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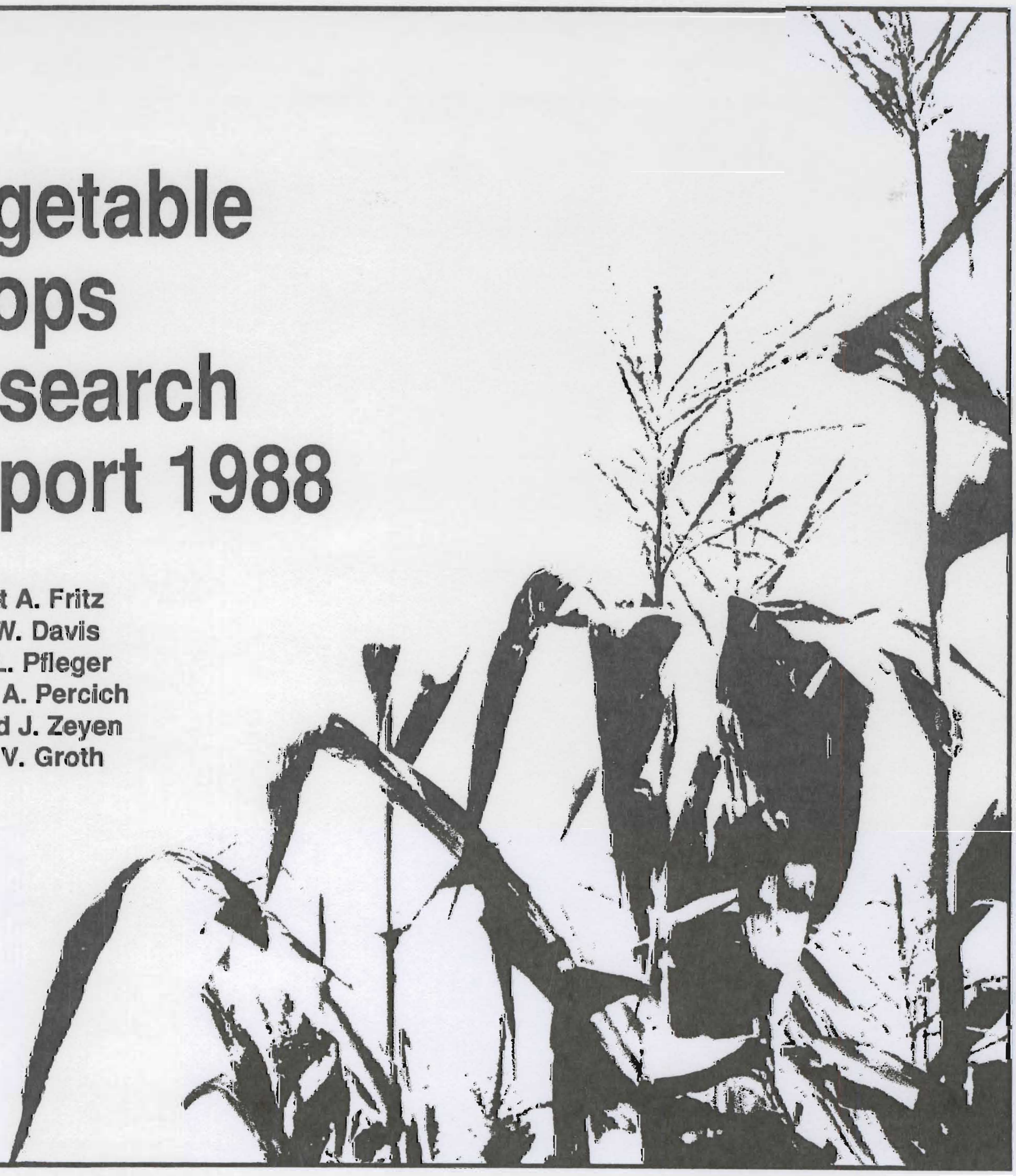

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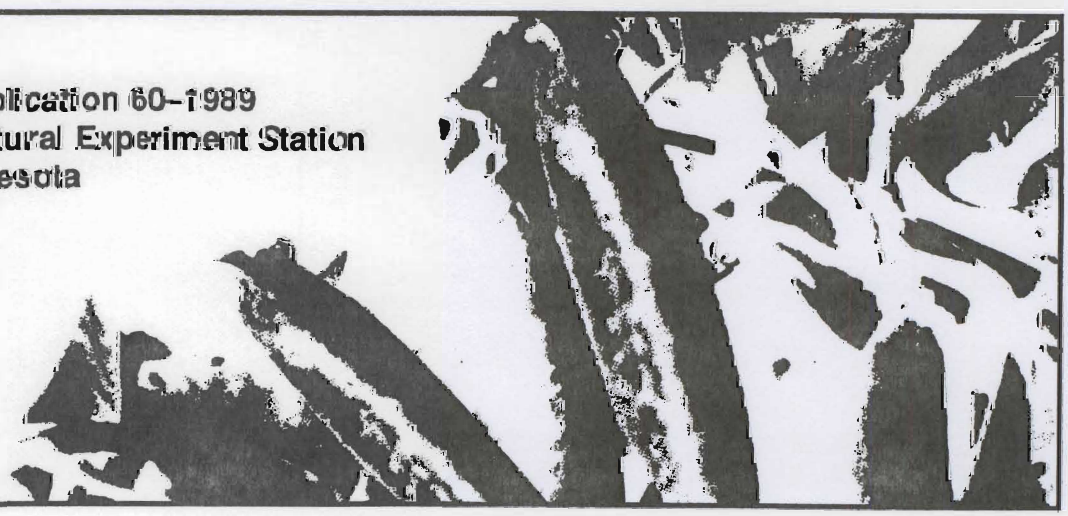

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DISCLAIMERS

Most of the research reported in this publication is preliminary. The results and conclusions should be interpreted with caution and should not be used in publications unless arrangements are made with the individual report authors.

CONTENTS

THE GERMINATION OF APHANOMYCES EUTEICHES OOSPORES IN THE ROOT ZONES OF VARIOUS PLANTS

Department of Plant Pathology, University of Minnesota, Saint Paul Minnesota

James A. Percich

ABSTRACT

Aphanomyces euteiches oospores on nucleopore membrane filters became activated (reduced cell wall thickness and granular cell contents) and then germinated in the presence of pea roots and soil. Membranes containing 1 X 10^3 oospores were placed on a smooth soil surface, overlaid with roots and nylon mesh, and covered with soil. After various periods of incubation at 24 C, the membranes were removed, placed on a glass slide coated with a thin film of melted water agar at 55 C. Upon cooling, the membranes were removed, and the adhering oospores were stained and observed. Oospore activation on membranes in contact with alfalfa, corn, oat, and wheat was 81, 76, 50, and 73%, respectively; but mean germination was only 9%. Roots of various plants were dipped into melted water agar containing 1 X 10^4 oospores/ml, after the agar solidified, the plants were placed in soil and incubated at 25 C. Oospore germination on agar-coated pea roots in sterile and non-sterile soil was 63 and 50 %, respectively after 5 days. Whereas, germination on membranes in direct contact with pea roots was 63 % in sterile and 42 % nontreated soils after 5 days.

INTRODUCTION

Common root rot of pea, caused by Aphanomyces euteiches alone or in combination with other pathogens, such as Pythium ultimum, is one of the most destructive diseases of pea in the midwest, where overall early losses have been estimated to be at least 10 percent. The pathogen has become a major impediment to the improvement of pea yields in the midwest for a number of decades, rendering fields unfit for pea production after as few as six consecutive seasons. Such infested fields tend to remain high risk for 15 years of more. The disease results in progressive cortical rot of the roots and of the below ground stem. Although the vascular system continues to function, hot dry weather which typically occurs at some point during the pod fill accelerates maturity, narrowing the maturity peak and decreasing yields. Despite repeated attempts to control root rot, with host resistance, inorganic and organic soil amendments, and/or fungicides this disease continues to be an important production problem for Minnesota and Wisconsin the region. Currently, the only cultural control now practiced that may be effective is allowing a severe extension of the allowable time between pea crops in a cropping sequence or rotation.

The purpose of this paper is present preliminary studies of A. euteiches oospore "activation" (pre-germination) and germination in the root zones of various crops. Also, to develop a technique to help facilitate biological and ecological studies of oospores in soil.

METHODS AND MATERIALS

Culture maintenance and oospore production. Aphanomyces euteiches was isolated from infected pea seedlings, maintained on potato dextrose agar (PDA), and stored at 4 C. A liquid culture medium consisting of 150 ml an autoclaved minimal salts solution and 15 non-fungicide seeds of sweet corn was inoculated with a mycelial plug of A. euteiches and incubated for 60 days at 24 C. The resulting oospores were removed from the mycelia by sonication, added to sterile glass distilled water, adjusted to the desired concentration, and stored at 4 C until needed.

Nucleopore membrane transfer technique. Non-fungicide treated pea seed ('Little Marble') were germinated in moist chambers with a 18 hr light/dark cycle at 24 C. Four day old seedlings were removed from the incubator, rinsed in sterile distilled water and placed on petri dish bottom containing a smooth soil, either sterile or nontreated (non-autoclaved), surface (Figure 1). The roots were pressed to the soil surface. Nucleopore membranes containing 1×10^3 oospores were applied directly onto the root(s) surface. A fine nylon mesh was applied over the roots and membranes, and then covered with enough soil to completely fill the petri dish bottom. The dish cover was applied to the bottom in such a way to allow the aligning of cut notched areas on the sides of both to facilitate the stem and leaves. The petri dish sections were held together by a rubber binder, and then placed in saturated sterile sand with the stem and leaves in an upright position (Figure 1). The plants were incubated for either 3, 4, 5, or 6 days with an 18 hr light/dark period at 24 C. The dishes were taken apart, membranes lifted from the root surface and placed (side containing oospores) on the surface of 2% water agar (WA) - coated glass slides at 55 C. The membrane were then carefully pealed from the solidified WA and observed with a microscope.

Also, other plant species (alfalfa, corn, oats and wheat), oospores on nucelopore membranes alone (in soil, on WA and floated on a water-based soil extract), or pea roots dipped in a WA suspension containing 1×10^4 oospores/ml at 55 C were studied as previously outlined.

All treatments and experiments were replicated five- and two-times, respectively.

RESULTS

Oospore germination in soil, soil extract and on pea roots. The germination of Aphanomyces euteiches was evaluated in soil, soil extract and on pea roots (Table 1). Oospore germination in untreated soil did not exceed 1% after 6 days incubation. Whereas, percent oospore germination in sterile soil was 5 and 12% respectively, after 1 and 6 days. Germination in sterile and nontreated soil extract was only 6 and 2%, respectively after 6 days (Table 1). However, percent oospore germination in the presence of pea roots in both sterile and nontreated soil was higher at all incubation periods when compared with the other treatments. Oospore germination in nontreated soil between day 1 and 6 increased from 10 to 48%, respectively. While oospore germination in sterile soil near pea roots was 30% after only 24 hr and increased to 63% after 6 days (Table 1).

Oospore activation and germination on agar-coated slides and pea roots. Oospores on agar-coated slides in either sterile or untreated soil did not germinate after 3 days incubation (Table 2). Activation and germination, 3 and 2 % respectively, occurred after 5 days in sterile soil only. Activation was observed on pea roots were after 3 days and decreased with increasing oospore germination. After 6 days, activation and germination were 19 and 5%, and 50 and 63 % respectively, in untreated and sterile soil (Table 2).

Oospore germination and activation in the rhizospheres of various plants. Aphanomyces euteiches oospores germinated on nucleopore membranes in the rhizospheres of alfalfa, corn, oats, pea, and wheat (Table 3). Germination on the roots corn or wheat after 6 days was only 7 and 8 %, respectively. However, on oat roots germination was higher than either corn or wheat, regardless of incubation period. Oospore germination on pea roots was 24, 49 and 60 % after 3, 4 and 5 days, respectively (Table 3).

Oospore activation increased with the time of incubation near the roots of all the test plants (Table 4). The average percent activation near alfalfa, corn or wheat roots was 77 % after 5 days. Even though oospore activation near oat roots was 53 % after only 24 hr it remained relatively constant with increasing periods of incubation. However, oospores near pea roots were activated but then germinated. Thus, the percent activation decreased with increasing periods of incubation (Table 4).

CONCLUSIONS

The oospores of Aphanomyces euteiches near the roots of pea after only 24 hrs become enlarged, show a reduction in cell wall thickness and granulation of the cytoplasm. This "activation" or pre-germination behavior was also observed near the roots of such "non-hosts" as alfalfa, corn, oats, and wheat after 72 hrs of incubation. Nevertheless subsequent oospore germination near the roots of these "non-hosts" was still only 30 % or less than on pea; the planting of alfalfa or oats in soils infested with A. euteiches may result in some potential reduction of total oospore numbers. However, it should be clearly stated that the observed results are preliminary and the controlled experimental methods used may not reflect actual field conditions. Nevertheless, the use of the nucleopore membrane transfer technique may be quite useful in studying such effects of as soil compaction, tillage and plant residue incorporation, pea resistant germplasm and/or other physical and chemical factors on the ecology of A. euteiches oospores.

The nucleopore membrane technique coupled with a modified Most Probable Number (MPN) method, that our laboratory is currently developing, may become an accurate and efficient means of determining the infective A. euteiches oospore population densities in typical pea growing soils of Minnesota and the region. It is also hoped that the use of these techniques along with an interdisciplinary investigation of common root rot of pea, may serve as a model for the ecological studies of other soil-borne fungal pathogens.

Figure 1. Plant/nucleopore membrane transfer technique to evaluate the behavior of Aphanomyces euteiches oospores in soil.

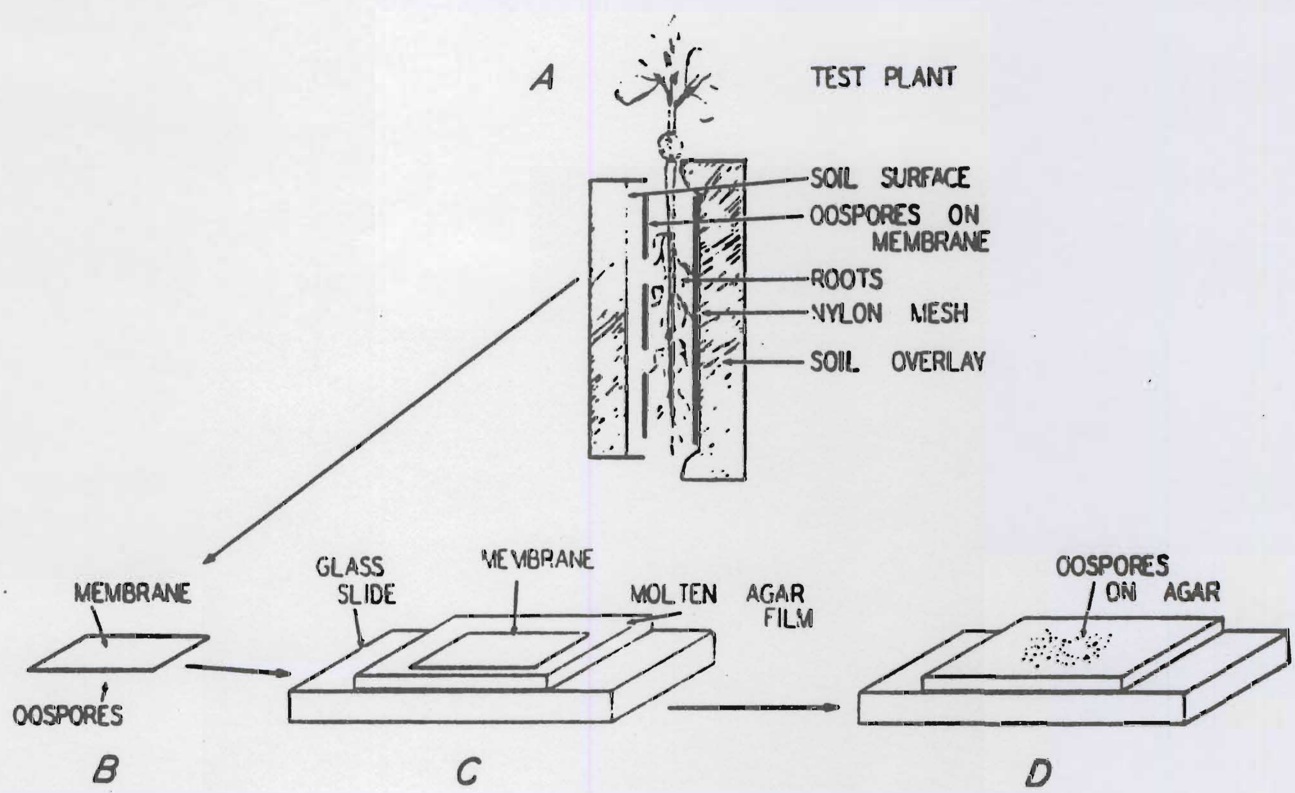

TABLE 1. THE EFFECT OF STERILE AND UNTREATED SOIL, SOIL EXTRACT AND PEA ROOTS ON THE GERMINATION OF APHANOMYCES EUTEICHES ON NUCLEOPORE MEMBRANES.

DAYS	SOIL		SOIL EXTRACT		SOIL & PEA ROOTS	
	STERILE	UNTREAT.	STERILE	UNTREAT.	STERILE	UNTREAT.
1	5[X/]	0	3	0	30	10
4	11	1	8	1	50	32
5	12	2	6	3	58	40
6	12	1	6	2	63	42

X/ AVERAGE PERCENT GERMINATION OF 300 OOSPORES

TABLE 2. THE ACTIVATION AND GERMINATION OF APHANOMYCES EUTEICHES OOSPORES ON WATER AGAR COATED GLASS SLIDES AND PEA ROOT SURFACES IN CONTACT WITH STERILE AND UNTREATED SOIL.

DAYS	DEVELOPMENT STAGE	GLASS SLIDES		PEA ROOTS	
		UNTREAT. SOIL	STERILE SOIL	UNTREAT. SOIL	STERILE SOIL
3	ACTIVATED	0[X/]	0	30	20
	GERMINATED	0	0	22	30
4	ACTIVATED	0	0	27	13
	GERMINATED	0	0	41	55
5	ACTIVATED	0	3	19	5
	GERMINATED	0	2	50	63

X/ AVERAGE PERCENT GERMINATION OF 300 OOSPORES

TABLE 3. <u>APHANOMYCES</u> <u>EUTEICHES</u> OOSPORE GERMINATION ON NUCLEOPORE MEMBRANES IN THE RHIZOPHERE OF VARIOUS PLANTS.

