Influence of Management Practices on Severity of Stem and Crown Rot, Incidence of Asparagus Miner, and Yield of Asparagus Grown from Transplants

J. P. DAMICONE and W. J. MANNING, Department of Plant Pathology, and D. N. FERRO, Department of Entomology, University of Massachusetts, Amherst 01003

ABSTRACT

Damicone, J. P., Manning, W. J., and Ferro, D. N. 1987. Influence of management practices on severity of stem and crown rot, incidence of asparagus miner, and yield of asparagus grown from transplants. Plant Disease 71:81-84.

Asparagus and pest management practices were evaluated for 4 yr in field plots planted with seedling transplants using a split-split plot design. The effects of preplant soil fumigation with Vorlex and diazinon insecticide sprays were assessed. Use of open-pollinated (Mary Washington) or F_1 hybrid (Jersey Centennial) asparagus and simazine weed control were also tested. Severity of stem and crown rot and internal crown discoloration and incidence of and damage by asparagus miner were assessed in 1980. Yield was measured in 1982 and 1983 and plant survival was assessed in 1983. Insecticide sprays led to reduced stem and crown rot and internal crown discoloration and a lower number of mines of the asparagus miner (*Ophiomyia simplex*) per stem. Stem rot severity increased linearly ($R = 0.695$) with number of mines per stem. Fumigation and insecticide treatments significantly improved yield as weight of marketable spears ($\geq$8 mm in diameter) in 1982 and 1983. Cultivar Jersey Centennial produced significantly higher yield than cultivar Mary Washington in 1983. Insecticide, fumigant, and F_1 hybrid effects significantly improved plant survival after 4 yr. Simazine effects on yield were minimal in 1982, but the herbicide-treated plots had significantly lower yields in 1983. Asparagus stem and crown rot appears to be a stress-related syndrome, in part, because some management practices reduced disease development despite crown infections by *Fusarium* spp.

Asparagus (*Asparagus officinalis* L.) stem and crown rot, caused by *Fusarium moniliforme* Sheldon, and wilt and root rot, caused by *Fusarium oxysporum* f. sp. *asparagi* Schlecht., are believed to contribute to reduced plant populations, low vigor of surviving plants, and reduced yields (1,5,11,12,14). Both causal *Fusarium* spp. are seedborne (2,10,11,13), infect year-old crowns used as plant stock (3), and are generally ubiquitous in agricultural soils. *F. moniliforme* is also an aerial contaminant in local asparagus fields (8). The fact that the progression of disease is relatively slow and that one or more *Fusarium* spp. can almost always be isolated from field-grown plants (3; W. J. Manning, *unpublished*) indicates that other factors in addition to *Fusarium* may also contribute to stem and crown rot of asparagus.

The most important insect pests of asparagus in Massachusetts are the common asparagus beetle (*Crioceris asparagi* L.) and the asparagus miner (*Ophiomyia simplex* Loew.). Foliar injury by larval and adult beetles feeding on cladophylls can be severe; however, visual population assessment and control are relatively simple. The asparagus miner is a more insidious pest, because the adult is only 2–3 mm long and larvae feed on stem cortical tissue beneath the epidermis at or above the soil line (6,9,18). Techniques for monitoring asparagus miner activity are available (7), and its population dynamics in Massachusetts are understood (6). Asparagus miner damage is also closely related to infection by *Fusarium* spp. (1,9,18).

Management practices such as soil fumigation, herbicide application, and other cultural techniques are available to improve asparagus performance. Soil fumigation has resulted in improved stand establishment with direct-seeded (11) and crown-initiated (16) asparagus. Vorlex fumigation has increased yields of crown-initiated asparagus but only when crowns were produced in a fumigated nursery (15). Weed control with simazine has improved yield and crown survival compared with hand-weeding (15). An F_1 hybrid asparagus cultivar adapted to the northeastern United States has recently been released (4). It is more uniform and productive in soils infested with *Fusarium* spp. pathogenic to asparagus than open-pollinated cultivars currently grown in Massachusetts (4). New techniques for transplanting asparagus seedlings have also been developed (17).

