagus rust in open field, in natural conditions of epidemiology, have been determined. The investigation presented here has been therefore mainly aimed at determining: 1) if there are plots with lack or low number of infected plants; 2) if the infected plants of these plots show low infection index; 3) if there is always a correlation between the susceptibility to rust and sensibility to attacks of *F. oxysporum* f.sp. *asparagi* and *R. violacea* that are the major responsible for asparagus field decline.

MATERIALS AND METHODS

In open field, research was carried out to evaluate the behaviour of some varieties and hybrids of asparagus against rust, *Fusarium* crown and root rot, violet root rot. Ten genotypes of asparagus were compared, replicated four times in a randomized complete block experiment design, in order to search that ones showing the best behaviour to escape the disease. Each plot, 7.2 m^2 (2.4×3.0m), included 20 plants (1.2m between 2 rows and 0.3m on the row, 10 plants/row) with density of 27778 plants per hectare.
The phytopatological observations were carried out on November when the control plots showed 100% infected plants by asparagus rust. The plants showed blackish and dehiscent telia. The microscopic exam of the dusty contents exhibited ellipsoidal and bicellular teliospores, 30÷50 x 17÷28 μ, pedicel provided. For each plot, the number of diseased plants was registered; for each plant was estimated the rust severity; all the plants were grouped into infection classes, calculating the frequencies. The asparagus rust severity was rated according the following evaluation scale: 0 = no symptoms; 1 = less 10% of infected shoots with up to 10 blisters for no more 10% of shoot lenght; 2 = less 20% of infected shoots with up to blisters for no more 20% of shoots lenght; 3 = less 40% of infected shoots with up to 80 blisters for no more 50% of shoots lenght; 4 = less 80% of infected shoots with up to 200 blisters and over, confluent too, for no more 80% of shoots lenght; 5 = completely infected or dead plants. Severity and diffusion of infection were obtained by resorting to the McKinney index. The McKinney index (I) was obtained by using the following relation:

$$I = \frac{\Sigma(f \cdot v)}{N \cdot X}$$

where:

- f = infection class frequence;
- v = number of each class;
- N = amount of observed plants;
- X = highest value of the evaluation scale.

Observations regarding *Fusarium* crown and root rot were carried out. The number of yellowing and dead plants or showing a dark brown discoloration of the inner stem after a diagonal cut into the steam were registered. The fungus was isolated and fast growth in Petri plates on potato dextrose agar (PDA) that turn red and then brown. White to pink mycelia of the fungus pathogen differentiated abundant single-celled kidney-shaped or oval microconidia, 8×3 μ sizes, abundant curved septate macroconidia (with 3÷5 septa), 30÷50×3.5 μ sizes, and terminal or intercalary chlamydospores. The isolate fungus was identified according to Nelson *et al.* (1983). Pathogenicity tests carried out in laboratory on stems of susceptible asparagus, by using the isolate of *F. oxysporum* f.sp. *asparagi*, confirmed the diagnosis. *Fusarium* crown and root rot was assessed by applying the following 0 to 4 rating scale: 0 = healthy plants; 1 = lack vigor plants; 2 = moderate overall stunting; 3 = overall severe stunting of plants; 4 = yellowing of plants showing necrosis into stem horizontal section or death of plants. The number of diseased plants was registered and was estimated the *Fusarium* crown and root rot severity. Grouping the plants into infection classes (according to the evaluation scale), the frequencies and the McKinney index were calculated.

Symptoms of violet root rot were noticed by observing roots and the basal portion of the stems. The plants were stunted and generally with lack vigor and characterized by a chlorosis and yellowing. The pathogen fungus was isolated and grown on 9-cm-diameter plastic plates of PDA in incubator at 25 °C. After 21 days, mycelial and hyphal characteristics were observed, allowing the identification of the fungus *R. violacea*. Plants with violet root rot was detected and percent basal stem surface area girdled by a dark brown rot was rated on a 0 to 5 scale: 0 = no visible lesions; 1 = less than or equal to 25%, one or few pin-point dark spots; 2 = 25 to 49%, necrotic lesions less than 0.5 cm long; 3 = 50 to 74%, necrotic lesions greater than 0.5 cm long; 4 = 75 to 100%, foliage yellow or necrotic (Shehata *et al.*, 1981). The percentage of plants affected by violet root rot was also calculated.