DAYS	PERCENT GERMINATION				
	ALFALFA	CORN	OAT	PEA	WHEAT
3	20[X/]	5	12	24	6
4	22	7	20	49	6
5	20	7	27	60	8

X/ AVERAGE PERCENT GERMINATION OF 300 OOSPORES

TABLE 4. <u>APHANOMYCES</u> <u>EUTEICHES</u> OOSPORE ACTIVATION ON NUCLEOPORE MEMBRANES IN THE RHIZOSPHERES OF VARIOUS PLANTS.

DAYS	PERCENT ACTIVATION				
	ALFALFA	CORN	OAT	WHEAT	PEA
2	20[X/]	33	53	29	46
3	74	52	66	65	63
4	74	73	58	70	27
5	81	76	50	73	12

X/ AVERAGE PERCENT ACTIVATION OF 300 OOSPORES

The Pea Disease Nursery at Waseca, MN

Dave Davis, Frank Pfleger and Vince Fritz

Departments of Horticultural Science and Plant Pathology

Evaluations in 1988

Both replicated (46 entries) and observational (39 entries) trials were evaluated for reaction to common root rot (*Aphanomyces euteiches*). In the replicated trial three replications (A, B, C) were placed in the disease nursery and 3 (D, E, F) were placed on a clean site about 50 feet away. Results from the diseased site are summarized in the table below. Entries were scored on a 0 to 5 scale for disease, based on appearance of the above ground plant symptoms, on June 15 and on July 2. The points on the scale are defined at the bottom of the table.

Table 1. Pea Root Rot Evaluations, University of Minnesota, Southern Experiment Station
Waseca, 1988

Four-Row Replicated Entries

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
1	87 MF 1	1.5	1.5	1.0	2	1	1.5
2	87 MF 2	1.0	1.0	1.0	2.5	1.5	1
3	87 MF 3	1.0	1.0	1.0	1.5	2.0	2.0
4	87 MF 4	1.5	2.5	1.5	3	3	2.5
5	87 MF 5	1.5	3.0	2.5	3	4	3
6	87 MF 6	1.5	1.5	2.0	1.5	1.5	1.5

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
7	87 MF 7	1.0	1.5	2.0	2	1.5	2
8	87 MF 10	1.5	2.0	2.5	1.5	2.5	2.5
9	87 MF 12	1.5	2.0	1.5	2.5	2	3
10	87 MF 15	1.0	1.5	2.0	1.5	2	2
11	87 MF 19	2.0	2.0	2.0	3	3.5	2.5
12	87 MF 21	1.5	2.0	4.5	2.5	3.5	3
13	87 MF 24	1.0	2.0	3.0	2	3	3.5
14	87 MF 25	2.5	1.5	2.0	2	2	2.5
15	87 MF 51	2.0	2.5	2.0	3	3	3
16	87 MF 57	1.0	1.0	1.5	1.5	1.5	2
17	87 MF 77	2.5	2.0	2.5	3	2.5	3
18	87 MF 78	1.0	2.5	2.5	3.5	2	2.5
19	87 MF 79	1.5	2.0	2.5	4	3	3
20	87 MF 81	1.0	1.0	1.5	2.5	2.5	2.5
21	87 MF 85	1.0	1.5	1.5	1.5	1.5	1.5
22	87 MF 88	3.0	2.5	2.0	2.5	3	2
23	87 MF 91	3.0	1.5	1.5	1.5	2	2
24	87 MF 93	2.0	2.5	2.0	1.5	2	1.5
25	87 MF 96	1.0	3.0	1.5	1	2	1.5

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
26	87 MF 98	2.0	2.5	2.5	2	1.5	1.5
27	87 MF 102	3.5	4.5	3.5			
28	86 MF 16	1.5	2.0	2.0	1.5	2.5	2
29	USDA 792022	1.5	2.0	1.5	1.5	1.5	1.5
30	A 1	2.5	1.5	2.0	3.5	1.5	2
31	A 2	2.5	4.0	3.5	2.5	4.0	3.5
32	A 3	3.0	3.0	2.0	4	4.5	3
33	A 4	3.0	3.0	2.0	4	4	4
34	A 5	3.0	2.0	3.0	3.5	2.5	3.5
35	A 6	4.0	2.0	2.0	4.5	3	4
36	A 7	1.5	2.0	1.5	1.5	3	3.5
37	A 8	2.5	3.0	1.5	4.5	4	3
38	A 9	5.0	4.5	2.5	5	5	4
39	A 10	4.0	2.0	1.5	2.5	1.5	1.5
40	A 11	2.5	3.0	2.0	2.5	3	3
41	Minn. 108	2.0	2.0	1.5	2	2.5	3
42	B 1	5.0	5.0		5	5	--
43	B 2	4.5	3.5	2.0	4.5	4.5	2.5
44	C 1	2.0	1.5	1.5	2.5	1.5	1

Field Number	Variety or Line Seed Source	6/15/88 A	6/15/88 B	6/15/88 C	7/2/88 A	7/2/88 B	7/2/88 C
45	C 2	1.0	1.0		1.5	1.5	--
46	8221	3.0	2.5	33.0	3	3.5	3
	Single-Row Entries						
61	87 MF 76	1.5	2.0	1.5*	2.5	23	
62	87 MF 92	1.5	2.0	1.5*	3	3	1.5
63	86 MF 86	3.0	2.5	2.0*	4.5	3	
64	86 MF 93	3.0	1.5*	1.5*	3	2.5	3
65	87 MF 29	2.0	1.0*	1.0*	3	2	2.5
66	87 MF 30	2.0	2.0*		5	3	4
67	97 MF 75	2.0	1.0*	1.0*	2.5	2	1.5
68	86 MF 72 sm	1.5	1.0*		3.5	2	
69	86 MF 72 wr	1.5	1.5*		2	3	
70	D 1	4.0	1.5*		5	3	
71	D 2	3.0	1.5*			2.5	
72	D 3	2.5	2.5*			2.5	
73	D 4	3.0	1.5			3	
74	USDA 87-29	1.0			2.5		
75	USDA 87-31	2.0			3		
76	USDA 87-48	2.0					

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
77	USDA 87-196	1.5			1.5		
78	USDA 87-772	2.0			3		
79	USDA 87-2001	1.0			1.5		
80	USDA 87-2009	1.5			1		
81	USDA 87-2276	2.0			3		
82	USDA 87-2380	2.0			2		
83	USDA 87-2384	2.0			2.5		
84	USDA 87-2388	2.0			3.5		
85	USDA 87-2389	1.5			1		
86	USDA 87-2404	2.0			3		
87	USDA 87-2432	2.0			3		
88	USDA 87-2471	1.5			1.5		
89	USDA 87-6021	1.5			2.5		
90	PI 180693	1.0*			1		
91	PI 176721	2.0			1.5		
92	USDA 79-2022	1.0			1.5		
93	Minn. 108	1.5			2		
106	Sunfire	1.5			2		
107	M 163	1.5*			5		

Field Number	Variety or Line Seed Source	6/15/88			7/2/88		
		A	B	C	A	B	C
108	Early Columbia	1.0*			1.5		
109	ES 41	1.5*			4		
110	M 163	4.5			5		
111	8615	1.5			3		
112	Alsweet II	2.5			5		

* border effect (east 3 rows of field--most likely less root rot)

Root Rot Scale:
0 = no damage
1 = 1-25% damage (1-25% of plants dead or showing symptoms)
2 = 26-50%" etc. 4 = 76-100% damage (etc.)
3 = 51-75%" etc. 5 = all dead

History of the Minnesota Root Rot Nursery

A root rot field nursery has been used at the University of Minnesota since the 1940s. The original nursery established on the campus at St. Paul was abandoned when the present nursery was established near Waseca, at the Southern Experiment Station, in 1976.

During the several decades over which it was used, large numbers of commercial pea varieties, breeding lines from various programs, and foreign introductions were screened in the St. Paul nursery by Dr. Tom King and his graduate students. Gradually, a form of recurrent selection took place as the more resistant or tolerant entries were crossed with one another and the subsequent progenies were evaluated in the nursery and the cycle repeated by new crosses of the best with the best. A number of breeding lines were provided to industry and public pea breeders in the 1950s and 1960s. Most of these were relatively viny, "wild" types, although some were white flowered. The most recent releases tracing back to the nursery at St. Paul were Minnesota 108 (in 1976) and Minnesota 494 A11 (in 1981). Both had been further selected via greenhouse and laboratory tests at St. Paul.

The nursery at Waseca, in the pea growing area, was established in 1976 on a clean soil site fairly typical of that used for peas. *Aphanomyces euteiches* inoculum produced in the laboratory from strains isolated from diseased pea fields in Minnesota and Wisconsin was spread on and disked into the soil at the new site. Thereafter, at least two crops each year of heavily sown peas were grown and plowed down while still lush and green. This continued for several years until a high potential for disease was established. Since that time, this nursery, approximately 150 feet by 160 feet, has been used each year for the screening of pea varieties and breeding material. In some years when the disease severity was extremely high we planted an oats or wheat cover crop on one-half of the nursery the following year.

Until 1988, test entries were planted in single row, 30-inch-row plots replicated 3 to 4 times. Beginning in 1988, the replicated test entries were planted in 4-row beds (not raised) with a 20-inch row spacing. Row length generally has been 18 to 20 feet each year.

Planting generally has been scheduled for the period May 5 to 15, intentionally late as the environmental conditions generally are more favorable for disease development, especially with the warmer weather associated with a later harvest date. Following stand establishment, we have irrigated heavily, keeping the soil wet for a week or so, to encourage root rot infection and disease development. Weed control has been by Randox and Caparol since these do not seem to be active in suppressing root rot and we wanted to get a true response picture from the entries. Those herbicides were supplemented by hand weeding. However, we have had serious weed problems and intend to switch to other herbicides for the 1989 season.

Pea material tested in the nursery at Waseca primarily has been Minnesota breeding material, with a limited number of entries each year from the USDA, Canners Seed Corporation, Green Giant/Pillsbury and Rogers Brothers, plus 2 or 3 from other firms.

Meanwhile, at St. Paul, since the early 1980s, pea disease resistance breeding has been decreased considerably due to shortage of personnel and funding, and also as more effort was diverted to sweet corn research. The main pea breeding effort recently has been the Waseca nursery, a modest undertaking.

Annual Weed Control in Canning Peas

Leonard B. Hertz and V. Fritz
Southern Experiment Station
Waseca, MN 1988

Hertz, Leonard B. and V. Fritz. This study was designed to evaluate several herbicides and herbicide combinations for control of annual weeds in canning peas. Pea seed, 'Canners 9901', was planted May 16, 1988 into a clay loam soil, pH 6.4 and 6.5% organic matter at the Southern Experiment Station, Waseca, MN. The plots were 7 by 30 ft., arranged in a randomized complete block, each with four replications. All herbicides were applied with a bicycle mounted CO_2 pressure sprayer. A visual rating of weed control was made on June 30. Weed populations were moderate and consisted of foxtail spp. (40%), redroot pigweed (55%), and velvetleaf (5%). Application dates, sprayer setting, environmental conditions, and plant sizes are listed below:

Date	May 16	May 16	June 7	June 13
Treatment	PPI	PRE	EPO	PO
Sprayer				
gpa	20	20	20	20
psi	30	30	30	30
Temperature (F)				
air	63	65	72	85
Wind (mph)	5-10 NW	5-10 NW	3-5 SW	15 SW
Sky	cloudy	cloudy	clear	clear
Relative humidity (%)	80	33	24	54
Pea				
leaf no.	--	--	4	7
Redroot pigweed				
leaf no.	--	--	1-3	4-6
Foxtail spp.				
leaf no.	--	--	2-3	3-6

Results of this study are summarized in the accompanying table. Weather conditions were poor for herbicide performance, and also hot, dry weather caused low pea yields and high Tenderometer (TDR) readings. Several herbicides performed well, including Treflan, Command, Pursuit, and Basagran. Basagran and COC plus Cantrol and Basagran plus COC produced excessive crop injury.

Table. Annual weed control in canning peas. (Hertz and Fritz).

Treatment	Rate	Method of appl.[V]	Weed control Grft[W]	Rrpw	Vele	T D R at harvest[X]	Plant stand	Yield
	(lb/A)		- - - -(%) - - -			(%)		(T/A)
Command+	0.5	PPI	95	100	95	137	100	0.65
Treflan	0.5	PPI						
Command+	0.75	PPI	93	100	100	131	98	0.66
Treflan	0.5	PPI						
Command+	0.5	PPI	100	100	93	125	100	0.67
Sonalan	0.5	PPI						
Command+	0.5	PPI	93	100	95	138	93	0.63
Surflan	0.5	PPI						
Command+	0.75	PPI	100	100	100	137	100	0.67
Surflan	0.5	PPI						
Sonalan	1.0	PPI	100	100	85	130	95	0.66
Treflan	0.75	PPI	98	100	85	133	90	0.69
Basagran+28%N[Z]	0.5	EPO	93	100	100	127	100	0.64
+Treflan	0.75	PPI						
Basagran+28%N	0.5	EPO	95	100	100	127	95	0.59
+Treflan	0.75	PPI						
Basagran+Dash[Z]	0.5	EPO	95	100	100	129	95	0.48
+Trefan	0.75	PPI						
Basagran+COC[Z]	0.5	EPO	93	100	100	135	88	0.54
+Treflan	0.75	PPI						
Cinch+	1.5	PRE	100	100	88	128	100	0.68
Treflan+	0.75	PPI						
Assure	0.125	PO						
Pursuit	0.063	EPO	85	100	93	142	100	0.71
Pursuit	0.094	EPO	90	100	98	142	100	0.66
Pursuit+	0.063	PPI	93	100	90	140	100	0.62
Treflan	0.5	PPI						
Pursuit+	0.063	PPI	98	100	90	135	98	0.62
Prowl	0.75	PPI						
Pursuit+	0.063	PRE	80	98	90	128	100	0.61
Dual	2.0	PRE						
Basagran+COC	0.5	EPO	90	100	98	70	93	0.23
+Poast	0.187	EPO						
+Can-trol	0.25	EPO						
Weeded	--	--	100	100	100	134	100	0.56
Untreated	--	--	0	0	0	129	100	0.70
LSD(0.05)	--	--	8.1	1.6	7.4	--	8.5	--

[V]Application: PPI = preplant incorporated; EPO = early postemergence; PO = postemergence
[W]Grft = green foxtail; Rrpw = redroot pigweed; and Vele = velvetleaf
xTDR: Tenderometer
[Z]Additive: 28% nitrogen, 2 qt/A; Dash = BASF adjuvant, 1 qt/A; COC = crop oil concentrate (BASF), 1 qt/A.

Heat Tolerance Studies in Snap Bean

D.W. Davis, P.H. Li, N. Chaisompongpan, K.J. Sauter, and J. Roguske
Department of Horticultural Science

The bean is notoriously sensitive to heat (even at adequate water supply) and shows this sensitivity by dropping blossoms and small pods. This results in reduced yields and split sets. Bean plants have much potential to recover from heat effects and produce a good yield, but our reliance on uniform and constant product flow for processing, and on a mechanized system with a once-over harvest strategy, is incompatible with split sets and harvest delays.

The Horticultural Science Department has been working on heat tolerance in beans since the early 1980s. The purpose of this report is to share with you our approaches and progress.

Concept of Heat Acclimation Potential

One of us (Paul H. Li) has advanced the idea that bean plants (& other crop species as well) have two forms or general ways of reducing heat injury. These are 1) heat tolerance per se, i.e. the immediate reaction or level of tolerance that a bean variety has when exposed to high temperature, and 2) heat acclimation potential. A variety having high heat acclimation potential may have a high or low immediate level tolerance, but, whatever its tolerance starting point, it has the capacity to be acclimated to a higher level of tolerance at the high temperature environment. Thus, it acclimates to a different capacity of heat tolerance during the heat exposure. Our idea is that the two forms of heat tolerance are independent. In breeding heat tolerant beans the researcher may want to select for both, but with emphasis on heat acclimation potential.

Objectives in our Work on Bean Heat Tolerance

Primarily, our work thus far fits under the following three objectives:

1. To develop techniques that are easy to use, fast and reliable so that we are able to distinguish heat tolerant from heat sensitive varieties.

2. To screen bean varieties and breeding lines from various parts of the world to find out which ones may have potential.

3. To learn more about why some beans may be tolerant and others sensitive.

Methods & Techniques Used

Several methods have been examined for usefulness in both screening varieties and breeding lines for heat tolerance and in telling us more about how heat stress affects the performance of the plant and its processes. Major effort has been spent on the following:

1. Loss of Cell Membrane Integrity

   At some level, as temperatures increase, the cell membranes lose their chemical and physical integrity. A symptom of this change is that electrolytes begin to leak out of the cells and into the surrounding environment. If these heat damaged tissues are placed in a liquid solution, such as distilled water, electrolytes will be present in the solution. The amount of electrolytes can be quantified by measuring the electrical charge. The strength of this electrical charge is an indication of the amount of heat damage.

2. Increased Production of Ethylene Gas by Heat Damaged Tissue

   Ethylene is normally produced by plant tissue, especially by ripening fruit, and by plant tissue which is aging. It has a hastening effect on further ripening and aging. For example, a ripening or over-ripe banana placed in a more or less tight container with other, less-ripe fruit such as apples, other bananas, etc. will hasten the ripening process of those fruit.

   Science is not certain as to all the reasons why ethylene is produced by plant tissue. However, in addition to increasing during the normal fruit ripening process and during the normal aging of tissue, we know that it also increases when plant tissue is physically stressed or when it is infected by disease.

   We have found that varieties of bean reliably and repeatably differ in the extent to which their ethylene output increases when the plants are subjected to heat stress. We are attempting to study the degree to which we can use this rate of increase to predict the heat sensitivity of a variety. Thus far it looks promising. One of us, Karl Sauter, conducted an inheritance study following crosses between heat tolerant and heat sensitive varieties and found level of ethylene output to behave as an inherited trait that can be increased or decreased by breeding. The question as to how helpful a decreased ethylene output will be in developing a heat tolerant bean variety has not yet been answered.

