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Project Title: Sweet corn diseases and their management in the PNW: Seed treatment evaluations and development of *Fusarium*-free seed

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Background: Sweet corn is susceptible to various pathogenic *Fusarium* species and has been long known to be subject to early season diseases of seed rot and seedling blight as well as root rot and later season problems with stalk rot and ear rots. More recently, fields in the Willamette Valley of Oregon as well as other areas have had outbreaks of plants exhibiting leaf-firing, in which the leaves die prematurely starting at the base of the plant and then progressing upwards, and a crown and stalk node rot. Recent investigations have shown that crown rot, accompanied by a stalk node rot, appears to explain much of the observed leaf firing and the concomitant loss in yield, rather than root rot and that adventitious roots may be diseased as the pathogen(s) move from the crown outward and upward.

Other factors contribute to sweet corn yield declines when *Fusarium* species are involved, especially in crown and stalk node rot, including characteristics of specific cultivars or hybrids, environmental conditions which stress plants or favor *Fusarium* (high temperatures seem to promote Fusarium crown and stalk node rot as well as soil compaction, dry soil conditions, high manure rates, etc.), and the microbial population associated with seeds or soil.

Commercial sweet corn seed lots have been found to have high percentages of seed containing *Fusarium* and seed-borne *Fusarium* are recovered from corn seed produced throughout the world; *F. verticillioides* and *F. proliferatum* are most commonly found. These two fungal species are known to cause seed rot, seedling blight, stalk rot, root rot, or ear rot of sweet corn, and we have commonly found them in consortium with *F. oxysporum* inside necrotic crown and stalk node tissues from more than a dozen commercial processing fields in the Willamette Valley. Sweet corn seed is usually treated with fungicides, which can greatly aid in controlling seed rot and seedling blight. There are a number of fungicide seed treatment options as well as biocontrol formulations, including some promising experimental materials and these were examined as solo treatments during 2012. During 2013, combinations of a subset of the materials as well as singular treatments were evaluated in an experimental field with high *Fusarium* pressure and results are reported below.

Fungicidal seed treatments may not prevent seedlings from becoming infected by seed-borne *Fusarium*, even though these treatments can assist seedlings in reaching the 2-leaf stage. Reduction or eradication of *Fusarium* from sweet corn seed is associated with an improvement in crown and stalk health as well as potential improvements in ear yields (Miller and Ocamb, unpublished), but removal of *Fusarium* from corn seed does not necessarily reduce losses from *Fusarium* diseases if pathogenic populations are present in the soil where the seeds are planted. And eradication of *Fusarium*, once on corn seed, is difficult to accomplish, especially on large scale amounts of seed (tons). But a reduction in seed-borne *Fusarium* accompanied by effective biological control microbes can lead large increases in ear yields with an associated reduction in

crown and stalk node rot and sometimes also in root rot severity when grown in our high pressure field (Ocamb, unpublished).

Fusarium species can associate with sweet corn seed through a number of different routes, including infection through corn silks or by *Fusarium* growing up through the stalk to reach the seed. The use of microbial amendments to prevent reduce *Fusarium* association with seed has shown promising results in our preliminary. We focused on the parents of a single corn hybrid very susceptible to yield losses from *Fusarium* crown and stalk node rot (Jubilee) and found a significant reduction in *Fusarium* numbers on silks and kernels produced by the 'Jubilee' seed parent after microbial treatment during 2010 and 2011. During 2013, we examined the performance of seed produced on biocontrol-treated seed parent plants, and did another Jubilee inbred cross with microbial amendments, results are reported below.

Objectives for 2013 and Accomplishments:

1. Conduct an evaluation of materials (focus on combinations) currently registered on sweet corn (resistant cultivar GSS1477) for control of seed rot and seedling blight.

An experimental field on the OSU-Botany Farm was inoculated during several growing seasons between 1990 and 2003 with a complex of *Fusarium* species, and has been repeatedly shown to have severe disease pressure for Fusarium crown and stalk node rot in sweet corn. Treatments examined during 2013 included conventional fungicides alone and in combinations, as well as biocontrol formulations (Table 1). Treated and nontreated seeds were sown in the "Fusarium" field in 20-ft long, 1-row plots with six replicates in a randomized block design on 28 June 2013 using hand-planters. Plants were irrigated twice weekly for the first two months and thereafter weekly with about 1.5 inches of water, depending on the weather, commencing on the day of sowing. Stand counts were made and plants were dug (5 per plot) at the 6-leaf stage for assessment of seminal and adventitious root rot.

