Northern Uniform Winter Wheat Scab Nursery
(NUWWSN)

Report on 2000-2001 Nursery

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This report is a compilation and analysis of data from the cooperative assessment of resistance to Fusarium Head Blight (scab) (causal agent *Fusarium graminearum* (teleomorph: *Gibberella zeae* Schwabe.)) in winter wheat germplasm adapted to the northern regions of North America. Funding for the evaluation comes from the U.S. Wheat and Barely Scab Initiative, state and provincial agricultural experiment stations, USDA-ARS, and private companies.

This report contains preliminary data that has not been confirmed and thus is not suitable for general release to the public. Interpretation of the presented results may be modified with additional research. Confirmed results should be published through established channels. This report is to be used as a tool for the cooperators in the NUWWSN, their staff, and persons having direct interest in the development of wheat germplasm and agricultural research programs.

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MATERIALS AND METHODS

Entries:

There were 45 lines and four checks in the 2001 trial (Table 1). The lines were from 15 breeding programs. Four entries were also in the 2000 NUWWSN (MO890525, MO981020, NY87047W-6048, NY87048W-7388). There were only 29 entries in the 2000 nursery, and 28 in the 1999 nursery.

Tests:

The entries were successfully evaluated in 11 field tests (locations) and four greenhouse tests (Table 2). Data was obtained from 14 cooperators while seed was sent to 21 cooperators.

Traits:

Data was collected on heading date, disease severity, disease incidence, disease index, kernel rating, percent scabby seed, and DON. These traits are described in Table 3. Data was not collected on all traits in all tests (Table 3). Some researchers collected additional data that are summarized and described in Table 15.

Cooperators in Kansas collected disease index at different times. We used the index data collected on May 29th as it provided a good differentiation between resistant and susceptible checks (Ernie, Freedom, P 2545) and had a relatively low CV. Cooperators in VA reported incidence on a 0-9 scale. This was converted to a 0-90% scale for analysis across tests and to calculate disease index.

Data Analyses:

Most cooperators sent entry means (not raw data) with some summary statistics from their trials. These means are presented in the appropriate tables and no additional within test analyses were performed. The entry means from individual tests were used to calculate entry means over tests. ANOVAs (model: trait = entry test) were conducted for each trait and the entry x test mean square (residual or error in this model) was used as the error term to calculate a LSD for entry means over tests. R^2 values in the tables indicate the proportion of total sum of squares accounted for by entry and test effects while $1-R^2$ is the proportion of total sum of squares due to the entry x test interaction (ETI) effect. There was no test for significance for this interaction

Based on $1-R^2$, ETI appeared quite large for DON, disease index and severity from the field trials, so multivariate statistics (Yan et al., 2000 Crop Science 40:597-605) were used to analyze the interaction and group those tests that produced similar results for disease index, severity, and DON. Entry means were then calculated over the tests that produced similar rankings (Tables 9, 10, 13). A group of tests that produced similar rankings and results was called a megaenvironment.

Due to the completeness of the data sets, regular entry means over all tests (or tests within a megaenvironment) are presented for all traits except disease severity from the greenhouse trials. For this trait, data was missing for several entries (due to vernalization problems in the IL test) so least square estimate of entry means over the three trials were derived and are presented in Table 14.

There was considerable missing data from the Nebraska field trial so this data was omitted from all means and analyses. The entry means from the NE trial are presented in all appropriate tables.

Correlations were calculated between all traits using entry means averaged over all appropriate tests.

RESULTS

All traits

Entry was a significant source of variance for all traits. There was little ETI for heading date, disease incidence, disease severity from greenhouse tests, kernel rating, and % scabby seed as entry + test effects accounted for more than 72% of the treatment sum of squares. Thus, entry means over all tests are appropriate estimators of genetic value.

ETI seemed to be an important source of variation of disease severity from field trials, disease index, and DON. Each is discussed below.

Disease severity from field trials

The ETI accounted for 46% of the treatment sum of squares for field disease severity. Multivariate analysis indicated that most of the ETI among the eight tests was due to differences between three groups of tests, called megaenvironments: (AR+IL+MO+VA) versus (IN+OH+ONT) versus MI. Correlations among entry means from tests within the same megaenvironment were mostly greater than 0.5. The correlations between entry means from different megaenvironments were less than 0.31, with the lowest correlation between the MI and AR+IL+MO+VA groups (r = 0.00).

The ETI would appear to have little effect on selection. Assuming selection of the six most resistant (or susceptible) entries, 66-80% of the resistant selections would be the same between any two megaenvironments (Figure 1). Four entries (25R18, Hondo, MO890525, SD97060) would be selected in all three megaenvironments, three (Harding, MO891020, NY87048W-7388) would be selected in two of three megaenvironments, and one (IL97-1828) would be selected in only one megaenvironment (Figure 1). Four entries (OH684, OH669, Patterson, P 2545) would be selected as susceptible in all megaenvironments.

Disease index

The ETI pattern for index was strongly associated with the ETI pattern for severity. This is logical as index is a function of severity and incidence and there was little ETI for incidence. ETI accounted for 55% of the treatment sum of squares for disease index. The tests were placed in three megaenvironments: (IL+MO+VA) versus (KS+OH+ONT) versus MI. Tests that were in the same megaenvironment for severity were in the same megaenvironment for index and the MI site was an outlier again. Correlations among entry means from tests within the same megaenvironment were mostly greater than 0.55. The correlations between entry means from these different groups were all less than 0.28, with the lowest correlation between the MI and IL+MO+VA groups (r = 0.04).

The ETI appears to have a slightly greater affect on selection for index than for severity. Assuming selection of the six most resistant (or susceptible) entries, three entries (MO980525, MO981020, SD97060) would be selected for resistance using data from any of the three megaenvironment (Figure 2). Three (Harding, Hondo, NY87048W-7388) would also be selected using data from either IL+MO+VA or KS+OH+ONT. Three entries (MDV71-19, OH669, P 2545) would be considered susceptible using data from any megaenvironment (Figure 2). One entry (97463A1-17-1) would be selected for resistance using IL+MO+VA data, but would be considered susceptible using MI data.

DON

Entry x test interaction accounted for 35% of the treatment sum of squares for DON. The VA and OH locations gave similar results (r = 0.60 between them) while the AR site gave different rankings from the other two sites (r = 0.38 between AR and other two sites) (Table 13). Only one genotype ranked 5th or lower in AR was similarly ranked in VA or OH. P 2545 was ranked last (highest DON) in OH but ranked 1st (lowest DON) in AR.

Correlations among traits

Correlations were calculated among entry means over appropriate tests for all traits including disease severity in the greenhouse (Table 15). Heading date was not highly correlated to any other trait, but was moderately correlated to DON (r = 0.42). There was a high correlation among head traits (incidence, severity, index) from the field (r = 0.74 to 0.95). These traits were moderately correlated to severity from the greenhouse (r = 0.46 to 0.59). Kernel traits (kernel rating, % scabby seed, DON) were highly correlated to one another (r = 0.70 to 0.84). Kernel rating and % scabby seed were highly correlated to the field head traits (r = 0.64 to 0.78), while DON was only moderately correlated to the field head traits (r = 0.47 to 0.50). All kernel traits were only moderately correlated to greenhouse severity (r = 0.31 to 0.49).

Most resistant and susceptible entries

Entries were rated for seven disease traits by comparing each entry mean to the best and worst entry mean for each of the seven traits (Tables 4, 5). Only two lines (MO980525, MO981020) were not significantly different from the most resistant entry for all seven traits. These entries also had low disease index and severity scores (Table 10) in all three megaenvironments, indicating stable resistance. They were also the most resistant in the 2000 NUWWSN greenhouse tests and had low index scores in 2000 field tests.

Seven entries appeared quite resistant based on six of seven traits, often having moderate severity in the greenhouse tests as their weakness. Nine other entries appeared resistant based on five of seven traits, generally having moderate severity in greenhouse tests and moderate to high incidence as their weaknesses. NY97048W-7388 also had low severity (field and greenhouse) in 2000. The probable source of resistance for these lines in presented in Table 6.

Two entries (OH669, NY88005-6035) were not significantly different from the most susceptible lines for all seven disease traits (Table 5). Four other entries were susceptible based on at least five of seven traits.

