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EVALUATION OF HYBRID CORN (*ZEA MAYS* L.)

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ABSTRACT

The evaluation of hybrid corn was done at stage 4 using 10 hybrids and growing them under different conditions and at different locations. Seedling vigour, stand count, plant height, cob height, grain quality, 50% silk emergence, moisture contents, barren plants, diseases and the yield were among the prominent agronomic characters used for the evaluation purpose. On the basis of yield, 631D528 was found to be the best hybrid followed by 671D423. These two hybrids proved to be much better than all of the commercially available hybrids that were used as check. These two hybrids also outclassed their competitors in other agronomically important characters like ear height, number of ears, grain quality and colour. These hybrids were also found to be very resistant against post harvest diseases. The germination rates of these two hybrids were quite high as compared to other hybrids and there was no seedling mortality due to abiotic conditions.

Key-words:

INTRODUCTION

Maize (*Zea mays* L.) is the world's third leading cereal crop after wheat and rice. It is cultivated on an area of on 0.9355 m ha annually with production potential of 1.7371 million tones and average yield of 1857 kg ha^{-} in Pakistan (Anonymous, 2004). It is an important cereal crop, because of its high valued food for human beings, feed for livestock and poultry and a raw material for various agro-based industries (Khan and Gill, 1991).

In Pakistan the principal maize growing areas lie in the two provinces NWFP and Punjab, while Sind and Balochistan are far behind in maize cultivation. The leading divisions are Peshawar, Malakand, Hazara, D.I.Khan, Rawalpindi, Lahore, Multan and Bahawalpur. In Azad Kashmir maize is grown only for fodder purposes, although District Kotli, Bagh, Muzafarabad and Mirpur having the environmental conditions which favour the maize cultivation but area under cultivation is very limited. In Pakistan low yield of maize is due to many constraints such as poor management practices, cultivation of low yielding varieties, inappropriate planting methods and lack of awareness about the recommended product technology adopted by the growers. (Chaudhary, 1983)**.** Increase in area under cultivation and use of hybrid seed are considered to be the main factors which can increase yield on per unit area basis. Maize breeders are now concentrating on the development of broad-based synthetic and composite varieties. Breeding objectives for maize are high yield, early maturity, adoption to specific ecological conditions, tolerance to soil and climatic stresses, high quality, and resistant to insect pest and diseases (Samad and Hadi, 1991). In Pakistan corn improvement was started in the early 50s, based on the transferring US hybrid corn seed production technology. Several corn hybrids from the USA, Canada, and Australia were introduced in 50s and early 60s. Some of these such as US13, Indiana909, and US523, were fairly high yielding and adapted to certain corn production areas. The program continued for several years but had to be discontinued because of limited adoption due to the following reasons**:**

- Our growers prefer early-maturing cultivars/hybrids which can tolerate high plant density and give fairly good grain and stover yield in spite of the use of low inputs and infrequent hoeing. The introduced hybrids were late-maturing and in several cases could not fit into the prevailing cropping patterns**.**
- High quality F1 hybrid seed production was a tedious job in those days due to lack of trained workers.
- The imported hybrids had deeply dented and mostly yellow grain, while preference was mostly for white and flint types.
- Specific hybrids are needed for specific ecological zones, and improved cultural practices are essentials for high yield. When hybrids either experienced climate stress, or where grown with sub-optimal cultural practices, growers were disappointed with their indifferent performances.
- Facilities for the production, distribution, and marketing of their hybrid seed were not adequate to make an impact on corn production.
- Our farmer are in the habit of using seed for several generations, and therefore experienced low yields after the first generation. They are unwilling to buy fresh seed at high cost for each sowing.

- The yield superiority of hybrids over the synthetic/composite varieties of the same maturity class was not significantly high to justify the introduction of the hybrid corn technology.

