CORN BREEDING AT NDSU

H.Z. Cross

ND101 and ND256 - Two Early Parental Lines of Corn

North Dakota's corn (*Zea mays* L.) production averaged $100 million over the last five years. Corn for grain (54 percent of corn acres) averaged $68 million. Production values have increased in the past decade due both to increased production and prices. Production increases can be attributed to increased acres and to higher yields.

In North Dakota corn is grown for grain, silage, and forage, but recent production increases have been in grain. Forage corn acreages have decreased from over 700,000 acres in the 1930s to less than 20,000 acres at present. Silage acreage peaked in the early 1960s at over 700,000 acres and then declined to around 350,000 acres where it has remained for the past 15 years. Over 400,000 acres of corn were harvested for grain in the 1940s and early 1950s. Then grain acreage declined to less than 200,000 acres until the mid-1970s when grian acreage again increased, and recently over 500,000 acres were harvested in 1981 and 1982.

Increases in acreage of corn grown for grain are due to many factors. Grain yields have increased rapidly in the last two decades making corn a more attractive cash crop. Corn marketing patterns are changing with more corn being shipped west. For corn being shipped west, North Dakota growers have competitive shipping costs with corn from Corn Belt states. Many growers have purchased row crop equipment to produce sunflower (*Helianthus annuus* L.). This equipment gives them the option of producing other row crops such as corn. Much of the recent corn acreage increase has been in areas of the state where corn had been a minor crop. New, early maturing hybrids with high yields and satisfactory lodging resistance have made corn grain production feasible in areas where it was previously unprofitable.

Two new corn parental lines have been developed in the corn improvement project at North Dakota State University. ND101 is an extremely early yellow dent inbred capable of producing 65 relative maturity (RM) hybrids. ND256 is another yellow dent inbred capable of producing 80 RM hybrids with high yields and strong stalks.

Figure 1. Dr. Cross examines an ear of ND101.

Cross is professor, Department of Agronomy.

Breeding History

A broad base synthetic, BS5, was the source population from which ND101 and ND256 originated. They each resulted from nine generations of selfing and selection for desirable plant and ear type.

Agronomic Description

ND101 typically produces short plants with ears borne below midpoint of the stalk. Plants have narrow, medium long leaves, and small tassels. Medium long, narrow ears have 10 to 12 rows of shallow kernels borne on relatively short shanks. In North Central Corn Breeding Research Committee (NCR-2) trials in 1982, ND101 was rated resistant to first generation European corn borer (*Ostrinia nubilalis* Hubner) and eyespot (caused by *Kabatiella zeae* Narita and Kiratsuka). ND101 silks 12 days earlier than CM105 at Fargo and is AES100 maturity in terms of the NCR-2 classification system.

ND256 plants are medium tall with ear placement slightly below midpoint of the stalk. Plants have medium long, wide leaves, and a medium sized tassel. Large diameter ears borne on short shanks are medium long and have 16 to 20 rows of deep kernels. In NCR-2 trials in 1983, this inbred was rated resistant to diplodia stalk rot, eyespot, and northern corn leaf spot (caused by *Helminthosporium carbonum* Ullstrup). This inbred silks 5 days earlier than CM105 at Fargo and is AES200 maturity.

Inbred Performance

ND101 and ND256 were evaluated for plant characters at Fargo in 1983 (Table 1). ND256 differed little from previously released ND lines for most plant characters, while ND101 was generally smaller than the other lines. They were evaluated for yield and other agronomic characters at both Fargo and Casselton (Table 2). Yields of these inbreds were comparable to other ND inbred lines while ear moisture at harvest was below average for ND101 and near average for ND256.

Figure 2. An ear of ND256.

Table 1. Summary of plant characteristics for ND101 and ND256 and eight standard inbreds grown at Fargo in 1983.