Table 1. Treatments examined in sweet corn 'GSS1477'

Trt #	Treatment
1	Allegiance-FL (0.75 fl oz/100 lb seed)
2	Captec 4L (4 fl oz/100 lb seed)
3	Dynasty (0.153 fl oz/100 lb seed)
4	Maxim 4FS (0.08 fl oz/100 lb seed)
5	Raxil 2.6F (0.1 fl oz/100 lb seed)
6	Stamina (1.6 fl oz/100 lb seed)
7	42-S Thiram (5 fl oz/100 lb seed)
8	Dynasty (0.153 fl oz/100 lb seed) + Maxim 4FS (0.08 fl oz/100 lb seed) + Allegiance-FL (0.75 fl oz/100 lb seed)
9	Stamina (1.6 fl oz/100 lb seed) + Maxim 4FS (0.08 fl oz/100 lb seed) + Allegiance-FL (0.75 fl oz/100 lb seed)
10	Captec 4L (4 fl oz/100 lb seed) + 42-S Thiram (5 fl oz/100 lb seed)
11	Dynasty (0.153 fl oz/100 lb seed) + Maxim 4FS (0.08 fl oz/100 lb seed) + Allegiance-FL (0.75 fl oz/100 lb seed) + Raxil 2.6F (0.1 fl oz/100 lb seed)
12	Stamina (1.6 fl oz/100 lb seed) + Maxim 4FS (0.08 fl oz/100 lb seed) + Allegiance-FL (0.75 fl oz/100 lb seed) + Raxil 2.6F (0.1 fl oz/100 lb seed)
13	Captec 4L (4 fl oz/100 lb seed) + 42-S Thiram (5 fl oz/100 lb seed) followed by MicroAF soil drench (12.8 fl oz/A)
14	Captec 4L (4 fl oz/100 lb seed) + 42-S Thiram (5 fl oz/100 lb seed) followed by MicroAF + MicroAZ soil drench (8 fl oz/10,000 ft^2)
15	Serenade ASO/Max (5.0 fl oz/100 lb seed) followed by MicroAF (12.8 fl oz/A) + Taegro (2 qts/A) soil drench
16	nontreated

Stand number (averaged across 6 replicate blocks) was significantly different among only a few treatments examined on 'GSS1477' (Fig. 1A). The percentage of plants per plot that emerged and were present at the stand count was generally greater among the seed treatments evaluated compared to the nontreated control, except in plots planted with seed treated with Allegiance which had significantly lower stand counts than the plots receiving Stamina, Dynasty, or Dynasty+Allegiance+Maxim. The primary root (radical) had mostly rotted by the 6-leaf stage (Fig. 1B), overall mean was 79% of the primary root was rotted across all treatments. No treatment significantly reduced primary root rot compared to the nontreated control, although plots receiving Captec+Thiram+MicroAF soil drench had less primary root rot than some other treatments. Captec+Thiram and Dynasty+Maxim+Allegiance+Raxil were found to have the lowest level of mesocotyl rot (Fig. 1C), though the majority of the mesocotyl was rotted by the date of sampling, averaging 84% across all treatments. The seminal root system overall average of rot was 36%. Plots receiving 42-S Thiram, Stamina+ Maxim+Allegiance, and Captec+Thiram+MicroAF had less seminal root rot compared to nontreated control plants or plots treated with Dynasty, Raxil, or Captec+Thiram (Fig. 1D). Adventitous root rot was apparent by the 6-leaf stage (Fig. 1E) and averaged 20% across all treatments while the lowest levels were found in the following five treatments: Raxil alone, Thiram alone, Serenade+MicroAF+Taegro, Captec+Thiram+MicroAF, and Dynasty+Maxim+Allegiance+Raxil treatments. The number of stalk nodes with rot varied among the treatments, with the nontreated control having among the smallest number affected (Fig. 1F).