Hybrid corn was and is a huge scientific and commercial success. About 95 percent of corn acreage now is planted to hybrid corn in developed countries. Now a day at least 20 percent more corn on 25 percent fewer acres is produced than in 1930, when seed of hybrid corn became available in quantity. The demand for hybrid seed in 1935 in the Corn Belt exceeded production, and the hybrid seed industry developed rapidly. Besides an increase in production, other benefits have been achieved by the use of hybrid seed. Hybrids make more efficient use of applied fertilizer. Progress has been made in developing hybrids resistant to some insects and diseases, the result was a product of higher quality and a more stable yearly production. Because of their greater uniformity in maturity and resistance to lodging, the hybrids have helped make large-scale mechanization possible.

Tests of commercially available corn hybrids are conducted annually at several locations in each maturity zones to provide farmers, seed producers, county extension agents, and other interested persons with information about hybrid performance Hybrids pass through different test stages, before it is cleared for the formers. Those in Stage- 2 are for the advanced hybrids tested previously for at least one year, and those in Stage- 3 are for new hybrid entries. New entries are tested for at least one year in stage before being included in the advanced tests (stage 4) (Scherder, 2004). The performance of a hybrid cannot be measured with absolute precision. Uncontrolled variability is involved in the determination of each yield average. This variability exists in all field experimentation; statistics are used as a tool to assist in making decisions. Hybrid performance may seem inconsistent from location to location and from year to year. The factors for these differences are rainfall, temperatures, soil fertility, diseases, insects, and other factors. (Scherder, 2004).

The present study reports the evaluation of some new corn hybrids for yield, grain quality, and other important agronomic characteristics at stage 4 in different agro-ecological zones of Pakistan. Results of the test can assist farmers in selecting hybrids best suited to their farming operations and production environments.

MATERIALS AND METHODS

Growing Conditions 2005

Environmental conditions did not vary greatly across these Punjab regions during the 2005 growing season, especially with regard to the amount and distribution of precipitation. Hot, wet soil conditions during emergence and early vegetative growth were followed by warm, dry conditions that began as early as mid September at some locations. Temperatures during grain fill were generally warmer than normal. Rainfall was near normal to below normal. Rainfall deficits were most pronounced at test sites

Previous studies (Stage 1 – 3)

At stage 1 the 19 new hybrid varieties tested were 791E433, 791DD30, 791D583, 791D825, 791E454, M30YN87, 791D112, 791D109, MN434, MN414, MN444, 791D201, 521D924, 671DD14, 671D423, 631B010, 631D528, 631D034, 791E455. Following hybrids (that had led the market) were used as check; 919, 979, NT6621, P31R88, P30Y87.

All of the above hybrids were statistically analyzed against the checks and only the hybrids showing the desirable characters were selected for Stage 2. The selected 18 hybrids viz. 671DD14, 671D423, 631B010, 631D528, 631D034, 919, 979, NT6621, P31R88, P30Y87, 791E455, 791E433, 791DD30, 791D583, 791D825, 791E454, M30YN87, 791D112.were tested at Major Research Locations (replicated plots) located throughout the Corn Belt, for possible promotion to the next stage of testing.

The 13 hybrids viz. 671DD14, 671 D423, 631B010, 631 D528, 631D034, 919, 979, NT6621, P31R88, P30Y87, 791E455, 791E433, 791DD30, 791D583 were selected after experiments of stage 2. These selected hybrids were advanced to New Experimental Trials and then Product Advancement Trials where additional attention was focused on performance reactions across various soils, environmental conditions, fertility levels and tillage practices - as well as overall traits and consistency.

Present study (Stage 4 trials):

The most promising hybrids were designated as Key Experimental and promoted to further testing in Monsanto Research Centre (MRC) Plots throughout Corn Belt. This final stage of testing involved comparisons against Monsanto's top hybrids, as well as competitors' best products. These hybrids were 671DD14, 671D423, 631B010, 631 D528, 631D034, 919, 979, NT6621, P31R88, P30Y87. Only stage-4 hybrid evaluation has been considered in this paper.

