Progress Report to the Oregon Processing Vegetable Commission

Proposal Title: Root Health and Maximizing Sweet Corn Yield

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Situation: A sweet corn yield reduction has been observed in Oregon when a field is planted several seasons to sweet corn whereas corn yields are greater when planting into fields rotated to non-grass species for several years. This phenomenon, termed the rotation effect, has been documented in field corn-soybean-wheat rotations in the Midwest, and probably other regions of the U.S. Leaf-firing, and an associated yield reduction, has been observed on sweet corn plantings in the Willamette Valley, especially with the cultivar 'Golden Jubilee', and may be indicative of problems in root health. Several root-invading plant pathogens have been found in roots, *Fusarium oxysporum, F. solani,* and *Pythium* species., but their involvement in the symptoms observed in the field is still unclear (Powelson et al., unpub.).

One of the under-lying questions is whether any biological differences exist between lower-yielding or plants exhibiting leaf-firing, and higher-yielding corn plantings. Such differences that may affect palnt health and yield include: plant pathogenic or beneficial microorganisms and root-feeding insects. Cultural practices and environmental conditions can have significant effects on root health and "firing" plants or reduced yield can be assoicated with formations of hard pans, pesticide use patterns, or a cropping sequence that promotes pathogenic microbial populations.

Objectives:

1. Examine pathogenic and beneficial microbial populations, as well as insect injury, associated with roots in historically lower-yielding sweet corn fields and compare to "new" corn plantings in close vicinity.

2. Examine abiotic factors in addition to pathogenic and beneficial microbial populations, as well as insect injury, associated with roots in sweet corn plantings exhibiting leaf-firing and those that have no evidence of leaf-firing, especially "new" corn plantings.

3. In greenhouse studies, examine soil from fields exhibiting leaf-firing and those that have no evidence of leaf-firing for soil microbial factors coupled with water stress to observe effects on root health and leaf-firing.

Methods:

Objective 1. Four sets of paired fields in the Willamette Valley were used, with one field being a "new" corn planting and another nearby field that has a historically low sweet corn yield. Corn plants were sampled at the 3 to 4-leaf-stage, 8 to 10 -leaf-stage, and at silking. In each field, plants were collected from transects, spaced across the field length and width. From each transect, approximately 10 ft of row of plants were sampled and rhizosphere soil was collected from 5 plants. Soil dilutions were made and plated separately onto media selective for *Fusarium* species (representative weak pathogen) and *Streptomyces* species (representative beneficial microorganism). Corn roots were then washed. Root volume, root rot, and insect feeding injury were assessed. Root or crown segments exhibiting rot were washed under running tap water for 30 minutes and then plated onto various specific/non-specific media for isolation of fungi and bacteria.

Objective 2. Seven fields in the Willamette Valley with leaf-firing were sampled. In one field, three transects of 10 plants each were sampled. In the other fields, five symptomatic plants were sampled. Roots and rhizosphere soil were sampled in the same manner as described above in Objective 1. A measurement of soil compaction and hard pan formation was made in each field with a hand-held penetrometers and 20 measurements were taken in each field using a "W" pattern across and down the field. In addition, a history of pesticide use, irrigation, and cultural practices will be collected from each grower. Soil tests for physical characteristics and nutrient levels will be made.

Objective 3. Soil from fields sampled in Objective 2 will be used in greenhouse evaluation for studies on root health and leaf firing. For each field, soil will be well-mixed, divided into three equal volumes and two portions will undergo steam pasteurization. One portion will be infested with *Fusarium* isolates collected from corn roots, crowns and stalks. Soil will be placed into half-gal pots and sowed with 'Golden Jubilee'. Within each soil treatment, pots will be divided into two groups: one group will receive watering optimum for corn growth and the other will be routinely over-watered (field capacity for 3 days) then allowed to dry out to – 10 bars. Corn plants will be destructively sampled at 30 and 70 days after sowing in a manner similar to that outlined in Objective 1.