Inbred	Leaf no.	Leaf length	Leaf width	Tassel branches	Shank length	Plant height	Ear height	Rust[1] rating
		in.				in.		
ND474	10.8	22.5	2.85	10	3.3	56	27	9.0
ND240	10.9	19.9	3.54	23	10.1	48	19	8.0
ND408	12.3	23.4	3.25	5	5.8	64	35	6.5
ND203	10.9	26.0	3.05	14	4.7	45	20	8.5
ND246	9.9	22.3	3.24	16	5.6	48	20	5.0
ND247	10.6	27.7	2.95	8	5.2	53	26	6.0
ND301	12.1	23.5	3.05	9	6.5	59	23	8.0
ND253	12.4	24.1	3.25	26	2.3	55	25	7.5
ND101	8.2	23.1	2.46	6	3.3	35	12	3.5
ND256	10.7	23.0	3.74	11	4.6	52	21	6.0
L.S.D. (0.05)[2]	1.5	3.0	0.75	9	3.7	7	9	2.5

[1] The scale used was 1 to 9 with 9 assigned when no pustules were found and 1 when the leaves were completely covered.

[2] Inbred differences larger than this value would be expected due to random environmental effects only one year in 20.

Table 2. Summary of yield and agronomic characteristics of ND101, ND256 and eight standard inbreds grown at Fargo and Casselton in 1983.

Inbred	Yield	Ear moist.	Stalk[1] lodg.	Root[2] lodg.	Ear length	Ear diam.	Kernel rows/ear	Ears/ plant	Shelling %	Kernel depth	Test wt.
	bu/A	-------- % --------			--- in. -----					in.	lb/bu
ND474	31.5	15.0	21.2	1.4	3.93	1.22	15.5	0.80	75.9	0.22	59.8
ND240	46.4	15.1	19.2	0.2	4.13	1.58	17.9	1.16	83.5	0.31	53.4
ND408	20.2	36.9	9.3	0.1	4.84	1.23	13.6	0.97	58.6	0.17	57.4
ND203	11.1	19.8	2.8	4.2	3.57	1.28	14.1	0.91	60.7	0.21	56.4
ND246	30.2	12.0	9.4	0.5	5.64	1.17	11.4	0.88	84.8	0.14	63.9
ND301	49.4	11.2	22.6	9.4	4.86	1.43	15.8	1.64	78.7	0.23	58.3
ND253	53.7	11.8	9.1	0.1	5.40	1.46	16.2	1.14	84.8	0.27	55.2
ND247	26.5	11.9	14.6	0.4	4.70	1.22	13.1	0.98	78.0	0.19	57.6
ND101	19.6	6.2	26.6	0.0	4.73	1.21	11.8	1.11	70.0	0.13	58.7
ND256	34.0	13.0	7.7	0.0	4.31	1.61	18.0	0.82	78.6	0.32	55.0
LSD (0.05)[3]	20.0	15.0	28.9	ns	1.12	0.25	2.2	0.35	18.0	0.08	3.8

[1] % of plants broken below the ear at harvest.

[2] % of plants lodged 30 degrees or more from vertical at harvest.

[3] Seed Table 1.

Table 3. Average performance of selected single cross hybrids with ND101, ND256, and a check hybrid tested at several North Dakota locations.