Table 1. Entries in the 2001 Northern Uniform Winter Wheat Scab Nursery

Entry	Name	Pedigree	Contributor
1	Patterson	Cultivar	Check
2	Freedom	Cultivar	Check
3	P2545	Cultivar	Check
4	Ernie	Cultivar	Check
5	Hondo	Cultivar	W. W. Bockus
6	KS96HW115	Arlin/KS89H130	W. W. Bockus
7	Heyne	Plainsman V/KS75216//SUM754308/3/Plainsman V/KS82W422	W. W. Bockus
8	MDV71-19	CK 983//GA-ANDY/VA 90-21-20	A.Cooper/J. Costa
9	MO980525	MO 11769/Madison	Anne McKendry
10	MO960827	MO 10501/IL 85-3132	Anne McKendry
11	MO981020	MO 11769/Madison	Anne McKendry
12	MO980429	MO 10136/Ernie	Anne McKendry
13	IL96-3514	IL90-7675 / L880437	Fred Kolb
14	IL96-6472	IL90-11637 / L889437	Fred Kolb
15	IL97-1828	P8138l1-16-2-1-1-3-3 / IL90-4813	Fred Kolb
16	IL97-4228	IL90-6364 // Y88-3a / IL85 -3132 - 1	Fred Kolb
17	IL97-6268	IL87-2834-1 / IL84-4046 // IL90-6364	Fred Kolb
18	Roane	71-54-147/CK68-15//IN65309C1-18-2-3-3	Carl Griffey
19	VA96-54-326	SC861562/COKER9803	Carl Griffey
20	VA98W-591	92-51-39(IN71761A4-31-5-48//71-54-247/MCN1813/AL870365(CK747*2/AMIGO)	Carl Griffey
21	VA98W-593	92-51-39(IN71761A4-31-5-48//71-54-247/MCN1813/AL870365(CK747*2/AMIGO)	Carl Griffey
22	VA99W-553	(SHI4/CHIL"S")/3/92-51-39//FFR555W/RCT/4/CK9803	Carl Griffey
23	VA99W-562	(CHILL "S"/YMI6)PION2548//PION2684	Carl Griffey
24	VA99W-567	(CHILL "S"/YMI6)PION2548//PION2684	Carl Griffey
25	25R18	WBG0195E2/2510//2510	Bill Laskar
26	OH669	BLUEBOY2/CLARK//HOWELL/OH416	Pat Lipps/C Sneller
27	OH684	OH470/OH449	Pat Lipps/C Sneller
28	OH699	OH470/OH449	Pat Lipps/C Sneller
29	NY87048W-7388	84074(Ho/Su Mei)/Harus	Mark Sorrells
30	NY87047W-6048	84074(Ho/Su Mei)/Houser	Mark Sorrells
31	NY89052SP-9232	881199 (Geneva/84004/6-1MR)/Geneva	Mark Sorrells
32	NY88024-117	Houser/Kleibr//White 3 way cross Composite	Mark Sorrells
33	NY88005-6035	NY6432-18/ Geneva bulk	Mark Sorrells
34	NY89103-9149	W7163/88038	Mark Sorrells
35	961331A46-1-6	9017/INW9811/3/FREEDOM//INW9824/4/9218	Herb Ohm
36	9793A1-5	INW9853/INW9811//ERNIE	Herb Ohm
37	97397B1-4-5	Fdm//Clk*4/N7840/3/Gfd/Clk*4/N7840	Herb Ohm
38	97398C1-5-3	Fdm//Clk*4/N7840/3/Gfd/Clk*4/N7840	Herb Ohm
39	97417A1-3-4	INW9811//Clk*4/N7840/3/Fdm//Clk*/N7840	Herb Ohm
40	97463A1-17-1	INW9812/Gld//Clk*4/N7840	Herb Ohm
41	GA901146 E 15	831127-3 // 821264 * 3 / 79102 (Blueboy/Amigo)	Jerry Johnson
42	KY92C-491-18-1	C762/GA 74-19//84C-048-1-1	D. Van Sanford
43	KY92C-432-62	84C-048-1-1/84C-051-6-1	D. Van Sanford
44	KY91C-170-3	NASW85-5626/2555//2548	D. Van Sanford
45	KY91C-170-4-1	NASW85-5626/2555//2548	D. Van Sanford
46	Harding	Brule//Bennett/Chisholm/3/Arapahoe	Amir Ibrahim
47	SD97060	ND8889/NE90574	Amir Ibrahim
48	D6234	F12.71/2*/Frankenmuth//C5107	R. Ward
49	D8006	Pioneer brand 2555/Lowell	R. Ward

Table 2. Testing information

Field: OH	Wooster, OH The Ohio State University Pat Lipps, Clay Sneller Reps: 3 Plot Size: 1 rowsx5' Seed date: 10/10/00 Harv. date: 6/20/01 Fertilizer: 300 lbs 6-24-24 in fall, 60 lbs N as Ammonium nitrate in March Inoculation: Infected corn kernels spread 2 wks prior to anthesis Precipitation during grain fill: Mist sprinkler (6-9:30 AM and 9-10:30 PM); 37.9 mm rain
Field: AR	Fayetteville, AR University of Arkansas Gene Miilus , Peter Rohman, Chris Weight Reps: 3 Plot Size: 1 rowsx5' Seed date: 10/19/00 Harv. date: 6/18/01 Fertilizer: 80 lbs N as Ammonium nitrate split application Inoculation: Infected corn Kernels applied 3 times Precipitation during grain fill: Mist sprinkler (8 times 11 minutes each between midnight and 8 AM) Date/Feekes growth stage when scored: 5/23/2001
Field: IL	Urbana, IL University of Illinois Fred Kolb, Larry Boze Reps: 3 Plot Size: 1 rowsx3' Seed date: 10/2/00 Harv. date: 7/2/01 Fertilizer: 40 lbs N pre plant Inoculation: Wheat kernels cultured with a mixture of isolates applied 3 times Precipitation during grain fill: Mist sprinkler .25 inch/ day Notes: symptoms occurred late in development: Severity lower than normal
Field: IN	Lafayette, IN Purdue University Herb Ohm Reps: 2 Plot Size: 4' x 3' Seed date: 9/27/00 Harv. date: Fertilizer: 30 N Fall + 80N-80P-0K in the spring Inoculation: Spore suspension in 1 floret at flowering Precipitation during grain fill: Mist sprinkler Date/Feekes growth stage when scored: 3 weeks after inoculation Notes: Date of inoculation 2-3 days after heading
Field: KS	Manhattan, KS Kansas State University W. Bockus, M. A Davis, R. Bowden Reps: 4 Plot Size: 1 rowsx7' Seed date: 10/4/00 Harv. date: 7/2/2001 Inoculation: infested corn kernels Precipitation during grain fill: Mist sprinkler 3min/ hour 9:0 Date/Feekes growth stage when scored: May 21, 23, 25, 29, June 1, 7
Field: MI	Mason, Michigan Michigan State University Rick Ward Reps: 1 Plot Size: 1 rows x 10' Seed date: 1 Harv. date: Inoculation: Corn inoculum spread Precipitation during grain fill: Mist sprinkler (15 seconds every half and hour)
Field: MO	University of Missouri A. McKendry
Field: NE	Mead, Nebraska University of Nebraska S. Baenziger, J. Watkins, J. Schimelfenig Reps: 1 Plot Size: 1 rows x 10' Seed date: 10/2/2000 Harv. date: 7/19/2001 Inoculation: Corn kernels applied 4 times (5/22, 6/4, 6/11, 6/18) Average temperature during grain fill: C 85-95 Date/Feekes growth stage when scored: 6/29/2001
Field: NY	New York Cornell University M. E. Sorrells, G. C. Bergstrom Reps: 6 Plot Size: 1rowx3' Seed date: 1 Harv. date: Inoculation: Infected corn kernels Precipitation during grain fill: Mist sprinkler at dusk Average temperature during grain fill: C
Field: ONT	Ridgetown, Ontario Univ. of Guelph L. Tamburic-Illncic, A. Schaafsma, A. Smid Reps: 4 Plot Size: Seed date: 1 Harv. date: Inoculation: Suspension of macroconidia at flowering stage Precipitation during grain fill: Mist sprinkler

Table 2. Testing information (continued)

Field: VA	Blacksburg, VA	Virginia Tech	C. Griffey, J. Chen, D. Nabati, J. Wison
	Reps: 3 Plot Size: 4' x 5'	Seed date: 10/3/2000	Harv. date: 7/7/2001
	Fertilizer: 25-100-120 before planting, 75-0-0 in April 01		
	Inoculation: Conidial suspension sprayed on plots		
	Precipitation during grain fill: 10.88 inches rain,		
	Average temperature during grain fill: C 15.93		
	Date/Feekes growth stage when scored: 10.5		
GH: IN		Purdue University	G. Shaner
GH: MI		Michigan State University	R. Ward
	Inoculation: Point inoculation on ten to twenty wheat heads		
GH: IL	Urbana/IL	University of Illinois	Fred Kolb and Larry Boze
	Inoculation: Needle inoculation		
	Notes: Some entries did not vernalize.		
GH: AR	Fayetteville/AR	University of Arkansas	Gene Milus , Peter Rohman, Chris Weight

Table 3. Description of traits

Code	Trait	Description	Test where data was collected
HD	Heading date	Days from Jan 1st when 50% of heads have emerged	IL, IN, KS, MI, OH, VA
SEV	Disease severity from field tests	% of infected spikelets in an infected head. Generally visually rated according to Stack & McMullen, 'A Visual scale to estimate severity of Fusarium Head Blight in Wheat', NDES. PP-1095	AR, IL, IN, MI, MO, NE†, OH, ONT, VA
INC	Disease incidence	% of heads with at least one infected spikelets	IL, MI, MO, NE†, NY, OH, ONT, VA
IND	Disease index	IND = (SEVxINC)/100	IL, KS, MI, MO, OH, ONT, VA
KR	Kernel rating	A visual assessment of the percent infected kernels	AR, IL, KS, NE†, OH
%SS	Percent scabby seed	Percent of scabby seed by weight	NE†, OH, VA
DON	DON (vomitoxin)	PPM of vomitoxin in grain sample as assayed by Part Hart, Michigan State University	AR, OH, VA
SEV-GH	Disease severity from greenhouse tests	Same as SEV except using greenhouse data	AR, IL, IN, MI

† NE data not used to calculate entry means over tests due to missing values, but the data is presented in the tables for individual traits.

Table 4. Entry means for 2001 NUWWSN (see Table 3 for information on traits and tests). Each entry was compared to the lowest (l) and highest (h) means in each column using $LSD_{(0.05)}$. "# low scores" is the number of disease traits for which an entry received a low score, "# high scores" is the times it received a high score.