Results

Incidence of lesions and *Fusarium* species in paired fields. In new ground, soil that hadn't been planted to sweet corn for many years, the number of sweet corn plants found to have lesions increased with each sample date (Table 1). These fields appeared to have lesion numbers similar to that found in "old" problematic fields at the 3-4 leaf stage. At the 8-10 leaf stage, plants on new ground had generally more lesions overall than the plants from old ground, but a lower proportion of these new-ground plant lesions yielded *Fusarium* species. By the third sample date, the plants on old ground had dramatically more lesions and greater numbers of brace roots as well as subcrown internodes from these plants were found to contain *Fusarium* species, compared to plants on new ground. The predominate *Fusarium* species isolated from lesions were F. oxysporum and F. solani (Table 2). *Pythium* species were rarely isolated from symptomatic roots (data not shown).

Fusarium species and actinomycetes (*Streptomyces* spp.) were isolated from rhizosphere soil samples. The data have not been completely tabulated because it was decided that *Fusarium* presence should be determined according to species and identifications will be carried out this winter. One set of paired fields have been analyzed in a gross manner and the population of both *Fusarium* and

Streptomyces species is much greater in the rhizosphere soil of plants grown on "new" ground compared to that found on "old" ground (Figures 1 and 2).

Insect feeding in paired fields. Evidence of insect feeding on corn roots was low. At silking, all three "old" fields had four or fewer plants (out of 30) that had obvious insect feeding. The fields on "new" ground had 1, 7, and 13 plants exhibiting root injury from insect feeding.

Hard pan formation in paired fields. There was no clear pattern of differences in force or depth reached with a hand-help penetrometer when each field is examined separately (Figure 3). When grouped together, the "new" fields had a depth of 20 inches while the "old" fields had a depth of 16 inches.

Incidence of lesions and *Fusarium* species in firing fields. Symptomatic plants sampled from these fields had dramatic necrosis of the root system (Table 3). Generally, the majority of brace root lesions sampled contained *Fusarium* species. Stalks of some plants also appeared to have stalk rot and *Fusarium* species were isolated from these lesions. The predominate *Fusarium* species isolated from root lesions were *F. oxysporum* and *F. solani* (Table 4). *Pythium* species were rarely isolated from symptomatic roots (data not shown).

Hard pan formation in firing fields. Four fields were sampled with a hand-held penetrometer and the depth obtained was 2, 4-10, 10-18, and 2-6 inches for fields O, P, Q, and R, respectively.

In conclusion, based on our first field season of data, not fully analyzed at the time this report was due:

1. Root systems of sweet corn plants grown in "new" soil appear to have fewer lesions at silking. Most of the lesions found at silking on plants growing on "old" soil have *Fusarium* species associated with them, rarely were *Pythium* species isolated.
2. Root systems of plants exhibiting "firing" exhibited tremendous necrosis and usually a smaller root system overall. *Fusarium* species were associated with root lesions. We also observed stalk rot and found *Fusarium* species associated with stalk rot.
3. Two fungal species were predominate in all isolations: *F. oxysporum* and *F. solani.*

Table 1. Lesions found on sweet corn plants grown on "new" ground and "old" problematic ground.

Field	VG or CC	No. plants with lesions	Total no. lesions (with or without *Fusarium*)	Sum of *Fusarium* lesions	*Fusarium* lesions on primary root	*Fusarium* lesions on subcrown internode	*Fusarium* lesions on brace roots	*Fusarium* lesions on stalk
Three-four leaf stage								
1	Old	3	3	3	2	0	1	0
2	Old	1	1	0	0	0	0	0
3	Old	2	2	2	1	1	0	0
4	Old	0	0	0	0	0	0	0
1	New	1	1	0	0	0	0	0
2	New	1	2	2	2	0	0	0
3	New	0	0	0	0	0	0	0
4	New	2	2	2	0	2	0	0
Eight-ten leaf stage								
1	Old	5	8	7	4	1	2	0
2	Old	26	34	29	4	21	4	0
3	Old	7	7	7	4	3	0	0
4	Old	5	5	5	3	2	0	0
1	New	14	20	12	5	4	3	0
2	New	12	14	14	2	6	6	0
3	New	20	21	20	5	15	0	0
4	New	4	4	4	1	3	0	0
At silking								
1	Old	30	123	78	14	11	53	0
2	Old	30	75	62	25	24	13	0
3	Old	30	95	74	24	16	34	0
4	Old	30	118	33	12	5	15	1
1	New	13	18	18	8	2	8	0
2	New	16	19	15	3	8	4	0
3	New	20	37	25	11	5	9	0
4	New	19	30	19	9	7	3	0

Table 2. *Fusarium* species isolated from lesions on sweet corn grown on "new" ground (N's) and "old" problematic ground (O's).

