EVALUATION OF INBRED PARENTS OF CORN HYBRIDS IN NORTH DAKOTA

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Information on performance of experimental corn hybrids and their parental inbreds is of importance to individuals and companies interested in developing commercial hybrids. Single cross hybrid yields are useful in predicting the future performance of that single cross hybrid per se, and the performance of double or three-way crosses containing the same inbred lines. General combining ability, a measure of the average performance of an inbred in hybrid combination, is used to select inbreds for possible hybrid production and for inclusion in breeding programs aimed at developing improved corn inbreds.

The major objective of the corn improvement project at North Dakota State University is development of parental inbred lines which can be used in producing better corn hybrids for North Dakota's corn growers. Production of hybrid seed corn requires much technical knowledge, specialized equipment, and labor for detasseling. Therefore, almost all hybrid corn seed is produced by commercial seed companies rather than individual growers. While many of the larger seed companies have research programs aimed at developing new parental lines, most smaller seed companies find the economic burden of inbred development too much to bear. These small companies, and to a certain extent the larger companies, rely heavily on inbreds developed by experiment stations (57 per cent of commercial hybrids had a public inbred parent, according to a 1975 survey). Because of the highly competitive nature of their business seed companies protect their hybrids by concealing the identity of the parental inbreds. Effective use of these inbreds depends upon seedsmen having information about which combinations of inbreds produce good hybrids.

Corn hybrids may react differently to variable environments. Therefore, new hybrids should be evaluated in environments similar to those where they will be grown. Evaluation of hybrids in Minnesota or South Dakota may not indicate their value for North Dakota. Many new inbreds have been released by experiment stations in the Northern Corn Belt in recent years. Some of these inbreds possibly could be used in producing hybrids in combination with one or more of the 35 inbreds released by the North Dakota Agricultural Experiment Station. Of the three basic types of corn hybrids, single crosses, three-way crosses and double crosses (1), single crosses appear to be the most desirable type to test. Considering only hybrids produced from the 35 North Dakota inbreds, there are 595 possible single crosses, 19,635 possible three-way crosses and 157,080 possible double crosses. Testing all possible hybrids obviously is impractical. However, the performance of three-way and double crosses can be accurately predicted from the yield estimates of their component single crosses. Several single crosses were produced from new and standard inbreds to evaluate their potential in North Dakota. The objective of the research reported herein was to provide more extensive and up-to-date information on experimental hybrids than is currently available (2,3).

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Procedure

The data presented were obtained from replicated one-row plots grown in lattice designs. The corn was seeded at excessive rates and thinned to near optimum stands at each location. Yields were not adjusted for stand differences. Most plots were approximately 1/1,000 of an acre. At maturity ears were hand harvested, weighed, dried, and reweighed to determine ear moisture content. Grain was shelled from the cob, weighed, and multiplied by an appropriate factor to compensate for variations in plot size and moisture content to obtain bushels of shelled grain per acre at 15.5 per cent moisture.

Stalk lodging is reported as the percentage of ear-bearing stalks which were broken below the ear at harvest. Root lodging is the percentage of stalks leaning 30 degrees or more from vertical at harvest. All lodging data were computed from actual plant counts within each plot.

Four different experiments were grown from

1972 to 1976 at from 5 to 11 environments (Table 1). Experiments I, II, and III involved 10 inbreds crossed in all possible combinations (a diallel set) to give 45 single crosses. Experiment IV involved all crosses among a set of 11 inbreds. One advantage of utilizing diallel sets is that estimates of the average performance of each inbred in all hybrid combinations, termed general combining ability (GCA) gives useful information about the parental inbreds which would not be obtained by testing random single crosses. The GCA estimates were obtained for each inbred line within each experiment by a combining ability analysis.

Results and Discussion

Experiment I

Yields over the five environments in 1972 averaged 98.2 bushels per acre. Yields of the 10 highest yielding hybrids (Table 2) ranged up to 115 bushels per acre. While the results of the combining ability analysis in this study are not applicable to inbreds other than the 10 included in the study, they do tend to point out weaknesses or strengths of various parental lines relative to the other lines in the experiment. The highest yielding hybrid was ND405 × NDB8, but as with many hybrids with NDB8, it had above average stalk lodging. Hybrids produced from NDB8 and CO303 were generally high yielding as indicated by the high GCA effects (Table 3). The lines ND363 and ND364 produced early maturing but low yielding hybrids. However, these parents imparted some stalk strength to their progeny. Since ND363 and ND364 are closely related inbreds, the hybrid ND363 × ND364 is low yielding (24 bushels per acre) as might be expected. If this hybrid were omitted from the combining ability analysis, the average yield performance yields of ND363 and ND364 relative to the overall mean. (GCA effect) probably would be approximately −2 rather than the −9 values reported.