	Trait:	HD	SEV	INC	IND	KR	%SS	DON	SEV-GH		
	# of tests:	5	8	7	7	4	2	3	4	# Low	# High
	Units:	Days	%	%	%	0-100	%	PPM	%	scores	scores
1	Patterson	136 l[†]	38.3 h	56.8 h	33.6 h	31.0 l	7.3	6.9 l	43.4	2	3
2	Freedom	140	19.8 l	58.3 h	20.2	50.1	6.5 l	12.6 l	35.9	3	1
3	P2545	138	39.5 h	67.5 h	40.6 h	66.5 h	13.7 h	16.2 l	52.1	1	5
4	Ernie	136 l	20.5 l	44.9 l	19.9	29.9 l	6.2 l	7.9 l	31.3	5	0
5	Hondo	141	16.0 l	45.3 l	12.6 l	33.1 l	6.0 l	4.9 l	38.3	6	0
6	KS96HW115	137	23.0	56.1 h	24.9	38.6	4.8 l	14.6 l	69.2	2	1
7	Heyne	140	18.2 l	52.1 h	14.7 l	24.6 l	5.7 l	15.1 l	34.4	5	1
8	MDV71-19	139	37.7 h	68.5 h	42.2 h	60.6 h	9.0	9.7 l	59.8	1	4
9	MO980525	143	11.0 l	29.7 l	6.9 l	23.0 l	2.4 l	5.3 l	17.0 l	7	0
10	MO960827	137	30.2	64.1 h	30.0	55.9	10.6 h	14.6 l	39.2	1	2
11	MO981020	139	13.7 l	34.1 l	9.1 l	27.3 l	6.0 l	5.8 l	19.3 l	7	0
12	MO980429	137	22.2	42.7 l	19.4	33.7 l	5.3 l	6.3 l	37.9	4	0
13	IL96-3514	138	22.8	45.2 l	20.5	27.4 l	4.2 l	3.2 l	37.6	4	0
14	IL96-6472	135 l	21.8	43.4 l	18.2 l	20.6 l	3.7 l	8.4 l	37.4	5	0
15	IL97-1828	137	18.2 l	41.3 l	14.8 l	19.8 l	3.7 l	4.6 l	45.2	6	0
16	IL97-4228	136 l	22.5	40.6 l	19.4	29.8 l	7.0	4.2 l	43.3	3	0
17	IL97-6268	139	19.6 l	43.3 l	15.9 l	32.6 l	6.1 l	5.6 l	35.9	6	0
18	Roane	138	18.3 l	54.6 h	18.0 l	32.0 l	3.8 l	5.4 l	33.5	5	1
19	VA96-54-326	138	21.9	47.6	19.7	49.0	5.6 l	7.3 l	92.7 h	2	1
20	VA98W-591	139	20.0 l	51.7 h	15.9 l	34.5 l	4.6 l	7.4 l	47.8	5	1
21	VA98W-593	138	27.6	55.3 h	21.4	36.3 l	7.0	5.3 l	59.8	2	1
22	VA99W-553	136 l	23.2	54.0 h	23.3	40.3	6.6 l	10.4 l	65.7	2	1
23	VA99W-562	140	25.6	55.1 h	25.5	50.3	8.7	11.1 l	50.1	1	1
24	VA99W-567	140	20.2 l	53.6 h	19.6	50.8	7.1	19.5 h	69.1	1	2
25	25R18	141	12.7 l	54.2 h	12.7 l	48.8	6.2 l	16.3 l	10.0 l	5	1
26	OH669	139	41.4 h	60.8 h	36.8 h	53.8	13.6 h	21.3 h	90.9 h	0	6
27	OH684	139	36.0 h	58.2 h	27.5	50.5	9.4	13.5 l	80.5 h	1	3
28	OH699	140	26.5	58.0 h	21.2	50.3	8.7	9.9 l	63.7	1	1
29	NY87048W-7388	144 h	17.7 l	47.1	12.5 l	24.0 l	3.3 l	8.4 l	23.7 l	6	0
30	NY87047W-6048	143	31.6 h	61.5 h	29.4	77.5 h	11.1 h	32.2 h	41.7	0	5
31	NY89052SP-9232	144 h	27.1	59.2 h	24.9	38.1	6.4 l	14.8 l	64.5	2	1
32	NY88024-117	143	27.9	57.8 h	26.8	49.7	7.3	19.5 h	55.9	0	2
33	NY88005-6035	144 h	34.7 h	57.6 h	30.7 h	70.3 h	10.8 h	29.5 h	51.8	0	6
34	NY89103-9149	146 h	24.9	57.0 h	22.3	62.3 h	10.6 h	22.6 h	42.0	0	4
35	961331A46-1-6	141	29.2	57.6 h	27.6	57.2	9.5 h	15.0 l	41.8	1	2
36	9793A1-5	136 l	18.2 l	40.9 l	14.3 l	24.2 l	4.9 l	5.4 l	39.5	6	0
37	97397B1-4-5	137	18.1 l	49.2	18.3 l	28.9 l	3.8 l	6.8 l	25.6 l	6	0
38	97398C1-5-3	140	21.2 l	62.1 h	21.6	45.5	5.7 l	8.5 l	35.6	3	1
39	97417A1-3-4	138	18.6 l	45.4 l	15.4 l	30.8 l	4.9 l	4.5 l	47.1	6	0
40	97463A1-17-1	135 l	23.2	44.3 l	19.7	21.0 l	4.0 l	9.9 l	23.6 l	5	0
41	GA901146 E 15	136 l	33.5 h	64.5 h	35.8 h	56.9	10.7 h	10.9 l	72.9 h	1	5
42	KY92C-491-18-1	137	27.6	56.2 h	29.0	47.8	7.2	8.5 l	68.9	1	1
43	KY92C-432-62	139	26.0	62.1 h	28.0	46.5	7.7	8.5 l	35.0	1	1
44	KY91C-170-3	138	27.4	60.6 h	27.2	51.7	8.9	18.1 h	65.9	0	2
45	KY91C-170-4-1	139	25.2	49.9	25.1	44.8	10.8 h	21.7 h	67.2	0	2
46	Harding	144 h	16.5 l	45.5 l	11.5 l	41.5	5.4 l	11.4 l	50.5	5	0
47	SD97060	145 h	14.2 l	43.5 l	10.4 l	35.8 l	7.2	9.5 l	36.5	5	0
48	D6234	141	24.6	62.4 h	23.9	41.3	6.8	15.2 l	50.4	1	1
49	D8006	138	32.1 h	61.0 h	30.6 h	59.3	12.3 h	26.9 h	64.1	0	5
	Average	139	24.2	52.7	22.2	42.0	7.1	11.9	47.8		
	LSD (0.05)	1.92	10.4	16.8	12.0	17.1	4.2	14.2	20.8		

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 5. Entry means for the most resistant and susceptible entries in the 2001 NUWWSN

	Trait:	HD	SEV	INC	IND	KR	PSS	DON	SEV-GH		
	# of test:	5	8	7	7	4	2	3	4	# Low	# High
	Units:	Days	%	%	%	0-100	%	PPM	%	scores	scores
9	MO980525	143	11.0 l	29.7 l	6.9 l	23.0 l	2.4 l	5.3 l	17.0 l	7	0
11	MO981020	139	13.7 l	34.1 l	9.1 l	27.3 l	6.0 l	5.8 l	19.3 l	7	0
5	Hondo	141	16.0 l	45.3 l	12.6 l	33.1 l	6.0 l	4.9 l	38.3	6	0
15	IL97-1828	137	18.2 l	41.3 l	14.8 l	19.8 l	3.7 l	4.6 l	45.2	6	0
17	IL97-6268	139	19.6 l	43.3 l	15.9 l	32.6 l	6.1 l	5.6 l	35.9	6	0
29	NY87048W-7388	144 h†	17.7 l	47.1	12.5 l	24.0 l	3.3 l	8.4 l	23.7 l	6	0
36	9793A1-5	136 l	18.2 l	40.9 l	14.3 l	24.2 l	4.9 l	5.4 l	39.5	6	0
37	97397B1-4-5	137	18.1 l	49.2	18.3 l	28.9 l	3.8 l	6.8 l	25.6 l	6	0
39	97417A1-3-4	138	18.6 l	45.4 l	15.4 l	30.8 l	4.9 l	4.5 l	47.1	6	0
4	Ernie	136 l	20.5 l	44.9 l	19.9	29.9 l	6.2 l	7.9 l	31.3	5	0
7	Heyne	140	18.2 l	52.1 h	14.7 l	24.6 l	5.7 l	15.1 l	34.4	5	1
14	IL96-6472	135 l	21.8	43.4 l	18.2 l	20.6 l	3.7 l	8.4 l	37.4	5	0
18	Roane	138	18.3 l	54.6 h	18.0 l	32.0 l	3.8 l	5.4 l	33.5	5	1
20	VA98W-591	139	20.0 l	51.7 h	15.9 l	34.5 l	4.6 l	7.4 l	47.8	5	1
25	25R18	141	12.7 l	54.2 h	12.7 l	48.8	6.2 l	16.3 l	10.0 l	5	1
40	97463A1-17-1	135 l	23.2	44.3 l	19.7	21.0 l	4.0 l	9.9 l	23.6 l	5	0
46	Harding	144 h	16.5 l	45.5 l	11.5 l	41.5	5.4 l	11.4 l	50.5	5	0
47	SD97060	145 h	14.2 l	43.5 l	10.4 l	35.8 l	7.2	9.5 l	36.5	5	0
8	MDV71-19	139	37.7 h	68.5 h	42.2 h	60.6 h	9.0	9.7 l	59.8	1	4
34	NY89103-9149	146 h	24.9	57.0 h	22.3	62.3 h	10.6 h	22.6 h	42.0	0	4
3	P2545	138	39.5 h	67.5 h	40.6 h	66.5 h	13.7 h	16.2 l	52.1	1	5
30	NY87047W-6048	143	31.6 h	61.5 h	29.4	77.5 h	11.1 h	32.2 h	41.7	0	5
41	GA901146 E 15	136 l	33.5 h	64.5 h	35.8 h	56.9	10.7 h	10.9 l	72.9 h	1	5
49	D8006	138	32.1 h	61.0 h	30.6 h	59.3	12.3 h	26.9 h	64.1	0	5
26	OH669	139	41.4 h	60.8 h	36.8 h	53.8	13.6 h	21.3 h	90.9 h	0	6
33	NY88005-6035	144 h	34.7 h	57.6 h	30.7 h	70.3 h	10.8 h	29.5 h	51.8	0	6
	LSD (0.05)	1.9	10.4	16.8	12.0	17.1	4.2	14.2	20.8		

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the corresponding column in Table 5 based on $LSD_{(0.05)}$

Table 6. Possible sources of resistance for the most resistant entries in Table 5.

