

Annals of Sri Lanka Department of Agriculture. 2006.8:107-114.

SUCCESSFUL DEVELOPMENT OF INBRED LINES AND HYBRIDS OF MAIZE (*Zea mays* L.) AT MAHA ILLUPPALLAMA

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ABSTRACT

Field Crop Research and Development Institute, Maha Illuppallama, initiated a Maize hybrid development program in 1998 using inbred lines from International Maize and Wheat Improvement Centre (CIMMYT), Mexico, to meet the rising hybrid seed demand, which is currently being met by importing hybrid seed by the private sector. Initially 165 single crosses were developed using CIMMYT inbred lines and one promising hybrid (KH 86) was released for farmer cultivation in 2004. This work was further strengthened by a local inbred line development program, initiated subsequently. Twelve source materials with diverse origin were used for development of 45 lines by self-pollination for seven generations. Hybrids were developed between non-sister lines and evaluated in order to find better genetic combinations. Test-crosses too were developed using a promising Mexican inbred line as the pollen parent to determine differences in genetic potential between the lines (combining ability). Selected hybrids were compared with parents and controls to estimate standard heterosis, heterobeltiosis and commercial heterosis. Based on five seasons of testing, 35 promising hybrids, which were found out-performing or in par with local hybrid and exotic commercial hybrids were selected for further testing for multi-location adaptation.

KEYWORDS: Heterosis, Inbred lines, Single crosses, Test crosses.

INTRODUCTION

Maize occupies the largest area (30,000 - 50,000 ha per annum) among the crop group Other Field Crops in Sri Lanka. It is the second most important cultivated cereal and the foremost feed grain in Sri Lanka. The current annual requirement of maize seed for animal feed is about 200,000 t, with imports of about 150,000 t, worth of over rupees 2500 million. To achieve self-sufficiency in maize, country has two options, namely extensive approach and intensive approach, where improved technology, including cultivars bear a high significance.

To ensure a healthy grain yield, operations such as, selection of suitable cultivars, early planting, drainage, tillage practices, balanced fertility and timely cultivation and harvest were found important. Rising income in much of the developing world and the consequent enhanced demand for meat and poultry products have resulted in a rapid increase in the demand for maize as a livestock feed. As a result, the world maize consumption has changed during the period 1982-84 to 1994-1996, from 91 to 98 kg/yr/head. Malawi has the highest per capita consumption of 137 kg/year of maize in the world, followed by Mexico with 127 kg/year (Michael and Pandey, 1998).

In the past 40 years, total maize production in many countries in the world, including USA and China, has increased by several fold due to cultivation of hybrids while land area devoted to the crop has virtually decreased. Shull (1908) was the first author to report increased yields from F_1 crosses between inbred lines, which is a result of strength of stalks and of roots, and resistance to specific diseases and insect pests etc. The cumulative interaction of many favourable dominant or partially dominant genes is the cause of hybrid vigour in hybrids.

A program of inbred line development was initiated at Field Crop Research and Development Institute, Maha Illuppallama to develop more adaptable inbred lines and hybrids with higher yield potential over exotic hybrids to substitute imports of hybrid seed upon which currently heavy expenditure is being made. The high heterosis displayed by the hybrids, in relation to mid-parent (heterosis), better parent (hetero-beltiosis) and over commercial hybrid (commercial heterosis) justify further evaluations of the lines and hybrids, from which the most superior ones are expected to be nominated for national release in the near future.

