ND252, ND253, ND254, NDSAB, and NDSF: THREE NEW INBRED LINES AND TWO GERMPLASM SOURCES OF EARLY CORN.

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Corn (*Zea mays* L.) acreage has been increasing steadily over the past decade in North Dakota, until almost 900,000 acres were planted to corn in 1982. Corn grain yields in the state have increased about 6.8 percent per year, which is probably a major reason for the increased acreage. Corn yields also are increasing nationwide and have risen by nearly 200 percent since 1950 (Anonymous, 1982). Although many factors have contributed to this yield increase, the two major ones are genetic improvement of the hybrids and increased use of nitrogen fertilizer (Sundquist et al., 1982).

Yield advances from nitrogen fertilizer have resulted from increases in proportion of total acres fertilized and increased application rates. Prospects for major yield gains from further increases in nitrogen use seem dim. In 1980 fertilizer nitrogen was applied to 96 percent of the total U.S. corn acreage, and responses to further application rate increases are decreasing while prices of nitrogen are increasing faster than other inputs (Sundquist et al., 1982). Conventional plant breeding is currently the single most important source of corn yield improvement, and future yield advances will probably be even more dependent on genetic improvement via plant breeding, a cost-effective and ecologically safe source of yield gains.

The corn breeding program at North Dakota State University dates back to the 1930s and has produced 45 inbreds and four synthetic varieties to serve as sources of future improved inbreds. ND252, ND253, and ND254 are new yellow dent inbred lines developed in the corn improvement project. NDSAB and NDSF are new synthetics for use in corn breeding programs to develop hybrids for extremely short season areas such as North Dakota. The effective use of these inbreds and synthetics requires knowledge of their ancestry and breeding behavior. While many of the experimental hybrids tested are not suitable for economical commercial production, their breeding behavior may suggest ways to best utilize these genetic materials in a breeding program.

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Breeding History

ND252 (tested as ND 79-10), a selection from the hybrid (W775 × W771), was self-pollinated for eight generations with selection for desired plant and ear traits. ND253 (tested as ND79-12) also was self-pollinated from a cross of two Wisconsin inbreds (W59 × W116) and was self-pollinated for eight generations with selection for plant and ear traits. ND254 (tested as ND 80-14) was selected from Rumanian Syn. D with seven generations of self-pollination and selection for plant and ear traits.

NDSAB was developed by one cycle of full-sib family selection among 100 full-sib families between NDSA and NDSB. Twenty families were recombined to form the original population which was then mass selected for three cycles for yield and standability. Thirty half-sib families were recombined each cycle. NDSF was developed by intercrossing approximately 65 inbreds which had been selected for early maturity and prolificacy. This synthetic was then intermated for two generations.

Agronomic Description

ND252 typically produces medium short plants with ears borne a little above mid-plant. Plants have short, wide leaves and medium sized tassels. Long, slender ears have 10 to 14 rows of shallow kernels borne on medium long shanks. ND252 is moderately resistant to head smut (caused by *Sphacelotheca reiliana* [Kuhn] Clint) and resistant to common rust (caused by *Puccinia sorghi* Schw.) (Table I). This inbred is about AES200 maturity in terms of the North Central Corn Breeding Research Committee classification system.

ND253 produces medium height plants with similar ear placement as ND252. Plants have large tassels and long, narrow leaves. Ears with 14 to 18 rows of medium sized kernels are borne on short shanks. ND253 appears resistant to wheat streak mosaic virus (WSMV) and had a moderately high stalk crushing strength. It also is moderately resistant to head smut, common smut (caused by *Ustilago maydis* [DC] Cda.), and common rust (Table 1).

ND254 plants are very short with ear placement slightly below midpoint of the stalk. Plants have short

Table 1. Head smut, common smut, and common rust infection levels of 10 standard and three new inbreds grown at Oakes, ND in 1981.