We began an integrated asparagus management program in 1980 to evaluate the influences of soil fumigation, insect and weed control, and cultivar type on establishment and productivity of newly planted asparagus and on the incidence of stem and crown rot and asparagus miner. We used *Fusarium*-free transplants rather than year-old crowns in order to start with disease-free planting stock. We previously reported that all crowns sampled after the first growing season were internally infected with one or more *Fusarium* spp. (3). *F. moniliforme* was the most virulent species and was isolated at a frequency of 58%, whereas *F. oxysporum* was less virulent and was isolated at a frequency of 30% (3). We report here on the influence of asparagus management practices on stem and crown rot development, incidence of and damage by the asparagus miner, and yield and plant survival. We also investigated the relationship between asparagus miner activity and Fusarium stem and crown rot.

MATERIALS AND METHODS

A fine sandy loam site (0.186 ha) typical of Connecticut River Valley asparagus culture was selected. It had been in fallow for 2 yr. The field was shown to be infested with stem and crown rot *Fusarium* spp. by bioassay of soil samples taken at random in the fall of 1979, using Mary Washington asparagus seedlings grown from seed treated with benomyl in acetone (2). Ten-week-old seedlings of cultivars Mary Washington (open-pollinated) and Jersey Centennial (F_1 hybrid) were produced as described previously (3). They were shown to be *Fusarium*-free by assay of surface-sterilized crowns excised from seedlings selected at random and plated on potato-carrot agar (pH 5.5) plus 100 mg/L chlortetracycline. The planting was established in May 1980 by manually transplanting seedlings in W-shaped furrows 30 cm deep with center planting beds 15 cm deep formed by a tractor-mounted bed shaper (17).

The experimental design was a split-split plot with four replicates. Each replicate contained two rows 1.83 m apart. In one row, 25 plants were spaced 30 cm apart for yield and plant survival evaluations. Fifty plants were spaced 15

Present address of first author: Department of Plant Pathology and Crop Physiology, Louisiana State University, Baton Rouge 70803.

Work supported in part by USDA/SEA special grant 901-15-49 and the Massachusetts Agricultural Experiment Station. Massachusetts Agricultural Experiment Station Journal Series Paper 2810.

Accepted for publication 11 June 1986.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

cm apart in the adjacent row to ensure adequate plants for destructive sampling. The field was divided into two main plots, one fumigated with Vorlex (80% chlorinated C_3 hydrocarbons, 20% methylisothiocyanate) in the fall of 1979 at 363 L/ha (15,16) and the other not fumigated (whole-plot treatment). Each main plot was divided into two subplots, and the insecticide diazinon was applied to one subplot of each main plot (split-plot treatment). Whole-plant sprays of diazinon at 0.63 kg a.i./ha were made when warranted by insect activity. Diazinon was applied when asparagus beetle populations reached 10 per plant or when gravid females of *O. simplex* were detected. Beetles were assessed by counting larvae and adults on 10 randomly-selected plants per replicate. *O. simplex* activity was determined using visual traps consisting of garden stakes 25 cm long × 2.2 cm wide painted yellow and coated with Tanglefoot (6,7). Insecticide sprays were necessary on six dates in 1980 and on seven dates each in 1981 and 1982. Cultivar and tillage treatments were randomized within each subplot (split-split-plot treatments). Either Mary Washington or Jersey Centennial cutivars were planted. Tillage treatments were either herbicide weed control or no weed control. Weed control treatments received a single application of simazine at 6.20 kg a.i./ha, banded 1.2 m wide across a row, in 1980, 1981, and 1982. Treatments not receiving herbicide were manually cultivated in 1980 to allow bed establishment, then weeds were allowed to develop each year. Two levels of each of four main factors (fumigation, insecticide, cultivar, and herbicide) gave 16 treatment combinations, each replicated four times. Calcitic lime was broadcast at 1,200 kg/ha over the field in 1981 and 1982 before spear emergence. The field was tilled lightly (5–6 cm deep) with a tractor-mounted Rototiller after liming. Fertilizer was broadcast and incorporated in 1981 with ammonium nitrate at 115 kg N/ha and in 1982 with super phosphate at 33.7 kg P/ha and ammonium nitrate at 76.3 kg N/ha.