	3-4 leaf				8-10 leaf				silking				Totals
	N1	**N2**	**N3**	**N4**	**N1**	**N2**	**N3**	**N4**	**N1**	**N2**	**N3**	**N4**	
F. avenaceum	0	0	0	0	0	0	0	0	0	1	0	0	1
F. culmorum	1	0	0	0	0	0	0	0	0	0	0	0	1
F. equiseti	0	0	0	0	0	0	0	0	1	0	0	0	1
F. moniliforme	0	0	0	0	0	0	0	0	0	0	1	0	1
F. oxysporum	0	0	0	0	0	7	2	2	47	47	54	17	176
F. oxysporum 'r'	1	0	1	0	5	13	3	0	6	6	6	11	52
F. proliferatum	0	0	0	0	0	0	2	0	3	0	15	2	22
F. sambucinum	0	0	0	0	0	0	0	0	0	0	0	0	0
F. solani	2	0	1	0	1	13	1	4	30	15	14	4	85
F. sporotrichioides	1	0	0	0	0	0	0	0	1	0	0	0	2

	3-4 leaf				8-10 leaf				silking				Totals
	O1	**O2**	**O3**	**O4**	**O1**	**O2**	**O3**	**O4**	**O1**	**O2**	**O3**	**O4**	
F. avenaceum	0	0	0	0	0	0	0	0	0	0	0	1	1
F. culmorum	0	0	0	0	0	0	1	0	0	0	0	0	1
F. equiseti	0	0	0	0	0	0	0	0	0	0	0	0	0
F. moniliforme	0	0	0	0	0	0	0	0	0	0	0	0	0
F. oxysporum	0	2	0	1	3	7	8	1	14	5	14	14	69
F. oxysporum 'r'	0	0	0	0	7	4	2	0	0	1	2	2	18
F. proliferatum	0	0	0	0	0	0	9	0	1	1	6	1	18
F. sambucinum	0	0	0	0	0	0	0	0	0	0	0	0	0
F. solani	0	0	0	1	1	2	9	1	5	8	5	3	35
F. sporotrichioides	0	0	0	0	0	0	0	0	0	1	0	0	1

Figure 1. Average number of *Fusarium* propagules isolated from rhizosphere soil samples.