MATERIALS AND METHODS

Development of maize inbred lines initiated during *maha* 1998/99, for which 12 different source materials of diverse origin were selected. Promising CIMMYT and local germplasm were used as source materials (FCRDI, 1999-2000). The standard method was adopted for line development in which selections were carried out in inter and intra row progenies. During *maha* 2000/01, 18 single cross hybrids were developed as early generation hybrids among selected S_3 lines. Ruwan and Pacific 11 were included as local checks in an experiment conducted under Randomized Complete Block Design (RCBD) with 4 replicates, designed for comparison of performances of the hybrids. Two rows of 5.0 m length were planted for each treatment at recommended spacing of 60cm between rows and 30cm within the row. To compare heterosis, seven selected non-related single cross hybrids were compared with their parents and Pacific 11, the commercial check, during *maha* 2001/02, as a further step. Data were collected on days to 50% flowering, plant and ear height, and individual plot yields. During *maha* 2002/03, 120 single crosses developed with more advanced lines were tested in 3 experiments. During *maha* 2003/04, 60 selected hybrids were tested in 3 experiments. Test-crosses were developed during *yala* 2003 and were tested in replicated trials conducted at Maha Illuppallama for 3 consecutive seasons, for studying the combining ability of the lines. Further evaluations are underway by developing new hybrids and test-crosses to obtain consistency of favorable performance of the inbred lines and their combinations. Thirty-five such combinations are seed multiplied during *maha* 2005/06 for multi-location

testing and in Variety Adaptability Testing in the seasons ahead. Performances of individual experiments are tabulated below.

RESULTS AND DISCUSSION

Grain yields of the early generation hybrids during *maha* 2000/01, were highly encouraging. The grain yields were in the range of 3.50 - 7.25 t/ha, eleven hybrids performing better than the local open pollinated check variety, Ruwan and nine hybrids out-performing the commercial exotic hybrid Pacific 11. Flowering of the lines varied between 57 to 62 days and the maturity reached in 105-110 days after seeding (Table 1). Plant height ranged between 210 to 260 cm, the tallest contributing the highest grain yield. In general, the longer the time from planting to flowering, the greater the plant height and the greater the grain weight/plant (CIMMYT, 1985). Ear placement was satisfactory in all hybrids except in one, which had a higher placement of ears of over 50% on the stem. The performance of hybrids was highly satisfactory and hence advancement of line development and selection was justifiable and substantial.

Table 1. Performance of early generation hybrids developed with S₃ lines in RCBD trial conducted at FCRDI, Maha Illuppallama during *maha* 2000/01.

Hybrid	Yield (t/ha)	Days to flowering	Plant height (cm)	Ear height (cm)
P36-5-2 X Ki 31-4	7.27a	58 fg	260 a	107 bcde
P31-2 X B1	6.37 ab	57 g	230 defg	89 gh
C2-6 X S5-2	6.21 ab	57 g	214 gh	82 hi
P36-2-2 X Ki 32-6	6.18 abc	62 ab	234 bcdef	116 ab
AC22 X Ki 32-8	6.06 abc	61 bcde	249 abc	113 bc
Ac 145-4 X KI 42-3	6.03 abc	59 cdefg	232 bcdef	99 cdefg
C2-5 X S5-7	5.95 abc	58 fg	214 gh	67 l
AC145-10 X Ki42-4	5.85 abcd	62 ab	250 ab	129 a
Pacific 11	5.62 bcde	58 fg	217 fgh	91 fgh
P31-3 X T 20	5.38 bcde	61 bcde	211 h	84 h
P36-4 X T 2	5.27 bcde	59 defg	237 bcde	82 hi
P36--2-1 X C2-2	5.25 bcde	59 efg	221 efg	93 efg
C2-9 X Ki 31-7	5.03 bcde	61 abc	216 fgh	90 defgh
Ruwan	4.71 cdef	59 efg	231 cdefg	92 efg
T 18 X Ki 32-5	4.45 def	60 cdef	214 gh	99 cdefg
P 36-3 X T 16	4.40 def	62 ab	240 bcd	105 bcdef
T 16 X B 6	4.32 ef	61 abcd	240 bcd	109 bcd
Ac 145-1 X Ki 32-9	3.51 fg	63 a	226 defgh	105 bcdef
P 31-14 X T 7	3.43 fg	61 acbd	231 cdefg	88 gh
Ki 32-2 X S5-11	2.84 g	61 abc	234 bcdef	96 defgh
Grand Mean	5.18	62	230	97
LSD	0.64	0.91	8.09	6.59
CV(%)	19.43	2.39	5.56	10.73

Similar performances were displayed when seven unrelated hybrids were compared with 14 parents during *maha* 2001/02 (Table 2). Grain yields of the hybrids ranged between 3.4 t and 5.00 t/ha, while yields of parent lines ranged from 0.32 - 2.60 t/ha. Of the seven hybrids tested, 4 hybrids performed better than the commercial check, which produced a grain yield of about 4.11 t/ha. Heterosis, of the hybrids in comparison to mid parent, better parent (heterobeltiosis), and commercial check (commercial heterosis) were calculated for major characters and presented in Table 3. The highest commercial heterosis for grain yield was produced by the hybrid C2 - 5 X S 5-7, which is about 25%. Three hybrids produced positive commercial heterosis values and three produced negative heterosis values for grain yield (Table 3).