Trial allocations:

Autumn season hybrids were evaluated with the cooperation of the farmers. On the basis of geographical characteristics, corn hybrid evaluation tests were located in the various regions of the country. Four sites were available for hybrid evaluation. Testing was available in four regions of the Punjab Province viz. Gojra (1), Depalpur (2), Manga Town (3) and Arif Wala (4) and farmers were asked to enter a hybrid in three sites within a testing region.

Field Trials:

The entries for each test site were planted in a randomized complete-block design. Each entry was replicated four times and planted in plots 45 ft. long and 5 ft. wide containing four rows seeded at 170,000 seeds per acre. Seeds were prepared according to the sowing plans by Assistant Manager Research and were sent to all experimental sites 10 days before actual planting. Best Monsanto and Competition hybrids were put as checks. Entries were randomized in all the replicates.

Seeds were treated with Confidor-SD at the rate 7gm/kg seed. Seeds were sown on pre-irrigated ridges at a depth of 5 cm with row to row and plant to plant distance of 70 and 20 cm, respectively. Two seeds were planted per hill and thinning was done 10 days after germination. Watch and ward was arranged to avoid bird/rodents damage. N-P-K fertilization rates per hector were 250-150-250, respectively. Trials were harvested when all the entries showed black layer formation. Data regarding various plant growth, vigour, yield and disease parameters were recorded and analyzed statistically by applying Duncan's Multiple Range Test (Steel and Torrie, 1980.).

RESULTS AND DISCUSSION

Plant agronomy traits:

Hybrids 631DO34 and 671D423 showed the best seedling vigour and were significantly different from P30487 which showed relatively low seedling vigour.

The varieties 979 and P31R28 showed seedling vigour between the highest and lowest values Table 1.

The initial stand count did not show any significant difference between the different varieties grown. However NT6621 showed the highest initial stand count vs. 631DO34 that showed the lowest initial stand count (Table 1).Different varieties showed significant difference in the final stand counts. The varieties NT6621 and P31R28 produced the highest final stand count (235 and 230 respectively). The varieties that produced the lowest final stand count were 631D034 and 631D528. A number of varieties fall between these two upper and lower values (Table 1). The tallest variety was 631D034 with a height of 275 cm and was found significantly different from 671DO34 that showed the shortest height of 212 cm (Table 1).

The variety 671D423 and 919 produce the highest number of barren plants. These showed significant difference from NT6621 and 631D528 which produced no barren plants at all (Table 1).

No stalk and root lodging observed at any location on any variety, so it revealed that all the varieties were strong enough to tolerate the extremes of wind and rain even in unfavorable conditions.

Ear agronomy traits:

The varieties 919, 671DD14 and 979 showed the highest ear tip filling and were significantly different from 631D034 which showed poor tip filling. The varieties 631D528 and 631B010 showed intermediate tip filling (Table 2). It was observed that the varieties 919 and 979 showed the best base filling. The data for these two above mentioned varieties was statistically analyzed and showed significant difference from the variety NT6621, which showed poor base filling. The statistical data for P31R28 and P30487 proved that the results of these two varieties in terms of base filling are intermediate between the highest and the lowest value (Table 2).

The variety 979 was found out to be the best variety in terms of ear height. It was significantly different from 631DO34 which showed the highest ear height (which is not a good agronomic character. The varieties 919 and Nt662 had their ear heights close to the best value i.e., they showed no significant difference from the ear heights of 979 as shown in Table 2. The variety NT6621 showed the highest ear count which made it the best variety out of all. NT6621 showed significant difference from 631DO34, which showed the least ear count. The variety P31R28 showed no significant difference from NT6621 in the number of ears, which made it a good variety in terms of car count (Table 2).

