PRELIMINARY INVESTIGATIONS INTO THE BIOLOGY AND CONTROL OF <u>BOTRYTIS PORRI</u> ON GARLIC

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ABSTRACT

Botrytis disease (B. porri) was damaging to the field of garlic in which plots were located, but disease was very light in the plots treated with fungicides, including untreated plots. Therefore, differences among fungicide treatments could not be assessed, and future plot design will be altered to correct for effect of spray drift and/or interruption of fungal spore dispersal in the 1985 plot design. Most disease loss in field was from plant death prior to harvest, with many sclerotia remaining in the soil. The disease occurred on necks at or below the soil line. Some harvested bulbs were encrusted with sclerotia. The field was irrigated more frequently than usual, perhaps accounting for higher disease incidence than experienced in most grower's fields in 1985.

Garlic for vegetative seed production has remained near or above 1,000 acres in central Oregon for several years. Seed is primarily utilized for commercial production in California.

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Diseases that damage seed, or which may be carried by seed are of concern to both the seed and commercial industries.

Botrytis neck and bulb rot, caused by both *Botrytis porri* and *B. allii* is known to occur in the coastal valleys of Oregon, and *B. porri*-induced neck rot (and perhaps *B. allii*) have damaged garlic in central Oregon in recent years. These diseases are rather new to the garlic industry and are not well described or studied, and control measures are not identified. Botrytis on garlic seems to be less of a problem in California, although the disease has been observed there. Trials were established in 1984 at the Madras field of the Central Oregon Experiment Station to investigate questions of epidemiology and control of these diseases. The disease studies reported here complement similar disease studies ongoing in California.

Objectives of the Oregon field research were:

1. To gather epidemiological evidence to help determine the role of seed, soil, and air-borne inoculum in botrytis spread and disease development. Various typical control measures were utilized to help in making these distinctions. This information might then assist in better designing later studies.

2. To the extent possible, determine the effectiveness of various standard control measures on botrytis diseases.

Materials and Methods

Seed and hot water seed treatments were as follows:

Trials with California Early Garlic (Virus-Free)

Virusfree garlic used in these trials was collected as bulbs at harvest in the summer/fall of 1984, and stored in King City, CA, until treatment. Bulbs were cracked under commercial conditions and hot water and formaldehyde treatment, if done, was treated on the day of, or within 24 hours of cracking. Seed was obtained from Basic American Foods.

All hot water and formaldehyde clove treatments were made in King City using 50-gallon, temperature controlled experimental treatment tanks. Treatments involving the University of California method of 30 minutes at 100 degrees F, followed by 20 minutes at 120 degrees F, both with Formaldehyde, followed by a 15-minute cold dip, and finally followed by drying in air at 90 degrees F, will be referred to as the Lear/Johnson treatment. After Lear/Johnson treatment, all cloves were stored under ambient conditions until shipment to Madras, Oregon, in late September 1984.

Trials with California Late Garlic and virus-infected California Early Garlic

Commercially cracked and hot water and formaldehyde treated seed was obtained from Vessey Company. No additional hot water and formaldehyde treatments were made. Cold fungicide treatments and seed and plot handling was the same as for Early Virusfree seed above.

For hand-planted trials, cloves for individual treatments were counted by hand for each seedline and stored until planting. Every effort was made to maintain clove weights for individual treatments within each trial as close as possible to reduce the influence of clove size in these trials. Individual trials were planted by having a standard two- or four-bed garlic planter make the desired two seedlines per bed without closing in the seedlines. It was found, however, that seedlines were partially closed anyway by the equipment, so these were reopened by hand using garden hoes. The cloves for each individual seedline of each plot replicate were planted and covered by hand. Plots were all single bed plots, either 5 or 10 feet long, and separated by a 2-foot alley unless noted. All garlic was planted at 16 cloves per bed foot, on 40" beds center-to-center.

All machine planted trials were in the commercially planted areas at the field. A 4-row planter operated by Central Oregon Seeds, Madras, OR, was used to plant the general field on October 2. No attempt to control seed size or plant population was made in machine planted trials.