The closely related inbreds, ND407 and ND405, also produce better average yields when ND407 × ND405 is omitted from the analysis.

Experiment II

This group of hybrids, which are generally later maturing than the group in Experiment I, were grown in 11 environments from 1973 to 1975. The three highest yielding hybrids in this group had ND408 as a common parent (Table 4). The general level of stalk lodging was higher in this experiment than in Experiment I. This probably should be partly attributed to the environmental conditions (more windstorms, etc.) than to poorer stalk quality of these hybrids.

Hybrids from ND408 and ND376 produced the highest average yields (Table 5). MS141 and ND376 appeared to confer the most stalk quality to their hybrids. NDB8 did not perform as well as a high yielding parent in this experiment as in Experiment I. One reason for this difference is that ND485 and NDB8 are related lines and the low yield of this hybrid reduced their average performance. Also, NDB8 was one of the latest maturing parents for Experiment I hybrids while it is relatively early among Experiment II parents. The environments sampled in Experiment II would tend to be more favorable for later hybrids than those produced from NDB8.

Experiment III

The 45 hybrids in this experiment were similar in maturity to those in Experiment I, but several different inbreds were used as parents and more of the environments sampled were in areas with shorter average growing seasons. Four of the five highest yielding hybrids included ND474 as one parent (Table 6). In general, root lodging was higher and stalk lodging lower than for Experiment II. A comparison of the average performances of these inbreds in hybrids (Table 7) indicated some similarities to the results for Experiment I. CO303 hybrids were generally high yielding, early, and susceptible to root lodging. ND363 hybrids were rather low yielding, early maturing, and resistant to lodging. In contrast to Experiment I, hybrids with ND474 as one parent were high yielding while ND468 crosses produced low yields. The reason for the poor performance of ND468 in this experiment is reflected in the stands at harvest. Seed produced from this inbred in 1973 was of low viability and plant counts at harvest were low in some environments for hybrids involving this parent. The reason for the better performance of ND474 as a parent in this experiment was not obvious. Perhaps, ND474 hybrids were relatively more adapted to the shorter growing seasons sampled by Experiment III. The parent line, CG10, produced high yielding hybrids with about average lodging resistance for this group of inbreds.

Experiment IV

The parental lines tested in this diallel set of crosses involved ND474 and ND363, two lines in common with Experiments I and III. Parental lines included two new inbreds released in 1974, ND240 and ND241, and an experimental line ND71-36. The experimental hybrid, CM182 × ND71-36 produced the highest yield (72.7 bushels per acre) over the five environments tested in 1976 (Table 8).

The average yield estimates (Table 9) for ND240 and ND241 hybrids were lowered because the sister cross ND240 × ND241 was very low yielding and crosses with related line ND71-36 were somewhat lower than average. By excluding the two related hybrids from the analysis for ND240 and ND241 the average yields of their hybrids relative to overall means would have been +2.3 and −0.5, respectively. Of the 11 parental lines in this experiment CM182 produced the highest yielding hybrids. These hybrids were early and had above average resistance to root lodging. As in the previous experiments, ND363 hybrids were rather low yielding but resistant to stalk lodging. The unreleased experimental inbred was a high yielding parent lacking stalk and root lodging resistance. ND474 performed intermediate with reference to its performance in the other two experiments.

Summary

Performance data were summarized from four experiments with hybrid corn grown from 5 to 11 environments. Grain yield, ear moisture content, stalk and root lodging were reported for the 10 highest yielding hybrids in each experiment and a general combining ability analysis was computed for each group of parental inbreds. Inbreds producing hybrids with high average yields included NDB8 and CO303 in Experiment I; ND408, ND376, and ND478 in Experiment II; ND474, CG10, CO303, and CG1 in Experiment III; and CM182, ND71-36, and possibly ND240 in Experiment IV.

Parental inbreds which conferred above average stalk lodging resistance to their hybrids were ND364 and ND363 in Experiment I; MS141, ND376, and ND481 in Experiment II; ND468 and ND363 in Experiment III; and ND363 in Experiment IV. Inbreds which apparently produced hybrids with low averages for root lodging included A90, NDB8, ND485, W153R, ND468, ND474, ND363, CM182, and PA363.

REFERENCES

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Table 1. Environments sampled for evaluation of four diallel sets of corn hybrids.