Incidence of diseases on various maize hybrids:

Plants of all the varieties were tested for maydis blight, but no symptoms were seen in any of the varieties grown in any of the locations. But at the post-harvest stages a small number of the plants were observed to be infected by *Helminthosporium maydis*, but at this stage damage was economically unimportant and hence ignored.

No symptoms of basal leaf sheath blight disease were observed at the milky stage, but at harvest some of the plants were observed to be affected with this disease. But it was ignored as it was economically and commercially unimportant.

Table 1. Plant agronomy characteristics of different hybrid corn varieties

Entry No.	Hybrid code	Location	Seedling vigour	Initial stand Count	Final stand Count	Plant Height (cm)	Barren Plants
		1	2	235	235	215	3
1	**671DD14**	2	1	235	232	210	0
		3	2	245	229	225	0
		4	1	228	220	200	0
		Mean	**1.5 bc**	**236 a**	**230 ab**	**212 e**	**0.75 ab**
		1	1	222	220	255	2
		2	1	219	216	260	5
2	**671D423**	3	1	242	239	235	0
		4	2	215	210	230	5
		Mean	**1.25 c**	**224 a**	**221 abc**	**245 cd**	**3.00 a**
		1	2	231	230	285	2
		2	1	230	228	280	0
3	**631B010**	3	2	235	225	280	3
		4	3	230	223	240	0
		Mean	**2.00 abc**	**231 a**	**226 abc**	**271 ab**	**1.25 ab**
		1	1	207	205	275	0
		2	1	202	200	275	0
4	**631D528**	3	2	225	221	260	0
		4	3	212	200	245	0
		Mean	**1.75 abc**	**211 a**	**207 cd**	**264 abc**	**0 b**
		1	1	200	197	285	2
		2	1	150	145	285	3
5	**631D034**	3	1	220	217	275	6
		4	2	224	208	255	3
		Mean	**1.25 c**	**199 a**	**192 d**	**275 a**	**3.50 a**
		1	1	225	220	240	5
		2	1	217	216	235	3
6	**919**	3	2	240	236	255	1
		4	2	227	226	215	3
		Mean	**1.5 bc**	**227 a**	**225 abc**	**236 de**	**3.0 a**
		1	2	211	205	255	5
		2	2	210	207	250	4
7	**979**	3	1	219	209	260	0
		4	3	219	212	230	4
		Mean	**2.00 abc**	**215 a**	**208 bcd**	**249 bcd**	**3.25 a**
		1	3	247	243	240	0
		2	2	241	240	240	0
8	**NT6621**	3	3	242	234	245	0
		4	2	229	223	220	0
		Mean	**2.50 ab**	**239.75 a**	**235 a**	**236 e**	**0 b**
		1	2	240	236	240	0
		2	2	235	235	240	4
9	**P31R28**	3	1	240	235	235	1
		4	2	227	215	225	4
		Mean	**1.75 abc**	**235 a**	**230 a**	**235 de**	**2.25 ab**
		1	2	223	220	255	1
		2	3	214	210	250	3
10	**P30Y87**	3	2	227	227	270	7
		4	4	237	226	215	3
		Mean	**2.75 a**	**225 a**	**220.7 abc**	**247.5 bcd**	**3.50 a**

Any two means within a column not followed by the same letter are significantly different at 5 % level of significance.

Table 2. Ear agronomy characteristics of different hybrid corn varieties.