Table 2. Performance of local inbred lines and their single crosses in RCBD trial conducted at FCRDI, Maha Illuppallama during *maha* 2001/02.

Hybrid	Yield (t/ha)	Days to flowering	Plant height (cm)	Ear height (cm)
P36-5-2 X Ki 31-4	3.75 b	54 hi	202 a	93 abc
P31-2 X B1	4.48 ab	53 ij	187 abc	98 ab
C2-6 X S5-2	3.44 bc	52 j	167 cde	73 bcdef
P36-2-2 X Ki 32-6	4.34 ab	58 de	205 a	72 bcdef
AC22 X Ki 32-8	3.41 bc	56 fg	190 ab	105 a
Ac 145-4 X KI 42-3	4.34 ab	54 hi	187 abc	100 a
C2-5 X S5-7	4.99 a	52 j	172 bcd	85 abcd
Ki 41-4	0.20 l	59 cd	200 a	90 abc
P 36-5-2	0.82 fg	56 fg	125 hi	55 fg
P 31-2	1.51 def	55 gh	123 hi	57 efg
B 1	2.34 cde	62 a	173 bcd	97 ab
S 5-2	1.48 efg	61 ab	122 hi	42 g
C 2-6	1.38 efg	59 cd	128 ghi	47 fg
Ki 32-6	0.93 fg	57 ef	122 hi	63 defg
P 36-2-2	0.32 hi	61 ab	127 ghi	53 fg
Ac 22	0.39 ghi	59 cd	118 l	45 g
Ki 32-8	1.60 def	60 bc	147 efg	82 abcde
Ac 145-4	0.33 hi	62 a	118 l	67 cdefg
Ki 42-3	2.60 cd	58 de	152 def	72 bcdef
C 2-5	1.07 fhgi	56 fg	127 ghi	57 efg
S 5-7	1.24 efg	57 ef	143 fgh	58 efg
Pacific 11	3.99 ab	55 gh	165 de	85 abcd
Grand Mean	2.23	57	154	72
LSD	0.41	0.58	8.03	9.62
CV(%)	30.24	1.67	8.52	21.81

Hybrids that out-yielded the check varieties tested during *maha* 2003/04 were selected for further studies to achieve consistency in performance (Table 4). Five hybrids out-performed the local check *Sampath* in the first experiment and five hybrids were outstanding compared to the exotic hybrid (Pacific 984) and 11 hybrids out-yielded the local check *Sampath*, in the 2nd experiment. In the 3rd experiment 16 hybrids performed

better than the local hybrid. Mean yield of Pacific 684 was high due to less number of evaluations.

Table 3. Heterosis, heterobeltiosis and commercial heterosis of early generation hybrids calculated yield data of field experiment conducted at FCRDI, Mahailuppallama during *maha* 2001/02.