Experiment I			Experiment II			Experiment III			Experiment IV		
Year	Location	Yield	Year	Location	Yield	Year	Location	Yield	Year	Location	Yield
		Bu/Ac			Bu/Ac			Bu/Ac			Bu/Ac
1972	Oakes, Irrig.	123	1973	Oakes, Irrig.	130	1973	Fargo	160	1976	Fargo, Irrig.	81
1972	Oakes	112	1973	Oakes	54	1973	Larimore	79	1976	Larimore	41
1972	Fargo	97	1973	Mooreton	121	1974	Mandan	23	1976	Mandan	41
1972	Larimore	74	1973	Fargo	115	1974	Larimore	76	1976	Carrington, Irrig.	89
1972	Mandan	43	1974	Oakes, Irrig.	107	1974	Casselton	90	1976	Carrington	39
			1974	Oakes	74	1975	Fargo	56			
			1974	Mooreton	69	1975	Casselton	72			
			1974	Casselton	84	1975	Larimore	95			
			1975	Oakes, Irrig.	121	1975	Mandan	73			
			1975	Oakes	74						
			1975	Casselton	121						

Table 2. Grain Yield and Other Agronomic Data for the 10 Highest Yielding Hybrids among 45 Hybrids grown in Experiment I over five locations.

Hybrid	Pedigree	Yield (Bu/Ac)	Ear mois. %	Stalk lodg. %	Root lodg. %
NDB454	ND405 × NDB8	115.3	33.8	10.8	0.0
NDB55	ND407 × CO303	114.8	30.2	8.7	16.5
NDR479	NDB8 × CO303	114.1	29.6	7.9	6.3
NDB592	ND405 × CO303	112.6	29.9	8.9	13.8
NDB459	ND403 × NDB8	111.7	35.3	11.7	5.0
NDB583	ND363 × ND407	111.2	29.4	2.8	3.4
NDB332	ND405 × A90	110.9	34.4	6.9	1.3
NDB477	ND468 × NDB8	109.7	33.5	12.7	3.3
NDB220	ND468 × A90	107.8	33.1	4.6	1.4
NDR166	NDB8 × MS1334	107.0	34.1	5.4	2.3
Mean (all hybrids)		98.2	31.4	5.8	5.8
LSD (.05)*		12.2	2.1	4.4	7.8

**Hybrids differences larger than this value would be expected due to random environmental effects only one year in 20.*

Table 3. Estimates of General Combining Ability Effects for 10 Parental Inbreds of Hybrids in Experiment I.

Parent line	Yield Bu/Ac	Ear moist. %	Stalk lodg. %	Root lodg. %
ND474	-3.71	-0.49	-1.10	-0.04
ND363	-9.33	-3.07	-1.85	-1.18
ND364	-9.69	-3.62	-2.65	0.04
ND468	3.00	0.25	0.48	-1.34
ND405	1.41	2.19	1.32	-0.23
ND407	1.69	3.16	0.19	-0.89
NDB8	9.19	0.62	2.74	-3.36
A90	1.13	1.54	-0.66	-3.99
CO303	8.42	-2.70	0.87	8.73
MS1334	-2.10	2.13	0.66	2.26
LSD (.05)*	4.04	0.69	1.47	2.60

**Average differences among inbreds of this amount could be explained by random environmental effects only once in 20 repetitions of this experiment.*

Table 4. Grain Yield and other Agronomic Data for the 10 Highest Yielding Hybrids among 45 Hybrids grown in Experiment II over 11 environments.

Hybrid	Pedigree	Yield Bu/Ac	Ear mois. %	Stalk lodg. %	Root lodg. %
NDC250	ND408 × W153R	109.7	27.9	18.3	6.2
NDC243	ND408 × NDB8	109.2	24.0	21.4	3.4
NDB187	ND408 × ND478	108.6	23.6	20.7	7.3
NDC252	ND376 × A624	108.1	25.1	15.0	10.1
NDC246	NDB8 × W153R	106.7	25.4	19.5	3.7
NDB676	ND478 × NDB8	105.8	20.0	17.9	6.3
NDC248	ND408 × A642	105.5	30.9	13.5	6.4
NDC244	NDB8 × A624	105.3	26.0	16.4	4.2
NDC238	ND485 × ND376	104.6	28.5	20.0	4.3
NDC254	ND376 × W153R	104.2	27.9	12.0	6.6
Mean (all hybrids)		95.2	26.8	15.2	5.7
LSD (.05)*		8.3	1.6	5.0	3.9

**See Table 2.*

Table 5. Estimates of General Combining Ability Effects for 10 Parental Inbreds of Hybrids in Experiment II.

