Contamination of Asparagus Flowers and Fruit by Airborne Spores of *Fusarium moniliforme*

R. L. GILBERTSON, Research Assistant, and W. J. MANNING, Professor, Department of Plant Pathology, University of Massachusetts, Amherst 01003

ABSTRACT

Gilbertson, R. L., and Manning, W. J. 1983. Contamination of asparagus flowers and fruit by airborne spores of *Fusarium moniliforme*. Plant Disease 67: 1003-1004.

Airborne spores of *Fusarium moniliforme* were found in two asparagus fields in western Massachusetts. *F. moniliforme* was isolated from female flowers, fruit, and seed of plants growing in commercial fields. Vascular colonization was not found in branchlets bearing contaminated flowers or fruit. *F. moniliforme* also was isolated from 1-yr-old volunteer asparagus plants, which originated from fallen fruit of the previous growing season. Airborne spores of *F. moniliforme* appear to be the source of contamination of asparagus flowers, fruit, and ultimately, the seed.

Fusarium moniliforme Sheldon, causal agent of asparagus stem and crown rot, has been isolated from seed produced in California (5,8), New Jersey (11), and Washington (10). Asparagus (*Asparagus officionalis* L.) seed grown in western Massachusetts had a contamination rate for *F. moniliforme* as high as 10% (6).

How *F. moniliforme* contaminates seed is not known. The fungus does not appear to be a vascular wilt pathogen so this would rule out systemic infection (6,11). Inglis (10) suggested that the fungus contaminated seed when they were extracted from fruit at harvest. Fruit damaged by feeding of asparagus beetles were most likely to contain seed contaminated by *F. moniliforme*. We investigated the association of *F. moniliforme* with female asparagus flowers, fruit, and seed and 1-yr-old volunteer seedlings that grew from fallen fruit to determine when *F. moniliforme* became a contaminant.

MATERIALS AND METHODS

Asparagus flowers were collected randomly from female plants in four commercial fields during July and August 1979 (early season) and August and September 1980 (late season). Branchlets with flowers were excised and five flowers per branchlet were removed individually. Three stages of flower development were identified: preopen, open, and senescent. One hundred flowers in each stage from each field were washed in sterile distilled water and plated on potato-carrot agar (PCA) acidified with lactic acid to pH 4.0 (PCAL). Sections from branchlets were surface-sterilized in 5% chlorine bleach solution for 5 min and also plated on PCAL.

Twenty-five immature and mature fruit were collected from randomly selected female plants during the 1979 growing season. Immature fruit were either washed 5 min in sterile distilled water or surface-sterilized for 5 min. All immature fruit were then sectioned and plated on PCAL. Mature fruit were surface-sterilized for 1 min. Surface tissue, internal pulp, and seed were then plated separately on PCAL.

Fifty randomly-selected 1-yr-old volunteer plants were exhumed from each of three fields in 1979 and washed under running tap water for 5 min. Crowns, roots, and stem sections were excised, surface-sterilized in 10% chlorine bleach solution for 5 min, and plated on PCAL.

Airborne *Fusarium* spores were monitored by exposing petri plates of *Fusarium*-selective Nash-Snyder medium (13) in two fields in late July 1979. In each field, plates were placed at six randomly selected stations, with three stations at the soil surface and three stations at an elevation of 1 m. Plates were exposed once for 15 min, then returned to the laboratory and incubated at 23 C for 5–7 days. *Fusarium* colonies were counted, single-spored, and cultured on PCA for identification according to the methods and scheme of Toussoun and Nelson (15).

Pathogenicity tests with selected single-spored isolates of *F. moniliforme* from flowers, fruit, and the air were conducted by inoculating 2-wk-old aseptically grown asparagus seedlings. Seed of cultivar Rutgers Beacon were soaked in benomyl in acetone to eliminate all seedborne *Fusarium* (3), rinsed in sterile water, then germinated on water-agar plates. Contaminant-free seedlings were transferred to 20-mm-diameter test tubes containing 15 ml slanted complete Hoaglund's solution agar. Seedlings were grown for 2 wk in a growth chamber at 23 C. Isolates to be tested were grown on PCAL for 1–2 wk after isolation from asparagus tissue or the air. Agar disks (5 mm^2) from cultures of each isolate were placed on the medium next to seedlings. Controls consisted of uninoculated seedlings. Seedlings were rated for disease 2–3 wk later, based on a 0–5 rating system, where 0 = clean, white roots and crowns, 1 = crown discoloration (CD), 2 = CD and one or two storage or feeder root lesions, 3 = CD and three or more stem or root lesions, 4 = crown and root rot, extensive lesions, and 5 = dead from crown and root rot. After evaluation, tissue sections were excised from crowns, surface-sterilized in 5% chlorine bleach solution for 1–2 min, plated on PCAL, and the isolate reidentified.