Inbred	Head smut	Common smut	Common rust
	----------% plants infected----------		(1-9)[1]
ND203	2.1	4.3	4.2
ND240	1.1	0.0	2.8
ND245	3.7	4.8	6.2
ND246	8.7	3.0	6.0
ND100	8.4	2.5	2.0
A654	2.1	0.0	2.0
CO109	4.2	0.0	2.8
W64A	0.5	6.2	1.3
CM105	0.0	0.0	2.0
ND247	1.8	0.8	2.1
ND252	1.1	3.6	1.8
ND253	0.6	1.1	2.0
ND254	0.0	6.7	2.9
L.S.D. (0.05)[2]	3.8	6.0	1.4

[1]The scale used was 1 to 9 with 1 assigned when no pustules were found and 9 when the leaves were completely covered.
[2]Inbred differences larger than this value would be expected due to random enviromental effects only one year in 20.

wide leaves and medium sized tassels. Medium long ears with 16 to 20 rows of small kernels are borne on medium long shanks. ND254 appears resistant to WSMV and moderately resistant to first generation European corn borer (*Ostrinia nubilalis* Hubner). It also is resistant to head smut and moderately resistant to common rust (Table 1). This inbred is AES200 maturity.

NDSAB plants are tall with ears borne slightly above mid-plant. This synthetic is similar in maturity, shelling percentage, and test weight to NDSC. It is higher yielding than NDSC but may be a little more susceptible to root lodging (Table 2). NDSAB is AES200-300 maturity.

NDSF plants are moderately short with ears placed slightly below mid-plant. NDSF has demonstrated higher shelling percentages and higher test weights than NDSAB. Yields are similar to NDSC, but NDSF is much earlier than NDSC or NDSAB. Lodging

Table 2. Agronomic performance of NDSAB and NDSF.

Entry	Yield	Ear moisture	Stalk lodging	Root lodging	Test weight	Plant height	Ear height	Shelling
	bu/A	%	%	%	lb/bu	cm	cm	%
---------- 1980 — 5 locations ----------								
NDSAB	88.8	35.1	18.7	0.0	56.5	171	93	79.2
NDSF	79.7	27.0	6.3	0.0	59.0	149	71	82.1
NDSC	74.1	36.4	16.9	0.3	55.4	160	73	77.9
NDSD	82.4	33.9	14.0	0.0	55.5	150	72	78.0
Pioneer brand 3978	125.1	29.8	1.5	0.0	58.5	153	75	85.9
L.S.D. (0.05)[1]	14.0	3.6	12.6	0.8	1.9	11	14	2.5
---------- 1981 — 5 locations ----------								
NDSAB	129.5	27.7	7.5	0.0	59.6	202	104	81.7
NDSF	106.5	23.3	7.1	0.0	60.9	175	72	84.1
NDSB	116.4	25.0	7.1	0.4	60.7	199	86	82.9
NDSC	108.1	27.1	11.6	0.0	59.7	190	87	81.5
NDSD	105.8	25.7	6.5	0.0	60.8	177	71	81.6
Pioneer brand 3978	158.1	25.4	0.0	0.3	61.1	183	88	86.0
L.S.D. (0.05)[1]	14.5	3.0	11.7	0.8	0.9	11	12	2.0
---------- 1982 — 5 locations ----------								
NDSAB	81.9	40.0	9.9	12.2	55.5	196	115	78.5
NDSF	67.4	29.7	18.3	7.2	59.5	165	71	80.8
NDSC	78.1	37.4	6.7	6.3	56.4	181	93	79.9
NDSB	77.3	36.7	11.5	9.2	58.1	190	98	79.8
Pioneer brand 3978	102.2	37.0	5.1	2.6	57.1	179	94	84.2
L.S.D. (0.05)[1]	12.8	3.3	7.1	7.1	1.2	11	13	2.3
---------- Mean — 15 environments ----------								
NDSAB	100.1	34.3	12.0	4.1	57.2	190	104	79.8
NDSF	84.5	26.7	10.6	2.4	59.8	163	71	82.3
NDSC	86.8	33.6	11.7	2.2	57.2	177	84	79.8
Pioneer brand 3978	128.5	30.7	2.2	1.0	58.9	170	86	85.4
L.S.D. (0.05)[1]	7.9	1.9	6.0	2.6	0.8	6	7	1.3

[1]Average differences among entries of this amount could be explained by random environmental effects only once in 20 repetitions of this experiment.

resistance is similar to NDSC (Table 2). NDSF is AES100-200 maturity.

Inbred Performance

ND252 was evaluated for yield and agronomic characters in 1978 at Fargo (Table 3). ND252 had below average yield, low ear moisture at harvest, and no root or stalk lodging. Shelling percentage, kernel rows/ear, and kernel depth were below average, but ear length was above average.