Wishing to learn something about the infection trend caused by *F. oxysporum* f.sp. *asparagi* or *R. violacea* in relation to disease caused by *P. asparagi*, the curvilinear regression between McKinney index of asparagus rust and those of Fusarium crown and root rot or violet root rot was estimated.

Meteorological data were detected during the year of the trial: minimum and maximum air temperature (°C) and relative humidity (%); rainfall and evaporative power, both in mm, as month's amount; duration of sunshine (direct radiation from the sun) in hours (month's average); global radiation (the total of direct solar radiation and diffuse sky radiation received by a unit horizontal surface) in MJm^{-2} (month's average); leaf wetting in minutes (month's amount); wind speed in $cmsec^{-1}$ (month's average). Data, reported

in figure 1, were recorded by sensors, set 2 m from the soil, of the agrometeorology and hydrometry automatic station (SIAP SM 3800).
Phytopathological data were transformed to angular values (Sokal and Rohlf, 1973), before analysis of variance (ANOVA), and compared using Duncan's test for multiple camparison among asparagus genotype with MSTAT statistical analysis program (Mstat, 1987).

RESULTS AND DISCUSSION

Meteorological conditions were very favorable for asparagus diseases develop. From August to November (time of the phytopathological observations) minimum and maximum temperatures ranged from 6 up to 18 °C and from 18 up to 30 °C, respectively (average 12÷24 °C); relative humidity exhibited values between 40 and 56% (minimum), 92 and 98% (maximum), and average 66÷77%; rainfall (month's amount) ranged from 23 (in October) up to 138 mm (in September), while evaporative power was 13÷20 mm; leaf wetting (month's amount) ranged from 1700 (in August) up to 2450 minutes (in November), while wind speed (month's average) was 1,2÷2,5 $msec^{-1}$; duration of sunshine and global radiation (month's average) were 0÷10 hours and 12÷20 MJm^{-2} (figure 1). Mild temperatures, high relative humidity (maximum values) and rainfall, leaf wetting long-lasting and low values of wind speed were favourable parameters of disease develop. Nevertheless, wind speed exhibited values able to spread urediniospores and teliospores that diffused rust on asparagus plants.
Two of ten asparagus varieties and hybrids compared in this study showed the lowest percentage of plants with rust symptoms. Italian asparagus cultivars "Marte" and "Grande" showed significantly the best behaviour in terms of resistance to rust. They exhibited 36.8% and 42.5% of diseased plants, respectively, only belonging to class 1 and 2 (figure 2). The diseased plants of "Marte" and "Grande" varieties showed slight symptoms so that the McKinney index exhibited lowest values that ranged from 9.1 up to 15.6%. The susceptible plots showed 100% of infected plants but different McKinney index for the various genotypes: 46% for "Eros", about 60% for "H 519", "Atlas" and "Golia", over 70% for "H 511", "UC 157", "Apollo" and "Argo". The McKinney index values of the susceptible genotypes were significantly different from those of "Marte" and "Grande" (table 1 and figure 2).