Entry No.	Hybrid Code	Location	Ear Height (cm)	Ear Count	Ear Tip Filling	Ear Base filling
		1	105	232	1	2
1	671DD14	2	100	221	1	1
		3	110	232	1	1
		4	95	221	2	2
		Mean	**102.5 cd**	**226.5 ab**	**1.25 c**	**1.5 bc**
		1	105	218	2	2
		2	110	183	2	1
		3	105	240	1	1
2	671D423	4	100	205	3	2
		Mean	**105 bcd**	**211.5 bc**	**2.00 bc**	**1.5bc**
		1	120	228	2	1
		2	115	211	2	1
	631B010	3	115	218	2	1
3		4	110	226	3	2
		Mean	**115 ab**	**220.75 abc**	**2.25 b**	**1.25 bc**
		1	120	222	3	1
		2	115	222	2	1
4	631D528	3	110	222	2	1
		4	100	212	2	2
		Mean	**111.25 abc**	**219.5 abc**	**2.25 b**	**1.25 bc**
		1	125	195	3	1
		2	120	130	3	2
5	631D034	3	115	235	3	1
		4	110	205	4	2
		Mean	**117.5 a**	**191.25 c**	**4.00 a**	**1.5 bc**
		1	110	215	1	1
		2	105	209	1	1
	919	3	95	210	1	1
6		4	95	223	2	1
		Mean	**101.25 cd**	**214.25 bc**	**1.25 c**	**1 c**
		1	100	200	1	1
		2	95	191	1	1
7	979	3	95	210	1	1
		4	100	215	2	1
		Mean	**97.5 d**	**204 bc**	**1.25 c**	**1 c**
		1	105	252	2	2
		2	100	250	2	2
8	NT6621	3	100	252	2	2
		4	105	224	3	3
		Mean	**102.5 cd**	**244.5 a**	**2.25 b**	**2.25 a**
		1	115	237	2	2
		2	110	235	2	2
9	P31R28	3	105	237	2	2
		4	95	211	3	2
		Mean	**106.25 abcd**	**230 ab**	**2.25 b**	**2 ab**
		1	120	219	2	2
		2	105	200	2	2
10	P30Y87	3	125	200	2	1
		4	95	223	3	1
		Mean	**111.25 abc**	**210.5 bc**	**2.25 b**	**1.5 bc**

Any two means within a column not followed by the same letter are significantly different at 5 % level of significance.

Table 3. Yield characteristics of different hybrid corn varieties.