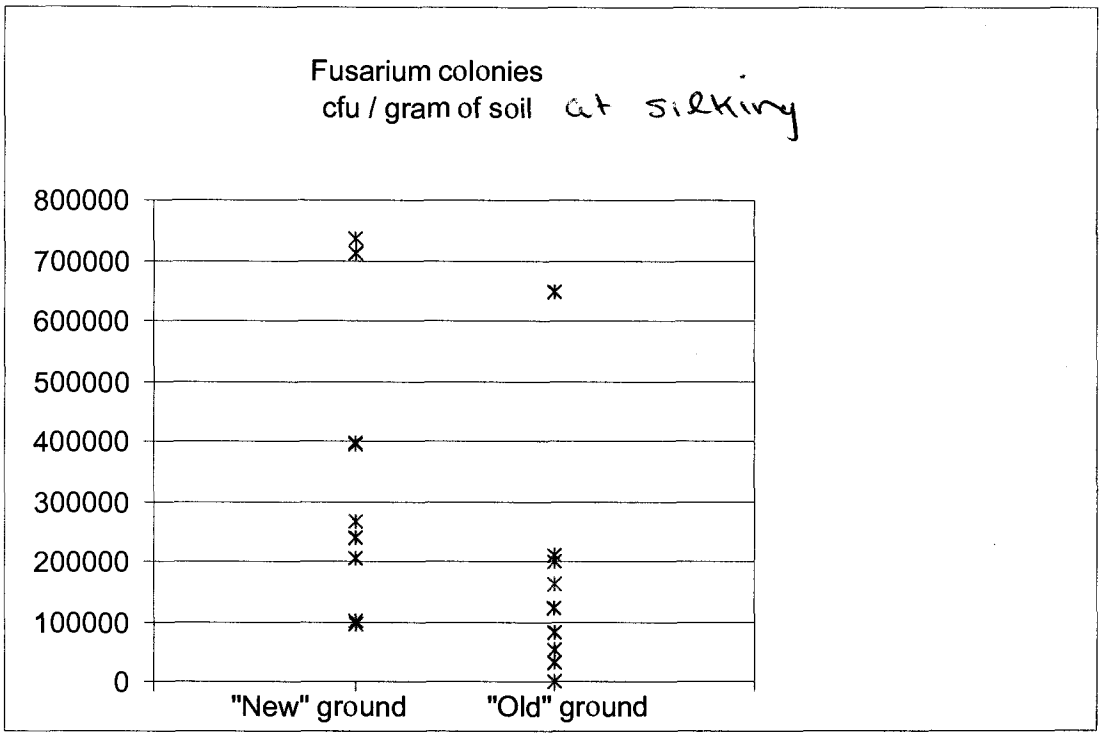


Figure 2. Average number of *Streptomyces* propagules isolated from rhizosphere soil samples.

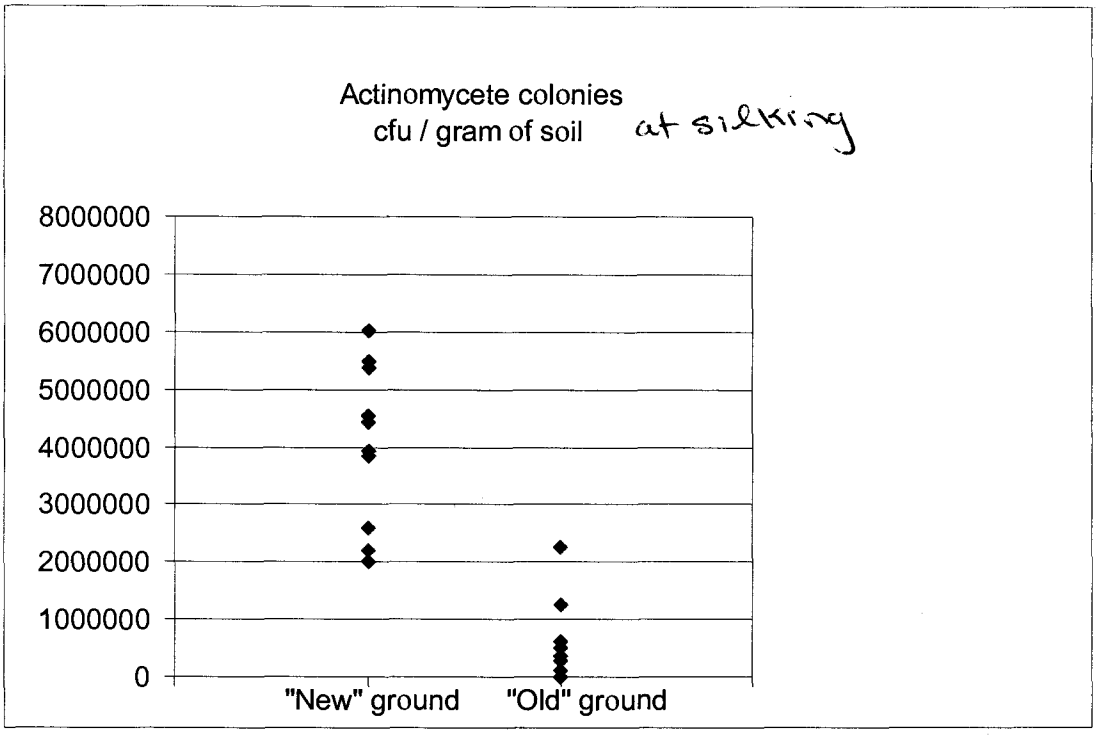
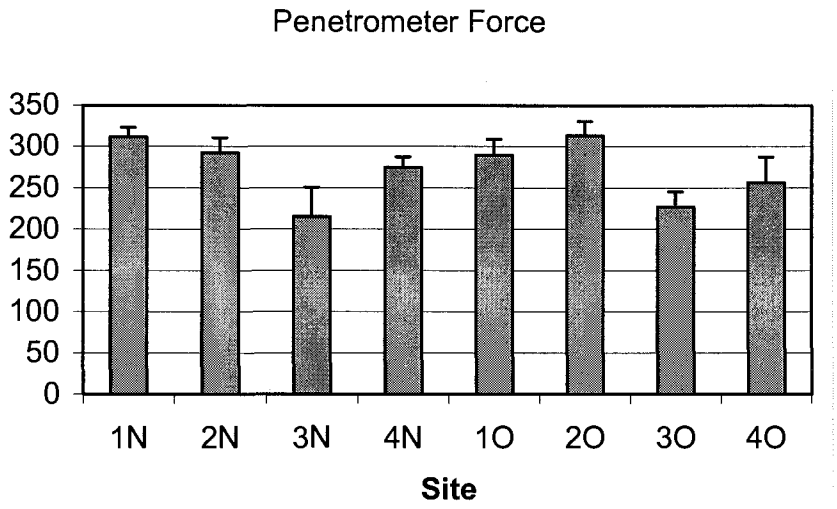