3. <u>Impact of Heat Stress on Reducing Photosynthesis</u>
One of us (Nawarat Chaisompongpan) recently completed a study showing that, following heat stress, varieties which have the potential to acclimate (as determined by conductivity) to heat also tend to have a faster photosynthesis recovery rate. When plants are returned to normal temperature conditions the recovery phase begins very soon and much recovery, in terms of rate of photosynthesis, can occur within several hours. Rate of photosynthesis is very sensitive to changes in temperature and such sensitivity may lead us to the development of a variety screening method for use in bean breeding.

4. <u>The production of Heat-Shock Proteins by Heat Stressed Tissue</u>
One of us (Jeff Roguske) is comparing heat tolerant and heat sensitive bean varieties with regard to the impact that heat has on the kinds of proteins synthesized in the plant. In work with various other organisms, scientists have found that in response to heat, organisms produce specific kinds of proteins. These proteins have come to be known as "heat shock proteins". The biological functions of these special proteins that are produced in response to heat is not known.

   Little work has been done to determine whether there are difference among varieties of a crop species in heat shock protein response to heat. This is, however, one of the main areas of interest in the study Jeff is undertaking.

5. <u>Observation of Pod Set and Seed Development</u>
To some extent the use of high temperature field environments may be useful in finding or developing bean varieties able to withstand high temperatures. Our difficulties along this line are two-fold. First, day to day temperatures in our Minnesota summers are so unpredictable that field screening is risky. Secondly, the temperature levels during the day or days preceeding a high stress temperature may tend to either acclimate the plants or make them supersensitive. Hence, it is difficult to use the field. We have conducted limited cooperative studies with Israel, where the regularity of high field temperatures may make field testing more feasible.

We should note also that pod set and seed number and development in greenhouse and growth chamber environments is another characteristic that we have used. These have been used following short term high temperature treatments, and often combined with methods 1 and 2 above.

In conclusion, we want to emphasize that our bean heat research is exploratory and that many years may elapse before we, or someone else using our results, can put it into practice. Meanwhile, we are learning many interesting things about how bean plants react to high temperatures. We will keep you informed of our progress and invite your suggestions and questions. We certainly are aware of the impact that heat has had on snap beans in the Midwest in recent years.

Several Edible Legumes as Potential New Crops
D.W. Davis

Southern pea

A number of early maturing new lines of this southern crop have been developed at Becker for adaptation to our region. They seem to be best adapted to the sandy soils and in normal years would do fairly well on dryland. These lines encompass a wide variety of seed types, including creams, blacks, greens, browns, and reds, as well as brown, red and black calico types. Two have been released as breeding lines, and another may be releasable as a variety.

Through cooperative work with Lincoln University, Missouri, the two breeding lines were included in regional trials in the Southern Region in 1989.

Mung Bean

Three accessions from Taiwan and TexSprout (a new Texas AES variety) were grown in 1989. TexSprout and two of the Taiwan accessions performed well, maturing dry seed by August 20 and producing approximately 1600 lbs of dry seed per acre when grown at 4 to 5 plants per foot in 30-inch rows under irrigation; dryland yield in 1989 was about 40% lower. Under irrigation these mung beans were lush, branched and upright, reaching about 30 inches in height. There was the suggestion that lodging problems might be more serious than with soybean.

Further research should be done with this crop.

Pigeon pea

This crop is known to be well suited to infertile soils in hot, dry subtropical and tropical climates where it normally is grown as a semi-woody, 2 to 3 year perennial, often reaching 6 to 10 feet in height. Where grown in subtropical to tropical climates, it is a crop requiring less care than most other row-crop legumes and, typical of indeterminate seed legumes, reliably provides some yield of forage and seed over a long potential harvest season. In 1989, we grew under both dryland and irrigation, three exceptionally early, compact, determinate mutant types obtained from ICRISAT via the USDA. Under irrigation, yields were about 1300 lbs of dry seed per acre at 4 plants per foot of row in 30-inch rows.

The above three crops all are deep rooted, warm season crops requiring a soil temperature of at least 55 to 60°F for rapid germination. Sandy soils, which warm quickly, seem ideally suited to these crops. More research, utilizing extra-early maturing varieties should be done on these crops in our region. However, based on our past seasons over several decades, there have been seasons in which these crops, except for the new southern pea types, would have not been able to mature. For this reason they may not have the long term potential of the lupine in our region.

Squash Breeding

D.W. Davis

Following several years of evaluation and selection, ten new squash lines were grown in 1988, each in its own small field and isolated to prevent crossing with one another and with other squashes. The objectives in 1988 were 1) to determine how much variability remains in these lines, 2) to evaluate each by cooking test, and 3) to increase seed to permit large scale commercial canning tests. These lines are still somewhat variable in type, rind color and quality. Further individual plant selection following self pollination is planned for 1989, and we will attempt to conduct commercial tests on one or two of the lines.

RUST EPIDEMIOLOGY AND FUNGICIDE EVALUATION SUMMARY

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EPIDEMIOLOGY

Introduction

Common leaf rust has more recently become a major threat to sweet corn production in Minnesota because of its ability to infect the crop very early in the growth of the plant. Severe infestations can significantly reduce yield recovery.

The hypothesis to be tested is that as plant populations are reduced in later plantings, the leaf canopy microclimate (humidity and air temperature) will be modified; and as a result, rust incidence and progression will be inhibited. A computer model will be developed that will have the ability to predict when conditions are favorable for rust incidence and will assist growers in determining when to start and stop the use of fungicides for rust control.

Materials and Methods

Treatments were comprised of four planting dates and four plant populations. Leaf canopy microclimate parameters were monitored and will be correlated with rust incidence/progression and yield recovery. Periodic leaf samples were collected and analyzed for % of leaf area infected with rust (Puccina sorghi).

Variety:	Jubilee
Planting Dates:	May 19, June 2, June 16, June 30
Populations:	17,000, 22,000, 27,000/A
Herbicides:	Lasso (alachlor) and Bladex (cyanizine) at 2.5 and 2.0 lb. a.i./A preemergence
Fertilizer:	Urea applied preplant at 140 lb/A

The experiment was artifically inoculated using spreader rows of stylepak and irrigated regularly in an attempt to establish the disease.

Results

High temperatures experienced during the growing season significantly prevented the establishment of an effective rust epidemic which hampered the evaluation of treatment effects in 1988. This is the third year of the study and it will continue in 1989.

Fungicide control strategies can be made more effective and economical for the grower as well as more environmentally sound by eliminating unnecessary applications and by facilitating the timeliness of applications when they are necessary.

FUNGICIDE EVALUATION SUMMARY

Introduction

Several fungicides were evaluated for rust control in sweet corn. Many of those evaluated were systemic. The proposed advantage over contact fungicides is their residual control qualities after initial application.

The objectives of study were to evaluate several fungicides for rust control potential and to determine if the use of any of these materials had any adverse effects on various yield fractions.

Materials and Methods:

Variety:	Jubilee
Planting Date:	June 30
Plant Density:	24,000/A
Herbicides:	Lasso (alachlor) and Bladex (cyanizine) at 2.5 and 2.0 lb. a.i./A preemergence
Fertilizer:	Urea applied preplant at 140 lb/A

1988 Fungicide Evaluation for Rust Control

Treatment	Rate (lb a.i./A)	Application Interval (days)
1. RH-7592 2F (Rohm/Haas)	.06 + 1 qt. COC/A	10
2. Tilt (Ciba-Geigy)	.11	14
3. Dithane F-45 (Rohm/Haas)	1.60 + 1 pt. B-1956/100 gal.	7
4. Tilt (Ciba-Geigy)	.055	7
5. Bayleton (Mobay)	.25	10
6. Systhane (Rohm/Haas)	.12 + 1 pt. B-1956/100 gal.	10
7. Tilt (Ciba-Geigy)	.11	7
8. Spotless (Ortho)	.10 + 6 oz. X-77/100 gal.	10
9. Manzate (DuPont)	1.2	7
10. Untreated	---	--
11. Bravo (Fermenta)	.52	7

The experimental plot design was a randomized complete block with four replications. At the four leaf stage, each corn plant was inoculated with rust urediospores suspended in oil. The average number of rust pustules/leaf was 4-5 at the time of initial fungicide application. Just prior to harvest, three leaves were sampled from each of five plants in each treatment to determine rust severity levels using a video area meter which contrasts healthy from diseased plant tissue for an objective severity reading. The specific locations of those leaves evaluated were, counting basipetally, the flag, secondary, and opposite/above ear positions. At harvest, various yield fractions were measured with theaid of a mechanical husker and cutter to mimic industry processing procedures:

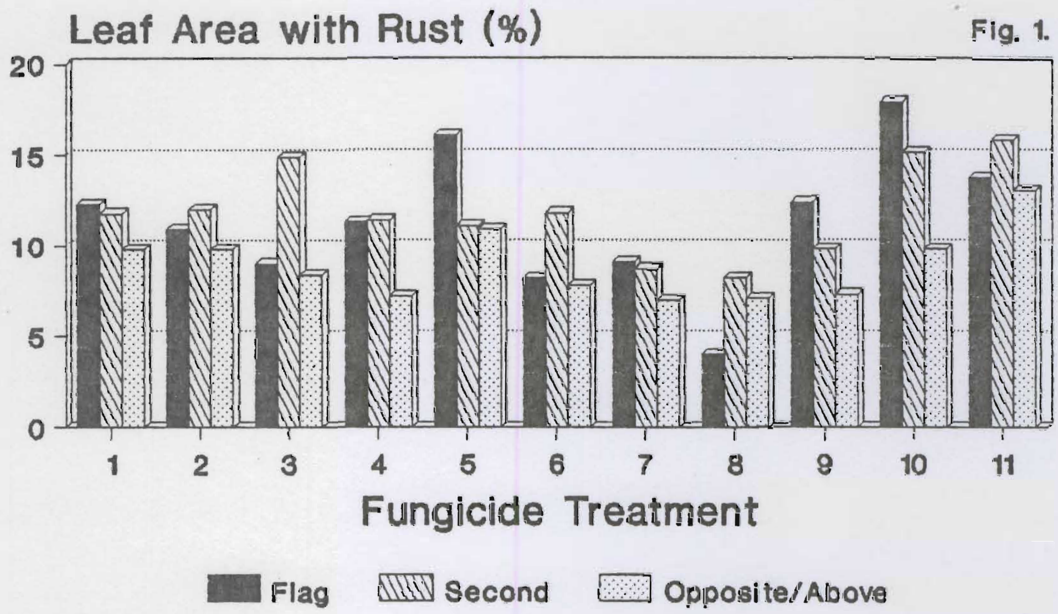
Unhusked weight
Husked weight
Useable ears for freezing
Ear length
Ear diameter
Cut corn recovery

All treatment plots were harvested when kernel moisture reached 72-74%.

Results

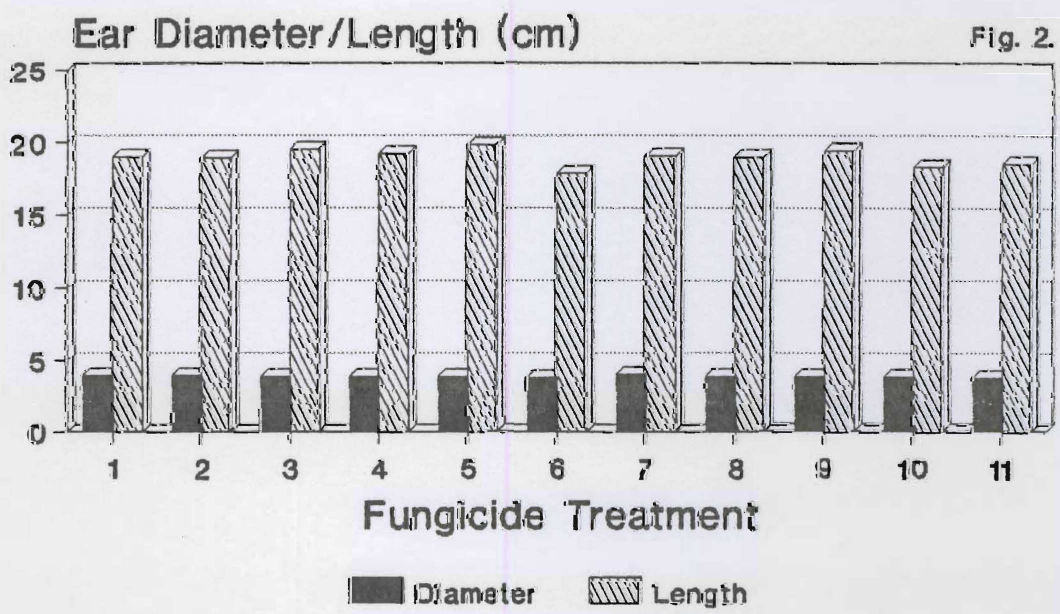
Rust severity in 1988 was very low (fig. 1), probably due more to the high temperatures rather than lack of moisture since the plot was irrigated repeatedly. Both Tilt (.11 lb a.i./A) and Spotless had good rust control compared to the control; however, these differences were not statistically significant. Ear diameter and length were not effected by fungicide treatment or rust severity (fig. 2). Yield fractions (unhusked, husked, cut corn weights) also were not effected (fig. 3). Useable ear production from Tilt and Spotless compared favorably to plots treated with Manzate or Dithane F-45 (fig. 4). RH-7592 and Systhane suppressed useable ear production.

Rust Severity**



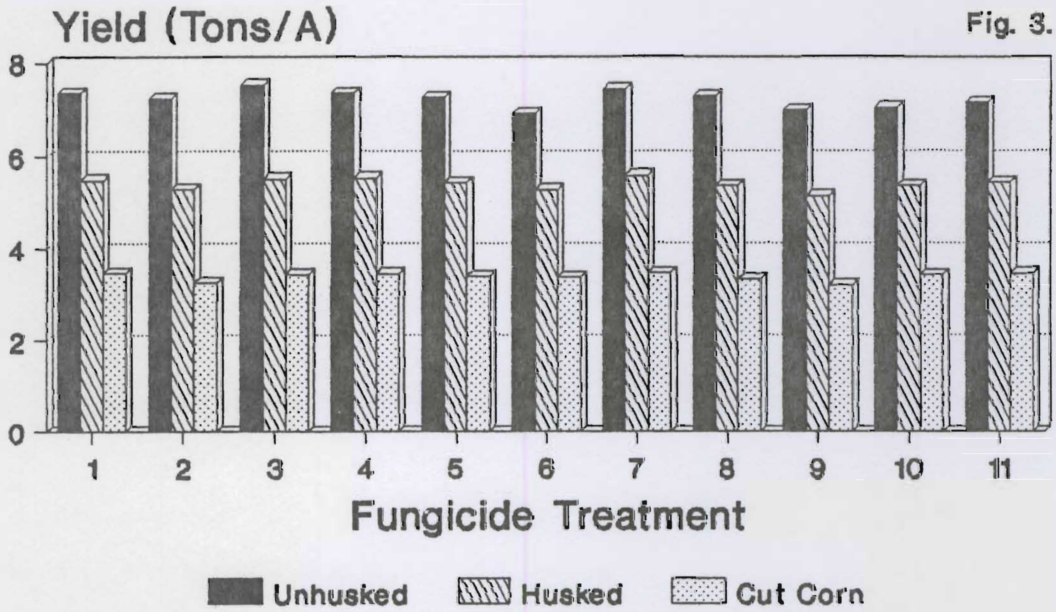
** Not Significant

Ear Diameter/Length**



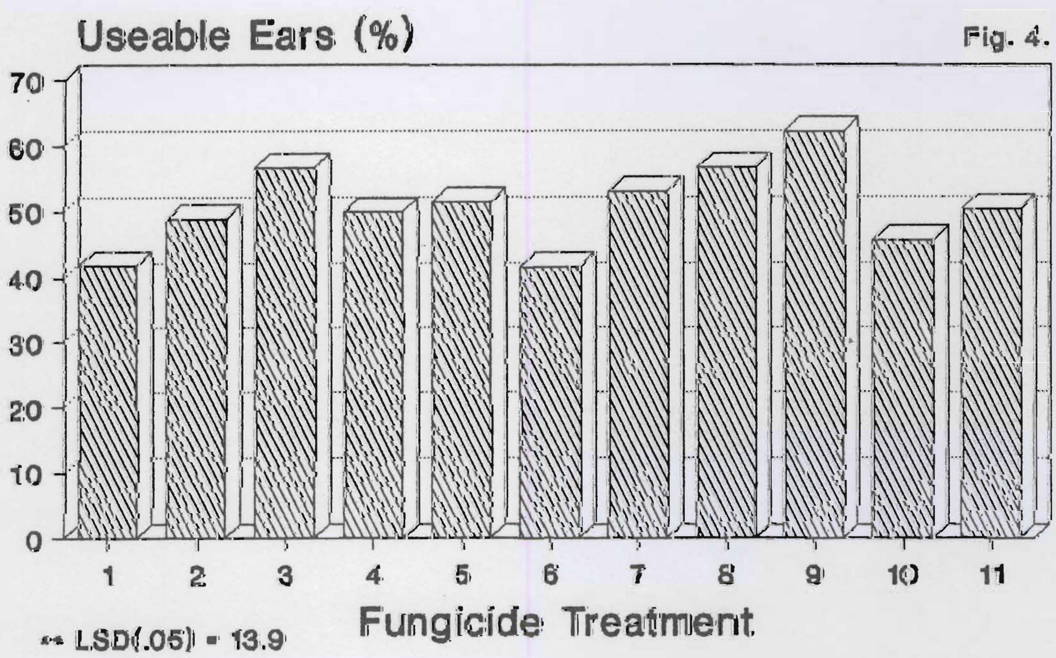
** Not Significant

Yield Fractions**



** Not Significant

% Useable Ears **



** LSD(.05) = 13.9

Screening "Rp" Rust Resistance Genes in Corn for Effectiveness Against Minnesota Rust Populations

J. V. Groth, E. V. Ozmon, and D.W. Davis

Summary of principal accomplishments

For the second year, germplasm containing a number of potentially useful single rust resistance genes was evaluated in a field plot at St. Paul, MN. This plot was inoculated in early June with urediniosprores collected in the same area in 1987. In a moderate-to-heavy rust epidemic, seven lines had some or all plants rust-free. Of these, only Rp1a, Rp1d, Rp3c have been rust free both years. Two other alleles that were rust free in the one year in which they were tested are Rp4? (1987, an unnamed allele) and Rp5 (1988). Virulence on Rp1i is not clearly established, and this gene merits retesting. All other genes had light to heavy infection, indicating that virulence to them already exists in Minnesota.