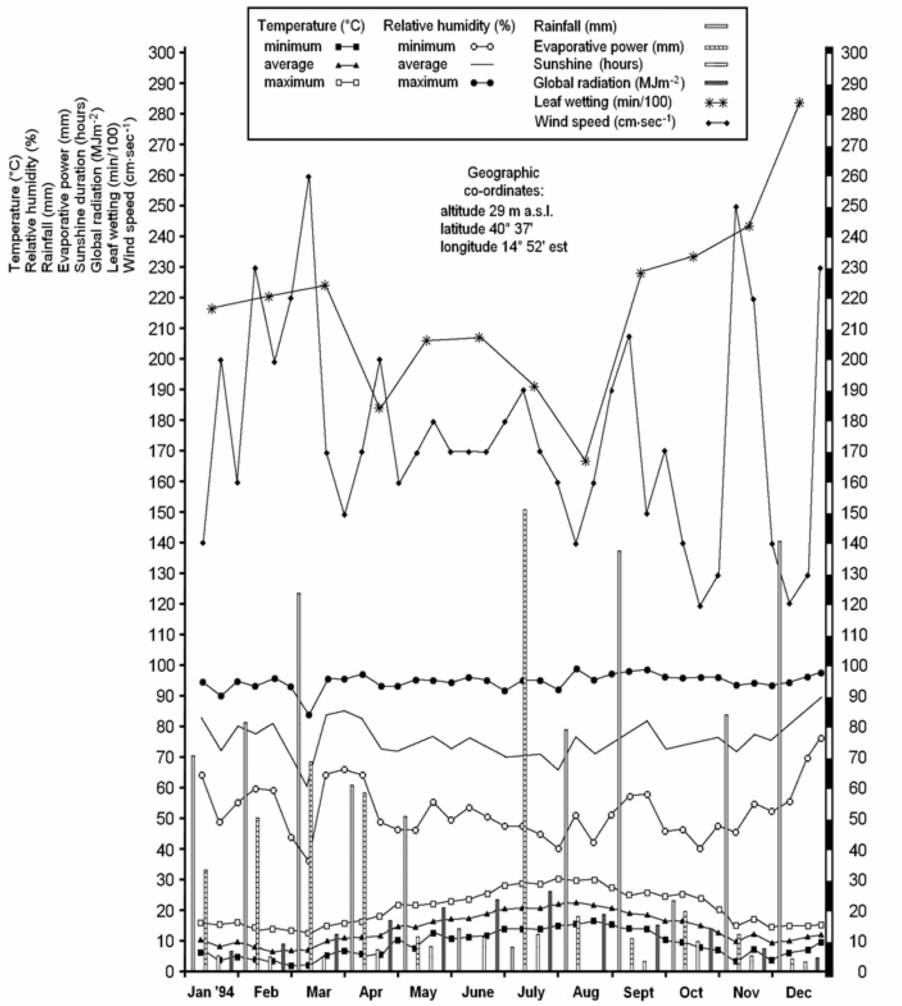

Figure 1. Meteorological data detected during the experimental trial year, at the automatic weather station of the Istituto Sperimentale per l'Orticoltura, Pontecagnano, Salerno, Italy.

Table 1. Behaviour of some genotypes towards asparagus rust (*)

Asparagus genotypes	Healthy plants %	Infected plants %	McKinney index %	
Argo	0.0	100.0 A	95.3	A
Atlas	0.0	100.0 A	63.1	D
Apollo	0.0	100.0 A	90.0	AB
UC 157	0.0	100.0 A	80.0	BC
Golia	0.0	100.0 A	63.1	D
Marte	63.2	36.8 B	9.1	F
Eros	0.0	100.0 A	45.9	E
Grande	57.5	42.5 B	15.6	F
H 511	0.0	100.0 A	71.2	CD
H 519	0.0	100.0 A	59.1	D

(*) Values separation in columns by Duncan's multiple range test ($P \leq 0.01$)