After the first growing season, nine plants per replicate (36 per treatment combination) were removed from the 15-cm-spaced rows, washed free of soil under tap water, and examined. Plants were rated for external stem and crown rot by the following disease index: 0 = no lesions on stem or crown, 1 = lesions on <25% of stem and crown, 2 = lesions on ≥25% to <50% of stem and crown, 3 = lesions on ≥50% to <75% of stem and crown, 4 = lesions on ≥75% to <100% of stem and crown, and 5 = lesions on 100% of stem and crown or dead plant. Each stem was examined individually for stem rot severity and incidence of *O. simplex*. Stem rot was quantified using the above disease index for stem only. Asparagus miner larvae, pupae, and empty puparia were counted after scraping off the lower epidermis of each stem. The number of mines per stem was expressed as the mean number of all three stages of *O. simplex* per stem. After removal of a 5-mm-diameter core sample from each crown for isolation of *Fusarium* spp. with a flame-sterilized cork borer (3), crowns were split longitudinally and evaluated for internal crown rot (red-brown discoloration) using a disease index where 0 = no crown discoloration, 1 = <25% crown section discolored, 2 = ≥25 to <50% crown section discolored, 3 = ≥50 to <75% crown section discolored, 4 = ≥75–100% crown section discolored, and 5 = crown section 100% necrotic.

Yield was evaluated in 1982 and 1983 and plant survival determined in June 1983. All emerging spears were harvested from the 30-cm-spaced rows during a 2-wk period in 1982 and a 3-wk period in 1983. All marketable spears ≥8 mm in diameter were trimmed to about 20 cm long and weighed. Yield was expressed as grams per replicate (7.6-m row planted with 25 plants 30 cm apart). Plant survival was expressed as number of surviving plants per plot (25 planted in 1980).

A five-way analysis of variance was performed on all data. All block (replicate) × treatment interactions were pooled into error mean squares. Significant main effects and treatment interactions were identified. Means from yield data for the 16 treatment combinations were separated using an LSD test, where indicated by a significant interaction, to identify optimal management strategies. Regression analysis was used to quantify the relationship between stem rot and asparagus miner damage. Unless otherwise stated, differences indicated are significant at $P = 0.01$.

RESULTS

Of all the management practices tested, insecticide treatment had the greatest impact on incidence of disease and asparagus miner in first-year asparagus. Diazinon insecticide sprays reduced external stem and crown rot and internal crown discoloration 30 and 31%, respectively (Table 1). Diazinon also reduced stem rot and incidence of *O. simplex* in plants from nonfumigated soil. Treatments receiving diazinon had 76% fewer mines per stem and 38% lower stem rot than untreated plants (Table 1). Vorlex fumigation had no effect on external stem and crown rot or internal crown discoloration indices in first-year plants (Table 1). Cultivar effects on external stem and crown rot were significant ($P = 0.05$); Jersey Centennial asparagus had 11% greater symptom severity than Mary Washington (Table 1). Internal crown discoloration did not differ for the two cultivars (Table 1). Among plants from nonfumigated soil, cultivar effects were significant on stem rot index ($P = 0.05$) and mines per stem (Table 1). Jersey Centennial plants had 20% more mines per stem and 6% greater stem rot symptoms than Mary

Table 1. Main effects of management practices on external stem and crown rot, internal crown rot, stem rot, and number of mines of *Ophiomyia simplex* per stem in first-year asparagus

Treatment or cultivar	External stem and crown rot index[a]	Internal crown rot index[b]	Stem rot index[c]	No. mines of *O. simplex* per stem[d]
Soil fumigant: Vorlex (L/ha)				
363	1.72	1.50	···	···
0	1.94	1.63	···	···
Insecticide: diazinon (kg a.i./ha)				
0.63	1.50**[e]	1.28**	1.45**	0.09**
0.00	2.16	1.86	2.35	0.40
Cultivar				
Jersey Centennial	1.93*	1.55	1.96*	0.27**
Mary Washington	1.72	1.59	1.84	0.22
Herbicide: simazine (kg a.i./ha)				
6.2	1.81	1.59	1.93	0.24
0.0	1.84	1.55	1.87	0.26

[a] Mean values from 288 plants; disease index of 0–5 (0 = healthy and 5 = dead plant).

[b] Mean values from 288 plants; disease index of crown cross section (0–5, where 0 = no crown discoloration and 5 = dead plant).

[c] Mean values from 144 plants; disease index of 0–5 (0 = healthy stem and 5 = dead stem).

[d] Mean values from 144 plants; mean number of larvae, pupae, and empty puparia.

[e] Values within a column and main effect differ significantly at * = $P = 0.05$ and ** = $P = 0.01$.

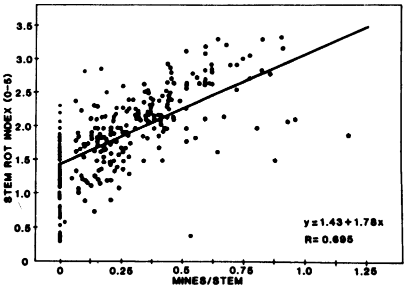

Fig. 1. Relationship of number of *Ophiomyia simplex* mines per stem and stem rot. Data points represent mean values of all stems for 288 plants sampled in 1980.