NAME	Possible sources of resistance
97397B1-4-5	Freedom, Ning7840, and/or from the moderate resistant cultivar Goldfield
9793A1-5	Ernie, INW9853
Hondo	Not known
IL97-1828	Not known
IL97-6268	Not known
MO980525	MO 11769, which is not a descendent of Ernie, Sumai 3, or Ning 7840
MO981020	MO 11769, which is not a descendent of Ernie, Sumai 3, or Ning 7840
NY87048W-7388	Su Mei, and/or from the moderate resistant cultivars Howser and Harus

Table 7. Heading date (julian days) for entries in 2001 NUWWSN

	NAME	ALL		IL	KS	MI	OH	VA
1	Patterson	136	l†	129	128	149	142	129
2	Freedom	140		132	131	159	148	130
3	P2545	138		131	130	156	143	131
4	Ernie	136	l	129	129	151	142	129
5	Hondo	141		135	132	159	147	131
6	KS96HW115	137		130	129	155	143	129
7	Heyne	140		133	131	157	146	131
8	MDV71-19	139		132	130	158	144	130
9	MO980525	143		137	134	161	150	133
10	MO960827	137		130	129	151	143	130
11	MO981020	139		131	130	159	144	131
12	MO980429	137		129	129	155	143	129
13	IL96-3514	138		131	130	155	144	130
14	IL96-6472	135	l	127	127	155	141	126
15	IL97-1828	137		130	129	151	143	130
16	IL97-4228	136	l	129	129	155	141	128
17	IL97-6268	139		131	130	159	144	130
18	Roane	138		131	130	157	145	130
19	VA96-54-326	138		130	130	162	142	128
20	VA98W-591	139		132	130	159	143	130
21	VA98W-593	138		132	131	158	143	129
22	VA99W-553	136	l	127	128	159	142	126
23	VA99W-562	140		132	130	162	144	129
24	VA99W-567	140		131	130	162	146	129
25	25R18	141		134	130	162	146	132
26	OH669	139		131	130	159	145	131
27	OH684	139		131	129	157	144	131
28	OH699	140		133	130	159	146	131
29	NY87048W-7388	144	h	137	134	164	150	133
30	NY87047W-6048	143		138	134	162	150	133
31	NY89052SP-9232	144	h	137	135	163	150	136
32	NY88024-117	143		137	135	162	148	131
33	NY88005-6035	144	h	138	138	162	152	131
34	NY89103-9149	146	h	140	138	162	150	138
35	961331A46-1-6	141		136	133	161	145	131
36	9793A1-5	136	l	127	129	155	142	127
37	97397B1-4-5	137		129	129	155	142	130
38	97398C1-5-3	140		133	132	159	146	132
39	97417A1-3-4	138		129	130	159	143	130
40	97463A1-17-1	135	l	127	128	151	142	128
41	GA901146 E 15	136	l	128	127	152	142	129
42	KY92C-491-18-1	137		130	129	155	144	129
43	KY92C-432-62	139		131	130	159	144	130
44	KY91C-170-3	138		130	130	157	143	129
45	KY91C-170-4-1	139		131	130	162	145	129
46	Harding	144	h	138	136	162	150	133
47	SD97060	145	h	140	135	164	151	135
48	D6234	141		133	131	163	147	132
49	D8006	138		131	130	155	145	130
	Average	139		132	131	158	145	130
	CV (%)	1.1		0.6	7.1	2.4		1.1
	LSD (0.05)	1.92		1.2	1.1		0.7	2.0
	R2	0.99						

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 8. Disease incidence (% heads with infected spikelets) for entries in 2001 NUWWSN

	NAME	ALL but NE		IL	MI	MO	NY	OH	ONT	VA	NE
1	Patterson	56.8	h[†]	45.8	90	97	6.2	81.7	29.8	47	75
2	Freedom	58.3	h	94.0	90	97	2.3	85.0	3.8	36	75
3	P2545	67.5	h	95.5	80	100	8.8	96.7	14.5	77	75
4	Ernie	44.9	l	10.0	80	90	2.0	91.7	11.8	29	75
5	Hondo	45.3	l	78.0	50	93	3.5	41.7	2.2	49	75
6	KS96HW115	56.1	h	87.8	90	93	1.6	76.7	2.5	41	75
7	Heyne	52.1	h	83.5	70	97	1.7	78.3	1.4	33	75
8	MDV71-19	68.5	h	97.3	90	100	10.2	90.0	17.8	74	75
9	MO980525	29.7	l	22.3	30	97	3.1	28.3	2.1	25	75
10	MO960827	64.1	h	91.0	70	100	5.9	86.7	21.9	73	75
11	MO981020	34.1	l	15.3	30	77	0.8	70.0	7.6	38	75
12	MO980429	42.7	l	15.5	60	83	5.1	95.0	16.5	24	75
13	IL96-3514	45.2	l	25.7	80	83	0.9	96.7	11.4	19	75
14	IL96-6472	43.4	l	8.8	80	67	2.3	85.0	17.6	43	75
15	IL97-1828	41.3	l	9.8	80	80	5.9	81.7	8.6	23	75
16	IL97-4228	40.6	l	13.3	70	70	1.6	93.3	14.8	21	75
17	IL97-6268	43.3	l	21.8	50	83	1.9	91.7	18.1	37	75
18	Roane	54.6	h	90.0	70	97	2.2	88.3	15.0	20	75
19	VA96-54-326	47.6		79.3	50	90	4.0	75.0	12.8	22	75
20	VA98W-591	51.7	h	75.0	60	80	1.2	91.7	9.0	45	75
21	VA98W-593	55.3	h	94.3	70	83	1.7	95.0	12.0	31	75
22	VA99W-553	54.0	h	58.8	70	97	13.4	95.0	14.9	29	
23	VA99W-562	55.1	h	96.3	70	100	1.0	80.0	7.0	31	75
24	VA99W-567	53.6	h	75.0	80	87	1.4	91.7	6.8	33	75
25	25R18	54.2	h	86.8	60	90	0.5	91.7	3.3	47	75
26	OH669	60.8	h	84.5	80	87	2.5	91.7	15.0	65	75
27	OH684	58.2	h	87.5	80	87	2.9	73.3	22.0	55	75
28	OH699	58.0	h	79.0	70	83	2.2	88.3	8.9	75	75
29	NY87048W-7388	47.1		90.3	20	100	1.8	63.3	1.3	53	0
30	NY87047W-6048	61.5	h	98.0	80	100	4.9	86.7	5.6	55	75
31	NY89052SP-9232	59.2	h	96.5	90	100	1.4	60.0	3.5	63	75
32	NY88024-117	57.8	h	98.0	60	97	2.2	81.7	1.9	64	20
33	NY88005-6035	57.6	h	99.5	80	100	3.1	68.3	4.2	48	75
34	NY89103-9149	57.0	h	97.0	80	100	1.7	48.3	4.9	67	75
35	961331A46-1-6	57.6	h	91.3	40	100	6.6	80.0	18.6	67	75
36	9793A1-5	40.9	l	26.3	40	83	2.7	83.3	11.9	39	75
37	97397B1-4-5	49.2		20.5	90	97	2.1	91.7	7.0	36	
38	97398C1-5-3	62.1	h	91.8	90	97	2.6	81.7	7.9	64	
39	97417A1-3-4	45.4	l	47.5	60	90	4.5	66.7	8.9	40	
40	97463A1-17-1	44.3	l	10.0	80	90	4.3	81.7	18.4	26	
41	GA901146 E 15	64.5	h	92.0	60	93	18.9	98.3	22.3	67	75
42	KY92C-491-18-1	56.2	h	85.3	70	93	1.9	91.7	11.6	40	75
43	KY92C-432-62	62.1	h	96.8	70	100	5.5	95.0	14.7	53	75
44	KY91C-170-3	60.6	h	92.5	70	93	5.0	90.0	14.9	59	75
45	KY91C-170-4-1	49.9		93.0	30	93	3.8	81.7	13.9	34	75
46	Harding	45.5	l	81.8	60	90	0.8	36.7	0.2	49	75
47	SD97060	43.5	l	65.0	60	93	1.4	41.7	0.3	43	75
48	D6234	62.4	h	93.5	80	93	2.3	80.0	4.9	83	75
49	D8006	61.0	h	89.0	80	90	6.6	86.7	10.4	64	75
	Average	52.7		68.9	68.2	91.4	3.7	80.1	10.5	46.0	72
	CV (%)	30.3		12.7	26.1	32			33.4	39.1	
	LSD (0.05)	16.8		12.1		14		28.3		24.4	
	R2	0.83									

[†] Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 9. Field disease severity (% infected spikelets) for entries in 2001 NUWWSN