Progress of work and principal accomplishments

Of 23 genes tested this year, seven of the lines had at least one clean plant. The plot was inoculated, but the late planting date of these lines ensured that some of the rust in the plot was from natural, airborne inoculum. The limited amount of seed available (kindly supplied in 1987 for testing and increase and augmented in 1988 by J. Pataky of the Department of Plant Pathology, University of Illinois) precluded replication; only about 15-20 plants occurred per plot. The Rp genes were placed in three categories: Rust free: 1a, 1d, 1g, 3a, 3b, 3c, and 5; Light rust only: 1b, 1e, 1i, 1k, and 4a; moderate to heavy rust: 1c, 1f, 1h, 1j, 1l, 1m, 1n, 3d, 3e, 3f, and 4b. Several plants of each line were bagged and selfed.

Work planned for next year

In next year's trial, we intend to eliminate lines which tested in the moderate-to heavy category in both 1987 and 1988. All other entries will be tested a third year as part of a recurring monitoring of virulence in the Minnesota rust population.

Usefulness of findings

These genes are most likely to be used in sweet corn for rust resistance to back up the currently used Rp1d. It will be important to provide the sweet corn breeders with current information as to which genes are likely to provide at least temporary protection. Many of the genes would prove to be ineffective at the start, and this information may prevent breeders from devoting even minimal resources to them. Similar studies at the Unversity of Illinois should complement this work, and provide a good picture of the variation in rust virulence on these genes.

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Seed production and handling in supersweet (sh2) sweet corn hybrids

A. Borowski, V. Fritz, and L. Waters, Jr.
Dept. of Horticulture

The use of shrunken-2 sweet corn hybrids by the processing industry has been limited due to poor seed quality. This poor seed quality contributes to erratic emergence and low seedling vigor, especially in cold soils. Seed vigor comprises those seed properties which determine the potential for rapid uniform emergence and development of normal seedlings under a wide range of field conditions (AOSA, 1983). The factors that may affect vigor are numerous and include: genetics, conditions at time of seed formation, date of harvest, maturity at harvest, mechanical damage, drying problems, storage temperature, relative humidity and duration, and insects and diseases (Amaral, 1981).

The following study examined maturity at harvest as a means of improving vigor. The seed industry currently harvests seed at 35-45% moisture. While this moisture level may be optimal for mechanical harvesting, seed may not be at a stage of maximum viability. Seedling vigor has been found to be highly dependent on date of harvest or stage of kernel maturity and poor seed quality could result from an untimely harvest (Knittle and Burris, 1976).

In 1987, hybrid seed of "Florida Staysweet" was hand harvested at 9 different moisture levels ranging from 81 to 23%. In 1988, four harvests of hybrids, "Florida Staysweet" and "Crisp N'Sweet 710, were conducted at moisture levels of 70, 60, 50 and 40%. Ears were artificially dried in a forced air dryer at 32C until they reached 10% moisture. Ears were shelled, and seeds were stored (4C, 45% RH) until used for testing.

Standard germination test results in 1987 for "Florida Staysweet" indicate the highest percent germination was obtained for seed harvested between 31 and 63% moisture (Table 1). Results of the modified seedling growth cold test (SGCT) show seed harvested at 57, 44, and 23% moisture had the highest percent germination. However, the percentage of abnormal seedlings was also high (Table 1).

Seed weight of 100 kernels indicated seed harvested between 31-52% moisture would be most vigorous (data not shown). Kernel dry weight is considered an accurate predictor of seedling vigor because it estimates the amount of stored reserves in the kernel that contribute to the vigor of the developing seedling (Knittle and Burris, 1976).

The Effect of Ethephon on Plant Height, Lodging, and Various Components of Yield in Three Sweet Corn Genotypes

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Keywords: Sweet Corn, Ethephon, Lodging, Ethylene, Zea mays var. sacharata.

Abstract: Ethephon was foliarly applied at .56 kg a.i./ha at two stages of embryonic tassel growth (2.5-5.0 and 15.0-23.0 cm in length) to three sweet corn genotypes (su, se, and sh_2) using ten cultivars. Ethephon significantly reduced plant height and improved resistance to lodging in one year. The second year of the study suggested a cultivar x ethephon effect on useable ear production. The three cultivars that responded most negatively to ethephon applications were 'Reward' (su), 'Sentry' (se), and 'Sweetie' (sh_2). This interaction could have been due to the high temperatures during the growing season causing differences in pollen grain mortality and/or differences in internal ethylene production between cultivars. The use of ethephon consistently reduces plant height, but under stressful production environments, a significant reduction in useable ear production could occur if a sensitive cultivar is used.

Sweet corn (Zea mays var. sacharata) production for processing in Minnesota is worth approximately $40 million dollars annually before processing. Traditionally, the industry has produced the sugary genotypes (su) for canning and freezing; however, due to the popularity of the sugary enhancer (se) and super sweet (sh_2) genotypes in the fresh market industry, several processors have begun evaluating these cultivars for production potential because of elevated sugar content. However, the sh_2 cultivars have significant production problems. One of these is a very high susceptibility to root lodging at the soil surface, primarily due to poor brace root development. In addition, cultural management systems used currently promote a rapid growth rate and high productivity per unit area contributing to susceptibility to lodging. Although yields from sh_2 cultivars are comparable or superior to the traditional su cultivars, harvesting costs can be significantly increased primarily due to the slow harvestor speed required in lodged fields.

Ethylene has been used in a wide range of applications in the production of many agronomic and horticultural crops. Some of these applications include: root initiation, fruit degreening, flower initiation, modification of flower sex expression, disease resistance, promotion of leaf and fruit abscission and dehiscence, release of seed and bud dormancy, release of apical dominance, and regulation of tissue proliferation (6). High rates of foliarly applied ethephon (.56 kg a.i./ha) on field corn effectively reduced root lodging by shortening internode length and promoting brace root development; however, it also reduced grain yield (1, 3, 4). Ethephon also affected grain yield by reducing the number of kernels per ear and individual kernel weight (1, 4). Similar results were noted in spring wheat (Triticum aestivum L.) and barley (Hordeum vulgare L.) (5). Gaska and Oplinger (2) evaluated the effects of ethephon on sweet corn and found

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that an application when the embryonic tassel length was 15 cm, may reduce lodging and maximize harvestable yield (unhusked and husked), and ear quality. These studies were conducted using 'Jubilee', the most widely used cultivar of the sugary (su) genotypes in the processing industry.

The objective of this study was to determine the effects of timing of foliarly applied ethephon in three sweet corn genotypes; sugary (su), sugary enhancer (se), and shrunken (sh_2) on lodging and yield.

Field experiments were conducted during 1987 and 1988 at the Southern Experiment Station in Waseca, MN on a 'Nicollet' clay loam with a pH of 6.4. The cultivars chosen from each genotype for the study are listed in table 1. The experimental design was a completely randomized block with three replications. Each experimental plot consisted of four rows of corn 6 meters long with 76 cm between rows. Plots were harvested when kernels reached 73-74% moisture. Harvesting was limited to 4.6 m of the center 2 rows. Data from all experiments were analyzed statistically using analysis of variance (ANOVA) and least significant difference.

In 1987, urea was broadcast preplant at 54 kg N/ha and incorporated with a spring tooth cultivator. Alachlor and cyanizine were broadcast applied preemergence at rates of 2.83 and 2.27 kg a.i./ha, respectively, for weed control. All cultivars were seeded on May 20 and after emergence, were thinned by hand to a final population of 60,000 plants/ha. The experiment was overhead irrigated to insure at least 2.54 cm water weekly. Carbaryl and mancozeb were sprayed as needed for insect and disease control at rates of 1.36 and 2.27 kg a.i./ha, respectively. Ethephon was foliarly applied at a rate of .28 kg a.i./ha using a high clearance sprayer equipped with flat fan nozzles and calibrated to deliver 189.5 l/ha at 280 kilopascals pressure. Ethephon was applied at two stages of plant growth; when the length of the embryonic tassel measured 2.5 - 5.0 cm or 15.0 - 20.0 cm in length. This was determined by manually disecting the main stalk and measuring the developing tassel.

Prior to harvest, a rating scale of 1-5 was used to classify degree of root lodging (1 = upright, 5 = severe lodging) and plant and ear height were measured on 10 plants from each treatment plot. At harvest, the following parameters were measured with the aid of a mechanical husker and cob cutter to simulate processor handling: unhusked and husked ear weights, useable ears for corn on the cob freezing which is defined by 13.3 cm of the ear having superior appearance (straight kernel rows and complete kernel fill), total ear production, ear length and diameter, and cut corn recovery, the primary yield component in the canning industry.

An identical study was conducted in 1988 which was planted on May 16. During the course of the season, excessively high temperatures resulted in abnormal plant growth (lack of synchronization of tasseling with silking) even though the experiment was irrigated to receive 2.5 cm of water weekly. Table 2 represents the contrast between the two years in heat unit accumulation prior to harvest for each cultivar used in the study. For this reason, the data were analayzed and will be discussed separately. The early ethephon application (2.5 - 5.0 cm tassel length) was not applied to the cultivar, 'Reward', in 1988 because the tassel length had exceeded 5 cm when the plots were first evaluated for tassel development.

In 1987, the data suggested that application of ethephon reduced lodging (fig. 1). The late application (15.0 - 20.0 cm tassel length) had the least amount of lodging. This increase in resistance to lodging was probably due to shorter internode lengths on the main stalk which is reflected in total plant height (fig. 2). This reduction in plant height was also associated with a slight decrease in ear height but probably does not present any practical problems with mechanical harvesting. Ear length reduction was small and did not reduce cut corn recovery (data not shown). Ear diameter also was not effected. Ethephon application increased total ear production, although the number of useable ears (for corn-on-the-cob freezing) remained unchanged (fig. 3).

Results from the second year of the study (1988) again indicated that the later ethephon application resulted in shorter internodes when compared to both the control and early ethephon application (fig. 4). Height of ear location on the stalk was reduced by 7 cm which was similar to 1987 data and does not pose any potential mechanical harvesting problem. Ear length and cut corn recovery were not effected by either application of ethephon. Total ear production was increased (fig. 5) and there was a cultivar x ethephon interaction for useable ear production ($p = .05$) (table 2). The interaction was inconsistent with genotype or heat unit accumulation. It may be that this interaction was manifested by interactions between environment/cultivar/and ethephon treatments. Differences in cultivar response to drought conditions may have effected internal plant ethylene concentrations produced by the plant and in turn, their response to foliar applications of ethephon (6). However, the intense heat during 1988 may have resulted in varying rates of pollen grain mortality thereby reducing kernel set and fill. Three cultivars in particular, 'Reward' (su), 'Sentry' (se), and 'Sweetie' (sh_2) responded very negatively to foliar applications of ethephon in 1988. It is important to note that ethephon affected the appearance of the ears which qualifies it for corn-on-the-cob freezing and bears great significance to those processors.

When contrasting the effects of foliarly applied ethephon among ten sweet corn cultivars in two extremely different years, it was clear that ethephon reduced lodging in sweet corn by reducing overall plant height. However, its effect on the components of yield can vary greatly. Under a stressful production environment, ethephon also reduced useable ear production for sensitive cultivars.

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List of Figures

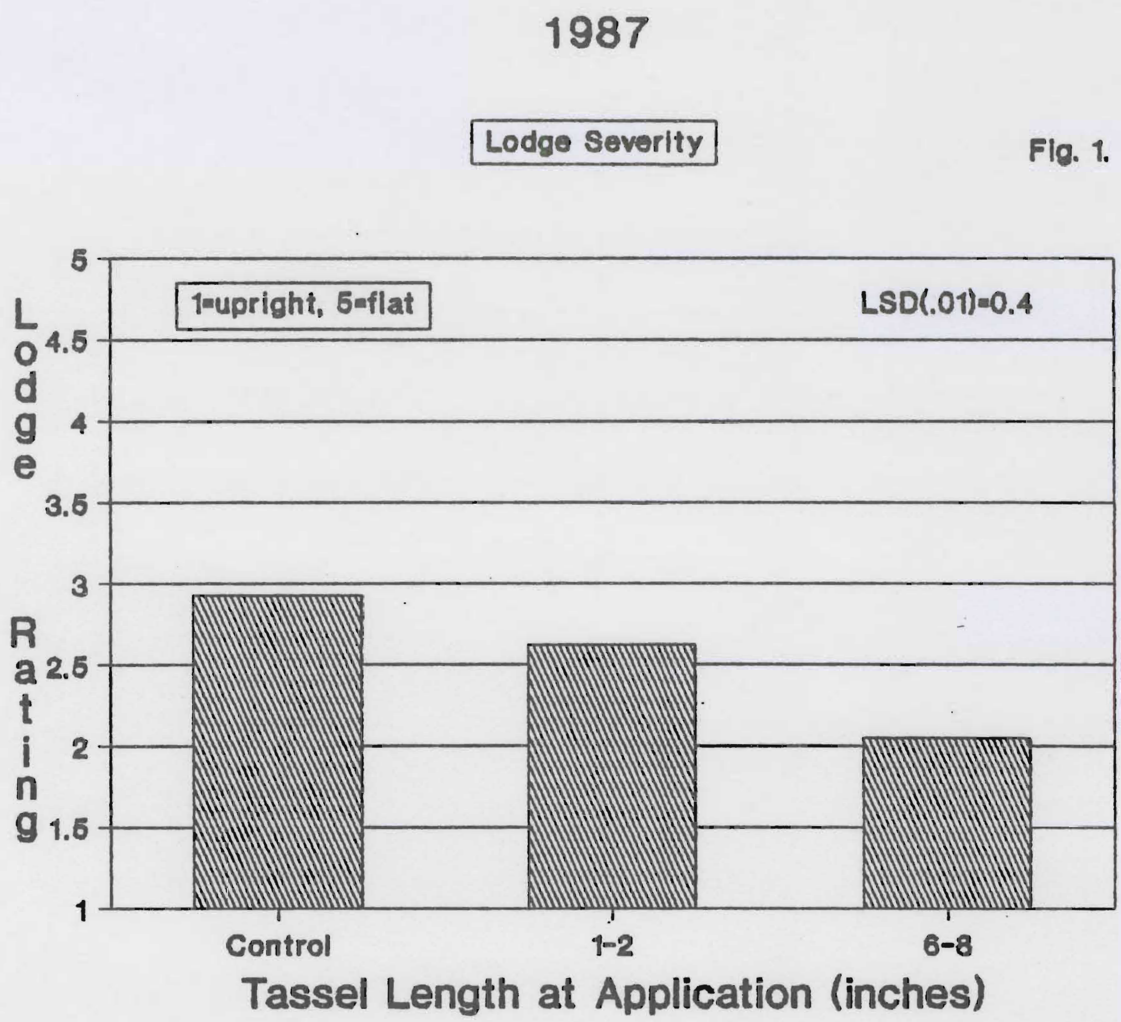
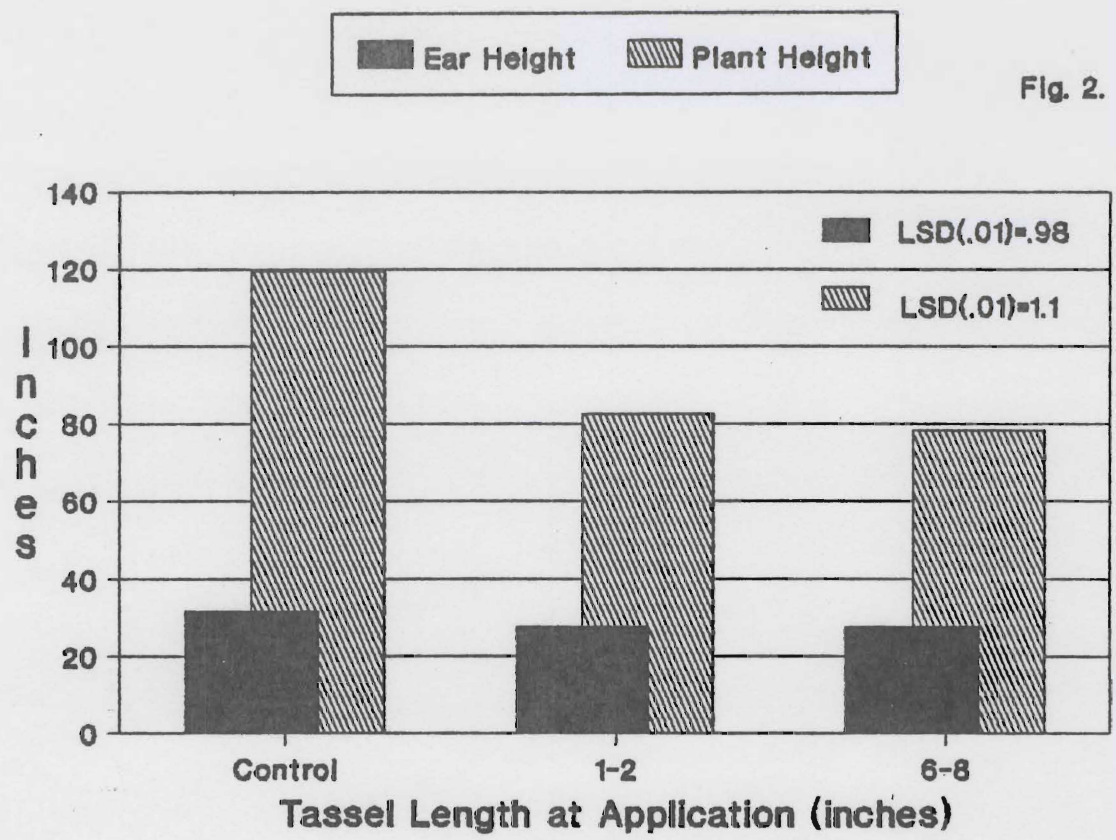

1987
Lodge Severity
1=upright, 5=flat
LSD(.01)=0.4
Lodge Rating
5
4.5
4
3.5
3
2.5
2
1.5
1
Control
1-2
6-8
Tassel Length at Application (inches)

Fig. 1.