Washington plants. Cultivar affected stem rot severity only for treatments not receiving diazinon (cultivar × diazinon interaction significant at $P = 0.05$). Simazine herbicide had no effect on any disease index assessed or on incidence of *O. simplex* (Table 1). Among plants from nonfumigated soil, regression analysis of stem rot index (y) on number of mines of *O. simplex* per stem indicated stem rot severity increased linearly ($y = 1.43 + 1.78x$, $P = 0.01$, $R = 0.695$) with increasing mines per stem (Fig. 1).

Management practices affected yields of marketable asparagus in both 1982 and 1983. Vorlex fumigation and diazinon sprays had significant main effects on yield (Table 2). Vorlex-treated plots had 46 and 78% greater yields than nonfumigated plots in 1982 and 1983, respectively. Plots receiving diazinon had 62 and 112% greater yields than nonsprayed plots in 1982 and 1983, respectively. Cultivar effect on yield was only significant in 1983 (Table 2), when Jersey Centennial had 144% greater yield than Mary Washington. Simazine herbicide was not beneficial in 1982, and it reduced yield 49% in 1983 (Table 2). Treatment interaction effects as well as main effects influenced yield. The diazinon × Vorlex × simazine interaction on yield was significant in 1982 ($P = 0.05$), whereas the four-way interaction between all main factors was significant in 1983 ($P = 0.05$, Table 2). Treatment combinations receiving Vorlex and/or diazinon had higher yields in 1982 ($P = 0.05$) than untreated plots of either cultivar (Table 3). Treatment combinations receiving Vorlex and diazinon, planted with Jersey Centennial, and not treated with herbicide had the highest yields in 1983 ($P = 0.05$, Table 4). Management practices were primarily additive because significant main effects accounted for 71 and 81% of the yield variation in 1982 and 1983, respectively.

Plant survival for 4 yr (July 1983) was influenced by management practices and broadly paralleled yield. Insecticide, cultivar, and herbicide effects on plant survival were significant (Table 2). Diazinon insecticide increased survival 40% from 12.7 (per 25 planted in 1980) in the control to 17.8. Plots planted with Jersey Centennial had 33% greater survival than Mary Washington (means of 17.5 and 13.1, respectively). Simazine herbicide lowered survival 39% from 17.8 in control plots to 12.8. The Vorlex × diazinon interaction effect on plant survival was significant (Table 2), and plots receiving fumigation only (16.4), insecticide only (17.8), or fumigation and insecticide (17.9) had greater survival than control plots (9.1). Significant main effects accounted for 60% of the plant survival variation.

DISCUSSION

Improved yield and increased plant survival resulting from preplant soil fumigation could not be attributed to a direct effect on crown invasion by *Fusarium* spp. (3) or on stem and crown rot development (Table 1). The mechanism of yield increase after Vorlex fumigation is unknown. Others have reported similar improvements in asparagus performance with Vorlex (15,16). The fumigation effect on yield lasted 4 yr in our study compared with 1–2 yr for crown-initiated asparagus (W. J. Manning, *unpublished*). Fumigation is most effective when *Fusarium*-free transplants are used for bed establishment.

Yields reduced by insect pests were associated with asparagus beetle defoliation (about 10% in 1980 and less in 1981 and 1982) and asparagus miner larval damage (Table 1). Plants mined by *O. simplex* developed greater stem rot (Table 1) that was apparently related to mine frequency (Fig. 1). Results here and elsewhere (9,18) show that stem rot occurs in the absence of *O. simplex*; however, severity is enchanced by cortical feeding from this pest. We also observed an increase in internal crown discoloration in plants mined by *O. simplex* (Table 1). This indicates that rot progressed from lower stems into the crown. Johnston et al (14) have shown

Table 2. Mean square comparisons for effects of asparagus management practices on yield and plant survival