	NAME	ALL		AR+IL+ MO+VA		AR	IL	MO	VA	IN+OH +ONT		IN	OH	ONT	MI	NE
1	Patterson	36.2	h	32.2		7	43.8	43	35	40.1	h	41	44.4	35.0	57.1	80
2	Freedom	17.0	l	20.6	l	8	23.3	32	19	13.4	l	11	22.0	7.3	35.7	20
3	P2545	39.6	h	38.8	h	15	55.0	42	43	40.4	h	44	56.9	20.2	40.0	30&100
4	Ernie	15.9	l	12.1	l	5	8.5	16	19	19.6	l	10	30.1	18.7	57.1	100
5	Hondo	15.3	l	21.2	l	7	15.8	35	27	9.3	l	16	7.2	4.8	15.4	30
6	KS96HW115	17.8		18.5	l	5	25.0	21	23	17.1	l	16	31.2	4.1	58.3	100
7	Heyne	16.6	l	16.8	l	7	19.3	22	19	16.4	l	29	17.0	3.3	28.6	20&100
8	MDV71-19	36.7	h	43.1	h	22	66.3	44	40	30.3		18	48.5	24.4	38.5	70
9	MO980525	10.3	l	13.1	l	7	12.5	19	14	7.4	l	12	3.4	6.9	13.3	80
10	MO960827	28.4		31.0		13	36.8	38	36	25.9		22	29.1	26.5	40.0	80
11	MO981020	12.5	l	14.6	l	5	10.3	14	29	10.4	l	9	9.2	13.1	20.0	80
12	MO980429	19.3		14.9	l	5	10.5	25	19	23.7		10	39.3	21.9	46.7	100
13	IL96-3514	19.2		13.7	l	7	13.8	21	13	24.7		14	45.1	14.9	53.3	100
14	IL96-6472	18.2		12.1	l	3	7.5	14	24	24.3		20	29.6	23.3	53.3	100
15	IL97-1828	14.0	l	12.0	l	7	9.0	11	21	16.0	l	10	24.3	13.6	50.0	100
16	IL97-4228	21.2		12.8	l	5	8.3	14	24	29.7		26	44.1	18.9	40.0	100
17	IL97-6268	18.0	l	12.8	l	5	16.0	16	14	23.3		17	30.2	22.8	35.7	100
18	Roane	18.0	l	16.9	l	5	19.5	31	12	19.2	l	18	20.2	19.4	21.4	70
19	VA96-54-326	23.0		21.8	l	8	24.3	34	21	24.2		28	28.0	16.7	15.4	80
20	VA98W-591	20.9	l	19.1	l	10	19.3	19	28	22.8		32	23.9	12.6	15.4	70
21	VA98W-593	30.9		20.3	l	7	21.3	28	25	41.5	h	61	46.5	16.9	15.4	80
22	VA99W-553	24.0		18.8	l	5	21.3	30	19	29.1		18	42.2	27.1	23.1	
23	VA99W-562	26.6		26.7		7	35.8	38	26	26.5		30	39.2	10.3	18.8	60
24	VA99W-567	22.1	l	17.0	l	5	23.8	17	22	27.2		29	41.0	11.7	11.8	80
25	25R18	12.5	l	13.0	l	5	10.8	12	24	12.1	l	7	22.2	7.1	13.3	80
26	OH669	41.6	h	35.6	h	10	62.5	27	43	47.6	h	56	67.7	19.2	46.2	70
27	OH684	36.6	h	30.0		15	48.8	24	32	43.2	h	63	38.8	27.9	38.5	80
28	OH699	25.8		28.6		15	32.5	19	48	23.0		28	26.1	14.9	28.6	90
29	NY87048W-7388	17.3	l	23.1		10	22.3	28	32	11.6	l	23	8.8	3.0	14.3	0
30	NY87047W-6048	29.7	h	34.3	h	15	50.0	35	37	25.2		21	45.5	9.1	40.0	20&80
31	NY89052SP-9232	25.2		36.4	h	15	52.5	42	36	14.0	l	19	15.6	7.4	29.4	20
32	NY88024-117	27.8		38.9	h	15	62.5	38	40	16.6	l	15	30.9	4.0	17.6	0&60
33	NY88005-6035	29.8	h	45.4	h	25	72.5	48	36	14.1	l	13	22.2	7.2	53.3	20
34	NY89103-9149	23.4		33.9		15	52.5	33	35	12.9	l	22	7.3	9.5	25.0	20
35	961331A46-1-6	29.9		36.1	h	15	41.3	47	41	23.8		16	28.7	26.6	17.6	30&80
36	9793A1-5	19.1	l	15.3	l	5	11.0	18	27	22.9		20	33.0	15.8	15.4	40?
37	97397B1-4-5	16.4	l	19.5	l	5	14.8	32	26	13.3	l	6	23.8	10.1	26.7	
38	97398C1-5-3	20.5	l	20.4	l	5	23.5	16	37	20.5	l	13	38.4	10.2	26.7	
39	97417A1-3-4	15.6	l	15.8	l	5	14.3	24	20	15.3	l	20	12.5	13.4	40.0	
40	97463A1-17-1	18.0		11.0	l	5	9.8	14	15	25.1		28	25.1	22.3	66.7	
41	GA901146 E 15	36.0	h	31.0		10	55.0	24	35	41.0	h	46	49.2	27.7	21.4	20&60
42	KY92C-491-18-1	25.7		24.2		5	30.8	34	27	27.1		17	49.1	15.3	42.9	90
43	KY92C-432-62	25.3		29.2		7	48.8	28	33	21.4	l	18	28.4	17.8	27.3	100
44	KY91C-170-3	26.5		24.5		7	31.0	25	35	28.4		26	38.8	20.5	35.7	90
45	KY91C-170-4-1	24.5		25.8		8	35.0	28	32	23.3		20	32.5	17.3	28.6	30
46	Harding	15.9	l	22.2	l	10	25.8	25	28	9.5	l	20	7.9	0.7	14.3	100
47	SD97060	13.3	l	18.0	l	5	20.0	25	22	8.7	l	14	10.7	1.3	15.4	100
48	D6234	22.2		29.8		13	31.3	23	52	14.6	l	13	21.0	9.9	33.3	30&70
49	D8006	33.0	h	33.9		15	37.5	37	46	32.1		30	52.6	13.8	25.0	60
	Average	23.1		23.6		9.0	29.5	27.1	28.8	22.7		22.8	30.4	14.8	31.6	
	CV (%)	43.6		33.6		21.8	29.6	32		39.7		39.0		25.9	46.8	
	LSD (0.05)	10.40		11.1		3.2	12.1	14		14.6		16.0	24.5			
	R2	0.54		0.77						0.71						

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

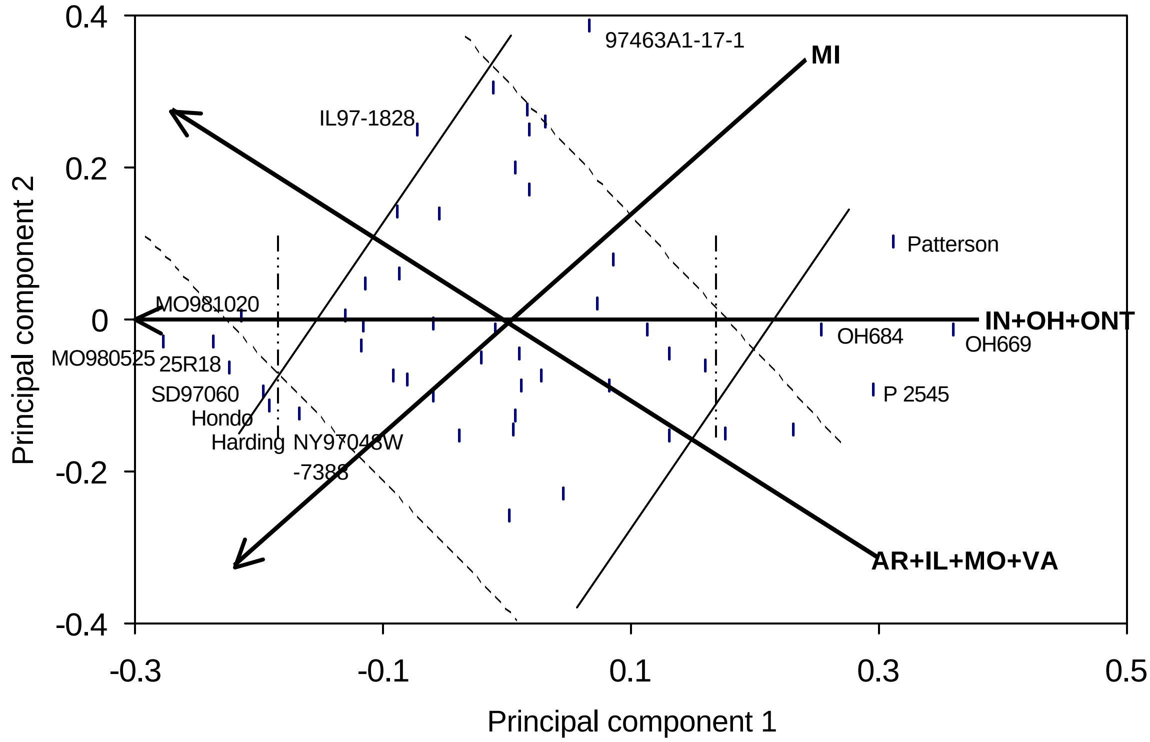

Figure 1. Biplot of entry, and entry x megaenvironment effects using three sets of disease severity means. Each set was the mean severity across tests that formed a single megaenvironment: (AR+IL+MO+VA), (IN+OH+ONT), and MI. Entries are represented by points (some are labeled). Megaenvironments are represented by character codes. Vectors are drawn from each megaenvironment through the origin with arrows pointing to decreasing severity values. The cosine of the angle between two vectors estimates the correlation between means in those two megaenvironments. For example, the angle between the MI and (AR+IL+MO+VA) vectors is close to 90^0, suggesting a correlation of nearly zero between these two sets of means (actual r is 0.00). The other two angles suggest correlations near 0.25. The relative performance of an entry in a megaenvironment is estimated by its position perpendicular to the vector for that megaenvironment. For example, the analysis estimates that OH669 had the highest severity score in the AR+IL+MO+VA and IN+OH+ONT megaenvironments, while Patterson had the highest severity in the MI test. Light lines perpendicular to each vector delineate the six best and six worst entries for each megaenvironment.