1987



Ear Height
Plant Height
LSD(.01)=.98
LSD(.01)=1.1
Inches
0
20
40
60
80
100
120
140
Control
1-2
6-8
Tassel Length at Application (inches)

Fig. 2.

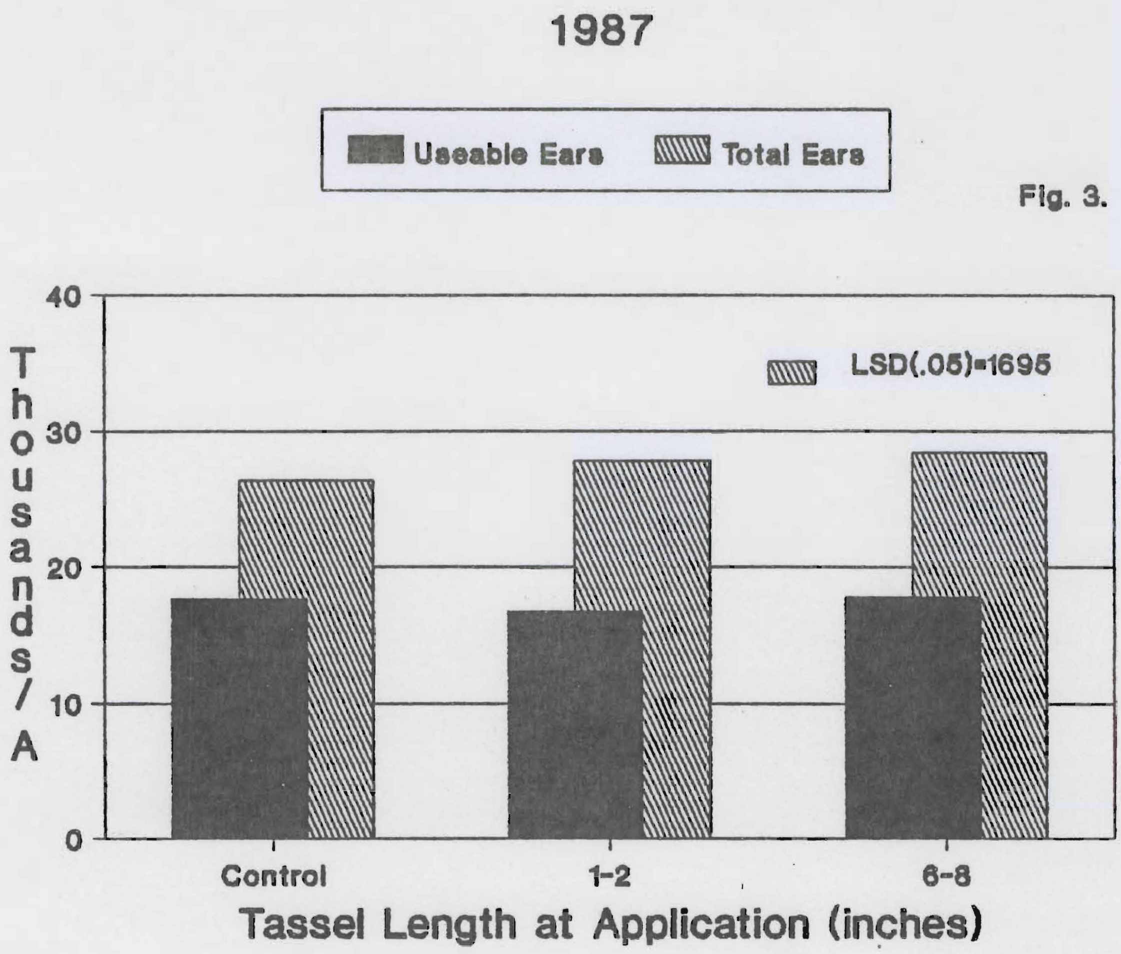
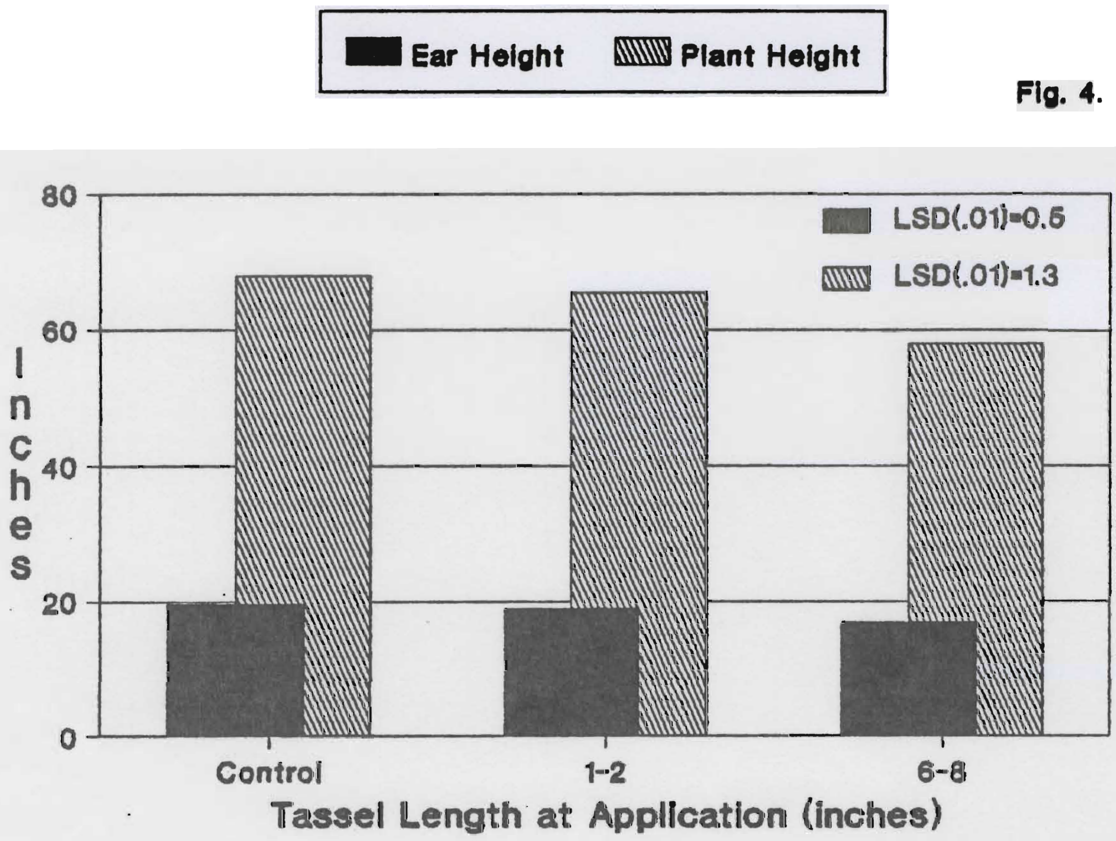

1987
Useable Ears
Total Ears
LSD(.05)=1695
Thousands/A
40
30
20
10
0
Control
1-2
6-8
Tassel Length at Application (inches)

Fig. 3.

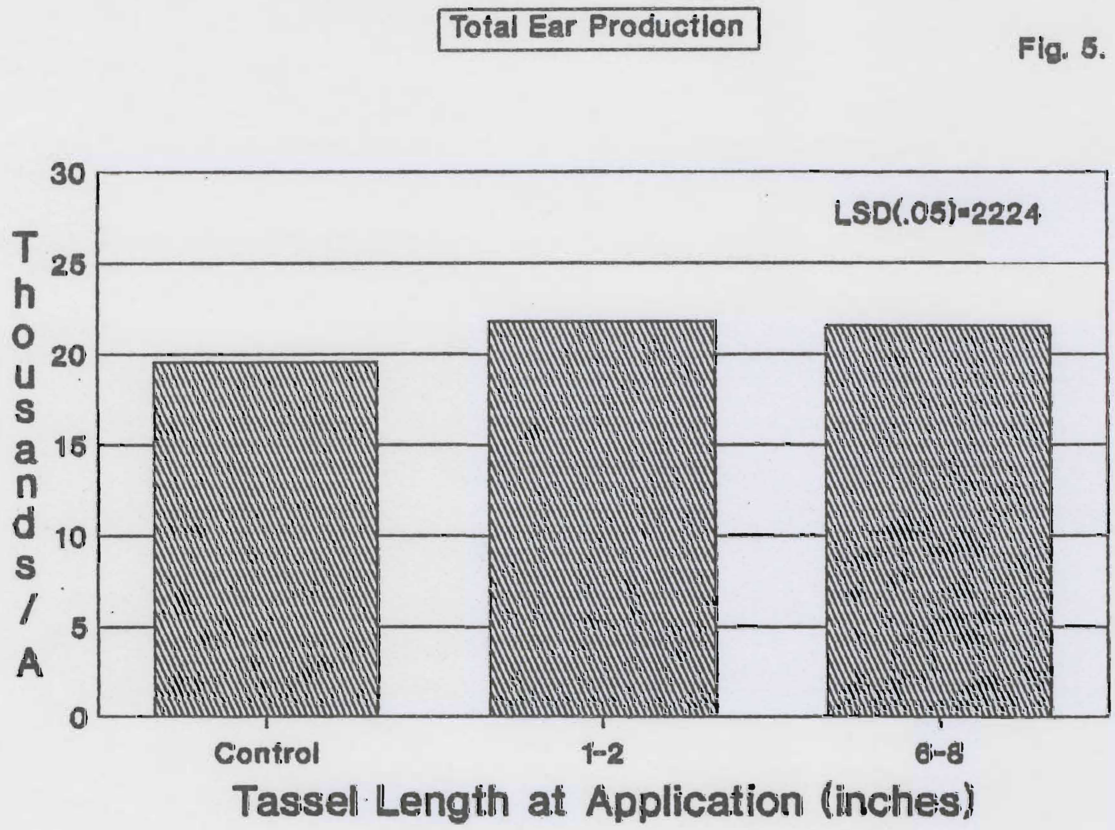
1988

Fig. 4.



Ear Height
Plant Height
LSD(.01)=0.5
LSD(.01)=1.3
80
60
40
20
0
Inches
Control
1-2
6-8
Tassel Length at Application (inches)

1988



Total Ear Production
Fig. 5.
LSD(.05)=2224
Thousands/A
30
25
20
15
10
5
0
Control
1-2
6-8
Tassel Length at Application (inches)

Table 1. Heat unit accumulation comparison between two years for ten sweet corn cultivars.

Cultivar	Genotype	Heat unit Accumulation[1] 1987	1988
Commander	su	1818	2149
Jubilee	su	1749	1955
Reward	su	1464	1753
Stylepak	su	1792	2063
Miracle	se	1661	1955
Sentry	se	1818	2242
Tendertreat	se	1911	2242
Crisp 'n' Sweet 710	sh_2	1749	1955
Summersweet 8000	sh_2	1792	2149
Sweetie	sh_2	1613	2149

[1] Calculated using a base temperature of 10°C from time of planting.

Table 2. Cultivar x ethephon effects on useable ear production in ten sweet corn cultivars (P = .05).

		Tassel length at application (cm)	
Cultivar	Control	2.5 - 5.0	15.0 - 20.0
	Useable Ears (thousands/ha)		
Commander (su)	8.13 (±4.14)	9.56 (±6.63)	9.56 (±7.22)
Jubilee (su)	19.61 (±5.04)	22.95 (±7.17)	22.00 (±2.99)
Reward (su)	28.69 (±1.43)	-------------	14.82 (±5.04)
Stylepak (su)	12.43 (±5.04)	22.95 (±11.74)	16.74 (±2.19)
Sentry (se)	23.91 (±3.61)	3.83 (±4.14)	20.56 (±5.04)
Miracle (se)	18.65 (±10.34)	12.91 (±4.30)	11.97 (±9.33)
Tendertreat (se)	29.65 (±10.38)	32.04 (±9.22)	30.13 (±21.42)
Crisp 'n' Sweet 710 (sh_2)	28.21 (±5.97)	16.74 (±10.08)	20.56 (±7.22)
Summersweet 8000 (sh_2)	17.22 (±5.17)	24.34 (±10.34)	18.65 (±6.25)
Sweetie (sh_2)	20.56 (±3.61)	18.65 (±8.96)	9.09 (±5.80)

Grass and Broadleaf Weed Control in Sweet Corn

Leonard B. Hertz and V. Fritz
Southern Experimental Station
Waseca, MN - 1988

A study was conducted to evaluate several combinations of herbicides for weed control in sweet corn. 'Jubilee' sweet corn was planted on May 17, in a clay loam soil, pH 6.4 and organic matter 6.5%, at the Southern Experiment Station, Waseca, MN. The plots were 10 by 30 ft with four rows spaced 30 inches apart and arranged in a randomized complete block with four replications. All herbicide applications were made with a CO_2 pressured bicycle sprayer equipped with 8002 nozzles. Weed control and crop injury were rated on June 30. Sweet corn from the two center rows in each plot was harvested by hand on August 19. Weed populations were low and consisted of foxtail spp. (56%), redroot pigweed (9%), velvetleaf (16%), and common lambsquarters (19%). Application dates, sprayer settings, environmental conditions, and plant sizes are listed below:

Date	May 17	June 9	June 13	June 16	June 20
Treatment	PRE	EPO	PO	PDIR	LPO
Sprayer					
gpa	20	20	20	28	20
psi	30	30	30	32	30
Wind (mph)	15E	5-10E	15-18SW	3-5NE	4-5NE
Temperature (F)					
air	70	51	77	51	71
Relative humidity (%)	33	19	54	36	43
Sky	clear	clear	clear	clear	clear
Sweet corn					
leaf no.	--	3-4	4-5	5-6	5-7
Foxtail spp.					
leaf no.	--	1-3	3-4	5-7	5-7
height(inch)	--	--	--	4-6	--
Redroot pigweed					
leaf no.	--	--	--	4-5	--
height(inch)	--	--	--	2-4	--

Weed control, corn injury, and yield are summarized in the accompanying table. All herbicides provided excellent control of broadleaf weeds. Combinations of Basagran and Aatrex plus Lasso, Tough plus Aatrex and Lasso, and EL-177 plus Lasso, and Laddok gave poor control of foxtail spp. Gramoxone Super and Roundup, post/directed applications, and Harmony gave excellent overall weed control, but injured the sweet corn.

Table. Weed control, crop injury and yield of sweet corn (Hertz and Fritz)

Treatment	Rate	Method of appl.	Weed control				Corn inj	Corn yield	
			^{x}Grft^{y}	Rrpw	Vele	Colq		Husk	Cut
		(lb/A)	- - - - - - %	- - - - - -			(%)	(T/A)	(T/A)
Harmony+COC	0.008	PO	83	100	100	100	60	1.1	0.7
+Lasso	2.0	PRE							
Laddok+28%N	0.43+0.4	EPO	73	100	98	100	0	2.1	1.4
+Lasso	2.0	PRE							
Laddok+Dash^{z}	0.43+0.4	EPO	85	95	88	100	0	1.7	1.2
+Lasso	2.0	PRE							
Laddok+COC	0.43+0.4	EPO	85	100	100	100	0	2.5	1.8
+Lasso	2.0	PRE							
Laddok+28%N	0.54+0.5	EPO	85	100	100	100	0	2.5	1.7
+Lasso+Dash	2.0	PRE							
Laddok+COC	0.54+0.5	EPO	85	100	100	100	0	2.4	1.8
+Lasso	2.0	PRE							
Laddok	0.54+0.5	EPO	93	100	98	100	0	2.3	1.6
+Lasso	2.0	PRE							
Buctril+Lasso	0.38+2.0	EPO+PRE	80	95	95	100	0	2.1	1.5
Tough+Aatrex	0.45+0.6	PO	83	100	95	100	10	2.4	1.7
+Lasso	2.5	PRE							
Tough+Aatrex	0.45+0.6	LPO	75	98	90	100	5	2.0	1.4
+Lasso	2.5	PRE							
Tough+Aatrex	0.6+0.6	LPO	78	100	100	100	0	2.4	1.7
+Lasso	2.5	PRE							
EL-177+Lasso	0.25+1.0	PRE	80	95	83	93	5	1.1	0.7
+Aatrex	1.0	PRE							
EL-177+Lasso	0.25+2.0	PRE	75	98	100	95	5	2.0	1.4
+Aatrex	1.25	PRE							
EL-177+Aatrex	0.25+1.0	PRE	65	100	93	95	0	1.3	0.9
+Bladex	1.0	PRE							
EL-177+Aatrex	0.3+1.25	PRE	75	93	85	98	5	1.6	1.2
GramoxoneSuper	0.21	PDIR	90	100	95	100	25	1.0	0.7
GramoxoneSuper	0.21	PDIR	95	100	100	100	18	2.1	1.6
+Aatrex	0.25	PDIR							
GramoxoneSuper	0.21	PDIR	95	100	100	100	23	1.6	1.3
+Aatrex	0.5	PDIR							
GramoxoneSuper	0.21	PDIR	98	100	98	100	15	2.1	1.6
+Aatrex	1.0	PDIR							
GramoxoneSuper	0.41	PDIR	98	100	100	100	30	2.5	1.8
Tandem	0.75	LPO	85	100	95	100	5	2.8	2.0
+Aatrex	1.5	LPO							
Tandem	1.5	LPO	90	100	100	100	10	2.6	1.9
+Aatrex	1.5	LPO							
Roundup	0.18	PDIR	80	100	100	100	23	2.6	2.1
Roundup	0.36	PDIR	98	100	100	98	23	2.6	1.8
Roundup+Dacamine	0.18+0.25	PDIR	85	100	100	100	5	2.7	1.8
Weeded	--	--	100	100	100	100	0	2.6	1.8
Untreated	--	--	0	0	0	0	0	2.0	1.4
LSD(0.05)			17	5	5	14	11	--	--

^{z}Additives: COC = Crop oil concentrate (BASF); 1 qt/A; Dash = Crop oil concentrate (BASF), 1 qt/A; 28% N = ammonium sulfate solution, 1 gal/A; N =1 gal/A; X-77 = non-ionic surfactant, 0.25%.

^{y}Weeds: Grft = green foxtail; Rrpw = redroot pigweed; Vele = velvetleaf; and Colq = common lambsquarters.

^{x}Application: PRE = preemergence; PO = postemergence; EPO = early postemergence; PDIR = postemergence directed; and LO = late postemergence.