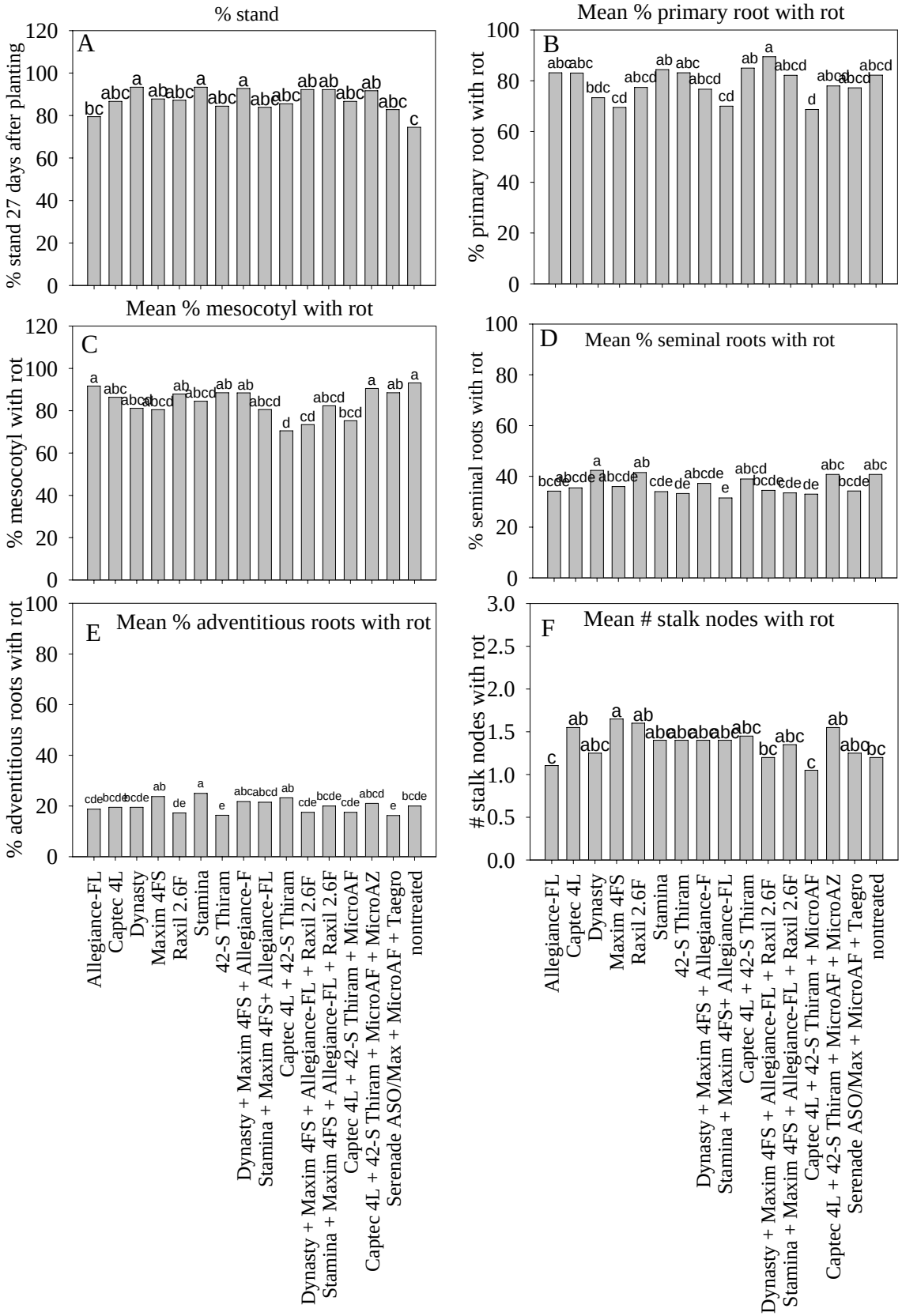

Figure 1. Stand and disease assessments of sweet corn 'GSS1477' during 2013. Within each figure, means labeled with the same letters are not significantly different (P=0.05) as determined by Fisher's F-protected LSD test.

Objective 2. Evaluate biological applications to sweet corn seed parents and subsequent *Fusarium* presence on silks and associated with seed infection/contamination.

Fusarium crown and stalk node rot as well as root rot was present but little difference was found between the biocontrol and nontreated Jubilee seed parent plants in terms of disease severity, though stalk node rot was significantly more severe in the nontreated plants. Biocontrol applications resulted in a significant increase in ear weights, both for the primary ear and total ear yield per plant. Evaluation of presence of Fusarium species associated with silk and seeds are currently under way at the time of writing of this report but results from 2012 isolations from kernels are silks are reported.

Kernels of the inbreds for 'Jubilee' were seed-treated with Apron Maxx RTA and then sown with a 4-row planter into a field not commonly rotated to corn on the OSU Botany Field Lab (Electric Rd., Corvallis) on 6 June 2013. Plots consisted of three rows of the 'Jubilee' seed parent with 2 rows of males between each plot of females. Plots were replicated three times as 55-ft long, 3-row plots for each treatment. There were two treatments for the seed parent: nontreated or MicroAF (an experimental microbial formulation) at 12.8 fl oz/A as a soil drench at planting and later as applications to silks twice a week for three weeks, until the exposed silks turned mostly brown (Aug 15, 19, 22, 26, 29 and the 4th of Sep). Plants were irrigated twice a week with approximately 1.5" of water, depending on the weather conditions up until post-silking and then once a week through ear fill. Nontreated parent plants were subsampled for disease evaluations 54 days after planting (Jul 30), just prior to tasseling, to see if Fusarium diseases were present in the field. On 21 Oct 2013, the primary ear was harvested from each of 25 plants in the center row of each seed parent plot. Most of the husks were removed, but one or two layers were left, and then each ear was placed individually into a fresh paper bag prior to drying <85ºF. After drying for several months, internal silks pieces and kernels will be excised in the laboratory and plated onto a *Fusarium*-selective medium. On 28 Oct 2013, all ears were collected from 15 individual plants in each plot and the husked weight of each ear was determined, including undeveloped ears, if present. For all ears harvested, dried kernels will be saved in paper envelopes for subsequent studies. Isolations from silk and kernel samples will take place over winter break but data from the same study done during 2012 are collated and reported here.