ND253 and ND254 were evaluated for inbred performance in 1980 (Table 4). ND253 had good inbred yields, below average root and stalk lodging, but above average ear moisture at harvest. Plant and ear height were near average as were ear length and kernel weight. ND253 had a very high shelling percentage, but below average test weight.

ND254 yielded above average, had no root or stalk lodging, and had below average ear moisture at harvest. It had above average shelling percentage and test weight but below average kernel weight.

Hybrid Performance

ND252 was tested in four hybrid combinations at three locations in 1980, 10 hybrid combinations at four locations in 1981, and 10 hybrid combinations at six locations in 1982 (Table 5). ND252 produced high yields in crosses with CM105, ND468, ND474, ND248, and ND240. It produced some heterosis when crossed to ND245 and ND246 (closely related sister lines) when compared to NDF465 (ND245 × ND246).

Three independent estimates of general combining ability (GCA) were obtained for ND252 (Table 6). General combining ability is the average performance of an inbred in various hybrid combinations. When tested in three environments in 1980, ND252 demonstrated very good GCA effects for low ear moisture and near average effects for yield, root lodging, and stalk lodg-

Table 3. Summary of yield and other agronomic characteristics for 10 standard inbreds and ND252 grown at Fargo in 1978.

Inbred line	Yield	Ear moist.	Plant ht.	Ear ht.	Stalk[1] lodging	Root[1] lodging	Ear length	Kernel rows/ear	Shelling %	Kernel depth
	bu/A	%	in.	in.	%	%	cm			cm
ND474	36.6	23.5	44	18	9.2	0.0	11.2	15.4	73.7	0.62
ND88	19.4	30.9	52	26	0.0	0.0	11.4	16.4	71.7	0.74
ND363	28.3	17.3	48	15	0.0	0.0	13.1	13.8	73.0	0.56
ND405	25.9	33.5	48	26	5.6	5.6	11.3	14.6	69.5	0.51
ND376	51.6	35.7	52	23	0.0	7.1	13.1	16.2	76.9	0.67
ND240	38.9	23.9	45	24	3.6	3.3	10.9	16.6	79.5	0.65
ND241	21.9	18.1	46	17	0.0	0.0	9.7	16.2	76.3	0.51
ND100	24.5	25.0	43	21	0.0	0.0	10.3	14.0	70.4	0.39
ND300	40.1	28.7	44	20	0.0	3.1	14.1	15.2	78.7	0.58
ND245	26.0	31.9	49	20	0.0	0.0	11.7	11.8	75.0	0.37
ND252	16.7	14.9	40	22	0.0	0.0	13.8	11.2	64.9	0.44
L.S.D. (0.05)[3]	14.8	10.5	7	8	10.1	12.2	2.0	2.0	6.3	0.19

[1]% of plants broken below the ear at harvest.
[2]% of plants lodged 30 degrees or more from vertical at harvest.
[3]See Table 1.

Table 4. Summary of yield and other agronomic characteristics for 12 standard inbreds, ND253, and ND254 grown at Fargo in 1981.

Inbred line	Yield	Ear moist.	Plant ht.	Ear ht.	Stalk[1] lodging	Root[1] lodging	Ear length	Kernel rows/ear	Shelling %	Test wt.	200 kernel wt.
	bu/A	%	in.	in.	%	%	cm			kg/hl	g
ND474	44.0	33.4	52	26	0.7	7.9	12.8	15.5	79.0	83.9	49.3
ND88	25.6	36.8	59	39	0.0	18.8	11.7	13.8	69.8	73.5	44.9
ND376	50.9	34.3	56	21	2.4	12.5	11.4	15.6	78.9	78.0	48.6
ND408	17.5	44.7	55	36	0.0	25.0	9.0	16.9	73.3	77.7	29.9
ND301	39.1	34.1	60	29	5.4	40.3	11.8	17.1	78.2	79.4	44.7
ND245	31.7	23.7	56	26	0.0	13.9	13.8	12.4	78.8	85.6	32.5
ND246	53.1	22.2	53	25	0.0	0.0	14.0	12.9	80.5	84.5	41.0
ND203	26.8	29.7	51	20	19.6	15.4	10.9	14.2	69.3	79.5	48.2
ND405	40.0	36.8	61	28	0.0	66.7	13.7	15.5	77.0	79.8	45.3
ND240	48.6	31.9	54	24	2.9	0.0	10.2	18.7	84.1	76.7	51.1
ND363	19.3	30.8	54	21	0.7	0.0	10.4	14.4	72.2	79.6	47.9
ND300	24.9	37.6	50	20	0.3	0.0	10.9	14.5	72.5	80.7	43.0
ND253	50.0	33.7	54	28	2.0	0.0	12.1	16.6	84.8	75.0	41.2
ND254	46.1	28.8	32	12	0.0	0.0	12.2	17.9	83.5	80.2	30.5
L.S.D. (0.05)[3]	13.7	5.6	11	14	28.7	43.5	2.2	1.8	8.5	3.5	6.3