Interaction Between Sweet Corn and the European Corn Borer

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University of Minnesota
and
David Andow
Department of Entomology
University of Minnesota

Much effort has been expended in various public and private U.S. field corn research programs toward developing resistance to European corn borer. As a result, several field corn inbreds having leaf feeding resistance and/or stalk tunneling, sheath, and collar resistance have been developed, including Oh 43, B52, B86 DE111, MO2 and a few others. Also, it has long been known that some tropical maize, such as Zapalote Chico and Antigua have resistance. In addition, over the years dent hybrids have been developed having a fair degree of resistance as compared to previously grown hybrids. However, all of these inbreds and hybrids were developed for leaf feeding and/or sheath, collar and stalk tunneling resistance. They have two problems. First, they are dent corns; secondly, for the most part they do not have high resistance to ear and kernel damage.

Borer resistance in sweet corn is generally recognized as very low, and there has not been the long history of major research effort toward developing resistance. Genetic material having some ear and kernel feeding resistance has been developed in the Cornell program, and, more recently, in the Minnesota program. In addition, studies by Andrew at Wisconsin and in our program at Minnesota demonstrate that a detectable but low level of ear feeding resistance is found among sweet corn hybrids. The Minnesota program also has released one sugary breeding population, AS9, having a high degree of leaf feeding resistance.

The purpose of this report is to provide an update on the Minnesota program with regard to 1) evaluation of the ear and kernel feeding resistance of commercial hybrids, 2) the development of genetic material having ear and kernel feeding resistance, 3) larval behavior on resistant versus susceptible plants, and 4) the inheritance of resistance.

<u>Evaluation of Ear Damage on Industry Hybrids</u>

In 1988, nine commercial sweet corn hybrids submitted by Minnesota processors were evaluated for ear feeding resistance. Six plots of each were grown. Within 2 days after silk appearance, approximately 40 freshly hatched larvae were placed on the tip of the first ear on all plants in each plot.

Twenty-one days later 9 such ears were evaluated in each of the 6 plots. Extra plots of Jubilee were planted earlier than, at the same time as, and later than the other hybrids in order to determine if different batches of larvae from the laboratory rearing behaved differently on different days of infestation. Thus the objective was to have a 'check' variety for each day of infestation/evaluation. The results, based on a 1 to 8 rating scale of ear damage, are summarized below.

Our interpretation of the data in Table 1 is that all of these hybrids are susceptible. This will not come as a surprise to the industry. There may be small differences in resistance among the 9 but one cannot determine from the data collected in 1988. The key break in the rating scale is in the 3 to 4 category area. An ear receiving a score of 4 or above definitely is badly damaged and in our opinion would be rejected during inspection on the factory inspection table. Ear damage on Arrestor, Banner and Napier, evaluated on August 12, average lower in ear damage score, but, as seen in Table 1, we did not have a Jubilee check for that date. Hence, the data on those 3 hybrids are more difficult to interpret.

<u>Progress in Development of Ear Feeding Resistance</u>

After several years of testing we have identified in our breeding material, families which have resistance to ear feeding by the borer. The development work, such as the initial crosses followed by years of selection, goes back much further, however, beginning, in some of the parentages, before 1975. Gradually, we selected the best each year, intercrossed these and moved ahead to the next year. In 1987, we evaluated 220 families and winnowed this to 88 this year. Of the 88, we feel that 65 have significant resistance. A summary of 11 of the better families for resistance and type is provided in Table 2. Some of these have first brood resistance also, and a few have rust resistance as well. Fewer than 11% of the plants in 9 of the 88 families had kernel damage at the ear tip compared to more than 95% for Jubilee following infestation at the tip of silking with about 40 larvae. Five of these 9 families are included in Table 2; four having poor agronomic type or fewer than 24 plants evaluated were omitted. More self pollinating will be done on the best ones in order to develop inbreds.

The resistant families described above may be of no value unless the resistance is transmittable to hybrids. Thirteen of the families are being test crossed to several commercial inbreds this winter and resistance of the resulting hybrids can be evaluated in the summer of 1989. The resistant families come from 7 different pedigrees.

Table 1. European Corn Borer Ear Damage Summary of Nine Processing Sweet Corn Hybrids, Minnesota AES, 1988.

Hybrid	Evaluation Date	Average Ear Damage*	% in Each Damage Class 1	2	3	4	5	6	7	8
Jubilee	8/1	5.3	0	0	0	32	25	14	21	0
Reliance	8/1	4.2	0	1	45	1	24	21	10	0
Yukon	8/1	4.1	0	0	40	30	20	3	7	0
Jubilee	8/2	4.9	0	0	26	15	22	22	15	0
Reliance	8/2	4.3	0	0	38	17	31	3	10	0
Yukon	8/2	4.5	0	0	37	23	13	10	10	10
Jubilee	8/3	3.7	0	0	53	26	21	0	0	0
Gold Ring	8/3	3.2	3	9	67	2	10	0	7	0
Crisp & Sweet 710	8/5	4.1	0	6	48	4	22	6	14	0
Jubilee	8/8	4.0	0	4	52	11	16	4	13	0
Excellency	8/8	3.3	6	13	55	4	19	4	0	0
Arrestor	8/12	3.0	8	19	60	0	10	0	2	0
Banner	8/12	3.3	5	3	73	0	13	0	5	0
Napier	8/12	3.6	2	5	52	19	19	3	0	0

* Averages are based on 54 plants.
The 8 categories in the ear damage scale used are as follows:

1 No damage to husks, silks or kernels
2 Silk and/or husk damage only
3 Up to 5% of the kernels damaged at the ear tip only
4 6-10% of the kernels damaged at the ear tip only
5 Up to 5% of the kernels damaged at the ear tip and at the ear side or at the side only
6 6-10% of the kernels damaged at the ear tip and at the ear side or at the side only
7 cob tunnelling from tip or shank
8 more than 10% of the kernels damaged on the ear.

Table 2. EuropeanCorn Borer Ear Damage Summary of Eleven S_1 Sugary Sweet Corn Families, Minnesota AES, 1987-1988

		Average Ear Damage*		% in Each Damage Class, 1988							
Family	Parentage group	1987	1988	1	2	3	4	5	6	7	8
403	2	2.0	2.3	8	58	29	0	5	0	0	0
404	2	2.2	2.2	21	50	25	0	4	0	0	0
408	9	2.9	1.7	43	35	22	0	0	0	0	0
424	2500	1.9	1.9	38	43	14	0	5	0	0	0
427	2	2.5	1.8	35	57	4	0	4	0	0	0
431	2	2.5	1.8	24	71	5	0	0	0	0	0
432	2	2.6	2.0	13	75	13	0	0	0	0	0
444	18	2.9	2.2	33	38	17	4	8	0	0	0
455	9	2.1	2.2	8	79	4	4	4	0	0	0
472	22	3.0	1.7	65	25	5	0	0	0	5	0
484	22	2.7	1.3	82	14	0	0	5	0	0	0
Jubilee	check	3.8	4.2	4	0	50	13	4	8	21	0

*mean ear damage is the mean from 24 plants divided among 8 reps (1987) or 6 reps (1988). See footnote to Table 1 for explanation of the rating scale.

Research on the Inheritance of Corn Borer Resistance

As a part of her research in the graduate program, one of us (Elizabeth Lamb) is investigating several resistant corn varieties and breeding lines to find out 1) if they differ from one another in the kind of resistance (leaf, sheath, collar, and ear) they possess, and 2) how their resistance is inherited. While these materials are of starchy, Latin origin, and unadapted to our region, they may provide some very useful information in the long term in our breeding program as well as useful genes for that program.

Three resistance sources---Maize Amargo; Zapalote Chico; and Antigua x San Juan---are being used. Progeny from crosses among these 3, and from each of the 3 crossed with a susceptible sweet corn, are being studied to determine 1) if there are different mechanisms of resistance in these 3 sources, and 2) how the resistance is inherited. Results from this part of our work are preliminary but should be complete by the time of our next meeting.

Research on the Behavior of Larvae on Resistant and on Susceptible Corns

One-hour, 24-hour and 120-hour dispersal of larvae has been studied on the borer resistance sources of corn listed in the above paragraph. Also, a part of the graduate program research effort by Elizabeth Lamb, this work essentially is a study of larvael movement and dispersal on the plants. It asks the question of whether or not larvae behave differently on a resistant plant than on a susceptible plant. If there are differences we may be able to use insect behavior as an indicator of resistance/susceptiblity when larvae are put on plants of unknown resistance in the breeding program. It may also tell us something about the mechanism of resistance.

Breeding for Multiple Pest Resistance in Sweet Corn

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Department of Horticultural Science and Plant Pathology

The combining of resistance to corn borer, leaf rust and maize dwarf continued in 1989. In the major experiment, 560 breeding lines were screened in 2 replications (1120 plots) for rust, maize dwarf and first brood (leaf feeding) borer; 149 of the 560 also were evaluated for second brood (ear feeding) damage.

This breeding material has in its parentage the AS11 population (rust and MDMV resistant) released in 1987 but other sources of resistance now have been added. At the same time that we have been selecting for multiple resistance each year we also have been selecting for ear and plant traits, such as vigor, freedom from smut, good standability, high kernel row number, good kernel color and kernel depth, light silk color, white cob color, and ear type, and strong, cleanly emerging tassels which produce an abundance of pollen for at least several days.

In 1988, we found that of the 560 lines, 249 are totally resistant to rust, 239 are totally resistant to maize dwarf, and 127 were totally resistant to both diseases. By "totally resistant" we mean that all plants in the plot were resistant. Ears from one or more self-pollinated plants of 234 of these 560 breeding lines were selected (a total of 483 ears--1 from each selfed plant); hence, essentially 326 (520-234) of the lines were discarded in 1988. The decision to retain a breeding line depended not only on its reaction to rust, corn borer and maize dwarf, but also on the plant and ear traits noted in paragraph 2 above.

Thus, we now have an elite group of breeding lines that are well on the way to inbred status. We will continue to work with these in 1989 in four ways, as follows:

1) We will continue to screen the now smaller set of lines for disease and insect resistance and for plant and ear traits. Meanwhile, we may be able to eliminate more of them, before the 1989 planting season, by checking the kernel pericarp toughness. We can do this by using a laboratory microscope to check the pericarp peel on several dry kernels on each saved ear.
2) Secondly, we will take the best selections from 1988, perhaps 50, and make test crosses with them in 1989 to determine if any can produce quasi-commercial hybrids. If so, the parental line may be a candidate for release.
3) Thirdly, we also will recombine through open pollination in an isolated field (to prevent outside pollen from coming in) the best selections from 1988. From these crosses we can start another

cycle of selection and in this cycle we can concentrate more on corn borer resistance because all of those we would choose for the recombination should be totally resistant to rust and maize dwarf.

4) Thirty of the 560 resistant breeding lines were crossed in 1988 with a corn population from Mexico having a high degree of resistance to various kinds of insects, in addition to European corn borer. The seed from these crosses was sent to Mexico in November where plants will be grown and self-pollinated. Hence, for the summer of 1989 we will have the F2 (segregating generation) to screen for multiple resistance.

Finally, I should note that some of the above material was hybridized two years ago with various corn-borer-resistant field corns. Several thousand plants from these crosses also were screened in 1989 and 186 plants were selected for multiple resistance, self-pollinated and seed saved for further screening in 1989.

LIVESTOCK STUDIES WITH SWEET CORN PROCESSING WASTE ENSILED AT DIFFERENT MOISTURE LEVELS - FINAL REPORT

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David M. Ziegler, Assistant Scientist
University of Minnesota Southern Experiment Station
Waseca, Minnesota 56093

SUMMARY

One hundred sixty-five tons of sweet corn processing waste (SCPW), ensiled at different moisture levels, were used for two consecutive feeding studies with two groups of 36 Holstein steers (avg. wt. 421 lb). The SCPW silage (80% moisture) in the first study replaced 0, 50 or 100% of the corn silage dry matter (DM) in a diet containing 60% corn silage and 40% corn plus protein supplement, dry basis. Steers fed 50% SCPW silage had similar gains ($P > .05$) but lower ($P < .05$) DM intake than steers fed 0% SCPW diet. Steers fed 100% SCPW silage had the lowest ($P < .05$) daily gain and dry matter intake. Amount feed (DM)/lb gain was not influenced ($P > .05$) by level of SCPW silage. Daily gains, daily feed (lb DM) and feed/gain (lb DM/lb) were 2.14, 11.90, 5.51; 1.91, 10.46, 5.48 and 1.35, 8.47 and 6.28 lb for steers fed 0, 50 and 100% SCPW silage diets, repsectively. In the second study SCPW was ensiled at 83, 78 or 71% moisture and fed to replace 0 or 100% of the corn silage DM in the control diet. Steers fed 0% SCPW had higher daily gains ($P < .05$) dry matter intake and dry matter digestibilities than steers fed the other three diets. Average daily gains were similar ($P > .05$) for steers fed SCPW silage diets but steers fed the 83% moisture SCPW silage had the lowest dry matter intakes ($P < .05$). All diets were utilized with similar feed efficiencies ($P > .05$). Daily gain, daily feed (lb DM) and feed/gain (lb DM/lb) were 2.59, 14.69, 5.66; 1.41, 9.26, 6.56; 1.65, 10.60, 6.47 and 1.65, 10.92 and 6.82 lb for steers fed 0 (control), 83, 78 and 72% SCPW silage diets, respectively. Results indicate that high moisture SCPW silage can effectively replace 50% of corn silage in growing diets. Reducing the SCPW moisture to 78% enhanced performance but further moisture reduction was not beneficial.

INTRODUCTION

Processing of sweet corn for human food consumption results in a residue that typically contains 90% husk and leaf, 8% cob and 2% kernel plus washed corn screenings that contain 5% solids. The combined dry matter of the residue is usually 20% or less. Over 400,000 tons of sweet corn processing waste (SCPW) are available each year from the 19 processors in southeast Minnesota. Typically the waste material is chopped and squeezed through a pressure chamber then ensiled in an open bunker silo. Producers can purchase the waste material either at the processing plant prior to ensiling or 6 to 8 weeks after the material has been stacked. Analysis of SCPW shows a similar crude protein content, slightly lower ash content but higher acid detergent fiber content when compared to regular corn silage or whole plant sweet corn silage (table 1).

Table 1. Typical comparative analysis of sweet corn processing waste, whole plant sweet corn and regular dent corn silages.

Analysis	Silages: Sweet corn processing waste	Whole plant sweet corn	Regular dent corn
Dry matter, %	16 - 20	33 - 38	40 - 45
Crude protein, % dry basis	7 - 9	7 - 9	7 - 9
Nitrogen, % wet basis	.18 - .23	.39 - .50	.45 - .58
Acid detergent fiber, %	38 - 44	28 - 32	28 - 32
Typical ash, %	3.4	6.7	4.7
Typical pH after ensiling	4.0	3.9	4.1

Earlier feeding trials conducted at the University of Minnesota (1) which utilized SCPW that had not been chopped and squeezed, indicated that the amount of dry matter per 100 lb gain was similar for cattle fed SCPW and those fed regular corn silage. The rate of gain in the cattle fed SCPW silage was inferior to those fed regular corn silage and whole plant sweet corn silage as the high moisture content of the SCPW silage limited daily dry matter intake. The problem of disposal of the SCPW is perennial and increasing each year especially as livestock feeding is the primary outlet for SCPW.

Abundance of corn and soybeans in the upper Midwest has reduced demand for SCPW as a livestock feed. There is a need to more precisely describe the feeding value of SCPW that has been chopped and pressure squeezed to enable feeding strategies to be investigated that may enhance efficient utilization of the SCPW by maintaining optimum economic performance in ruminant livestock production. In southeast Minnesota the Holstein steer is being used in increasing numbers for dairy-beef production. There is a lack of information on the effective utilization of SCPW in Holstein feedlot diets.

In addition there is a need to address methods of enhancing feeding quality of SCPW, an initial question being to evaluate the implications of reducing moisture content of SCPW and effect on nutritional quality as related to a livestock feeding model which are feedlot Holstein steers in the studies reported here.

Objectives

The objectives of this work with SCPW silage are:

1) to investigate feeding strategies for SCPW silage in diets fed to growing Holstein steers.
2) to evaluate the feeding value of SCPW ensiled at different moisture levels.
3) to address the practical implications of reducing the moisture content of SCPW silage on the disposal and utilization of the silage.

EXPERIMENTAL PROCEDURES

Trial one

Sixty-six tons of sweet corn processing waste (SCPW) obtained directly from General Foods in Waseca during the 1986 corn pack after having been chopped and squeezed through a pressure chamber, was ensiled in horizontal 8-mil plastic bags using a silopress. Packing the waste residue in the storage bags reduced the initial moisture content from 85 to 81%. The ensiled residue was stored in the bags from September, 1986, until February, 1987, when the feeding trial was initiated. Thirty-six Holstein steers (avg. wt. 400 lb) were randomly assigned to three treatment groups among six pens (six animals per pen). Diets, dry basis, consisted of: 1) 60% corn silage and 40% corn grain plus supplement, 2) 30% corn silage, 30% SCPW silage and 40% corn grain plus supplement, and 3) 60% SCPW silage and 40% corn grain plus supplement. Each diet was replicated two times. Supplement was fed at 1 lb per head daily (table 2). Composition analysis of the SCPW silage is shown in table 3.

Table 2. Composition of Supplement[a]

Ingredient	Amount lb/ton
Soybean meal	260
Urea	340
Ground corn	430
Dicalcium phosphate	240
Limestone	520
Trace mineralized salt	150
Vitamin - monensin premix[b]	60

[a] Fed at 1 lb per head daily.
[b] To supply 25,000 IU vitamin A, 2500 IU vitamin D and 200 mg monensin per lb supplement.

Table 3. Composition analysis of sweet corn processing waste silages used in feeding trials.

	Composition, % dry basis			
Item	Dry matter	pH	Crude protein	Acid detergent fiber
	%			
Trial 1:				
High moisture SCPW[a]	19.09	4.00	7.41	39.36
Trial 2:				
High moisture SCPW[a]	17.56	3.92	8.23	42.35
Medium moisture SCPW[b]	22.32	3.99	7.06	44.03
Low moisture SCPW[c]	28.72	3.74	6.62	43.83

a Sweet corn processing waste ensiled directly from the processing plant.

b Sweet corn processing waste pushed through an additinal squeeze process to reduce moisture.

c Sweet corn processing waste pushed through an additional squeeze two times to reduce moisture futher.