<i>HYbrid</i>	<i>Days to flower (%)</i>	<i>Plant height (%)</i>	<i>Ear height (%)</i>	<i>Grain yield (%)</i>
P36-5-2 X Ki 31-4				
Heterosis	-5.75	24.06	28.6	435.7
Heterobeltiosis	-7.84	0.8	3.33	357.3
Commercial heterosis	-2.3	22.1	9.7	-6.0
P31-2 X B1				
Heterosis	-8.88	25.8	28.3	130.7
Heterobeltiosis	-13.47	7.6	1.75	88.6
Commercial heterosis	-3.6	13.0	15.6	12.0
C2-6 X S5-2				
Heterosis	-13.7	33.3	64.7	142.0
Heterobeltiosis	-15.25	2.9	57.2	134.0
Commercial heterosis	-6.69	0.96	-13.76	-13.7
P36-2-2 X Ki 32-6				
Heterosis	-1.52	65.1	74.2	600.0
Heterobeltiosis	-4.29	61.9	60.5	366.6
Commercial heterosis	4.88	24.2	18.3	8.77
AC22 X Ki 32-8				
Heterosis	-5.88	43.5	65.8	211.0
Heterobeltiosis	-7.13	29.6	28.6	112.5
Commercial heterosis	1.26	15.15	23.5	-14.78
Ac 145-4 X KI 42-3				
Heterosis	-10.66	38.6	44.3	196.5
Heterobeltiosis	-13.96	23.8	39.6	66.5
Commercial heterosis	-3.07	13.0	17.6	8.52
C2-5 X S5-7				
Heterosis	-9.15	27.6	48.0	333.9
Heterobeltiosis	-9.74	19.4	45.7	305.4
Commercial heterosis	-6.69	4.0	0.0	25.0

Finally test-cross performance was considered for identifying lines with the best performance (Table 5) and 3 season data indicated that the lines Ki 42-5 (5.18 t/ha), Ki 32-6 (4.96 t/ha), T -2 (4.88 t/ha), T-7 (4.80 t/ha), Ki 42-6 (4.74 t/ha) and P 36-5-1 (4.33 t/ha) were outstanding and would be further studied in the future evaluations. Thirty-five hybrids identified through test-cross and single-cross performance were seed multiplied for multi-location testing in the seasons ahead.

Table 4. Performance of the single crosses in RCBD experiment conducted at FCRDI, Maha Illuppallama during maha 2003/04.

Hybrid	Yield (t/ ha)	Days to flowering	Hybrid	Yield (t/ ha)	Days to flowering	Hybrid	Yield (t/ ha)	Days to flowering
KH 364	5.40 abc	52	KH 348	4.88 abcd	53	KH 179	4.94 bcdef	53
KH 183	5.02 abcd	53	KH 349	3.46 f	57	KH 177	4.58 cdef	53
KH 365	4.69 cde	58	KH350	4.40 cdef	53	KH185	4.87 bcdef	53
KH 366	4.32 de	54	KH351	5.64 ab	55	KH188	5.14 bcde	57
KH 367	4.83 cde	56	KH190	4.70 bcde	53	KH190	5.21 bcde	55
KH 368	3.35 f	58	KH352	5.48 ab	53	KH184	4.18 ef	57
KH 369	3.96 ef	60	KH353	4.81 abcd	53	KH186	4.95 bcdef	59
KH 370	5.09 abcd	61	KH354	5.41 ab	53	KH181	4.45 def	55
KH 371	5.23 abcd	53	KH355	5.67 a	55	KH194	5.92 ab	59
KH 372	5.90 ab	54	KH356	5.17 abc	58	KH191	4.92 bcdef	57
KH 373	5.34 abc	56	KH357	5.22 abc	58	KH200	4.88 bcdef	60
KH 374	5.92 ab	53	KH358	3.79 ef	53	KH211	4.55 cdef	59
KH 375	4.57 cde	53	KH359	4.11 def	53	KH304	4.43 def	59
KH 376	4.92 cde	58	KH360	5.22 abc	55	KH206	5.65 abc	59
KH 278	4.91 cde	56	KH361	4.12 def	53	KH214	5.43 bcd	59
KH 377	5.09 abcd	58	KH362	5.46 ab	55	KH215	5.26 bcde	59
KH 378	5.11 abcd	53	KH215	5.24 abc	58	KH212	5.69 abc	55
KH 379	5.93 a	60	KH363	4.39 cdef	58	KH218	6.68 a	59
KH 380	4.30 def	58	Sampath	4.79 abcd	60	KH288	3.85 f	60
KH 214	4.96 bcd	56	Pacific 984	5.31 abc	60	KH196	4.83 bcdef	59
KH 381	4.36 de	58				KH235	4.67 cdef	62
Sampath	5.26 abcd	63				KH222	5.19 bcde	57
						Sampath	4.63 cdef	59
LSD	= 0.41			0.37			0.44	
CV(%)	= 13.76			11.55			14.81	

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Table 5. Performance of the lines in test crosses at FCRDI, Maha Illuppallama during maha 2003/04, yala 2004 and maha 2004/05.