[1]% of plants broken below the ear at harvest.
[2]% of plants lodged 30 degrees or more from vertical at harvest.
[3]See Table 1.

Table 5. Average performance of selected single cross hybrids with ND252, ND253, and ND254 and check hybrids.

Hybrid	pedigree	Yield	Ear moisture	Stalk lodging	Root lodging	P.I.[1]
		bu/A	%	%	%	
		Means of 3 locations in 1980				
NDF218	ND100 × ND252	69.8	23.9	0.0	3.8	96.2
NDF217	ND240 × ND252	77.4	22.7	0.0	0.1	112.4
NDF216	CM105 × ND252	85.1	22.0	0.0	15.7	127.5
NDF219	ND468 × ND252	86.5	20.4	0.0	0.7	139.7
NDF226	ND100 × ND253	75.8	27.5	0.0	5.9	90.8
NDF225	ND240 × ND253	83.3	27.6	0.6	4.2	99.5
NDF177	CM105 × ND253	97.0	23.0	0.0	3.0	139.0
NDF227	ND468 × ND253	82.8	24.9	0.8	7.9	109.6
Pioneer brand 3978		108.4	23.9	1.8	1.4	149.5
Sokota brand TS28		86.7	26.6	0.1	8.4	107.4
L.S.D. (0.05)		24.1	6.4	3.5	10.9	
Mean (64 hybrids)		79.5	26.2	0.4	4.3	100.0
		Means of 3 locations in 1981				
NDF260	ND100 × ND254	98.6	18.4	20.0	0.4	107.2
NDF299	ND240 × ND254	97.0	17.9	28.6	3.8	108.4
NDF336	A509 × ND254	106.5	18.8	49.1	3.9	113.4
NDF375	CM105 × ND254	114.5	20.1	2.1	0.0	114.0
L.S.D. (0.05)		19.5	2.7	23.6	10.4	
Mean (144 hybrids)		96.2	19.2	29.6	4.1	100.0
		Means of 4 locations in 1981				
NDF473	ND245 × ND254	107.6	26.8	6.4	0.5	109.1
NDF483	ND246 × ND254	109.6	27.6	5.2	0.0	107.9
NDF490	ND240 × ND254	106.1	28.1	2.7	0.7	102.6
NDF463	CM165 × ND254	120.4	28.4	6.5	0.8	115.2
NDF519	W59E × ND254	108.9	28.8	2.2	0.0	102.7
NDF524	ND248 × ND254	112.6	30.7	3.1	0.0	99.7
NDF513	ND100 × ND254	107.3	31.0	3.0	0.6	94.1
NDF452	ND474 × ND254	135.0	32.1	4.4	0.0	114.3
NDF500	A654 × ND254	117.3	34.4	2.6	0.0	92.7
NDF635	CG10 × ND254	110.3	35.0	6.0	0.0	85.6