RESULTS

Fungal colonies grew from flower surfaces at random and were not associated with any flower stage or structure. Flowers sampled both early and late in the growing season yielded *F. moniliforme* (Table 1). The number of isolates of *F. moniliforme* from flowers increased late in the season, especially for senescent flowers.

Washed and surface-sterilized immature fruit from all four fields yielded *F. moniliforme* (Table 1). Colonies grew from fruit surfaces and internal pulp. Incidence of *F. moniliforme* ranged from zero to three colonies per 25 fruit, with an overall incidence of 7%. Mature fruit from all four fields also yielded *F. moniliforme*. Fruit surfaces yielded zero to four colonies per 25 fruit, whereas pulp yielded two to four colonies per 25 fruit, for an overall incidence of 9.5% from mature fruit. *F. moniliforme* was isolated from five of 50 seeds extracted from mature fruit. *F. moniliforme* was not isolated from any of the branchlet sections plated on PCAL.

One-year-old volunteer seedlings showed typical decline symptoms, reddish brown lesions on roots and stems, and internal crown discoloration. Crown infections usually originated at the point

Portion of the first author's M.S. thesis. Paper 2558 of the Journal Series of the Massachusetts Agricultural Experiment Station.

Present address of the first author: Department of Botany and Plant Pathology, Colorado State University, Fort Collins 80523.

Accepted for publication 18 March 1983.

Table 1. Number of *Fusarium moniliforme* colonies[a] obtained from asparagus flowers and fruit from four fields in western Massachusetts

	Field 1	Field 2	Field 3	Field 4
Flowers[b]				
Early season[c]				
Preopen	4	7	2	1
Open	1	4	0	1
Senescent	1	4	6	4
Late season[c]				
Preopen	8	16	3	0
Open	5	8	8	0
Senescent	0	28	13	0
Fruit[d]				
Immature[e]				
Washed	0	3	3	0
Surface-sterilized	3	2	1	2
Mature[e]				
Surface-sterilized	4	0	1	2
Internal pulp	2	4	4	2

[a] All tissues plated on acidified potato-carrot agar.
[b] One hundred flowers per stage of development, washed in sterile water.
[c] Early season = July and August, late season = August and September.
[d] Twenty-five fruit per treatment.
[e] Immature = July, mature = September.

Table 2. Number of isolates of *Fusarium moniliforme* obtained from 1-yr-old volunteer asparagus seedlings from three fields in western Massachusetts

	No. isolations per field[b]			No. *F. moniliforme* colonies		
Tissue sources[a]	**Field 1**	**Field 2**	**Field 3**	**Field 1**	**Field 2**	**Field 3**
Crowns	50	25	20	3	14	5
Storage roots	40	40	25	3	19	4
Feeder roots	...	25	...	...	2	...
Stem	...	25	...	...	9	...

[a] Tissue sections surface-sterilized in 10% chlorine bleach solution and plated on acidified potato-carrot agar.
[b] From 50 randomly selected seedlings from each field.

of seed coat attachment. *F. moniliforme* was isolated from crown, storage root, feeder root, and stem tissues (Table 2).

F. moniliforme was isolated on Nash-Snyder medium in plates exposed to the air in both fields at both locations within each field. Plates on the ground averaged three colonies of *F. moniliforme*, whereas those in the air had only one colony per plate.

F. moniliforme isolates from air, flowers, fruit, and volunteer seedlings were highly virulent when used as inoculum with aseptically grown asparagus seedlings on Hoaglund's agar slants. Disease ratings averaged between 4 and 5 in severity.

DISCUSSION

F. moniliforme has been reported to invade banana, corn, and pineapple flowers (1,2,12). We found *F. moniliforme* associated with female asparagus flowers, fruit surfaces, interior pulp of mature fruit, and seed extracted from mature fruit. *F. moniliforme* also caused crown rot disease in volunteer seedlings originating from fallen fruit of the previous season.