Table 10. Disease index ([severity% x incidence%]/100) for entries in 2001 NUWWSN

	NAME	ALL but NE		IL+MO +VA		IL	MO	VA	KS+OH +ONT		KS	OH	ONT	MI	NE
1	Patterson	33.6	h[†]	25.4		18.5	41.7	16	35.8	h	37.5	36.3	33.7	51.4	5.4
2	Freedom	20.2		20.0	l	22.1	31.0	7	16.4	l	24.0	18.7	6.5	32.1	0.5
3	P2545	40.6	h	42.5	h	52.6	42.0	33	41.6	h	51.3	55.0	18.5	32.0	
4	Ernie	19.9		7.1	l	0.9	14.4	6	24.2		27.0	27.6	18.0	45.7	1.1
5	Hondo	12.6	l	19.4	l	12.7	32.6	13	7.4	l	15.5	3.0	3.7	7.7	0.5
6	KS96HW115	24.9		16.9	l	22.1	19.5	9	23.8		43.8	23.9	3.8	52.5	0.3
7	Heyne	14.7	l	14.3	l	15.7	21.3	6	13.3	l	23.3	13.3	3.2	20.0	
8	MDV71-19	42.2	h	46.1	h	64.4	44.0	30	40.8	h	55.5	43.7	23.1	34.6	6.9
9	MO980525	6.9	l	8.4	l	2.8	18.4	4	6.4	l	11.8	1.0	6.5	4.0	0.3
10	MO960827	30.0		32.7	h	34.0	38.0	26	27.9		32.5	25.2	26.1	28.0	6.8
11	MO981020	9.1	l	7.8	l	1.6	10.8	11	11.5	l	16.0	6.4	12.1	6.0	1.3
12	MO980429	19.4		9.2	l	1.7	20.8	5	26.7		21.8	37.4	21.0	28.0	1.1
13	IL96-3514	20.5		7.6	l	3.4	17.4	2	26.0		21.3	43.6	13.1	42.7	0.3
14	IL96-6472	18.2	l	6.7	l	0.6	9.4	10	21.5		18.0	25.2	21.3	42.7	2.1
15	IL97-1828	14.8	l	4.9	l	1.0	8.8	5	16.3	l	16.0	19.8	13.0	40.0	0.6
16	IL97-4228	19.4		5.3	l	1.1	9.8	5	30.7		35.5	41.1	15.6	28.0	0.8
17	IL97-6268	15.9	l	7.3	l	3.5	13.3	5	23.8		22.3	27.7	21.5	17.9	1.1
18	Roane	18.0	l	16.5	l	17.5	30.1	2	20.4		24.8	17.9	18.6	15.0	0.4
19	VA96-54-326	19.7		18.4	l	19.5	30.6	5	24.9		37.5	21.0	16.3	7.7	0.8
20	VA98W-591	15.9	l	14.5	l	15.3	15.2	13	19.5		24.8	21.9	11.9	9.2	1.5
21	VA98W-593	21.4		17.1	l	20.0	23.2	8	29.2		27.5	44.2	16.0	10.8	1.3
22	VA99W-553	23.3		15.8	l	12.4	29.1	6	33.1		32.5	40.1	26.7	16.2	
23	VA99W-562	25.5		26.9		34.6	38.0	8	28.2		44.0	31.4	9.2	13.1	0.7
24	VA99W-567	19.6		13.3	l	18.0	14.8	7	29.3		38.8	37.6	11.6	9.4	0.8
25	25R18	12.7	l	10.3	l	9.2	10.8	11	16.7	l	23.0	20.4	6.7	8.0	0.7
26	OH669	36.8	h	34.9	h	53.1	23.5	28	38.6	h	35.0	62.1	18.7	36.9	5.2
27	OH684	27.5		27.0		42.0	20.9	18	26.9		24.8	28.4	27.4	30.8	4.9
28	OH699	21.2		25.2		23.9	15.8	36	17.6	l	16.0	23.0	13.7	20.0	4.9
29	NY87048W-7388	12.5	l	21.7		20.1	28.0	17	6.4	l	10.8	5.6	2.8	2.9	0.5
30	NY87047W-6048	29.4		34.7	h	49.1	35.0	20	23.2		21.3	39.4	8.9	32.0	
31	NY89052SP-9232	24.9		38.5	h	50.6	42.0	23	10.8	l	16.0	9.4	7.1	26.5	1.6
32	NY88024-117	26.8		41.4	h	61.2	36.9	26	17.6	l	24.0	25.2	3.5	10.6	
33	NY88005-6035	30.7	h	45.7	h	72.2	48.0	17	11.7	l	13.3	15.2	6.6	42.7	1.1
34	NY89103-9149	22.3		35.6	h	50.9	33.0	23	9.6	l	17.0	3.5	8.4	20.0	1.9
35	961331A46-1-6	27.6		37.3	h	38.0	47.0	27	24.6		24.5	22.9	26.5	7.1	
36	9793A1-5	14.3	l	9.6	l	2.9	14.9	11	21.6		21.8	27.5	15.6	6.2	
37	97397B1-4-5	18.3	l	14.5	l	3.4	31.0	9	20.1		28.8	21.8	9.8	24.0	
38	97398C1-5-3	21.6		20.3	l	21.4	15.5	24	22.1		25.3	31.4	9.5	24.0	
39	97417A1-3-4	15.4	l	12.3	l	7.2	21.6	8	15.8	l	25.8	8.4	13.1	24.0	
40	97463A1-17-1	19.7		5.9	l	1.0	12.6	4	22.3		24.5	20.5	22.0	53.3	
41	GA901146 E 15	35.8	h	32.0	h	50.6	22.3	23	47.2	h	66.3	48.3	27.0	12.9	
42	KY92C-491-18-1	29.0		22.7		25.4	31.6	11	34.9	h	45.0	45.0	14.8	30.0	1.6
43	KY92C-432-62	28.0		30.8	h	47.4	28.0	17	28.2		40.0	27.0	17.6	19.1	3.0
44	KY91C-170-3	27.2		24.2		28.2	23.3	21	30.9		37.8	34.9	20.1	25.0	4.2
45	KY91C-170-4-1	25.1		23.3		33.0	26.0	11	32.4		53.8	26.6	16.7	8.6	1.8
46	Harding	11.5	l	19.4	l	21.6	22.5	14	4.6	l	10.0	2.9	0.8	8.6	0.1
47	SD97060	10.4	l	15.5	l	14.3	23.3	9	5.6	l	11.0	4.4	1.3	9.2	0.1
48	D6234	23.9		31.2	h	29.1	21.4	43	15.6	l	20.5	16.8	9.6	26.7	
49	D8006	30.6	h	32.0	h	33.6	33.3	29	32.7		38.8	45.6	13.8	20.0	4.0
	Average	22.2		21.4		24.2	25.4	14.7	22.8		28.1	26.1	14.1	22.9	2.0
	CV (%)	51.1		44.3		33.5			35.7		30.6		19.2	60.8	
	LSD (0.05)	12.0		15.4		11.2			13.2		12.9	24.7			
	R2	0.45		0.73					0.76						

[†] Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

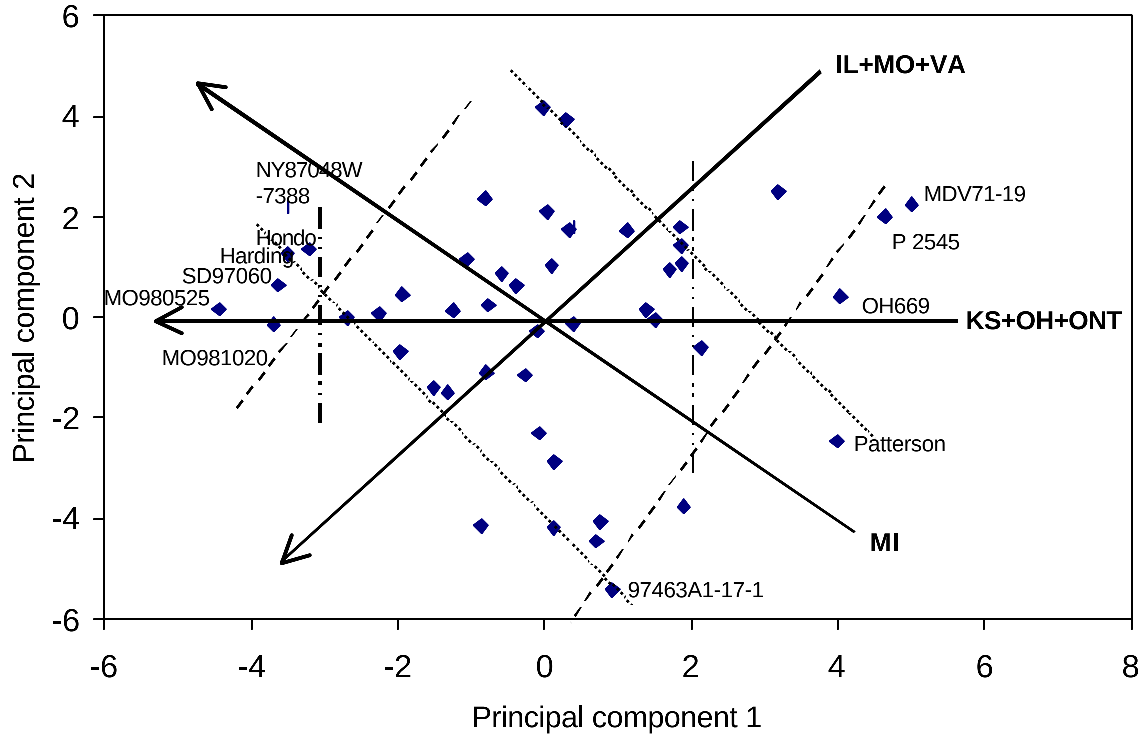

Figure 2. Biplot of entry, and entry x megaenvironment effects using three sets of disease index means. Each set was the mean index across tests that formed a single megaenvironment: (IL+MO+VA), (KS+OH+ONT), and MI. Entries are represented by points (some are labeled). Megaenvironments are represented by character codes. Vectors are drawn from each megaenvironment through the origin with arrows pointing to decreasing index values. The cosine of the angle between two vectors estimates the correlation between means in those two groups. For example, the angle between the MI and (IL+MO+VA) vectors is close to 90^0, suggesting a correlation of nearly zero between these two sets of means (actual r is 0.04). The other two angles suggest correlations near 0.25. The relative performance of an entry in a megaenvironment is estimated by its position perpendicular to the vector for that megaenvironment. For example, the analysis estimates that MDV71-19 has the highest index score in the IL+MO+VA and KS+OH+ONT megaenvironments, while Patterson had the highest index in the MI test. Light lines perpendicular to each vector delineate the six best and six worst entries for each megaenvironment.