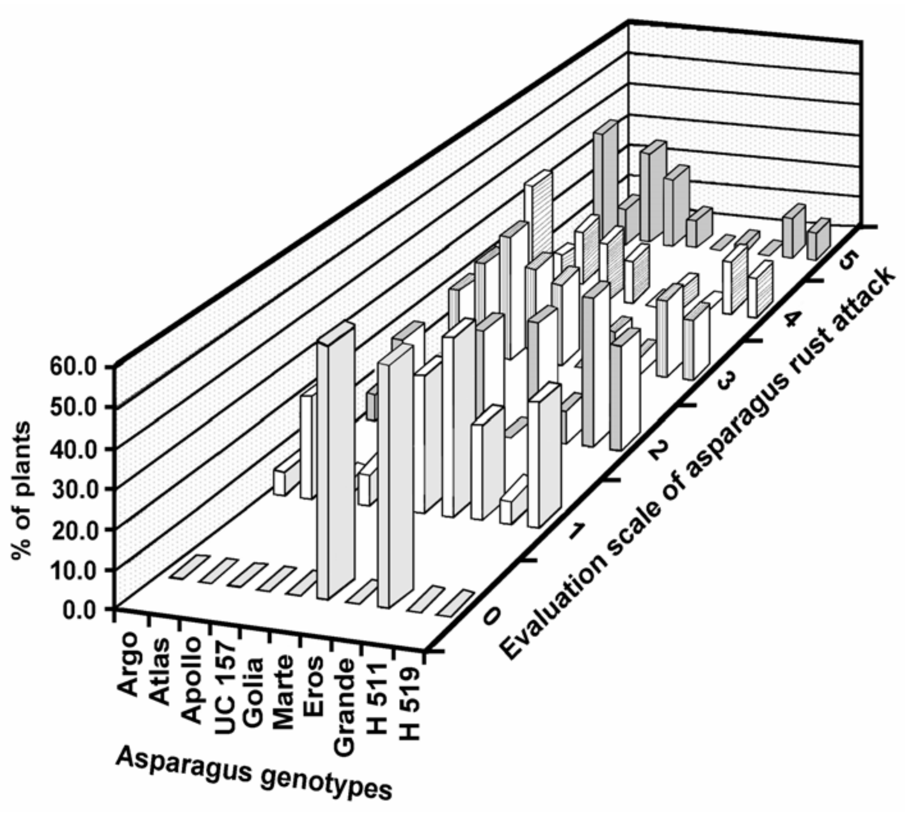

Figure 2. Plant percentage distribution of each asparagus genotype among infection classes of the evaluation scale rating rust attack.

“Marte” and “Grande” showed a good tolerance to *F. oxysporum* f.sp. *asparagi* exhibiting 100% of healthy plants. The other genotypes showed over 70% of infected plants, with lack vigor (up to 89% of plants for “Eros”), moderate (from 2.5% up to 16%) or overall severe stunting (from 2.4% for “Eros” up to 10÷12.5%) and yellowing or dead plants that ranged from 0 for “Eros” up to 87.5% for “Argo”. Similar trend showed the McKinney index that was 0% for “Marte” and “Grande”, 28 and 45% for “Eros” and “H 519”, from 57 up to 79% for “Atlas”, “Golia”, “H 511” and “UC 157”, 90÷96% for “Apollo” and “Argo” (table 2).

Table 2. Behaviour of some genotypes towards Fusarium crown and root rot caused by *F. oxysporum* f.sp. *asparagi* (*).

Asparagus genotypes	Diseased plants %		Plants (%): symptoms and evaluation scale classes: No symptoms (0)	Lack vigor (1)	Moderate stunting (2)	Overall severe stunting (3)	Yellowing or dead (4)	McKinney Index %	
Argo	100.0	A	0.0	0.0	2.5	10.0	87.5	96.2	A
Atlas	70.0	B	30.0	6.3	10.0	11.2	42.5	57.5	CD
Apollo	96.2	A	3.8	2.4	3.8	10.0	80.0	90.0	AB
UC 157	97.5	A	2.5	12.5	12.5	11.3	61.2	79.0	AB
Golia	72.5	B	27.5	10.0	8.8	11.3	42.4	57.8	CD
Marte	0.0	C	100.0	0.0	0.0	0.0	0.0	0.0	F
Eros	100.0	A	0.0	88.8	8.8	2.4	0.0	28.4	E
Grande	0.0	C	100.0	0.0	0.0	0.0	0.0	0.0	F
H 511	100.0	A	0.0	20.0	15.0	11.3	53.7	74.7	BC
H 519	78.7	B	21.3	30.0	16.2	12.5	20.0	45.0	DE

(*) Values separation in columns by Duncan’s multiple range test ($P \leq 0.01$).

“Marte” and “Grande” showed the same reaction to the infection by *F. oxysporum* f.sp. *asparagi* and *R. violacea*. Percent of diseased plants and McKinney index of “Marte” and “Grande” were significantly different from those the other genotypes. As for Fusarium crown and root rot, “Marte” and “Grande” genotypes that exhibited highest tolerance to rust showed significantly lowest diseased plant percentage and McKinney index for violet root rot (table 3).

Table 3. Behaviour of some asparagus genotypes towards violet root rot caused by *R. violacea* (*).

Asparagus genotypes	Diseased plants %		Plants (%): symptom spread and evaluation scale classes No lesion (0)	Up to 25% (1)	25 to 49% (2)	50 to 74% (3)	75 to 100% (4)	McKinney Index %	
Argo	90.0	A	10.0	1.3	3.7	5.0	80.0	86.0	A
Atlas	48.8	B	51.2	7.5	12.5	11.3	17.5	34.1	B
Apollo	88.8	A	11.2	7.4	3.8	6.3	71.3	79.7	A
UC 157	86.3	A	13.7	12.5	10.0	7.5	56.3	70.0	A
Golia	47.5	B	52.5	11.3	8.7	8.7	18.8	32.8	B
Marte	0.0	C	100.0	0.0	0.0	0.0	0.0	0.0	C
Eros	62.5	A	37.5	55.0	3.7	1.3	2.5	19.1	BC
Grande	0.0	C	100.0	0.0	0.0	0.0	0.0	0.0	C
H 511	77.5	A	22.5	8.7	7.5	12.5	48.8	64.1	A
H 519	82.5	A	17.5	60.0	8.7	5.0	8.8	31.9	B