The pattern of isolation of *F. moniliforme* from flowers suggests that contamination is due to random or chance contact with airborne spores. Contamination did not occur via vascular elements because *F. moniliforme* was not isolated from branchlets bearing contaminated flowers and fruits. *F. moniliforme* is known to be a cortical stem rot pathogen of asparagus (6,7,11) rather than a vascular wilt pathogen. Recovery of *F. moniliforme* from internal tissues of surface-sterilized fruit indicates invasion via infected flowers. Seed from fruit also yielded *F. moniliforme* colonies on PCAL. Disease incidence in volunteer seedlings from fallen fruit and recovery of *F. moniliforme* indicated contaminated seed was the inoculum source. *F. moniliforme* does not survive well in soil because it does not form chlamydospores (2,15).

Isolation of pathogenic isolates of *F. moniliforme* by trapping airborne spores confirmed the importance of wind in inoculum dissemination (2). Sources of airborne inoculum include asparagus stems and corn ears and stalks infected with *F. moniliforme*. Potential inoculum of *F. moniliforme* on infected asparagus stems increases with plant age (6). Damicone and Manning (4) reported that *F. moniliforme* from corn is also pathogenic to asparagus. Others confirmed that aerial contamination is important in inoculum dissemination for *Fusarium* spp. associated with diseases of carnation (9) and tomato (14).

Our results help explain one avenue of contamination of asparagus flowers, fruit, and seed by *F. moniliforme*. They also help explain why *F. moniliforme* is present on some seed in all seed lots and indicate this is one way *F. moniliforme* is continually reintroduced into commercial asparagus fields.

ACKNOWLEDGMENTS

We thank Ralph Baker and Earl Ruppel for reviewing the manuscript.

LITERATURE CITED

1. Bolkan, H. A., Dianese, J. C., and Cupertino, F. P. 1979. Pineapple flowers as principal infection sites for *Fusarium moniliforme* var. *subglutinans*. Plant Dis. Rep. 63:655-657.
2. Booth, C. 1971. The Genus *Fusarium*. Commonwealth Mycological Institute, Kew, Surrey, England. 237 pp.
3. 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.
4. Damicone, J. P., and Manning, W. J. 1980. *Fusarium moniliforme* var. *subglutinans* pathogenic on corn and asparagus. (Abstr.) Phytopathology 70:461.
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. Gilbertson, R. L. 1981. Sources of inoculum and disease increase of stem, crown, and root rot of asparagus caused by *Fusarium oxysporum* and *Fusarium moniliforme*. M.S. thesis, University of Massachusetts, Amherst. 169 pp.
7. Graham, K. M. 1955. Seedling blight, a fusarial disease of asparagus. Can. J. Bot. 33:374-400.
8. Grogan, R. G., and Kimble, K. A. 1959. The association of Fusarium wilt with the asparagus decline and replant problem in California. Phytopathology 49:122-125.
9. Horst, R. K., Nelson, P. E., and Toussoun, T. A. 1970. Aerobiology of *Fusarium* spp. associated with stem rot of *Dianthus caryophyllus*. (Abstr.) Phytopathology 60:1296.
10. Inglis, D. A. 1980. Contamination of asparagus seed by *Fusarium oxysporum* f.sp. *asparagi* and *Fusarium moniliforme*. Plant Dis. 64:74-76.
11. 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.
12. Kucharek, T. A., and Kommedahl, T. 1966. Kernel infection and corn stalk rot caused by *Fusarium moniliforme*. Phytopathology 56:983-984.
13. Nash, S. M., and Snyder, W. C. 1962. Quantitative estimates by plate counts of propagules on the bean root rot *Fusarium* in field soils. Phytopathology 52:567-572.
14. Rowe, R. C., Farley, J. D., and Coplin, D. L. 1977. Airborne spore dispersal and recolonization of steamed soil by *Fusarium oxysporum* in tomato greenhouses. Phytopathology 67:1513-1517.
15. Toussoun, T. A., and Nelson, P. E. 1976. A Pictorial Guide to the Identification of *Fusarium* Species. Pennsylvania State University Press, University Park. 43 pp.