For certain treatments, seed was immersed in fungicide dips for 15 minutes, then air dried before planting. These treatments were made on October 4 and 5, and seed was planted October 5. All in-furrow treatments were applied with a hand pump backpack sprayer at 50 gallons per acre over the cloves in the open furrows. The cloves were covered with soil by hand after the treatments were applied. Additional fungicide treatments were made during the growing season with a hand pump backpack sprayer at 30 to 40 gallons per acre, with spray directed over the foliage and particularly at the neck region. All formulations, rates, and date of application for all fungicide treatments are shown in Tables 1 through 5.

The field received 400 lbs/A 16-16-16 in September 1984. On April 7, 1985, 150 lbs/A of nitrogen as ammonium nitrate was applied. Standard chemical weed control was supplemented with some hand weeding. The field was watered by solid set sprinkler irrigation. The field was irrigated somewhat more frequently than typical for commercial practices in Central Oregon. For example, seven short irrigations were applied between April 18 and May 15, 1985; commercial growers typically applied one to three irrigations in this period.

Notes were collected weekly during the season. Stand counts were collected as listed in tables. Harvest data were collected in July, with plants dug by hand, observed for disease, and weighed after roots below the stem plate and foliage higher than 2 cm above the bulb were removed. Although disease notes were taken, bulbs were considered harvestable if stem plates and covering leaf sheaths were intact upon squeezing the bulb by hand. Late garlic was harvested on July 12 and Early garlic on July 17, although necks were not fully dried in either case.

All treatments were in randomized block design and data were analyzed by standard analysis of variance methods.

Results

Botrytis trials are summarized in Tables 1, 2, and 3. For Trials 1 and 2, although abundant botrytis disease was present around the trials, only scattered plants were diseased in the trials, even in experimental check plots which were without any in-season sprays or without cold-dipped fungicide seed treatments. For Trial 3, more botrytis disease was present, but this was relatively uniform among all treatments. Also, for Trial 3, high variability among machine-planted stands made statistical distinction among treatments more difficult.

The disease first was noted in the field about April 10, 1985, because of lesions and sporulation of botrytis on the neck at or just below the soil line. Only *B. porri* was found. Decay from the lesions spread up and down leaves, but also inward from leaf to leaf. Flagging of affected leaves quickly followed extensive lesion development. Most plants showing lesion development before late May died, with abundant sclerotia forming in the lower neck area below the soil line. As bulbs began to develop, the disease continued but fewer of the larger, more mature plants died. Nevertheless, sclerotia formation in outer neck leaves was abundant and rot continued to progress inward in the neck region on these larger plants. The worst-affected plants were highly noticeable throughout the season by the extensive leaf flagging and early senescence of plants toward drydown. At harvest, only a few harvested bulbs were noted to be encrusted with sclerotia.

The main differences seen among treatments in Table 1 appear to be caused by hot water and formaldehyde treatment, and these differences relate to performance factors other than botrytis disease.

Discussion

Only B. porri was abundant by early to mid-May in both early and late garlic. If B. allii was present, it was not found. Relatively little disease occurred in in-season spray trials in which 5 fungicide applications were made starting early in the season, including the experimental checks in these trials. We suspect that the experimental checks were protected from B. porri infection by one or both of two processes: (1) Airborne spores of B. porri did not effectively spread into the interior of the trial area to reach the experimental check plots, and (2) sufficient spray drift from adjacent sprayed beds protected the experimental check plots. If true, then the materials used (which are known to be effective against most botrytis species) may have worked well, but the experimental design was insufficient to assess this. A better design can be chosen for future experiments.

Another spray trial in which two May sprays were applied soon after the disease was apparent on garlic necks also failed to show treatment differences, however, B. porri was already present in these plots before the first application. Also, these plots were not uniformly planted, thus experimental error was high, reducing ability to assess treatment differences.