Hybrid	Pedigree	Yield	Ear moisture	Stalk lodging	Root lodging	Test weight	P.I.[1]
		bu/A	----------- % -----------			lb/bu	
		Means of 5 locations in 1983					
NDF767	ND101 x ND474	64.5	15.5	26.8	0.3	60.3	104.8
NDF789	ND101 x ND248	52.6	14.1	20.9	3.0	57.2	93.9
NDF799	ND101 x ND240	71.8	17.9	11.0	2.0	54.3	101.0
NDF825	ND101 x ND249	68.9	14.1	32.3	0.8	57.8	123.0
NDF832	ND101 x ND250	54.6	12.7	26.0	3.0	60.0	108.2
NDF839	ND101 x ND251	57.0	12.4	25.3	8.6	59.9	115.7
NDF846	ND101 x CM105	84.0	14.8	7.5	7.3	55.7	142.9
NDF779	ND101 x ND245	50.6	10.0	9.8	0.0	62.0	127.4
NDF768	ND256 x ND474	79.6	17.0	8.1	3.8	56.8	117.9
NDF780	ND256 x ND245	76.4	14.9	9.7	11.2	59.5	129.1
NDF790	ND256 x ND248	74.1	17.3	14.1	2.3	53.7	107.8
NDF800	ND256 x ND240	73.9	18.5	15.8	6.8	53.8	100.6
NDF811	ND256 x A554	77.1	16.8	8.3	7.1	54.5	115.5
NDF819	ND256 x CO109	63.9	14.7	13.7	8.6	57.0	109.4
NDF826	ND256 x ND249	65.4	16.6	28.5	10.3	55.0	99.2
NDF833	ND256 x ND250	71.0	18.7	11.3	13.7	56.0	95.6
NDF840	ND256 x ND251	72.3	14.7	14.1	5.2	56.0	123.8
NDF847	ND256 x CM105	65.3	15.3	8.2	1.6	55.0	107.5
Pioneer brand 3978		83.0	17.3	13.3	0.6	55.7	120.8
LSD (0.05)[2]		13.4	5.0	12.8	13.4	2.3	
		Means of 3 locations					
NDF236	ND101 x ND100	110.0	18.4	21.0	10.6	52.6	119.3
NDF799	ND101 x ND240	90.3	19.2	15.5	4.0	55.2	93.9
NDF326	ND101 x A509	101.1	23.3	23.5	8.0	53.2	86.6
NDF846	ND101 x CM105	128.9	20.5	11.0	3.4	54.2	125.5
NDF238	ND256 x ND100	122.4	17.2	11.3	0.7	55.9	142.0
NDF800	ND256 x ND240	106.9	24.2	30.7	21.2	54.2	88.2
NDF328	ND256 x A509	106.9	20.8	20.8	2.6	56.2	102.6
NDF847	ND256 x CM105	103.9	17.1	23.5	1.0	56.5	121.3
LSD (0.05)[2]		19.5	2.7	23.6	10.4	1.7	

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

[2] See Table 1.

Neither inbred had any root lodging; stalk lodging was above average for ND101 and below average for ND256. Test weights were slightly below average for ND256 and above average for ND101.

Hybrid Performance

These inbreds were tested in four hybrid combinations each at three locations in 1981 and in several hybrid combinations at five environments in 1983 (Table 3). ND101 produced high yields with CM105 in both years. It also performed well when crossed to ND240 and produced a 65 R.M. hybrid when crossed to ND245. ND256 performed best in crosses with ND245, ND474, A554, and ND100.

Table 4. Average general combining ability effects for ND101 and ND256 compared to standard inbreds.[1]

Inbred	Yield	Ear moisture	Stalk lodging	Root lodging	Test weight
	bu/A	---------	%	---------	lb/bu
		Design II analysis over 3 locations in 1981			
ND101	11.38	1.10	-11.84	2.43	-1.71
ND256	13.82	0.58	-8.02	2.30	0.24
CG10	-2.70	0.15	-3.80	1.90	-0.81
ND474	-9.54	-0.15	6.90	2.90	-1.13
ND300	3.18	0.75	-6.60	-0.10	-1.48
LSD(0.05)[2]	9.75	1.36	11.79	5.22	0.85
		Diallel analysis over 5 locations in 1983			
		ND101			
CM105	5.07	0.16	-3.94	-1.04	-1.55
ND474	7.20	1.18	1.10	0.34	0.85
ND245	-3.72	-1.78	-9.16	-0.30	2.71
ND249	-8.25	0.14	9.62	-1.58	0.83
ND240	2.15	0.75	-0.65	-1.74	-2.44
ND250	6.90	-0.07	-3.52	4.63	-1.14
ND251	-4.85	0.55	2.57	2.08	0.34
ND248	-0.33	0.82	2.51	0.26	-0.89
ND101	-5.71	-1.71	1.51	-2.61	0.68
LSD(0.05)[2]	4.73	1.78	4.55	4.72	0.80
		ND256			
CM105	1.40	0.29	-2.41	-2.83	-0.76
ND474	4.90	0.58	0.84	-0.48	-0.45
ND245	-1.38	-2.11	-6.48	-0.46	3.19
A554	1.92	0.82	-5.28	4.07	0.28
ND249	-10.13	-0.23	11.04	-2.22	-0.58
ND240	-0.08	0.14	1.99	-3.15	-1.85
ND250	5.69	-0.26	-2.91	6.34	1.51
ND251	-4.44	0.21	2.63	1.31	0.45
ND248	0.57	0.40	3.20	-1.89	-0.37
ND256	1.56	0.18	-2.62	-0.66	-1.42
LSD(0.05)[2]	4.47	1.67	4.29	4.45	0.76