NDF459	CM165 × ND252	109.9	27.1	5.0	0.0	110.1
NDF469	ND245 × ND252	71.2	27.5	1.1	0.0	70.3
NDF479	ND246 × ND252	73.2	27.6	5.7	0.0	72.0
NDF583	ND248 × ND252	114.0	28.8	7.4	0.7	107.5
NDF595	W59E × ND252	88.8	28.8	3.4	0.8	83.7
NDF217	ND240 × ND252	115.9	29.9	7.0	0.0	105.3
NDF448	A654 × ND252	104.8	30.4	5.6	0.0	93.6
NDF529	ND474 × ND252	113.8	30.6	7.2	0.8	101.0
NDF509	ND100 × ND252	96.6	31.5	4.0	0.0	83.3
NDF502	CG10 × ND252	118.3	32.4	5.6	0.0	99.2
NDF465	ND245 × ND246	43.1	28.1	1.8	0.8	41.6
Pioneer brand 3978		137.8	33.1	9.8	0.0	113.1
L.S.D. (0.05)		12.4	2.9	11.2	1.2	
Mean (100 hybrids)		111.2	30.2	5.4	0.2	100.0
		Means of 6 locations in 1982				
NDF529	ND474 × ND252	74.0	31.2	1.2	8.8	111.8
NDF541	ND249 × ND252	71.4	29.4	10.0	7.1	114.5
NDF216	CM105 × ND252	70.7	30.7	0.7	1.1	108.6
NDF564	CM182 × ND252	65.4	31.0	3.2	6.9	99.5
NDF574	ND247 × ND252	68.7	29.2	1.7	5.2	110.9
NDF583	ND248 × ND252	76.9	29.8	4.3	5.9	121.6
NDF217	ND240 × ND252	66.4	31.4	2.5	5.0	99.7
NDF595	W59E × ND252	57.3	29.8	4.0	3.7	90.6
NDF600	A509 × ND252	60.8	29.7	2.0	4.3	96.5
NDF606	ND301 × ND252	62.3	33.2	2.5	5.6	88.5
NDF532	ND474 × ND253	74.4	28.4	5.0	9.8	123.5
NDF544	ND249 × ND253	75.0	30.9	4.2	9.4	114.4
NDF375	CM105 × ND253	72.7	35.5	1.6	2.9	96.5
NDF567	CM182 × ND253	71.9	33.7	1.8	3.9	100.6
NDF577	ND247 × ND253	71.5	31.4	1.3	4.3	107.3
NDF586	ND248 × ND253	73.7	33.2	4.6	3.6	104.6
NDF592	ND240 × ND253	74.2	36.8	2.6	6.5	95.0
NDF598	W59E × ND253	62.1	30.6	1.2	1.2	95.7
NDF603	A509 × ND253	67.9	35.0	2.6	2.5	91.5
NDF609	ND301 × ND253	74.3	35.9	3.6	9.7	97.6
Pioneer brand 3978		78.9	32.8	1.6	5.0	113.4
L.S.D. (0.05)		9.0	3.5	8.4	9.7	
Mean (100 hybrids)		68.8	32.5	7.3	6.6	100.0