Disease was present during 2013 in our corn breeding plot where seeds of the hybrid, Jubilee, were produced. Generally, disease severity was similar among the two parents with two to three stalk nodes exhibiting rot prior to tasseling. Rot of the primary root and the mesocotyl were nearly 100% while crown rot incidence was 100% and the crown grayscale averaged 106 and 113 for the pollen and seed parent plants, respectively. Adventitious root rot averaged about 20%. There was a significant increase in husked ear yield when plants were treated with MicroAF (Table 2), yielding about double the average yield per plant and an 18% increase in primary ear weight compared to the nontreated plants during 2013 (Table 3).

Table 2. Effect of MicroAF on 2013 ear yield in OSU-BPP breeding plot

Sweet corn inbred	Biocontrol treatment	Average ear yield per plant (g)[1]	Primary ear wt (g)[1]
Female parent of Jubilee	nontreated	188 b	169 b
Female parent of Jubilee	MicroAF	383 a	199 a

[1]Within each column, means labeled with the same letters are not significantly different (P=0.05) as determined by Fisher's F-protected LSD test.

Table 3. Relative ear weights after biological treatment during 2012 and 2013

Year	% change in primary ear wt[1]	% increase in ear wt per plant[1]
2012	27	74
2013	18	104

[1]Relative change in mean ear weights compared to nontreated control plants.

The presence of *Fusarium* species was low on silks in both treatments and relatively lower on kernels produced from MicroAF-treated mother plants (5 kernels and 5 silks portions from the primary ear of 120 biocontrol-treated mother plants were examined) grown during 2012 for hybrid seed production (Table 4) compared to the nontreated plants.

Table 4. Effect of biocontrol treatment on *Fusarium* recovery from silks and kernels

Sweet corn inbred	Biocontrol treatment	% silk samples with *Fusarium* spp.	% kernels with *Fusarium* spp.
Female parent of Jubilee	nontreated	1	20
Female parent of Jubilee	MicroAF	2	5

Objective 3. Evaluate 1st generation 'Jubilee' seed produced from seed parent plants treated with biocontrol applications.

Kernels produced by the inbreds for 'Jubilee' during 2012 were treated with Captec 4L (4 fl oz/100 lb seed) + 42-S Thiram (5 fl oz/100 lb seed) and then sown with a 3-row planter into the experimental *Fusarium* field (described above) on the OSU Botany Field Lab on 21 June 2013. Seed from the nontreated seed parent as well as from the seed parent plants treated with MicroAF were sown as three row plots replicated six times and treated culturally as described above. Plants were sampled for disease evaluations 74 days after sowing (Aug 19), after silking commenced. On 15 Oct 2013, all ears were collected from 10 individual plants in each plot and the husked weight of each ear was determined, including undeveloped ears, if present.

Rot levels of the primary root, mesocotyl, and adventitious root system were very similar between the two groups of offspring (Table 5) but the crown grayscale was darker (lower number) in the plants that grew from seed produced by nontreated seed parent plants. The average weight of the primary ear was significantly greater for plants that grew from seeds produced on microbe-treated mother plants (Table 6), and generally more than one well-developed ear was produced on these F1 plants, leading to a significantly greater total ear yield per plant.

Table 5. Effect of MicroAF treatment of 2012 seed parent on disease in offspring in a *Fusarium* field

Treatment	Mean % primary root with rot[1]	Mean % mesocotyl with rot[1]	Mean % adventitious roots with rot[1]	# stalk nodes discolored[1]	Incidence of crown rot[1]	Mean crown grayscale[1]
nontreated	98 a	91 a	38 a	2 a	100 a	100.0 b
MicroAF-treated mother plants	100 a	90 a	33 a	2 a	97 a	103.4 a

[1]Within each column, means labeled with the same letters are not significantly different (P=0.05) as determined by Fisher's F-protected LSD test.

Table 6. Effect of MicroAF treatment of 2012 seed parent on offspring ear yields

Treatment	Primary ear wt (g)[1]	Average ear yield per plant (g)[1]
nontreated	230 b	231 b
MicroAF-treated mother plants	291 a	446 a

[1]Within each column, means labeled with the same letters are not significantly different (P=0.05) as determined by Fisher's F-protected LSD test.

Objective 4. Cooperate with other sweet corn projects within and outside of OSU.

Ocamb compared two sweet corn varieties ('Jubilee' and 'GSS1477') for development of Fusarium crown and stalk node rot over a second season. Plants were sampled on seven different dates during the growing season, beginning at the 4-leaf stage and through ear development. Data will be presented at the oral reports.

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