Source of variation	df	Mean squares[a] Yield (g/plot)[b] 1982	 1983	 No. surviving[c] 1983
Whole plot				
Blocks	3	92,690.1	23,383.8	19.1
Vorlex (V)	1	1,207,251.6*	1,428,921.4**	217.6
Error a	3	51,161.1	94,677.3	45.8
Split plot				
Diazinon (D)	1	1,904,490.0**	2,354,306.6**	420.2**
D × V	1	158,404.0	5,757.0	210.2**
Error b	6	36,381.7	55,769.6	15.5
Split-split plot				
Cultivar (C)	1	17,226.6	3,176,860.6**	306.2**
C × V	1	102,560.1	648,031.6	20.2
C × D	1	225,625.0	143,356.9	.6
C × V × D	1	80,656.0	791.0	27.6
Simazine (S)	1	75,762.6	1,901,985.8**	400.0**
S × V	1	8,602.6	15,718.9	4.0
S × D	1	18,496.0	79,735.6	7.6
S × V × D	1	278,256.2*	518,940.1*	115.6*
S × C	1	21,978.1	13,659.8	60.1
S × C × V	1	16,056.6	33,260.6	18.1
S × C × D	1	30.2	33,994.1	.2
S × C × D × V	1	4.0	361,952.6*	6.2
Error c	36	67,657.9	83,913.1	26.0

[a] * = $P = 0.05$ and ** = $P = 0.01$.

[b] Marketable spears (≥8 mm in diameter) harvested for 2 wk in 1982 and 3 wk in 1983 from plots planted with 25 plants in 1980.

[c] Number of surviving plants per plot planted with 25 plants in 1980.

Table 3. Influence of management practices on yield of asparagus cultivars Jersey Centennial and Mary Washington in 1982

Fumigant: Vorlex (L/ha)	Herbicide: simazine (kg a.i./ha)	Insecticide: diazinon (kg a.i./ha) 0.63 Jersey Centennial	 Mary Washington	 Mean	 0 Jersey Centennial	 Mary Washington	 Mean
363	6.2	1,125.5[z]	1,135.5	1,130.5 a	902.5	529.2	715.8 bc
	0.0	800.7	944.5	872.6 ab	905.7	673.7	789.7 b
0	6.2	755.0	845.5	800.2 b	453.7	447.0	450.3 cd
	0.0	807.7	902.2	854.9 ab	304.0	309.7	306.8 d

[z] Mean yield values (in grams per replicate) for four plots planted with 25 plants each in 1980 (marketable spears ≥8 mm in diameter). Values followed by the same letter do not differ significantly at $P = 0.05$ according to LSD test (LSD = 313.4).

Table 4. Influence of management practices on yield of asparagus cultivars Jersey Centennial and Mary Washington in 1983

Fumigant: Vorlex (L/ha)	Herbicide: simazine (kg a.i./ha)	Insecticide: diazinon (kg a.i./ha) 0.63 Jersey Centennial	0.63 Mary Washington	0 Jersey Centennial	0 Mary Washington
363	6.2	1,205.0 a[z]	257.5 bc	446.7 bc	67.5 c
	0.0	1,258.7 a	737.0 ab	1,112.5 a	373.0 bc
0	6.2	386.0 bc	219.2 bc	236.7 bc	64.7 c
	0.0	1,129.1 a	604.2 b	270.0 bc	157.0 c

[z] Mean yield values (in grams per replicate) for four plots planted with 25 plants each in 1980 (marketable spears ⩾8 mm in diameter). Values followed by the same letter do not differ significantly at $P = 0.05$ according to LSD test (LSD = 522.0).

that *F. moniliforme* can progress acropetally into the crown from lower stem inoculations. *F. moniliforme* was the most prevalent and virulent pathogen isolated from crowns sampled from this test in 1980 (3). Enhancement of rot progression from lower stem to crown by asparagus miner feeding may contribute to early bed decline as shown by the poor yield and plant survival in plots not receiving insecticide.

Jersey Centennial asparagus produced higher yield and plant survival than Mary Washington in 1983. Both cultivars sampled from this test in 1980 were infected with one or more of the same *Fusarium* spp. after the first year (3). Although no cultivar differences were observed in stem and crown rot development for diazinon-treated plants, these results and those of others (4) indicate that Jersey Centennial has improved yield and survival response despite *Fusarium* infections.

Weed competition was shown not to contribute to reduced yield and plant density in this study, because herbicide treatment gave variable results. Herbicide weed control did not adversely affect yield in 1982; however, reduced yields were associated with simazine application in 1983. This may have resulted from a stem dieback disease caused by *Phoma asparagi* that developed in July 1982 and only occurred in weedfree plots. Fumigation, insecticide sprays, and cutivar did not affect foliar blighting caused by *Phoma* (J. P. Damicone, *unpublished*). Asparagus overgrowth by weeds apparently limited the aerial dissemination of *Phoma*. Any beneficial weed control effects were perhaps confounded by this disease in the 1983 yield and survival results. Simazine was not shown to influence plant susceptibility to *Fusarium* infection (3) or stem and crown rot (Table 1).