[1]P.I. = Performance index = (Yield/test mean)/(Ear moisture/test mean) × 100.

Table 6. Averge general combining ability effects for ND252, ND253, and ND254 compared to various sets of standard inbreds.

Inbred	Yield	Ear moisture	Stalk lodging	Root lodging
	bu/A	%	%	%
Design II analysis over 3 locations in 1980				
ND252	- 0.14	-3.51	-0.36	0.74
ND253	4.91	-0.01	-0.01	0.91
CG10	2.02	2.52	-0.36	3.96
ND474	- 2.05	-0.46	-0.11	-0.82
L.S.D. (0.05)	12.03	3.19	1.73	5.43
Design II analysis over 3 locations in 1981				
ND254	7.95	-0.45	-4.60	-2.10
CG10	- 2.70	0.15	-3.80	1.90
ND474	- 9.54	-0.15	6.90	2.90
ND300	3.18	0.75	-6.60	-0.10
L.S.D. (0.05)	9.75	1.36	11.79	5.22
Diallel analysis over 4 locations in 1981				
ND254				
CM165	4.45	-2.31	1.66	0.22
ND245	- 9.70	-2.83	0.16	0.05
ND248	1.27	-0.48	-0.24	-0.15
ND246	-10.97	-2.22	-1.21	0.02
ND100	- 5.88	0.15	-2.66	0.14
ND240	2.86	-0.76	1.22	-0.16
W59E	- 0.48	-0.13	-2.33	0.08
ND474	3.18	1.56	1.30	0.01
A654	5.25	2.76	-1.69	-0.09
CG10	7.95	3.65	3.98	-0.23
ND254	2.23	0.57	-0.14	0.12
L.S.D. (0.05)	3.94	0.90	3.54	0.39
ND252				
CM165	3.39	-2.29	1.33	0.16
ND245	- 6.85	-2.61	-0.55	0.02
ND248	2.36	-0.52	0.01	-0.06
ND246	- 7.65	-1.97	-1.34	0.04
ND100	- 2.90	0.35	-2.74	0.10
ND240	3.92	-0.42	1.47	-0.21
W59E	- 0.17	0.02	2.39	0.09
ND474	2.17	1.56	1.40	0.11
A654	3.97	2.51	-1.57	-0.08
CG10	6.96	3.54	3.76	-0.22
ND252	- 5.22	-0.10	0.67	0.02
L.S.D. (0.05)	3.94	0.90	3.54	0.39
Diallel analysis over 6 locations in 1982				
ND252				
ND474	6.49	-0.79	1.37	1.69
ND240	1.59	1.44	3.08	-0.52
CM182	- 5.47	2.51	-1.57	-1.15
A509	- 1.76	-1.77	1.08	-0.94
W59E	- 1.92	-0.40	0.36	-2.00
ND301	2.89	0.94	-2.87	6.81
ND248	1.37	-1.07	1.08	-0.63
ND247	0.89	-1.45	-3.01	0.91
ND249	1.11	-0.64	9.71	-0.77
CM105	- 3.80	3.08	-4.44	-2.10
ND252	- 1.45	-1.84	-4.79	-1.27
L.S.D. (0.05)	2.86	1.11	2.65	3.08
ND253				
ND474	5.74	-1.54	1.82	1.78
ND240	1.57	1.51	3.16	-0.38
CM182	- 5.61	2.31	-1.64	-1.46
A509	- 1.84	-1.72	1.21	-1.13
W59E	- 2.21	-0.79	0.15	-2.26
ND301	3.31	0.74	-2.69	7.21
ND248	0.27	-1.20	1.18	-0.87
ND247	0.40	-1.71	-2.98	0.81
ND249	0.70	0.96	9.20	-0.55
CM105	- 4.39	3.09	-4.28	-1.93
ND253	2.11	0.28	-5.08	-1.26
L.S.D. (0.05)	2.86	1.11	2.65	3.08

ing. In 1981 when tested in a diallel (all possible crosses among a group of inbreds) including closely related lines, ND245 and ND246, ND252 hybrids appeared to yield more than ND245 or ND246 hybrids, but they had higher ear moisture and tended to stalk lodge a little more. Grain yield GCA effects for these three inbreds were biased downward since they are related lines and hybrids between them have reduced hybrid vigor. In the 1982 diallel ND252 demonstrated very good GCA effects for stalk lodging resistance, ear moisture at harvest, and root lodging resistance.

ND253 was evaluated for GCA effects at three locations in 1980 and six locations in 1982. In both trials it had high GCA effects for yield and near average GCA effects for ear moisture. In 1982 it had the lowest GCA effects of all inbreds tested for stalk lodging and had below average root lodging GCA.

ND254 also was tested for GCA effects in two independent trials. In 1981 it produced high GCA effects for yield and low GCA for ear moisture, stalk lodging, and root lodging. In a diallel analysis in 1981, it produced above average GCA effects for yield and near average effects for ear moisture, root lodging, and stalk lodging.

Seed Increase and Distribution

Germplasm quantities of breeder seed of ND252, ND253, ND254, NDSAB and NDSF will be maintained by the Agricultural Experiment Station, North Dakota State University, Fargo. Inbred seed is normally produced by self-pollination in ear-to-row progenies while synthetic seed is usually grown in isolation and allowed to open-pollinate. ND252, ND253, and ND254 are available in normal cytopolasm only and will be distributed in 50-kernel lots to the extent of available supplies. NDSAB and NDSF will be distributed in 200-kernel lots to the extent of available supplies. All seed requests should be directed to the author.

REFERENCES

1. Anonymous. 1983. **The 1982 Plant Breeding Research Forum.** Pioneer Hi-Bred International, Inc. Johnston, IA.

2. Sundquist, B. W., K. M. Menz, and C. F. Neumeyer. 1982. **A technology assessment of commercial corn production in the United States.** Minnesota Agric. Exp. Stn. Bull 546.