Figure 3. Average force applied and depth reached with a hand-held penetrometer.



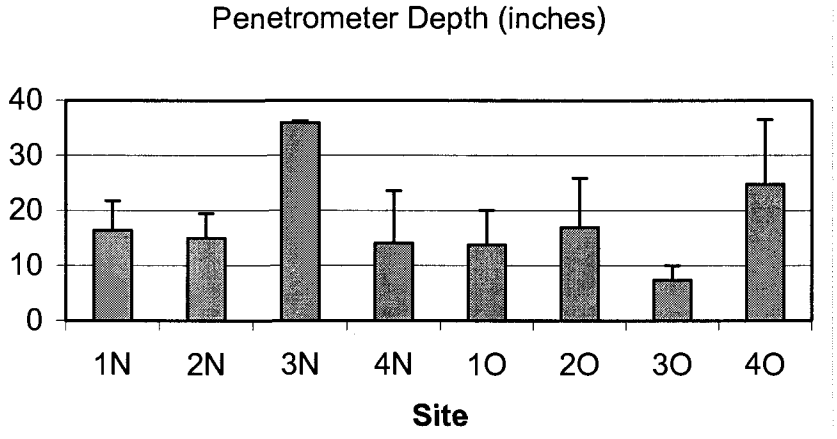


Table 3. Lesions found on sweet corn plants exhibiting "firing"

Field	No. plants sampled	No. Plants with lesions	% roots necrotic	*Fusarium* lesions on brace roots (3 sampled per plant)	*Fusarium* lesions on stalk
L	30	25	-	13	1
M	6	6	>60	9	5
N	6	6	>60	5	0
O	5	5	>35	9	4
P	5	5	>25	14	0
Q	5	5	>50	13	0
R	5	5	>55	14	1

Table 4. *Fusarium* species isolated from lesions on sweet corn plants exhibiting "firing".

	Fields sampled						
Fusarium sp.	**L**	**M**	**N**	**O**	**P**	**Q**	**R**
F. avenaceum	0	1	0	0	0	0	1
F. culmorum	4	0	0	1	0	1	0
F. equiseti	1	1	0	2	0	2	1
F. moniliforme	0	0	0	0	3	1	0
F. oxysporum	8	9	5	3	9	2	7
F. oxysporum 'r'	6	1	0	2	4	5	8
F. proliferatum	0	1	0	2	0	0	0
F. sambucinum	0	1	0	0	1	1	0
F. solani	9	2	1	3	5	3	1
F. sporotrichioides	0	3	0	0	0	0	0