[1] General combining ability effects are differences between the mean of all hybrids in the test and all hybrids produced form a particular inbred. Negative values indicate hybrids containing that inbred were below average while positive values indicate above average performance.

[2] See Table 1.

The hybrids with ND101 and ND256 were components of diallel (all possible crosses among a group of inbreds) sets of hybrids which permitted estimates of general combining ability (GCA) effects (Table 4). In 1981 a partial diallel (Design II analysis) indicated ND101 had higher GCA effects for yield than ND474 or CG10 while ND256 had higher effects than all three check inbreds. GCA effects for stalk lodging resistance for both inbreds were superior to ND474. ND256 also had superior GCA for test weight than the check inbreds.

In more extensive tests in 1983 ND101 had below average GCA effects for yield, ear moisture, and stalk lodging resistance. It was above average for test weight and root lodging resistance. ND256 was evaluated in 10 hybrid combinations in 1983. Its GCA effects were above average for yield, stalk lodging resistance, and root lodging resistance. It was near average for ear moisture and below average for test weight.

Seed Increase and Distribution

Germplasm quantities of breeder seed of ND101 and ND256 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. ND101 and ND256 are available in normal cytoplasm only and will be distributed in 50-kernel lots to the extent of available supplies. All seed requests should be directed to the author.

ND304W - An Early White Dent Germplasm Line of Corn

About 3.5 million metric tons of maize (*Zea mays* L.) are dry milled annually in the U.S. (Watson, 1977). The utilization of dry milled corn has almost doubled in the past 25 years (Sundquist et al., 1982). A generation ago white corn for dry milling purposes was produced in the southern United States with Kentucky being the leading state (Aldrich et al., 1975). Today there are advantages to producing white corn for dry milling in the central and northern Corn Belt. Nesheim (1973) has pointed out that mills must carefully examine incoming corn for presence of molds and aflatoxin and purchase only sound lots. Shotwell et al., (1973 a, b) reported that corn grown in the northern U.S. Corn Belt had lower levels of aflatoxin when compared to corn grown in the southern U.S. Sundquist et al. (1982) stated that in 1945 exports accounted for only one-half of one percent of corn disappearance in the U.S. but that by 1980 exports accounted for 31 percent. While most of the domestic consumption of corn is for animal feed (Sundquist et al., 1982), many countries use corn mainly for human consumption. As the export market expands, perhaps the export market for high quality white corn for dry milling also will increase.

At present the corn hybrids being used in the dry milling industry are adapted to the central and southern Corn Belt and the southern U.S. (Aldrich et al., 1975). There are limited numbers of very early parental inbreds which could be used to produce very early maturing white hybrids suitable for use by the U.S. dry milling industry. If early maturing and high yielding white hybrids suitable for milling were available, there might be opportunities to produce white corns in northern areas such as North Dakota with very low incidence of aflatoxin.

ND304W is a white dent inbred released in December 1983 by the North Dakota Agricultural Experiment Station as a germplasm source for producing early white dent hybrids.

Breeding History

ND304W was selected from a cross of (ND408 x B73) x W23yy. It was self-pollinated for six generations with selection for desired plant and ear traits.