Entry No.	Hybrid code	Location	10 cob weight (kg)	10 cob kernel weight (kg)	% Moisture Contents	Shelling Recovery	Plot weight (kg)	Yield per hectare (kg) At 15% MC
		1	2.94	2.28	34.8	78	44.32	12998.4
1	**671DD14**	2	2.4	1.90	33.3	79	43.91	13343.4
		3	2.69	2.10	29.7	78	44.59	14100.6
		4	2.80	2.10	32.9	75	46.05	13364.85
		Mean	**2.7 a**	**2.09 ab**	**32.67 a**	**77.5 ab**	**44.71 ab**	**13451.8 b**
		1	2.58	2.15	30.6	83	44.34	14729.3
		2	2.55	2.23	35.9	87	47.38	15237.8
2	**671D423**	3	2.65	2.04	29.9	77	46.5	14474.8
		4	2.88	2.26	32.4	78	45.97	13978.6
		Mean	**2.66 a**	**2.17 a**	**32.2 a**	**81.25 a**	**46.04 ab**	**14605.12 a**
		1	2.07	1.41	34.0	68	38.41	9941.1
		2	2.25	1.50	32.5	67	35.00	9128.4
3	**631B010**	3	2.30	1.61	33.6	70	37.02	10121.7
		4	2.23	1.48	32.7	66	34.02	8760.6
		Mean	**2.21 b**	**1.5 d**	**33.2 a**	**67.75 e**	**36.11 d**	**9487.95 e**
		1	2.49	2.13	36.9	85	50.20	15527.5
		2	2.65	2.1	30.7	79	47.15	14886.5
4	**631D528**	3	2.5	1.95	29.3	*78*	45.14	14355.7
		4	2.81	2.19	29.7	78	47.36	14401.3
		Mean	**2.61 a**	**2.09 ab**	**31.65 a**	**80 ab**	**47.46 a**	**14792.7 a**
		1	1.99	1.45	36.5	73	39.59	10532.0
		2	2.79	2.01	36.5	72	45.36	11959.0
5	**631D034**	3	2.24	1.53	32.7	68	38.26	10976.6
		4	2.71	1.93	33.8	71	36.66	9937.1
		Mean	**2.43 ab**	**1.73 cd**	**34.87 a**	**71 de**	**39.96 c**	**10851.0 d**
		1	2.41	1.89	32.1	73	43.59	12525.3
		2	2.55	1.96	31.22	76.00	43.67	12842.5
6	**919**	3	2.40	1.71	33.2	70	40.01	10789.31
		4	2.54	1.8	34.8	71	44.32	11831.95
		Mean	**2.47 ab**	**1.84 bc**	**32.83 a**	**72.5 cde**	**42.98 bc**	**11997.26 cd**
		1	2.65	1.94	29.9	73	45.32	13374.6
		2	2.55	1.98	29.7	77	45.99	14047.8
7	**979**	3	2.11	1.65	36.5	78	42.70	12196.8
		4	2.37	1.95	37.2	70	47.30	11991.4
		Mean	**2.42 ab**	**1.88 bc**	**33.32 a**	**72.5 cd**	**45.32 ab**	**12902.65 bc**
		1	2.43	1.82	33.62	74.75	44.10	12344.1
		2	2.39	1.75	31.5	73	41.02	11829.32
8	**NT6621**	3	2.32	1.69	32.01	72	44.23	12486.63
		4	2.41	1.66	31.2	69	42.36	11596.96
		Mean	**2.38 ab**	**1.73 cd**	**32.08 a**	**72.18 de**	**42.9 b**	**12064.25 cd**
		1	2.70	1.96	33.2	72	42.19	11765.46
		2	2.53	1.88	33.92	74.25	44.27	12492.1
9	**P31R28**	3	2.77	2.40	32.6	86	45.12	12971.06
		4	2.39	1.69	38.1	71	39.60	10036.7
		Mean	**2.59 a**	**1.98 abc**	**34.45 a**	**75.81 bcd**	**42.79 bc**	**11816.3 cd**
		1	2.86	1.97	32.4	69	44.38	11938.0
		2	2.30	1.66	32.8	72	43.94	12260.6
10		3	2.25	1.73	32.8	75	43.03	12567.9
	P30Y87	4	2.18	1.57	37.4	72	41.90	10657.7
		Mean	**2.39 ab**	**1.73 cd**	**33.85 a**	**72 de**	**43.31 b**	**11856.05 cd**

Any two means within a column not followed by the same letter are significantly different at 5 % level of significance.

Yield agronomic traits:

Hybrids 671DD14, 671D423 and 631D528 showed the highest cob weights. But no significant difference was observed among these and the other varieties (Table 3). Hybrid 671D423 showed the highest kernel weight of 2.17kg/10 cobs. This differs significantly from the variety 631B010 which has kernel weight of 1.5kg/10cobs. The 919 and 979 varieties had kernel weights that were intermediate between the kernel weights of the above two varieties (Table 3).

The moisture contents vary between 34.87% and 31.65% in all the varieties grown. No significant difference was observed among the moisture contents in different varieties.

The highest shelling recovery was recorded in 671D423, which was 81.25. It showed significant difference from 631B010 with shelling recovery of 67.75. Intermediate shelling recovery was seen in P31R28, which was

75.81. The highest plot weight of 47.46kg was observed in 631D528. This shows significant difference from the plot weights of 631B010 (36.11kg). The plot weight of 919 and P31R28 were intermediate between the above two highest and lowest plot weights (Table 3).

The varieties 671D423 and 631D528 gave the highest yields per hectare which were 14605.12 and 14792.7 respectively. This showed that the above two varieties were the most successful in the locations they were gown at. However 631D034 gave the lowest yield per hectare which was 10851.0 kg/hectare. Although varieties such as 671DD14 and 979 showed significant difference from 671D423 and 631D528 (highest yielding varieties), but still gave relatively good yields per hectare.

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