Parent line	Yield Bu/Ac	Ear moist. %	Stalk lodg. %	Root lodg. %
ND478	2.89	-3.50	-0.10	3.24
ND485	-10.22	0.95	3.69	-2.18
NDB8	-0.74	-1.86	2.03	-0.79
ND408	9.06	0.74	1.77	-0.77
ND376	4.49	1.54	-2.28	1.75
A624	0.45	0.58	0.42	1.54
MS141	-5.53	-0.84	-6.55	-0.88
W153R	2.28	0.68	0.59	-1.45
NY540	-3.93	4.09	2.38	-0.93
ND481	1.26	-2.37	-1.96	0.48
LSD (.05)*	2.75	0.53	1.68	1.31

**See Table 3.*

Table 6. Grain Yield and other Agronomic Data for the 10 Highest Yielding Hybrids among 45 Hybrids grown in Experiment III over nine environments.

Hybrid	Pedigree	Yield Bu/Ac	Ear mois. %	Stalk lodg. %	Root lodg. %
NDB575	ND474 × CO303	94.8	25.9	3.9	28.0
NDC208	CO303 × CG10	91.0	31.1	5.3	29.9
NDC200	ND474 × MS93	88.1	33.0	5.7	15.4
NDC202	ND474 × MS92	87.3	34.5	9.7	19.6
NDC203	ND474 × CG10	87.0	33.8	5.8	9.8
NDC207	CO303 × MS92	84.6	31.5	3.5	42.9
NDC205	CO303 × MS93	84.3	32.8	7.2	47.3
NDC227	CG1 × CG10	84.0	41.2	3.4	14.6
NDC221	ND302 × CG10	83.6	31.1	6.0	19.5
NDC206	CO303 × CG1	83.2	34.4	8.8	19.2
Mean (all hybrids)		72.9	33.4	4.2	20.8
LSD (.05)*		11.1	2.4	3.5	9.6

**See Table 2.*

Table 7. Estimates of General Combining Ability Effects for 10 Parental Inbreds of Hybrids in Experiment III.

Parent line	Yield Bu/Ac	Ear mois. %	Stalk lodg. %	Root lodg. %
ND474	11.84	-2.65	1.73	- 5.27
CO303	7.96	-4.44	1.12	12.62
ND302	- 2.31	-3.89	1.13	0.71
ND363	- 7.25	-2.51	-1.20	- 3.35
ND468	-19.87	1.70	-2.39	- 7.95
MS93	- 2.49	3.45	0.57	6.02
CG1	5.93	5.56	1.18	- 7.22
MS92	2.95	3.32	-0.70	4.24
CG10	9.70	1.68	-0.71	- 1.46
ND364	6.47	-2.22	-0.73	1.66
LSD (.05)*	3.70	0.81	1.19	3.20

**See Table 3.*

Table 8. Grain Yield and other Agronomic Data for the 10 Highest Yielding Hybrids among 55 Hybrids grown in Experiment IV over five locations.

Hybrid	Pedigree	Yield Bu/Ac	Ear mois. %	Stalk lodg. %	Root lodg. %
NDC461	CM182 × ND71-36	72.7	19.4	6.6	8.6
NDC456	CM182 × PA363	68.9	26.1	0.9	1.3
NDC267	ND240 × ND474	68.2	20.5	3.8	7.0
NDC453	CM182 × ND474	67.1	24.4	3.4	0.9
NDC418	ND241 × CM174	66.4	25.8	11.3	3.7
NDC409	ND240 × CM182	65.1	19.5	8.9	0.8
NDC412	ND240 × PA363	65.7	27.6	6.8	2.7
NDC495	PA363 × ND71-36	65.0	26.6	6.3	8.4
NDC419	ND241 × CM182	65.0	24.7	7.7	1.6
NDC485	A654 × PA363	64.8	29.2	1.6	0.0
Mean (all hybrids)		58.1	25.1	8.1	6.3
LSD (.05)*		7.8	2.9	7.7	7.2

**See Table 2.*

Table 9. Estimates of General Combining Ability Effects for 11 Parental Inbreds of Hybrids grown in Experiment IV.

Parent line	Yield Bu/Ac	Ear mois. %	Stalk lodg. %	Root lodg. %
ND240	-0.02	0.07	1.76	0.42
ND241	-3.26	2.48	0.37	1.02
CM174	-1.93	-3.20	2.60	-0.47
ND363	-3.91	-0.36	-4.24	-0.02
CM182	6.57	-2.31	-0.39	-3.24
CM7	-4.21	-1.92	0.91	-1.22
ND474	1.79	1.84	-1.90	-0.97
CO109	-1.12	-2.15	0.46	4.80
A654	-0.04	4.19	-2.03	-0.02
PA363	2.12	2.71	-0.65	-2.86
ND71-36	4.03	-1.35	3.11	2.55
LSD (.05)*	2.62	0.96	2.56	2.41

**See Table 4.*