All steers were fed a similar corn silage - corn grain diet prior to the start of the trial and were changed to their respective treatment diets over a 2-day period. During the trial steers were full fed their respective diets once daily. Feeds were weighed individually and mixed in the feed bunk. Daily feed intake and refusals were recorded. Initial and final weights were obtained after withholding feed and water 16 hours. Steers were vaccinated for IBR, PI_3, BVD and seven strains of clostridia prior to the trial. Steers were implanted with Ralgro every 70 days after weaning.

Trial two

During the 1987 corn pack two hundred tons of SCPW obtained directly from General Foods in Waseca, as in trial one, were ensiled at different moisture levels in 8-mil horizontal plastic storage bags using the silopress. The highest moisture silage (83%) was obtained by ensiling the SCPW directly as taken from the plant. The other two moisture levels were obtained by passing the SCPW through a french screw press which mulched the waste material and squeezed out further effluent. A single pass through the screw press reduced the moisture to an average of 78% and a double pass through the press reduced the moisture to an average of 71%. Sufficient quantity of SCPW was ensiled at each moisture level to conduct a 120-day growing trial with Holstein steers. All silages were ensiled for 42 days before being fed. Composition analysis of the respective SCPW silages are shown in table 3.

Thirty-six Holstein steers (avg wt. 432 lb) were randomly assigned to four treatment groups among six pens (six animals/pen). Diets, dry basis, consisted of one replicate pen each of: 1) 60% corn silage and 40% corn grain plus supplement and 2) 60% "high" moisture SCPW silage and 40% corn grain plus supplement. Two replicate pens were assigned to each of 3) 60% "medium" moisture SCPW silage and 40% corn grain plus supplement. The supplement was the same as that used for trial one being fed at 1 lb per head daily (table 2). During the final week of the trial fecal grab samples were taken from each steer over a 5-day sampling period. Samples were taken twice daily at different hours each day. The fecal samples were used to estimate apparent dry matter digestibilities of the diets based on acid insoluble ash content of the feed and feces. The procedure for this second trial other than discussed above was similar to trial one.

RESULTS AND DISCUSSION

Trial one

Steer performance data are in table 4. Steers fed 30% SCPW silage diets had a similar daily gain ($P > .05$) but lower ($P < .05$) dry matter intake than steers fed 0% SCPW silage diets. Steers fed 60% SCPW silage had the lowest ($P < .05$) daily gain and dry matter intake. Amount of dry matter required per 100 lb gain was not influenced ($P > .05$) by level of SCPW, although steers fed 60% SCPW tended to require more feed per unit of gain. Yamoor et al. similarly found that cattle fed regular corn silage diets utilized feed with similar efficiency to those fed SCPW silage. Based on SCPW silage being typically sold for $4/ton, corn grain at $90/ton and corn silage at $23/ton, the lowest feed costs/100 lb gain were for steers fed the 30% SCPW silage diets (table 4).

Results of this first trial indicated that high moisture SCPW silage can replace 50% of the corn silage in a growing diet for Holstein steers without affecting performance. These results concur with the findings of Jaster et al. (2) who fed 50:50 SCPW to regular corn silage diets to growing dairy heifers. Replacing all of the corn silage with SCPW silage reduced intake by almost 29% and daily gain by 37% compared to steers fed corn silage diets. The high moisture content of the SCPW silage appeared to be the major factor affecting intake and daily gain when fed to growing feedlot cattle. During this first study the use of horizontal bags for ensiling high moisture SCPW resulted in loss of up to 30% of feed material through spoilage due mainly to loose packing at the front of the bag. The silopress equipment was modified to aid in packing high moisture material but it was less than ideal.

Table 4. Performance of steers fed different levels of sweet corn processing waste ensiled directly from processing plant.

Item				
Waste, % of DM	0	30	60	
Corn silage, % of DM	60	30	0	
Corn grain/supplement, % of DM	40	40	40	Sx[a]
No. of steers	12	12	12	
Initial wt, lb[b]	410	410	409	
Final wt, lb	592	572	524	
Daily gain, lb	2.14[c]	1.91[c]	1.35[d]	.40
Days on feed	85	85	85	
Daily feed, lb of dry matter				
Corn silage	7.14	3.07	--	
Corn silage, fed during transition to waste silage only	--	.30	.30	
Waste silage	--	2.93	4.72	
Ground corn	3.95	3.34	2.64	
Supplement	.81	.82	.81	
Total	11.90[c]	10.46[d]	8.47[e]	1.20
Feed/100 lb of gain, lb of dry matter				
Corn silage	334	161	--	
Corn silage fed during transition to waste silage only	--	16	22	
Waste silage	--	153	350	
Ground corn	185	175	196	
Supplement	38	43	60	
Total	557[c]	548[c]	628[c]	64
Feed cost/100 lb gain, $[f]	16.59	15.03	16.38	

[a] Standard error.
[b] Obtained after withholding feed and water 16 hours.
[cde] Means with different superscripts differ ($P < .05$).
[f] Based on sweet corn processing waste @ $4.00/ton; corn grain @ $90.00/ton; corn silage @ 23.00/ton.

Following this first trial there still remained questions to be addressed concerning the efficient use of SCPW as a livestock feedstuff. These questions were: 1) what is the optimum moisture content of SCPW that can be achieved practically at the processing plant to maintain production throughput and quality silage available for livestock?; 2) what effect does reducing moisture content of SCPW, through mechanical means, have on its nutrient quality?; and 3) what is the practical moisture content of the pre-ensiled waste to achieve that which will give the optimum economic value for both the food processor and livestock producer? Trial two was, therefore, designed to address the questions above.

Trial two

In contrast to high losses of ensiled feed material in the horizontal plastic bag reported for the previous study, the material was packed more efficiently for this second trial and total losses were estimated as 5% on average. Both the single ("medium") and double pressed ("low") silages packed more tightly than the highest moisture silage. Towards the end of this second trial, the ambient temperature dropped to well below 0°F and the outside layers of the silages began to freeze. Continuous low temperatures reduced the ability to efficiently feed out of each bag and the trial was terminated after 98 days due to these difficulties.

Steer performance data for the second trial are given in table 5. Steers fed 0% SCPW diets had higher ($P < .05$) daily gains and dry matter intake than steers fed the other three diets. Average daily gains of steers fed the 60% SCPW silages were not different ($P > .05$) regardless of moisture content although steers fed the highest moisture SCPW silage tended to have the lowest average daily gains. Steers fed the highest moisture SCPW silage diets had the lowest dry matter intakes ($P < .05$). The amount of dry matter required/100 lb gain was not different ($P > .05$) between diets although steers fed 0% SCPW diets tended to require lower amounts feed/100 lb gain.

Table 5. Performance of steers fed sweet corn processing waste ensiled at different moisture levels.

Ensiled processing waste, % moisture Waste, % of DM Corn silage, % of DM Corn grain, supplement, % of DM Item	 0 60 40	83 60 0 40	78 60 0 40	72 60 0 40	Sx^a
No. of steers	6	6	12	11	
Initial wt., lb[b]	434	423	436	433	
Final wt, lb[b]	688	561	598	595	
Days on feed	98	98	98	98	
Daily gain, lb	2.59^c	1.41^e	1.65^{de}	1.65^{de}	.53
Daily feed, lb of dry matter					
Corn silage	8.69	-	-	-	
Corn silage, fed during transition to waste silage only	-	.09	.10	.11	
Waste silage	-	5.32	6.16	6.26	
Ground corn	5.08	2.96	3.51	3.63	
Supplement	.91	.89	.91	.92	
Total	14.68^c	9.26^e	10.68^d	10.92^d	.83
Feed/100 lb gain, lb of dry matter					
Corn silage	335	-	-	-	
Corn silage (transition only)	-	6	6	7	
Waste silage	-	377	373	379	
Ground corn	196	210	213	220	
Supplement	35	63	55	56	
Total	566^c	656^c	647^c	662^c	83.0
Apparent dry matter digestibility, %	74.61^c	62.61^d	62.25^d	61.40^d	

[a] Standard error.
[b] Obtained after withholding feed and water 16 hours.
[cde] Means in the same row with different superscripts differ ($P < .05$).

Performance of steers fed 0% SCPW silage was similar in terms of feed efficiency to steers fed the same diet in trial one, although daily gains were higher. This was probably due to slightly heavier calves being used for trial two which resulted in higher average daily dry matter intakes. Performance of steers fed the high moisture SCPW silage in trial two was slightly better than those fed similar diets in trial one mainly due to higher crude protein content of the SCPW used in the second trial.

Replacing the corn silage with high moisture SCPW reduced daily steer gains by 46%, daily dry matter intake by 37% and feed efficiency 14% compared to steers fed 0% SCPW, respectively. Replacing corn silage with "medium" or "low" moisture SCPW resulted in a reduction of 36% in average daily gain for both silages. Daily dry matter intakes were reduced by an average of 27% and feed efficiency by an average of 14% for both silages compared to steers fed 0% SCPW silages. Steers fed the 0% SCPW silage diets had the highest apparent dry matter digestibilities ($P < .05$). There were no differences ($P > .05$) in apparent dry matter digestibilities of the three SCPW silage diets. These results are consistent with the performance data already discussed.

CONCLUSIONS

Sweet corn processing waste silage is a good nutritious roughage source for ruminants. The high moisture content of the SCPW does limit maximum dry matter intake by feedlot cattle due to bulk density and rumen distension effects on feed intake. Replacing 50% regular corn silage with SCPW silage in growing diets does not inhibit steer performance and has the potential of reducing the feed cost of gain in the feedlot.

Practically from the food processor's viewpoint, it appears from this data that it would be difficult for the processing plants to justify the reduction of SCPW moisture content below 78% prior to ensiling as quality of the product for livestock feeding is not enhanced. Minimum moisture reduction by a preliminary squeeze at the plant is advantageous from the environmental point of view. Chopping the SCPW prior to ensiling does enhance the silage quality.

A major concern not directly addressed by the feeding trials reported here is the disposal of the effluent run-off from the silage stacks and that which is squeezed out from the waste prior to ensiling. Analysis of the effluent taken from the "medium" and "low" moisture SCPW silages used in trial two indicates a low pH solution containing quite a high level of crude protein and soluble carbohydrates.

Table 6. Nutrient analysis of effluent extracted from sweet corn waste silage pressed to 78 and 71% moisture from 85% moisture content, respectively.

Analysis	Silage effluent 78% silage	Silage effluent 71% silage
Dry matter, %	6.5	6.7
Crude protein, % dry basis	15.9	16.7
Nitrogen, % wet basis	.16	.18
Volatile Fatty Acids, % dry basis		
Acetic acid, %	1.90	3.50
Propionic acid, %	.02	.03
Isobutyric acid, %	.40	.80
Butyric acid, %	.40	1.20
Lactic acid, %	5.90	7.90
Water soluble carbohydrates		
% dry basis	61.0	25.0
% wet basis	4.0	1.7
Average pH of effluent	4.2	3.9

Reduction of moisture content of the SCPW below 78% by mechanical means not only increases the loss of nutrients from the silage but also enhances the concern for effluent disposal. Aeration of lagoons at processing plants has improved the quality of the effluent being irrigated onto the land but unless the sweet corn processing industry adopts a process of dehusking the corn ears which does not require high volumes of water, the disposal of the effluent will remain an annual concern. Livestock feeding of the SCPW silage is probably the best use of this waste feedstuff to date. Again, the quality of the SCPW can only be enhanced if a reduction in water volume can be achieved during the sweet corn processing system.

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ANNUAL REPORT OF COOPERATIVE REGIONAL PROJECTS
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1. PROJECT NE-124, Genetics and Physiology of Sweet Corn Quality, Pest Resistance and Yield

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3. PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

A. Subcommittee on genetics and metabolism (Illinois, Indiana and Pennsylvania)

The sugary enhancer (se) gene has been shown to increase the kernel sucrose content in sugary (su) cultivars when homozygous. While the beneficial quality attributes se imparts to su kernels has produced an interest by the sweet corn industry to utilize this gene, relatively few su se cultivars have been developed and released. Unlike other endosperm mutations, su se kernels are not readily apparent in segregating populations. The only reliable method of identifying kernels likely to contain the se allele is by quantifying the sugar content of the kernel. The time and expense has limited the incorporation of this gene into elite backgrounds by breeders. What is needed is a genetic marker which can readily and easily identify kernels containing se.

Single kernel analysis and the B-A translocation procedure were used in conjunction to identify the chromosomal location of the se gene. A deficiency on the long arm of chromosome 4 permitted the expression of the se phenotype, high sugar and light kernel color, in a hemizygous condition.

Single-kernel analysis was successfully used to identify se kernels in segregating populations that were homozygous for the su gene. It was determined that sucrose was the principle sugar affected by the expression of the se gene. It was also determined that characteristic high levels of maltose content in mature su se seed and light yellow kernel color are not always associated with se se kernels. These two traits possibly represent gene linkage. Characteristic high levels of percent moisture content in su se kernels at advanced stages of kernel development was identified as an expression of high sugar content in the kernel. su se kernels were also found to weigh less at maturity than su + kernels. Sugar analyses of dent kernels segregating for se gene dosage suggest that this gene is expressed in normal dent corn and results in increased kernel sucrose content.

Amylose percentage and distribution of linear chains of ampylopectin were determined by gel filtration after debranching with isoamylase on mature starch granules of sweet corn P39-5xP51-B su, bt, su;bt and normal counterparts. Starch gelatinization properties determined by DSC and starch-granule susceptibility to amylase were also investigated. Starch granules of su;bt are of the high amylose type, easily digested, and have lower gelatinization temperature and smaller H than the other genotypes. Brittle-1 is epistatic to su for pasting characteristics (DSC), however, su is epistatic to bt for ratio of FrIII to FrII of amylopectin.

Gelatinization and retrogradation properties of a number of mature starches of su2, du,wx,ae, and several combinations in the Oh43 inbred were examined by DSC. Conclusion temperature (T_c) for wx, and du were 7-8° and 3°, respectively higher than normal starches, T_c for su2 was 10-11° lower than normal starch. For ae;du,ae;du;wx,du;wx,ae;su2,wx, and ae;wx;02 starches T_c was higher and for su2; wx,du;su2, and du;su2;wx T_c was much lower than for normal starches. H of wx was highest, du and du;wx were near normal, and su2 was very low and all other combinations were lower than normal. T of retrograded starches was lower and wider (T_0 -T_c) than respective native starches. H increased with time of storage and peaked within one week. The H of retrograded starches was smaller than respective native starches and the H for wx containing starch was large, while su2 containing starch was small.

Inbreds 27 and hybrids 67 (public and private yellow sweet corns) were analyzed for carotenoids by HPLC. The range of relative total pigment was ten-fold (3404 to 337), and the median was about 1250. The range of relative total -carotene equivalent was 20-fold (212 to 10), and the median was about 50. The inactive xanthophylls, lutein, zeaxanthin and zeinoxanthin, were more abundant than the provitamin A, and their ratios varied widely. Although lutein was usually the most abundant zeaxanthin exceeded lutein in a few samples. This in desirable because zeaxanthin imparts a deeper yellow color to the kernel than lutein, and may also be correlated with high cryptoxanthin. Zeinoxanthin exceeded cryptoxanthin in nearly all samples.

B. Subcommittee on environmental influences and seed quality (Florida, Idaho, Illinois, Minnesota, New York, and Wisconsin)

Supersweet corn seed was treated with Captan, Thiram, Difolitan, Apron, and Imazalil in combination or alone to evaluate their effect on emergence and stand establishment. The seed was treated by a standard batch seed dusting method, or during seed priming which allowed the seed to partially hydrate in the presence of the chemical solution. Three microbial treatments were also evaluated for their effects on stand establishment and early seedling growth using the priming technique. The seeds were sown on four planting dates in the Spring of 1988, on sandy soil in Gainesville. The first planting experienced severely low temperatures, however, 76% emergence was obtained with a Captan, Thiram, Apron, and Imazalil combination treatment compared to 56% for the control. Similar differences in stand were observed on the second planting while stands were similar regardless of treatment in the third and fourth plantings where soil temperatures were warmer. Seed priming with seed treatment improved the rate of germination. The addition of the microbial treatments did not improve stands of the corn.

Germination Test Reproducibility; Germination test results were inconsistent across testing labs. Lab interacted with seedlot, some labs obtained high results with one seedlot while other labs obtained highest results with different lots. Extending the test 2 days or performing the test in soil instead of towels improved but did not solve reproducibility problem. Timing of Harvest for Optimum Seed Quality: Rolled towel germinability paralleled dry matter accumulation reaching a plateau of 98%. Black layer formed 5-10 days after maximum dry weight. Field emergence reached a maximum 10-20 days after black layer and began to decline 20-30 days after black layer. Seed quality from late planting was highly erratic. Kernel moisture was not useful as a maturity indicator. Seed enhancement by Moisturization: Moisturization by incubation with moist solid media prior to planting reduced field emergence by three percent in two experiments and 13 percent in another experiment. Vigor Testing: The best standard rolled towel predictor of field emergence among ten commercial lots was the 7 day test with a two day extension (r=.90). This was better than other versions of rolled towel germination or the soil (or sand) test (r=0.78). Among lots differing in harvest produced on station, rolled towel germination, single seed leachate conductivity, and germination following accelerated aging were correlated with field emergence (0.613, - 0.654, 0.770 respectively). The cold test in rolled towels with soil added was not significantly correlated with field emergence.

A series of <u>shrunken</u>[2] composite populations selected over 11 cycles for improved cold tolerance and seed weight were tested by NE-124 scientists in Illinois and Wisconsin to uncover relationships between kernel morphological and carbohydrate characteristics and field emergence, seedling vigor, and stand uniformity. It was shown that high sugar content, kernel leachate conductivity and visible signs of *Fusarium moniliforme* infection in mature-dry kernels was detrimental to subsequent seedling emergence and vigor. Kernels with increased starch content and kernel weight displayed improved cold tolerance.

Foliar applications of ethephon (CERONE) were evaluated for effects on plant architecture, resistance to lodging, and various yield fractions (husked yield, cut corn recovery, and usable ears for c-o-c freezing). The results indicated that foliar appliacations (.25 lb. a.i./A) applied when the embryonic tassel is 12-20 cm long, plant height was reduced by approximately 20 cm. Ear height was reduced by 12 cm. In addition, lodging was significantly reduced without having any deleterious effects on yield fractions.