Agronomic Description

ND304W produces medium tall plants with ears borne about midway up the stalk on short shanks. Plants have leaves of medium length and width and small tassels. The medium long ears are thick and have 18 to 22 row of kernels borne on a white cob. Dent kernels have white endosperm and a medium hard texture.

This inbred has not been evaluated for resistance to specific insects, diseases, or herbicides. ND304W appears to be AES300 maturity in terms of the North Central Corn Breeding Research Committee's classification system.

Hybrid Performance

ND304W was tested in four hybrid combinations at three locations in 1983 (Table 1). In these crosses to yellow endosperm inbreds, ND304W performed best when crossed to CM105. Its general combining ability (GCA) for yield was equivalent to the three standard yellow inbreds (Table 2). ND304W's GCA for grain moisture was better than similar GCAs for ND300 or CG10 and its GCA for stalk lodging was better than any of the check inbreds. However, ND304W had an inferior GCA for test weight compared to ND474 or ND300.

ND304W has not been evaluated in hybrid combinations with other white endosperm inbreds. It also has not been evaluated for quality characteristics required by the dry milling industry.

Seed Increase and Distribution

Germplasm quantities of breeder seed of this germplasm line will be maintained by the Agricultural Experiment Station, North Dakota State University, Fargo. This line is available in normal cytoplasm only and will be distributed in 25 kernel lots to the extent of available supplies. Seed requests should be directed to the author.

Table 1. Average performance of selected single cross hybrids with ND304W and two commercial checks tested at three North Dakota environments in 1983.

Hybrid	Pedigree	Yield	Grain moisture	Stalk lodging	Root lodging	Test wt.	P.I.[1]
		bu/A	- - - - - - - - -	%	- - - - - - - - - -	lb/bu	
NDF971	ND304W x ND245	74.8	13.7	24.6	1.0	58.2	138.9
NDF904	ND304W x CM105	80.6	13.1	10.3	0.0	53.4	156.5
NDH006	ND304W x ND301	78.4	17.7	18.1	1.9	54.6	112.7
NDF937	ND304W x ND230	56.1	15.5	41.9	1.7	56.6	92.1
Pioneer Brand	3978	75.0	16.0	21.8	0.0	58.4	119.3
Pioneer Brand	3901	93.1	31.3	7.7	4.4	51.4	75.7
LSD(0.05)[2]		23.9	4.5	7.0	3.1	2.3	—
Mean (144 hybrids)		67.6	17.2	27.2	1.0	55.8	100.0

[1] P.I. = Performance index = (yield/test mean)/(ear moisture/test mean) x 100. The P.I. is a measure of a hybrid's yield compared to other hybrids of similar maturity as indicated by grain moisture at harvest.

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

Table 2. Average performance of ND304W and three standard inbreds in crosses to four tester inbreds grown in three environments in 1983.

Inbred	Yield	Grain moisture	Stalk lodging	Root lodging	Test weight	P.I.[1]
	bu/A	--------	%	--------	lb/bu	
ND474	72.85	14.62	32.02	0.72	58.2	126.8
ND300	70.42	18.42	31.85	1.92	58.2	97.3
CG10	68.48	18.70	30.50	0.58	56.0	93.2
ND304W	72.48	15.00	23.72	1.15	55.7	123.0
LSD(0.05)[1]	11.97	2.24	3.48	1.56	1.1	—

[1] See Table 1.

Figure 3. An ear of ND304W.

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NDSG(MS)C_5, NDSC(FS)C_1, and NDSD(FS)C_1:

Three New Germplasm Sources of Early Corn

Hybrid seed is now used for almost all the U.S. corn (*Zea mays* L.) production. Uniformity is a major advantage of hybrids over open-pollinated varieties. Each plant of a single cross hybrid variety is genetically identical, while open-pollinated varieties are a composite of genetically diverse individual plants. This uniformity gives the hybrid numerous advantages.

Many genes influence a complex trait such as grain yield. Each plant of an open-pollinated variety differs in its genetic yield potential. Some plants inherit many favorabel yield genes while others inherit fewer. The average yield potential of an open-pollinated variety is determined by both the genetic composition of each plant and the frequency of occurrence of high, medium and low yielding types. If one could identify the highest yielding plant and duplicate it many times so all plants in the corn field are genetically identical, much higher yields would result.