Table 11. Kernel rating (visual rating of % infected seeds) for entries in 2001 NUWWSN

	NAME	ALL but NE		AR	IL	KS	OH	NE
1	Patterson	31.0	l[†]	17	25	67.5	14.3	40
2	Freedom	50.1		42	45	70.0	43.3	40
3	P2545	66.5	h	57	58	77.5	73.3	60
4	Ernie	29.9	l	13	28	62.5	16.0	40
5	Hondo	33.1	l	27	33	40.0	32.3	40
6	KS96HW115	38.6		18	38	65.0	33.3	40
7	Heyne	24.6	l	20	30	30.0	18.3	40
8	MDV71-19	60.6	h	50	50	72.5	70.0	40
9	MO980525	23.0	l	43	13	32.5	3.5	5
10	MO960827	55.9		53	53	72.5	45.0	40
11	MO981020	27.3	l	28	25	50.0	6.0	40
12	MO980429	33.7	l	30	33	45.0	26.7	40
13	IL96-3514	27.4	l	18	30	50.0	11.7	40
14	IL96-6472	20.6	l	17	8	47.5	10.0	40
15	IL97-1828	19.8	l	20	13	40.0	6.0	20
16	IL97-4228	29.8	l	27	33	50.0	9.3	40
17	IL97-6268	32.6	l	35	28	62.5	5.0	40
18	Roane	32.0	l	32	30	52.5	13.5	40
19	VA96-54-326	49.0		27	58	72.5	38.3	40
20	VA98W-591	34.5	l	32	45	45.0	16.0	40
21	VA98W-593	36.3	l	33	43	45.0	24.0	40
22	VA99W-553	40.3		38	38	50.0	35.0	
23	VA99W-562	50.3		42	40	72.5	46.7	40
24	VA99W-567	50.8		33	40	70.0	60.0	40
25	25R18	48.8		57	23	55.0	60.0	40
26	OH669	53.8		37	35	70.0	73.3	40
27	OH684	50.5		42	45	60.0	55.0	40
28	OH699	50.3		57	38	50.0	56.0	40
29	NY87048W-7388	24.0	l	30	25	32.5	8.3	40
30	NY87047W-6048	77.5	h	77	58	85.0	90.0	40
31	NY89052SP-9232	38.1		57	35	55.0	5.3	40
32	NY88024-117	49.7		57	50	67.5	24.3	40
33	NY88005-6035	70.3	h	73	65	75.0	68.3	40
34	NY89103-9149	62.3	h	63	58	75.0	53.3	40
35	961331A46-1-6	57.2		50	48	67.5	63.3	40
36	9793A1-5	24.2	l	10	25	52.5	9.3	40
37	97397B1-4-5	28.9	l	15	23	57.5	20.0	40
38	97398C1-5-3	45.5		43	33	80.0	26.0	
39	97417A1-3-4	30.8	l	23	30	62.5	7.7	
40	97463A1-17-1	21.0	l	12	15	55.0	2.0	20
41	GA901146 E 15	56.9		37	58	80.0	52.7	20
42	KY92C-491-18-1	47.8		32	45	62.5	51.7	60
43	KY92C-432-62	46.5		40	50	57.5	38.3	55
44	KY91C-170-3	51.7		47	43	70.0	46.7	50
45	KY91C-170-4-1	44.8		40	40	67.5	31.7	40
46	Harding	41.5		70	60	15.0	21.0	30
47	SD97060	35.8	l	60	43	35.0	5.3	80
48	D6234	41.3		43	43	57.5	21.7	
49	D8006	59.3		52	50	70.0	65.0	80
	Average	42.0			38.3	58.3	32.9	40.9
	CV (%)	29.2		14.8	21	18.3		
	LSD (0.05)	17.1		9.2	11	15.1	32.5	
	R2	0.72						

[†] Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 12. % scabby seed (% scabby seed based on weight) for entries in 2001 NUWWSN

	NAME	ALL but NE		OH	VA	NE
1	Patterson	7.3		6.8	7.7	5.7
2	Freedom	6.5	l†	5.2	7.8	3.0
3	P2545	13.7	h	13.9	13.5	4.9
4	Ernie	6.2	l	4.1	8.3	0.6
5	Hondo	6.0	l	5.3	6.7	1.8
6	KS96HW115	4.8	l	4.8	4.7	4.2
7	Heyne	5.7	l	4.1	7.3	1.1
8	MDV71-19	9.0		9.0	9.0	4.2
9	MO980525	2.4	l	1.2	3.5	0.6
10	MO960827	10.6	h	5.8	15.3	2.0
11	MO981020	6.0	l	2.4	9.5	0.8
12	MO980429	5.3	l	5.4	5.2	1.0
13	IL96-3514	4.2	l	4.1	4.2	0.3
14	IL96-6472	3.7	l	3.7	3.7	2.0
15	IL97-1828	3.7	l	3.7	3.7	0.6
16	IL97-4228	7.0		2.6	11.3	1.9
17	IL97-6268	6.1	l	3.6	8.5	1.0
18	Roane	3.8	l	2.3	5.2	31.0
19	VA96-54-326	5.6	l	4.4	6.7	46.0
20	VA98W-591	4.6	l	4.5	4.7	31.0
21	VA98W-593	7.0		4.9	9.0	49.0
22	VA99W-553	6.6	l	3.1	10.0	
23	VA99W-562	8.7		7.1	10.3	18.0
24	VA99W-567	7.1		7.9	6.3	77.0
25	25R18	6.2	l	4.7	7.7	42.0
26	OH669	13.6	h	11.6	15.5	60.0
27	OH684	9.4		6.5	12.2	35.4
28	OH699	8.7		6.6	10.8	56.0
29	NY87048W-7388	3.3	l	2.8	3.8	2.4
30	NY87047W-6048	11.1	h	11.9	10.3	2.1
31	NY89052SP-9232	6.4	l	4.5	8.2	1.0
32	NY88024-117	7.3		5.8	8.7	1.0
33	NY88005-6035	10.8	h	11.8	9.8	1.6
34	NY89103-9149	10.6	h	9.2	12.0	0.9
35	961331A46-1-6	9.5	h	8.8	10.2	28.6
36	9793A1-5	4.9	l	3.5	6.3	5.8
37	97397B1-4-5	3.8	l	2.4	5.2	4.9
38	97398C1-5-3	5.7	l	3.6	7.7	
39	97417A1-3-4	4.9	l	4.0	5.8	
40	97463A1-17-1	4.0	l	2.7	5.3	1.2
41	GA901146 E 15	10.7	h	8.0	13.3	2.1
42	KY92C-491-18-1	7.2		6.5	7.8	3.1
43	KY92C-432-62	7.7		5.1	10.2	3.6
44	KY91C-170-3	8.9		4.3	13.5	3.7
45	KY91C-170-4-1	10.8	h	6.1	15.5	0.0
46	Harding	5.4	l	3.4	7.3	1.1
47	SD97060	7.2		4.5	9.8	1.9
48	D6234	6.8		3.8	9.8	
49	D8006	12.3	h	8.1	16.5	23.0
	Average	7.1		5.5	8.7	12.6
	CV (%)	29.4			41.9	
	LSD (0.05)	4.20		6.1	4.9	
	R2	0.82				

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 13. DON (vomitoxin in ppm) for entries in 2001 NUWWSN

	NAME	ALL		VA+OH		AR	VA	OH
1	Patterson	6.9	l[†]	5.9	l	9	1.7	10.0
2	Freedom	12.6	l	5.9	l	26	3.1	8.7
3	P2545	16.2	l	22.9	h	3	6.4	39.3
4	Ernie	7.9	l	9.4	l	5	2.5	16.3
5	Hondo	4.9	l	4.9	l	5	2.5	7.3
6	KS96HW115	14.6	l	9.9	l	24	2.8	16.9
7	Heyne	15.1	l	13.7	lh	18	1.7	25.7
8	MDV71-19	9.7	l	9.6	l	10	3.1	16.0
9	MO980525	5.3	l	3.0	l	10	2.4	3.5
10	MO960827	14.6	l	11.9	lh	20	3.4	20.3
11	MO981020	5.8	l	5.2	l	7	3.3	7.0
12	MO980429	6.3	l	5.5	l	8	1.7	9.3
13	IL96-3514	3.2	l	3.3	l	3	0.8	5.7
14	IL96-6472	8.4	l	4.1	l	17	1.1	7.0
15	IL97-1828	4.6	l	2.4	l	9	1.4	3.3
16	IL97-4228	4.2	l	3.8	l	5	1.3	6.3
17	IL97-6268	5.6	l	4.0	l	9	1.9	6.0
18	Roane	5.4	l	4.6	l	7	1.2	8.0
19	VA96-54-326	7.3	l	4.5	l	13	0.9	8.0
20	VA98W-591	7.4	l	5.6	l	11	1.9	9.3
21	VA98W-593	5.3	l	5.5	l	5	2.3	8.7
22	VA99W-553	10.4	l	5.7	l	20	1.6	9.7
23	VA99W-562	11.1	l	11.7	lh	10	2.1	21.3
24	VA99W-567	19.5	h	13.8	lh	31	2.3	25.3
25	25R18	16.3	l	15.5	h	18	1.6	29.3
26	OH669	21.3	h	18.5	h	27	5.6	31.3
27	OH684	13.5	l	9.2	l	22	4.7	13.7
28	OH699	9.9	l	5.9	l	18	2.1	9.7
29	NY87048W-7388	8.4	l	3.1	l	19	0.9	5.3
30	NY87047W-6048	32.2	h	16.4	h	64	2.0	30.7
31	NY89052SP-9232	14.8	l	8.8	l	27	4.2	13.3
32	NY88024-117	19.5	h	6.8	l	45	3.5	10.0
33	NY88005-6035	29.5	h	13.2	lh	62	4.7	21.7
34	NY89103-9149	22.6	h	7.4	l	53	3.7	11.0
35	961331A46-1-6	15.0	l	7.0	l	31	4.1	9.9
36	9793A1-5	5.4	l	4.6	l	7	2.2	7.0
37	97397B1-4-5	6.8	l	2.3	l	16	1.1	3.4
38	97398C1-5-3	8.5	l	6.3	l	13	2.5	10.0
39	97417A1-3-4	4.5	l	3.8	l	6	1.9	5.7
40	97463A1-17-1	9.9	l	2.4	l	25	1.0	3.7
41	GA901146 E 15	10.9	l	9.3	l	14	3.3	15.3
42	KY92C-491-18-1	8.5	l	9.8	l	6	2.3	17.3
43	KY92C-432-62	8.5	l	6.2	l	13	1.1	11.3
44	KY91C-170-3	18.1	h	16.2	h	22	4.1	28.3
45	KY91C-170-4-1	21.7	h	17.1	h	31	4.1	30.1
46	Harding	11.4	l	8.7	l	17	3.3	14.0
47	SD97060	9.5	l	3.3	l	22	3.3	3.3
48	D6234	15.2	l	9.8	l	26	3.3	16.3
49	D8006	26.9	h	21.4	h	38	5.4	37.3
	Average	11.9		8.3			2.6	14.0
	CV (%)	73.8		73.9		27.8	36.1	
	LSD (0.05)	14.2		12.4		8.5	1.3	18.4
	R2	0.65		0.76				