(*) Values separation in columns by Duncan's multiple range test ($P \leq 0.01$)

The linear regression between McKinney index of asparagus rust and that of *Fusarium* crown root rot has showed a linear equation with the following main characteristics: intercept a = -17.4; regression coefficient b_1 = 1.186; correlation coefficient R^2_1 = 0.98. The linear regression between McKinney index of asparagus rust and that of violet root rot has exhibited an intercept a = -20.1; regression coefficient b_2 = 1.03; coefficient of correlation R^2_2 = 0.91 (figure 3). The regression analyses indicated that there was a strong correlation between asparagus rust ratings and both of *Fusarium* crown root rot and violet root rot.

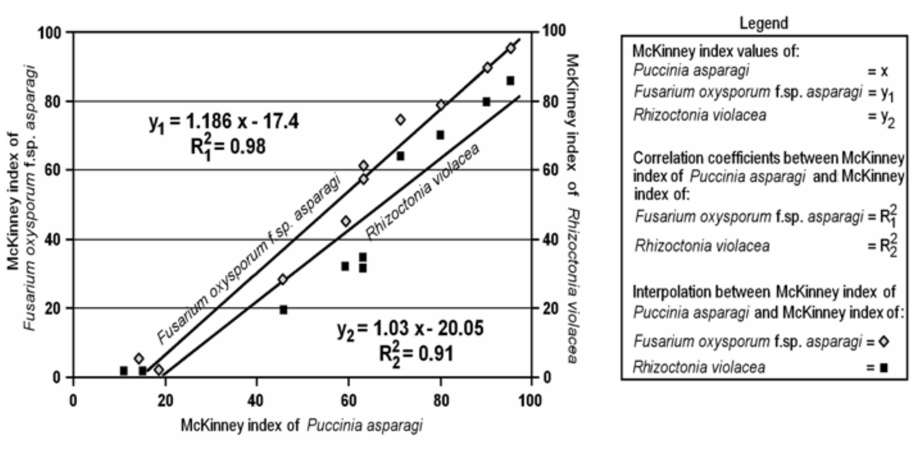

Figure 3. Relationship of asparagus rust McKinney index (%) to *Fusarium* crown root rot McKinney index (%) and violet root rot McKinney index (%). R^2 values were 0.98 and 0.91, respectively. Regression equations: y_1 = 1.186 x – 17.4 (*Fusarium* crown root rot McKinney index); y_2 = 1.03 x – 20.05 (violet root rot McKinney index).

Observing the figure 3, when the incidence of McKinney index for rust was less 20%, plants were no susceptible to attack of pathogens causing asparagus decline. Then, for asparagus rust McKinney index over 20%, the ulterior increases of rust infection induced proportional develop of *Fusarium* crown root rot and violet root rot, when the respective pathogens colonized the soil and the environmental conditions were favourable.

The major sensibility of asparagus plants attacked by *P. asparagi* to *F. oxysporum* f.sp. *asparagi* and to *R. violacea* is probably in relation to the lesions caused from two last pathogens. The lesions interest the water conductor system into roots and stems of plants because pathogen hyphae invade cortical and phloem tissues. *P. asparagi* causes lesions on the stems and shoots that induce greater loss of water and consequent stress of the plant water supply mechanism. The evapotranspiration increase caused by rust cannot be compensated by increase of water absorption from soil in relation to the lesions caused by *F. oxysporum* f.sp. *asparagi* and *R. violacea*. Although asparagus is drought-tolerant, small deficits in soil moisture can result in large reductions in growth and increases in infection by *F. oxysporum* f.sp. *asparagi* and *R. violacea*.

In our environmental condition, effective management strategies for asparagus rust should include planting resistant cultivars that induce good resistance to pathogens causing asparagus decline (*F. oxysporum* f.sp. *asparagi* and *R. violacea*).

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