Basically, this is the objective of hybrid corn breeders. They strive to develop a hybrid plant with a maximum number of favorable yield genes. This hybrid plant can then be exactly reproduced millions of times for use in commercial production fields. Identifying plants with the maximum favorable yield genes is the major problem in hybrid breeding. This problem can be reduced by selecting source populations with a high frequency of plants with many favorable yield genes. Synthetics are open-pollinated varieties created by combining several corn strains with desirable characteristics.

Synthetics are becoming common source populations for new parental inbred lines for use in Corn Belt hybrids. The usefulness of a synthetic as a source population often can be enhanced by increasing the frequency of favorable genes through various recurrent selection procedures.

NDSG(MS)C_5, NDSC(FS)C_1, and NDSD(FS)C_1 are new yellow dent synthetics developed in the corn improvement project at North Dakota State University for use in early maturity corn breeding programs.

Breeding History

NDSG(MS)C_5 was developed by five cycles of mass selection for yield and standability from NDSG, an unreleased experimental synthetic. Equal numbers of seeds from 30 ears (half-sib families) were composited to give an improved population each cycle. Selection intensity was approximately 1 percent. NDSG was derived from the open-pollinated variety Minnesota 13 by two cycles of mass selection for larger kernel size and several cycles of selection for improved agronomic appearance.

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Table 1. Agronomic performance of NDSG(MS)C_5, NDSC(FS)C_1, and NDSD(FS)C_1 grown over three years in North Dakota.

Entry	Yield	Ear moist.	Stalk lodg.	Root lodg.	Test weight	Plant height	Ear height	Shelling
	bu/A	---------	%	-------	lb/bu	-----	cm -----	%
			1981 - 5 locations					
NDSG	43.9	26.8	31.0	0.0	58.6	169	69	82.0
NDSG(MS)C_5	111.2	26.2	13.0	0.0	59.3	192	94	81.6
NDSC	108.1	27.1	11.6	0.0	59.7	190	87	81.5
NDSC(FS)C_1	129.0	29.0	9.6	0.0	61.0	202	92	80.9
NDSD	105.8	25.7	6.5	0.0	60.8	177	71	81.6
NDSD(FS)C_1	107.9	20.9	3.6	0.0	62.4	174	81	84.2
Pio.Brd 3978	158.1	25.4	0.0	0.3	61.1	183	88	86.0
LSD(0.05)[1]	14.5	3.0	11.7	0.8	0.9	11	12	2.0
			1982 - 5 locations					
NDSG	62.9	34.5	22.5	11.2	56.2	179	94	80.4
NDSG(MS)C_5	76.9	39.0	14.7	11.1	55.0	190	103	79.0
NDSC	78.1	37.4	6.8	6.3	56.4	181	93	79.9
Pio.Brd 3978	102.2	37.0	5.1	2.6	57.1	179	94	84.2
LSD(0.05)[1]	12.8	3.3	7.1	7.1	1.2	11	13	2.3
			1983 - 5 locations					
NDSG	66.7	23.4	32.1	20.4	57.2	188	91	82.5
NDSG(MS)C_5	83.3	27.1	16.4	19.6	57.5	188	97	82.5
NDSC	69.2	29.5	14.6	8.9	59.5	170	84	80.9
NDSC(FS)C_1	94.0	28.8	17.1	8.3	58.9	188	79	80.9
NDSD	86.4	26.3	10.9	7.0	60.5	178	89	81.1
NDSD(FS)C_1	93.0	28.8	12.1	7.5	58.9	173	76	81.4
Pio.Brd 3978	122.9	25.2	10.3	2.9	60.1	165	69	86.2
LSD(0.05)[1]	13.7	3.4	10.2	8.7	1.2	40	30	2.0
			Mean 15 environments					
NDSG	57.8	28.2	28.5	10.5	57.3	179	85	81.6
NDSG(MS)C_5	90.5	30.8	14.7	10.2	57.3	190	98	81.0
NDSC	85.1	31.3	11.0	5.1	58.5	180	88	80.8
Pio.Brd 3978	127.7	29.2	5.1	1.9	59.4	176	84	85.5
LSD(0.05)[1]	7.8	2.0	5.5	3.8	0.7	7	8	1.4
			Mean 10 environments					
NDSC	88.6	28.3	13.1	4.4	59.6	180	86	81.2
NDSC(FS)C_1	112.0	28.9	13.4	4.2	60.0	195	86	80.9
NDSD	96.1	26.0	8.7	3.5	60.6	178	80	81.4
NDSD(FS)C_1	100.4	24.8	7.8	3.8	60.6	174	78	82.8
Pio.Brd 3978	140.5	25.3	5.2	1.6	60.6	174	78	86.1
LSD(0.05)[1]	10.0	2.8	7.8	4.4	0.8	10	7	1.2