<i>Entry</i>	<i>Maha 2003/04</i>		<i>Yala 2004</i>	<i>Maha 04/05</i>	<i>Mean</i>
	<i>yield (t/ha)</i>		<i>yield (t/ha)</i>	<i>yield (t/ha)</i>	<i>yield(t/ha)</i>
CML 20 X T-2	4.28	5.97	4.38	4.88	
CML 20 X T -16	3.82	4.11	2.81	3.58	
CML 20 X C ₂ -2	3.85	5.22	3.74	4.27	
CML 20 X C ₂ -3	4.38	4.74	4.18	4.43	
CML 20 X C ₂ -6	4.42	5.17	2.86	4.15	
CML 20 X C ₂ -9	3.89	4.81	3.05	3.88	
CML 20 X S 5 - 8	4.24	5.26	2.98	4.16	
CML 20 X S 5 - 11	4.97	4.59	3.51	4.39	
CML 20 X B - 6	3.78	4.79	3.27	3.95	
CML 20 X B - 12	4.66	5.07	3.06	4.26	
CML 20 X P 31-7-2	4.32	4.29	4.45	4.35	
CML 20 X P 31-3	4.62	-	-	-	
CML 20 X Ki 42-4	4.53	5.48	3.57	4.53	
CML 20 X Ki 42-5	5.80	5.97	3.76	5.18	
CML 20 X Ki 42-6	4.95	5.73	3.55	4.74	
CML 20 X P 36-4	4.47	5.12	3.55	4.38	
CML 20 X Ki 31-4	4.76	5.33	4.50	4.86	
CML 20 X Ki 32-3	4.07	5.97	4.00	4.68	
CML 20 X Ki 32-5	4.62	5.71	3.13	4.49	
Sampath	5.42	5.30	4.91	3.90	4.88
Pacific 984	6.86	5.64	-	-	6.25
CML 20 X Ki 32-6	5.35	5.67	3.85	4.96	
CML 20 X Ki 32-7	5.21	-	-	-	
CML 20 X Ki 32-8	5.93	-	-	-	
CML 20 X Ki 32-9	4.81	-	-	-	
CML 20 X Ki 32-10	5.34	-	-	-	
CML 20 X T -1	4.61	4.97	-	-	
CML 20 X T -7	5.53	5.51	3.37	4.80	
CML 20 X T -10	6.56	-	-	-	
CML 20 X S 5 - 3	5.18	-	-	-	
CML 20 X P 31-7-1	4.74	4.59	3.15	4.16	
CML 20 X P 31-12	5.46	4.75	3.31	4.51	
CML 20 X P 31-14	6.03	-	-	-	
CML 20 X Ki 42-1	5.69	-	-	-	
CML 20 X Ki 42-3	5.71	-	-	-	
CML 20 X P 36-2-2	4.92	-	-	-	
CML 20 X P 36-3	4.83	-	-	-	
CML 20 X P 36-5-1	4.79	4.02	4.18	4.33	
CML 20 X AC 145-1	4.41	-	-	-	
CML 20 X AC 145-3	4.72	-	-	-	
LSD(0.05)	NS	0.46	NS	NS	
CV(%)	17.22	16.32	31.74	24.89	

CONCLUSIONS

Performance of some crosses was highly satisfactory, out-yielding local hybrid and commercial hybrids included as controls in number of experiments conducted. Thirty-five selected promising hybrids are being evaluated for including the most promising 8-10 hybrids in National Coordinated Variety Trials for identifying the best hybrids for nominating for national release.

REFERENCES

- CIMMYT, 1985. Institutional Innovations in National Agricultural Research, 25 Hallauer, 1988. Corn and Corn Improvement. ASA.
- Field Crop Research and Development Institute*, (1999- 2000). Research Reports, Maha Illuppallama.
- Michael, M.M. and S. Pandey, 1998. Maize Seed Industries. *CIMMYT Publication*, 32-76, 335-337.
- Shull, G.H. 1908. The composition of a field of maize. *American Breeders' Association Report 5*: 51-59.