Insect management, preplant soil fumigation, and use of F_1 hybrid asparagus reduced Fusarium stem and crown rot and incidence of and damage by the asparagus miner. Improvements in yield and plant survival also resulted from these management practices. Yield loss and reduced plant density are indications of Fusarium stem and crown rot (1,11,14). Crowns sampled from this test were infected with one or more *Fusarium* spp., and management practices did not affect the distribution frequencies of the *Fusarium* spp. isolated (3). The improvement in yield and plant survival associated with asparagus crop and pest management practices implies that factors in addition to *Fusarium* contribute to stem and crown rot. The increase in stem and crown rot associated with management practices resulting in poor yields and plant survival suggests that the disease is stress-related. This study also demonstrated that low yield and plant density occur relatively quickly with poor crop and pest management practices.

LITERATURE CITED

1. Cohen, S. I., and Heald, F. D. 1941. A wilt and root rot of asparagus caused by *Fusarium oxysporum* (Schlecht.). Plant Dis. Rep. 25:503-509.
2. Damicone, J. P., Cooley, D. R., and Manning, W. J. 1981. Benomyl in acetone eradicates *Fusarium moniliforme* and *F. oxysporum* from asparagus seed. Plant Dis. 65:892-893.
3. Damicone, J. P., and Manning, W. J. 1985. Frequency and pathogenicity of *Fusarium* spp. isolated from first-year asparagus grown from transplants. Plant Dis. 69:413-416.
4. Ellison, J. H., Vest, G., and Langlois, R. W. 1981. "Jersey Centennial" asparagus. HortScience 16:349.
5. Endo, R. M., and Burkholder, E. C. 1971. The association of *Fusarium moniliforme* with the crown rot complex of asparagus. (Abstr.) Phytopathology 61:891.
6. Ferro, D. N., and Gilbertson, R. L. 1982. Bionomics and population dynamics of the asparagus miner, *Ophiomyia simplex* (Loew.) in Western Massachusetts. Environ. Entomol. 11:639-644.
7. Ferro, D. N., and Suchak, G. J. 1980. Assessment of visual traps for monitoring the asparagus miner *Ophiomyia simplex*, Agromyzidae: Diptera. Entomol. Exp. Appl. 28:177-182.
8. Gilbertson, R. L., and Manning, W. J. 1983. Contamination of asparagus flowers and fruit by airborne spores of *Fusarium moniliforme*. Plant Dis. 67:1003-1004.
9. Gilbertson, R. L., Manning, W. J., and Ferro, D. N. 1985. Association of the asparagus miner with stem rot caused in asparagus by *Fusarium* species. Phytopathology 75:1188-1191.
10. Graham, K. M. 1955. Seedling blight. A fusarial disease of asparagus. Can. J. Bot. 33:374-400.
11. Grogan, R. G., and Kimble, K. A. 1959. The association of Fusarium wilt with the decline and replant problem in Calif. Phytopathology 49:122-125.
12. Grove, M. D. 1976. Fusarial disease of asparagus. (Abstr.) Proc. Am. Phytopathol. Soc. 3:317.
13. Inglis, D. A. 1980. Contamination of asparagus seed by *Fusarium oxysporum* f. sp. *asparagi* and *F. moniliforme*. Plant Dis. 64:74-76.
14. Johnston, S. A., Springer, J. K., and Lewis, G. D. 1979. *Fusarium moniliforme* as a cause of stem and crown rot of asparagus and its association with asparagus decline. Phytopathology 69:778-780.
15. Lacy, M. L. 1979. Effects of chemicals on stand establishment and yields of asparagus. Plant Dis. Rep. 63:612-616.
16. Manning, W. J., and Vardaro, P. M. 1977. Soil fumigation and preplant fungicide crown soaks: effects on plant growth and *Fusarium* incidence in newly planted asparagus. Plant Dis. Rep. 61:355-357.
17. Ombrello, T. M., and Garrison, S. A. 1978. Establishing asparagus from seedling transplants. HortScience 13:663-664.
18. van Bakel, J. M. M., and Bethe, J. G. C. 1974. The asparagus miner fly (*Ophiomyia simplex* (Loew Spencer) and the appearance of root rot *Fusarium oxysporum* (Schlecht.) in asparagus. Gewasbescherming 5:1-4.