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 14. Greenhouse disease severity (% infected spikelets) for entries in 2001 NUWWSN. Least squares were used to estimate average over all tests.

	NAME	ALL		AR	IN	IL	MI
1	Patterson	43.4		48	21.1	35.6	69.0
2	Freedom	35.9		7	17.8	66.9	51.8
3	P2545	52.1		35	53.0		54.2
4	Ernie	31.3		22	14.4	48.9	40.1
5	Hondo	38.3		6	19.2	52.0	75.8
6	KS96HW115	69.2		64	34.1	88.7	90.0
7	Heyne	34.4		21	28.9	33.1	54.7
8	MDV71-19	59.8		21	61.2	75.2	81.6
9	MO980525	17.0	l	3	7.5		26.5
10	MO960827	39.2		11	16.1	64.3	65.6
11	MO981020	19.3	l	7	10.7	37.1	22.3
12	MO980429	37.9		24	23.8	51.0	52.7
13	IL96-3514	37.6		4	5.7	84.2	56.4
14	IL96-6472	37.4		22	22.9	57.2	47.6
15	IL97-1828	45.2		7	66.1 .		48.3
16	IL97-4228	43.3		32	38.9	44.7	57.6
17	IL97-6268	35.9		24	18.0	49.1	52.4
18	Roane	33.5		7	29.5		49.8
19	VA96-54-326	92.7	h	87	100.0	91.1	92.5
20	VA98W-591	47.8		10	37.4	79.3	64.7
21	VA98W-593	59.8		59	34.3	72.1	73.8
22	VA99W-553	65.7		40	77.0	77.1	68.9
23	VA99W-562	50.1		9	37.9	63.5	90.1
24	VA99W-567	69.1		61	64.2	70.6	80.6
25	25R18	10.0	l	3	2.8	19.9	14.3
26	OH669	90.9	h	80	89.3	94.7	99.7
27	OH684	80.5	h	50	98.9	75.6	97.3
28	OH699	63.7		53	45.5	78.3	77.8
29	NY87048W-7388	23.7	l	6	14.8	35.4	38.7
30	NY87047W-6048	41.7		20	24.4	64.9	57.3
31	NY89052SP-9232	64.5		29	55.6	77.6	95.9
32	NY88024-117	55.9		15	55.7	78.3	74.6
33	NY88005-6035	51.8		12	27.2	70.1	98.1
34	NY89103-9149	42.0		10	8.4	73.3	76.4
35	961331A46-1-6	41.8		8	26.9	78.5	53.9
36	9793A1-5	39.5		24	33.2	58.8	42.1
37	97397B1-4-5	25.6	l	10	22.0	40.8	29.6
38	97398C1-5-3	35.6		1	22.5	43.4	75.6
39	97417A1-3-4	47.1		17	45.0	65.0	61.2
40	97463A1-17-1	23.6	l	7	13.2	41.9	32.5
41	GA901146 E 15	72.9	h	75	49.1	79.0	88.6
42	KY92C-491-18-1	68.9		62	45.7	89.8	78.1
43	KY92C-432-62	35.0		17	15.4	40.6	67.1
44	KY91C-170-3	65.9		37	49.6	70.5	106.3
45	KY91C-170-4-1	67.2		63	32.7	86.8	86.2
46	Harding	50.5		30	4.7	64.2	102.9
47	SD97060	36.5		12	0.0	44.5	89.3
48	D6234	50.4		24	26.9	62.9	87.9
49	D8006	64.1		54	43.4	55.9	102.9
	Average	47.8		27.5	34.5	62.9	67.4
	CV (%)	31.1			34.6	44.8	
	LSD (0.05)	20.8			25.5	34.1	
	R2	0.79					

† Indicates a mean that is not different from the lowest (l) or highest (h) mean in the column based on $LSD_{(0.05)}$

Table 15. Correlations among entry means for traits, as averaged over appropriate tests

	HD	SEV	INC	IND	KR	PSS	DON	SEV-GH
HD	1.00	-0.14	0.07	-0.19	0.32*	0.13	0.42*	-0.12
SEV	-0.14	1.00	0.74*	0.95*	0.65*	0.78*	0.47*	0.59*
INC	0.07	0.74*	1.00	0.82*	0.77*	0.68*	0.54*	0.46*
IND	-0.19	0.95*	0.82*	1.00	0.70*	0.76*	0.47*	0.56*
KR	0.32*	0.65*	0.77*	0.70*	1.00	0.84*	0.75*	0.45*
PSS	0.13	0.78*	0.68*	0.76*	0.84*	1.00	0.70*	0.49*
DON	0.42*	0.47*	0.54*	0.47*	0.75*	0.70*	1.00	0.31*
SEV-GH	-0.12	0.59*	0.46*	0.56*	0.45*	0.49*	0.31*	1.00

* indicates significance at 0.05 probability level

Table 16. Other traits for entries in 2001 NUWWSN

	NAME	NY: % heads with > 50% spikelets infected	MO: Field point inoculation spread index	MO: Septoria leaf bloth % canopy	AR: GH Leaf Rust [1]
1	Patterson	1.43	0.32	38	6.8
2	Freedom	0.21	0.21	47	2.9
3	P2545	0.88	0.73	32	4.3
4	Ernie	0.21	0.25	33	7.4
5	Hondo	0.39	0.19	55	5.3
6	KS96HW115	0.11	0.32	56	7.1
7	Heyne	0.00	0.19	49	2.2
8	MDV71-19	1.92	0.36	39	2.1
9	MO980525	0.00	0.14	18	5.0
10	MO960827	0.75	0.24	30	5.6
11	MO981020	0.14	0.17	25	6.0
12	MO980429	1.63	0.38	25	5.4
13	IL96-3514	0.12	0.21	43	1.5
14	IL96-6472	0.14	0.07	35	6.4
15	IL97-1828	0.37	0.34	30	6.3
16	IL97-4228	0.18	0.14	41	5.3
17	IL97-6268	0.25	0.17	27	4.9
18	Roane	0.08	0.18	28	5.3
19	VA96-54-326	0.84	0.47	43	4.4
20	VA98W-591	0.00	0.15	23	2.6
21	VA98W-593	0.52	0.24	29	4.0
22	VA99W-553	0.98	0.11	51	6.3
23	VA99W-562	0.00	0.54	48	2.7
24	VA99W-567	0.00	0.28	31	2.2
25	25R18	0.00	0.08	32	3.4
26	OH669	0.46	0.73	30	8.0
27	OH684	0.55	0.65	44	6.5
28	OH699	0.00	0.53	37	5.8
29	NY87048W-7388	0.09	0.15	29	5.1
30	NY87047W-6048	0.00	0.20	38	6.3
31	NY89052SP-9232	0.00	0.26	28	5.7
32	NY88024-117	0.00	0.51	34	6.0
33	NY88005-6035	0.20	0.33	44	3.1
34	NY89103-9149	0.00	0.65	32	4.9
35	961331A46-1-6	0.37	0.32	28	1.0
36	9793A1-5	0.12	0.28	26	6.0
37	97397B1-4-5	0.00	0.23	40	4.4
38	97398C1-5-3	0.45	0.17	23	5.2
39	97417A1-3-4	0.65	0.16	54	3.7
40	97463A1-17-1	0.20	0.15	29	3.7
41	GA901146 E 15	2.25	0.59	27	3.5
42	KY92C-491-18-1	0.22	0.13	47	5.3
43	KY92C-432-62	0.49	0.23	40	3.3
44	KY91C-170-3	1.28	0.90	55	5.5
45	KY91C-170-4-1	0.42	0.48	42	6.0
46	Harding	0.00	0.62	47	2.0
47	SD97060	0.00	0.18	32	3.1
48	D6234	0.00	0.37	27	4.3
49	D8006	1.52	0.81	52	4.9
	AVERAGE		0.33	36.4	
	LSD (0.05)		0.20	18.5	

[1] Rated 0-9 21 days after inoculation with three races:TLGL (virulent on Lr1,2a,2c,3,9,11,10);TNRL (Lr1,2a,2c,3,9,24,3ka,11,30,10);MCRL (Lr1,3,26,3ka,11,30,10)