We observed that botrytis activity occurred early and that many plants with infected necks died before bulbing, reducing stand numbers. Later infected plants were also common, some of these developed substantial or total bulb rot with heavy sclerotial encrustation. Many bulbs matured in spite of disease ingress upon the neck region, with no apparent infection of cloves or damage to bulb-covering leaf sheaths. Although the sclerotia-encrusted bulbs and cloves are highly noticeable at harvest and these may be important in disease spread among fields, most sclerotia formed on plants which died early and these sclerotia remained in the field. The losses of unharvested plants were far greater than infected-but-harvested bulbs.

The epidemic development of botrytis disease in this field most likely was from airborne spore spread produced from within the field. This field had no history of garlic, and seed lots were considered sound. However, the source of initial inoculum remains obscure. From what is known of other botrytis diseases, the possibilities include at least the following:

a. Inoculum as sclerotia or spores, with or on seed or planting equipment.
b. Inoculum as inconspicuous hyphae (mold) within dormant cloves.
c. Inoculum from B. porri that resides on various crop debris in local soils, irrespective of garlic or

other *Allium* cropping (i.e., the fungus could already have been in this field even though garlic had never been grown).

d. Inoculum from unrecognized sporulation on onion debris in an adjacent section of our field.

e. Inoculum as spores entering the field by air movement over sporulation on debris in other fields in the area.

Distinguishing the true source(s) of primary inoculum may be difficult, and experience with botrytis diseases on other crops has shown preconceptions frequently to be misleading. Nevertheless, knowing the true source(s) of initial inoculum may be very important in the success and cost effectiveness of control efforts.

Recommendations

Recommendations from the 1984-85 data and observations include:

We believe understanding the true source(s) of initial infections is important, but point out that efforts to elucidate these sources may be difficult and time-consuming. Also, we caution that early success may be misleading if several sources operate in nature.

We believe future investigation of botrytis control on garlic must consider changes in experimental design from that selected in these control trials, perhaps more widely separating sprayed plots. Also, we believe earlier disease observations must be made, and perhaps destructive sampling methods should be utilized to assess early disease activity and stand losses. Also, we suggest that grower's practices of spraying well after activity is highly noticeable may be inadequate since such mid-season spraying may miss the early disease infections most likely to result in plant loss.

The Madras field had abundant botrytis disease, in contrast to most grower's fields where light disease was evident. We overwatered (sprinkler irrigation) in comparison to grower's practice in the area, thus, high foliage dampness, higher humidity, and prolonged soil wetness around necks from frequent irrigation may promote botrytis infection and development. This may necessary for consistent data in generally arid Central Oregon and may better explain why the disease incidence varies from year to year. Botrytis has been worse in grower's fields in wetter areas, and in years with higher rainfall and humidity. Also, botrytis more consistently occurs in the Willamette Valley under higher rainfall, where *B. allii* has also been observed to be active similar to *B. porri*. Future botrytis studies may best be placed in areas of higher rainfall (e.g., the Willamette Valley) and/or under heavy overhead irrigation elsewhere.

We recommend further study of spray timing to better control early infection and better inhibit epidemic disease development, hopefully with one or two spray applications based upon weather, irrigation and crop growth parameters. <u>No specific spray control recommendations for growers can be made at this time. The best control recommendations may be to irrigate and otherwise manage garlic in a manner that will minimize humidity in the plant canopy and minimize free water on leaf and neck surfaces.</u>

TABLE 1. Fungicide Trial #1 for Control of Botrytis

Location: Central Oregon Experiment Station
Madras, OR

Variety: Cal. Early (virus-free)
Seed Source: Basic
Plot Size: 1 bed x 10 ft.

Bed/Row & Seed Spacing:
40" beds, 16 cloves/bed ft.
in 2 seedlines per bed
Seed Sized/Graded?: Yes
How Planted?: By hand
Date Planted: 10-5-84
Date of Stand Count: 4-10-85
Date Harvested: 7-17-85[A]