[1] Synthetic differences larger than this value would be expected due to random environmental effects only once in 20 repetitions of the experiment.

aimed at capturing the farmer's attention and persuading him to make purchases.

Two programs, rebates and interest concessions, surfaced as being relatively effective in stimulating agricultural equipment sales. Rebate programs were the most effective at promoting sales, but also caused the most confusion. Interest concessions were second at increasing sales while being a virtual trouble-free promotion to local retailers. Other marketing incentives were considered ineffective means of increasing agricultural purchases.

Retailers believed marketing incentive programs helped them increase sales and survive a low volume marketing year. They felt that the single most effective way for them to increase their sales volume would be for the manufacturer to cut prices, although most used many or all of the promotions. This would allow the local retailer to deal more effectively with farmers. Also, farmers' confidence and trust, which were eroded by the manufacturers' programs would have been preserved. Local retailers welcomed the marketing incentive programs and believed some to be effective in stimulating agricultural equipment sales.

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NDSC(FS)C_1 and NDSD(FS)C_1 were developed by one cycle of reciprocal full-sib selection among full-sib families between NDSC and NDSD synthetics released earlier (1). Among approximately 400 sets of attemted crosses, 33 successful full-sib families with corresponding selfed ears were obtained. These were tested at three locations and 15 superior families were identified based on a rank-summation-index which weighted yield 40 percent and 20 percent each for ear moisture at harvest, stalk lodging resistance, and root lodging resistance. Remnant seed from selfed ears from plants which produced the superior full-sib families were planted and intercrossed within both NDSC and NDSD by making full-sib matings and compositing seed within each for the improved synthetics NDSC(FS)C_1 and NDSD(FS)C_1.

Agronomic Description and Performance

NDSG(MS)C_3 plants are tall with ears borne slightly below midplant (Table 1). This synthetic is about the same maturity as NDSC and is taller with higher ear placement. It has lower test weights and more root lodging than NDSC. Compared to NDSG this version is much improved for yield and resistance to stalk lodging. Plants are later and taller than the original NDSG. Maturity is AES200-300 in terms of the North Central Corn Breeding Research Committee classification system.

NDSC(FS)C_1 plants are taller than NDSC plants but appear unchanged relative to maturity, shelling percentage, test weight, and lodging resistance. However, grain yield has been improved by 26 percent over NDSC. This synthetic also is AES200-300 maturity.

NDSD(FS)C_1 plants are similar to NDSD plants in plant and ear height, test weight, and lodging resistance. However this synthetic has improved shelling percentages and tends to have higher yields and lower moisture at harvest than NDSD. NDSD(FS)C_1 is AES200-300 maturity.

Seed Increase and Distribution

Germplasm quantities of breeder seed of NDSG(MS)C_1, NDSC(FS)C_1, and NDSD(FS)C_1 will be maintained by the Agricultural Experiment Station, North Dakota State University, Fargo. Seed iwll be distributed in 200-kernel lots to the extent of available supplies. All seed requests should be directd to the author.

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