Sweet corn for processing is planted over a period of 6 to 8 weeks from May through June. This extended planting season has often raised questions concerning N requirements as the planting date is parogressively delayed. Proper plant populations also need to be selected in order to maximize efficiency of N utilization. Yields increased with N fertilizer up to 120 lbs/A. When averaged over all planting dates, maximum cut corn yields were obtained with a population of 17,000/A and a N rate of 120 lbs/A. Maximum useable ear recovery resulted from a population of 22,000/A and a N rate of 120 lb/A.

Cerone growth regulator was evaluated at 0.25 and 0.38 lb Al/acre, at two application timings, on four sweet corn hybrids to determine the potential for reductions in plant height. Measurements were taken on silking date, plant ht., ear ht., ear wt., ear length, tip fill, tip cover and marketable ears. The tallest hybrids (Tendertreat se] and Silver Queen [su] were reduced to the stature of Jubilee' (su) without significant effects on any of the other variables. However, the hybrids Jubilee and Crisp n Sweet (sh2) had significant numbers of ears in which the cob grew beyond the husk, rendering them unsaleable. This was most apparent when Cerone was applied at late-whorl. When data was subjected to split-plot analysis, significant treatment X hybrid interactions occurred. It is apparent that Cerone can be used to reduce very tall hybrids to a desirable stature without affecting yield characteristics, but all hybrids do not react in similar fashion to this growth regulator.

11 seed treatments using combinations of Captan, Imazilil, Nussan, and Apron were examined in the field and in the growth chamber. Significant improvements in germination and reductions in die-back were observed for improved by using certain seed treatments.

Many people have felt that field emergence of sh2 hybrids may be improved by planting on sandy soils. This experiment was designed to test this hypothesis. Over two years emergence on a loamy sand was never better than on a silt loam and for most planting dates it was reduced.

Chilling (5°C-24 hrs) of seed immediately after planting in rag dolls reduced emergence by 30% averaged over six hybrids. The same treatment (5°C-24 hours) applied after 24 hours at 21°C reduced germination by only 5%, a nonsignificant change from the unchilled control. Reduction in germination was also obtained by soaking the rag dolls in ice water and then placing them in a 21°C chamber.

C. Subcommittee on germplasm resources (Hawaii, Indiana, Massachusetts, Minnesota, and Wisconsin)

The variation existing in publicly released sweet corn was quantified. This was done through pedigree analysis, biochemically and morphologically. Not suprisingly, the preliminary analysis indicates that the germplasm base is narrow and that Golden Bantam played a major role in its development. U.S. Corn Belt Dent and certain Latin American races such a Tuxpeno can contribute to an improved stalk and root quality and plant health. A number of recurrent selection programs are underway to incorporate desirable traits from non-sweet germplasm. Traits include rust and MDMV resistance and improved stalk quality.

Fasarium moniliforme was the primary target of research reported this year, in its four common phases in Hawaii -- as kernel and cob rot, as poor seedling emergence and mortality, as "staygreen" plant and as a stalk rot. The latter two are very rare in Hawaii, expressions dependent on hot wet weather that are rare here. Consistently good expression on genetic variability in kernel rot and seedling emergence have advanced most supersweet stocks to satisfactory levels of resistance. "Staygreen" and stalk rot resistance do not appear highly correlated to the kernel traits. Breeding continued for these and other traits in a program of tropical hybrid and synthetic development based largely on the gene brittle.

The Vg gene reduces both the ligule during the vegetative phase and the glume wings during the floral phase. Thus, the Vh recognizes the homology of these two structures and thereby supports the validity of the phytomer concept as a developmental pattern common to both phases. Because the liguleless effect of the Vg gene can be scored in seedlings grown in greenhouse sand flats during the winter, one may identify homozygotes ahead of the summer field planting. Only homozygous Vg inbreds are useful and comparable in breeding glumeless sweet corn. Vegetative multiranking is a transposed manifestation of floral multiranking of value in understanding the genetic control of morphogenesis and of potential value for increasing yield.

The natural grouping of maize by differences in rachilla and cupule development is correlated with differences in ear shapes, pyramidal and cylindrical, and by apparent independent domestications out of two different teosintes, Chalco (Central Plateau) and Balsas (Guerrero). Much of the hybrid vigor expressed in the Southern dent-like by Northern flint-like crosses within the Corn Belt maize appears to be the dispersed hybrid vigor resulting from the interaction of germplasm tracking back some 8000 years to these two different teosintes.

Selection was practiced on S_0 ears to increase kernel weight of sugary-2 opaque-2 stocks, based on performance of populations per se and of comparable testcrosses to su2 o2 SX stocks. Highly significant increases of 0.71 g (per 25 kernels) per cycle in the populations, and of 0.42 g (per 25 kernels) per cycle in the testcrosses, were realized. Significant positive indirect effects were noted for yield and for ear and plant height.

Natural selection was evaluated in a study of 5 isoenzyme marked chromosome segments. A composite was established, based on an adapted su sweet corn crossed with a tropical maize composite. During the 4 formative years, there was no evidence of natural selection resulting in a significant loss of linked tropical germplasm for four of the 5 segments studied.

D. Subcommittee on Diseases and Pests (Delaware, Georgia, Hawaii, Idaho, Illinois, Indiana, Minnesota, New York and Pennsylvania)

The results of the NE-124 nursery indicated that common smut was the prevalent disease in 1988. Other diseases and pests seemed to be limited due to severe drought conditions at many locations although common rust, Stewart's wilt, northern leaf blight, corn ear worm, European corn borer, and sap beetles were reported from multiple locations. The use of hybrids resistant and susceptible to common smut gave a good indication of the range of responses that were observed at various locations under moderate disease pressure.

Results from specific experiments were reported from studies with European corn borer, corn earworm, common rust, maize white line mosaic, gray leaf spot, northern leaf blight, Stewart's wilt, and seed-borne fungal infection.

The basic seed protectants captan + thiram (CT) gave a significantly higher stand especially in combination with metalaxyl and benomyl or thiabendazole. Interaction of genotype, fungicide, and planting date were shown to be complex. *Thichoderma* species appear to be useful as seed applied biocontrol agents. Moisturization impaired emergence. *Fusarium moniliforme* increased as harvest was delayed. Seed was much lower in *Penicillium* sp. than typical commercial lots. Stand losses up to 60% were recorded in commercial fields. Blighted seedlings consistently showed lesions on the scutellum, mesocotyl and occasionally discoloration of the crown. Isolations from the diseased tissues yielded species of *Penicillium* and *Fusarium*. Preliminary tests revealed that shrunken-2 sweet corn seed were commonly contaminated with species of *Rhizopus*, *Aspergillus*, *Penicillium* and *Fusarium*. Testing methods using blotter and culture media (PDA, PDA + Osgall, Fusarium-selective medium) were evaluated. Oxgall containing media appeared useful for detection of slow growing species in the presence of rapidly growing fungi.

Ascospore morphology and nuclear conditions were examined in collections of *Gibberella zeae* (asexual state: *Fusarium graminearum*). Findings suggest that other characters besides ascospore septation are necessary to separate generations in the Hypocreales.
Incidence-severity relationships for common rust (*Puccina sorghi*) on a susceptible and a resistant sweet corn hybrid were similar, with severities of 1, 2, 3 and 4% occurring at about 52, 82, 92 and 95% incidence. A 1 to 2% rust severity threshold is proposed for initiating fungicide applications to control rust on susceptible hybrids. Fungicide trials substantiated the proposed threshold. Substantial differences were noted among sweet corn inbreds for apparent incidence, in vitro incidence and emergence of kernels infected with *Fusarium*

moniliforme. A strong maternal influence was observed in reciprocal crosses of resistant and susceptible inbreds. The effect of Stewart's and Goss' wilts on sweet corn yield depended on the level of host resistance and the time of infection. A resistant hybrid sustained no yield reduction; whereas, yield reductions increased with earlier infection (three- to five-leaf stage as compared to five- to seven- or seven to nine-leaf stages) for moderately susceptible and susceptible hybrids.

Sixty-five of 88 sugary S_1s evaluated for the second year exhibited significant ear feeding resistance following artificial infestation at the ear tip with European corn borer larvae, as compared to Jubilee. Fewer than 11% of the plants in the 9 best entries had kernel damage at the ear tip compared to 90% for Jubilee.

Fungicide evaluation (systemic and contact) for common rust control potential was conducted on 'Jubilee' sweet corn. Due to extreme environmental conditions (heat and drought), rust severity was considered mild. The maximum severity recorded was 18% of the flag leaf area infected with rust pustules. Diniconazole and propiconazole gave the best control (4 and 8% of the leaf area infected, respectively) when compared to standard mancozeb treatments. Useable ears (for corn on the cob freezing) were significantly reduced in myclobutanil and RH-7592 treated corn when compared to mancozeb treatments.

Interactions between planting date and population and their effects on leaf canopy microclimate and rust severity continue to be studied. A data base of temperature and relative humidity within the leaf canopy associated with three population densities at four planting dates is being compiled and will be related to rust severity and the resulting yield fractions (husked weight, useable ears, and cut corn recovery). The long term objective is a computer prediction model to assist growers/processors in implementing control strategies.

Thirty-six s2 families of Zapalote Chico were obtained from CIMMYT, planted at Aurora, N.Y. and relatively well adapted plants were self-pollinated to begin generating a set of Zapalote Chico inbreds to serve as potential sources of corn earworm and European corn borer resistance.

Work is continuing to incorporate resistance to Cercospora zeae-maydis, casual agent of gray leaf spot. Resistance is quantitative, strongly additive and not highly complicated.

4. USEFULNESS OF FINDINGS

A. Subcommittee on genetics and metabolism.

The sugary enhancer gene has already become important in the seed trade and fresh market. However breeding work with this gene has been hampered by the difficulty in recognizing its presence. The research on characterizing its expression and genetic location will greatly assist plant breeders in developing new varieties with high quality. Furthermore the important information on the biochemistry and physiology of the seed has resulted from the study endosperm mutants. Sugary enhancer results in unusual types and levels of sugars. Studies of this mutant will lead to increased understanding of the enzymes involved in carbohydrate synthesis in maize.

New uses of the maize crop as well as the improvement of sweet corn quality will result from the research on carbohydrate characterization. The industrial use of maize is an important industry and an improved understanding of carbyhydrates could result in entirely new uses and will also allow plant breeders to develop varieties that produce desired levels of various components. It will also allow the selection of improved sweet corns that have improved sugar levels and also improved germination.

The pigment B-carotene is an important nutritional component in the human diet. Research on the levels of this and other pigments in sweet corn could result in improved nutritional value of sweet corn.

B. Subcommittee on environmental influences and seed quality.

While the shrunken-2 and sugary enhancer genes result in improved quality and increased consumer acceptance their use has been limited due to reduced field emergence. Research on seed production methodology, and seed treatments, has produced information that will be immediate use to seed producers in their efforts to produce high quality seed. likewise information on the environmental causes of poor emergence has resulted in information enabling the farmer to make informed decisions regarding the timing of planting.

The use of plant growth regulators in decreasing stalk lodging was shown to be useful on certain cultivars and thus could result in increased harvestable yields and product quality. However, it was also shown that certain cultivars do not react to these regulators in the same way and in some cases they could damage the crop. Thus, these products must be used with care.

C. Subcommittee on germplasm resources.

The improvement of sweet corn depends upon the identification of useful variation and the level of existing variation. The determination of the molecular variation existing in sweet corn and the relationships of the inbreds allows the breeder to create new breeding pools. The identification of promising exotic germplasm pools gives the sweet corn breeder a basis on which to choose new material to add to his/her program. Given the advanced state of sweet corn germplasm it is extremely inefficient to incorporate germplasm whose potential is unknown. Studies on the changes in isozyme patterns during the adaptation of tropical maize germplasm to the temperate zone could result in the identification of genes of chromosome segments important in adaptation. And also result in techniques allowing the direct selection of such segments.

Fusarium moniliforme is one of the most serious pests of sweet corn throughout the world. Identification of sources of resistance as well as selection criteria will result in great improvements in the sweet corn crop. The investigations on sugary-2 opaque-2 corn will result in improved nutritional value and seed quality of high protein maize.

The vestigial glume gene (Vg) results in reduced glumes at the base of the kernel. Thus, effective kernel depth is increased. However, due to associated pollination problems Vg has not been used in any commercial hybrids. The observation that Vg reduces ligule development may allow the commercialization of this useful system.

D. Subcommittee on diseases and pests.

The prominent pest in 1988 was common smut. Other pest and disease problems were probably limited by severe drought conditions at many locations. Common rust, Stewart's wilt, NLB, corn earworm, European corn borer and sap beetles also were noted at multiple locations. The nursery indicates that the major disease and insect problems on sweet corn are somewhat different than those on dent corn; and that the importance of sweet corn pests and diseases varies between regions.

It is possible to improve seed quality with regard to the presence and deleterious effects of fungi in the kernel by timely harvest and improvements in drying and conditioning practices. Mixtures of at least three or four fungicides will be necessary to protect commercial lots of sh2 seeds. A biocontrol agent performed as well as a powerful three component mixture, and treatment with antagonistic fungi may be useful commercially. Moisturization probably should not be considered as a way of enhancing sh2 seed at this time.

The studies described provide useful information which will allow for a better understanding of the methods by which to best control diseases of sweet corn. Estimates of yield reductions can be used to determine economic levels of control. Evaluations of resistance and other control measures will determine how these low levels of disease can best be achieved.

Corn borer resistance would reduce one of the most significant costs in the production of sweet corn for processing.

Comparative evaluations of systemic and contact fungicides have shown differences in rust control potential. In addition, deleterious effects on various yield fractions have been associated with some of the systemic materials and should be considered when implementing control strategies.

An investigation of cultural effects (other than fungicides) on rust incidence and severity will aid in the development of a computer prediction model for use by processors. Preliminary results from Zapalote Chico s2's suggest that temperately-adapted breeding lines can be developed from this material. Lines being developed will provide breeders with an exotic source of insect resistance in a form readily manipulated for both conventional and novel breeding approaches to incorporating this resistance into elite sweet corn lines.

The results suggest that incorporating resistance to gray leaf spot should not be extremely difficult and that with adequate screening techniques, resistance levels should improve.

5. <u>WORK PLANNED FOR NEXT YEAR</u>

Data analysis of precise chromosomal location of the _se_ gene by RFLP analysis and linkage to morphological marker genes in chromosome 4L of the maize genome.

Ascertain the metabolic effect of _Se_ on kernel carbohydate metabolism through the use of several _su_, _+_, and _su se_ isolines in both developing and germinating kernels.

Continue studies of the effect of _se_ on dent kernel carbohydate metabolism.

Plans are to continue the tissue culture studies, the endosperm developmental studies, genetic studies with _sugary-2_ mutable alleles.

Characterization of endosperm carbohydrates will continue for food and nonfood application and nutritional quality improvement.

Characterization of compartmentation of enzymes of carbohydrate metabolism in the amyloplast and cytosol of maize endosperm will be continued.

The concentration of fructose-2,6-bisphosphate and PPi in maize endosperm will be measured.

Molecular, pedigree, and morphological data will be complied form a data base on sweet corn diversity.

Gain from recurrent selection programs will be evaluated.

New maize synthetics will be developing incorporating the _sh2_ gene and coordinated selection programs using sites in various states will be initiated.

Recurrent selection for corn borer resistance will continue.

Results from field studies in two different locations for 2 years will be correlated with laboratory analyses for seed quality parameter. In addition, inbred isoline homozygous for normal, _su_, _se_, $\underline{bt}_1$, and $\underline{sh}_2$ will be field tested for cold tolerance.

Fungicide seed treatments will be evaluated at multiple locations.

Investigation of seed production practices on seed quality will continue. These experiments will include timing of harvest, moisture at harvest, drying temperatures, and seed moisturizing treatments.

Techniques for the application and timing of application of plant growth regulators will be investigated.

The disease and insect nursery will be continued in 1989 to identify pest and diseases prevalent on sweet corn. The use of hybrids resistant and susceptible to specific diseases can be valuable in determining the range of reactions, such as with the common smut in 1988.

Work will be continued on standardization of methods of seed health testing, identification of the fungi associated with sweet corn seed and evaluation of their pathogenic potential. Characterization of seedling blight symptoms will be continued and the casual agents isolated and tested for pathogenicity. A worldwide network of locations will be established to uniformly evaluate combinations of fungicides for treatment of shrunken-2 seed. Another seed production experiment will be conducted in which four seed parents with diverse seed quality attibutes will be grown together and hybrid seed harvested repeatedly between 20 and 90 days after midsilk. Seed produced will be characterized regarding presence of seed borne organisms, germinability, vigor, and field emergence ability. A major survey of shrunken-2 seedlots will be performed. The finished product will be surveyed industry-wide and for about ten lots, samples will be pulled at every phase in the production/conditioning sequence. Samples will be characterized regarding vigor, germinability, field emergence, and seedborne microflora.

Evaluations of fungicidal control of rust will be continued for one more year to substantiate previous findings. The northern leaf blight yield loss work and resistance evaluations will be expanded. Work with the four-leaf seedling blight program and seed-borne fungal infection will be expanded. Interesting "side projects" on Gibbrella zeae and Spharellopsis filum (=Darluca filum), a common hyperparasite of P. sorghi, will be done as time permits.

Testcrosses utilizing sugary lines resistant to ear feeding by European corn borer will be evaluated to determine if the resistance in the lines is transmitted to the hybrid. Also, resistant lines will be recombined. Work on the nature of resistance and its genetic manipulation will be initiated to determine if these sources are of value.

Work will also be continued toward the development and release of new sources of "partial" resistance to leaf rust as a supplement to the hypersensitive reaction forms of "strong" resistance now in use by the industry.

Fungicide evaluations will continue. Also, epidemiological studies on planting date x population density interactions on leaf canopy microclimate and rust incidence will continue.

Adapted Aapalote Chico inbreds will be developed, and preliminary tests will be done to determine their CEW and ECB resistance. Contingent on the availability of support for molecular work, crosses to initiate molecular analysis of resistance in Zapalote Chico may be made.

Replicated field plots of promising sweet corn hybrids will be conducted in the Hudson Valley. Basic virus studies with MWLMV will include characterization of the virus genome, cloning of the satellite virus, and further studies with potential fungal vectors.

Will continue efforts on the improvement of gray leaf spot resistance. Genetics analyses currently underway should be completed during the year.

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