Seed Treatments						
Hot Water + Formaldehyde[B]	Fungicide Cold Dip[C]	Post-Emergence Foliar & Basal Fungicide Sprays[D]	% of Seed Emerged (% Stand)	% of Stand Harvested As Bulbs	No. Bulbs/ Bed Ft. Harvested	Lbs/A Harvested[A]
-	-	-	79	93	11.8	13.419
+	-	-	70	91	10.2	11,382
-	Rovral 50W	-	86	94	12.9	13,192
-	-	Rovral 50W	88	95	13.4	13,455
+	Rovral 50W	-	68	82	8.9	9,972
+	-	Rovral 50W	80	87	11.0	11,903
+	Benlate 50W	-	76	93	11.3	13,070
+	-	Benlate 50W	63	79	8.0	10,044
+	Ronilan 50W	-	69	89	9.9	12,721
+	-	Ronilan 50W	67	85	9.1	9.440
	Coefficient of Variation		6.4	3.6	7.5	14.5
	LSD (.05)[E]		6.9	4.7	1.2	2,487

A Tops were not fully dry at time test was harvested.
B Small test lots were treated experimentally with standard Lear-Johnson methods.
C All products applied @ 2 lbs. a.i./100 lbs. seed.
D All products applied 5 times between 4/12/85 - 6/8/85 @ 0.75 lbs. a.i./A.
E F-test significant at 1% level in all categories.

TABLE 2. Fungicide Trial #2 for Control of Botrytis

Location: Central Oregon Experiment Station
Madras, OR

Variety: Cal. Late
Seed Source: Vessey
Plot Size: 1 bed x 10 ft.

Bed/Row & Seed Spacing:
40" beds, 16 cloves/bed ft. in 2 seedlines per bed
Seed Sized/Graded?: Yes
How Planted?: By hand
Date Planted: 10-5-84
Date of Stand Count: 4-10-85
Date Harvested: 7-17-85[A]

Seed Treatments: Hot Water + Formaldehyde[B]	Seed Treatments: Fungicide Cold Dip[C]	Post-Emergence Foliar & Basal Fungicide Sprays[D]	% of Seed Emerged (% Stand)	% of Stand Harvested As Bulbs	No. Bulbs/ Bed Ft. Harvested	Lbs/A Harvested[A]
+	-	-	86	100	13.7	9,379
+	Rovral 50W	-	91	100	14.5	10,237
+	-	Rovral 50W	91	100	14.5	10,378
+	Benlate 50W	-	87	103	14.4	9,839
+	-	Benlate 50W	83	97	12.9	8,764
+	Ronilan 50W	-	91	103	14.9	11,175
+	-	Ronilan 50W	89	100	14.2	10,205
		Coefficient of Variation	5.8	3.6	7.4	15.6
		LSD (.05)[E]	NS	NS	NS	NS

A Tops were not fully dry at time test was harvested.
B Commercially treated by Vessey.
C All products applied @ 2 lbs. a.i./100 lbs. seed.
D All products applied 5 times between 4/12/85 - 6/8/85 @ 0.75 lbs. a.i./A.
E F-test not significant at 5% level in any category.

TABLE 3. Fungicide Trial #3 for Control of Botrytis

Location: Central Oregon Experiment Station
Madras, OR

Variety: Cal. Late
Seed Source: Vessey
Plot Size: 1 bed x 10 ft.

Bed/Row Spacing:
40" beds, 2 seedlines per bed
Seed Sized/Graded?: No
How Planted?: By machine
Date of Stand Count: 4-10-85
Date Harvested: 7-17-85[A]

Seed Treatment Hot Water + Formaldehyde[B]	Midseason Foliar and Basal Fungicide[C] Sprays	Stand Count (Plants Bed-Ft.)	% of Stand Harvested	No. Bulbs/ Bed Ft. Harvested	Lbs/A Harvested[A]
+	-	19.9	74.4	14.4	11,034
+	Rovral 50W	18.5	81.9	15.1	11,131
+	Ronilan 50W	17.4	74.4	12.9	10,264
+	Benlate 50W	17.9	76.8	13.8	10,893
	Coefficient of Variation	16.9	18.6	19.9	19.4
	LSD (.05)[D]	NS	NS	NS	NS

A Tops were not fully dry at time test was harvested.
B Commercially treated by Vessey.
C All products applied on 5/17/85 & 5/23/85 @ 0.75 lbs. a.i./A.
D F-test not significant at 5% level for any category.