Lowland Tropical Maize Subprogram Annual Research Report 2002

Pedigree	Yield	% ER	MF	FF	PH (cm)	EH (cm)	% Mo	PA	EA	% RL	% SL	% BH
CML494 x CML495	7.576	5.18	51.9	51.5	235.8	115.2	19.34	2.59	2.75	7.91	2.04	2.09
CML247 x CML254	6.517	3.33	55.0	54.5	225.4	125.6	20.75	2.65	2.41	16.02	4.60	1.74
Number of locations	20	19	18	19	19	19	20	18	19	16	18	17
Paired T test prob.	0.0110	0.1807	0.0000	0.0000	0.0218	0.0007	0.0368	0.6959	0.0988	0.0839	0.1519	0.5434

CIMMYT

ANNUAL RESEARCH REPORT

2002

TROPICAL LOWLAND MAIZE SUBPROGRAM

Hugo Cordova and Slobodan Trifunovic

Tropical Lowland Team

Hugo Córdova, Slobodan Trifunovic, Narciso Vergara Gilberto Avila, Antonio Ramírez, Octavio Cano and Esperanza Calderon

CIMMYT Maize Program

ANNUAL RESEARCH REPORT 2002

LOWLAND TROPICAL MAIZE SUBPROGRAM

SECTION **Page No.**

I. General Comments

2002 was a good year for the research activities in the tropical lowland subprogram. Dedication of the staff always striving for excellence, allowed us to develop new products that will allow national programs and private seed industry to put in the hands of farmers planting maize in the tropical mega-environment, maize cultivars that possess yield stability and buffer capacity to absorb the many constraints to maize production, resulting from the changing climate and environment. Our efforts of contributing to increase food security and alleviate malnutrition in the developing world, received a tremendous retribution when three new countries released QPM cultivars in the developing world. Venezuela, Colombia, and Nicaragua released new QPM hybrids and varieties and seed production have started.

In 2002 we planted trials in 12 locations: three in Mexico, Cotaxtla,-Veracruz, Agua Fria- Puebla and Tampico-Tamaulipas, four in Guatemala, Las Vegas, Cuyuta, La Maquina- ICTA, and Zacapa one in Turipana, Colombia and one in India, Bihar. Few trials were planted in Panama, Honduras and Paraguay. The 2002 results are really exciting with yields up to 14 t/ha at Zacapa, Guatemala in single cross hybrids and 13 t/ha at Comayagua, Honduras in three way cross hybrids, tropical x subtropical inbreds elite, single cross hybrids yielded up 18t/ha at Bihar, India. Our hybrids also performed well under stressed and non-stressed environments, seven new TWC tropical white hybrids outyielded CML442 x CML444 with 17 to 48% more yield.

Normal and QPM synthetic varieties were extensively tested in marginal environments in Latin America and Asia. New QPM synthetics yielded five t/ha across 11 locations, 15 % more yield than the best QPM varieties and similar to the best normal check, information will provide bases for release of new open pollinated varieties in 2003. In this report we make recommendation focused on how the new products developed can effectively be used to contribute to increase maize productivity in the developing world once germplasm is adopted by farmers. As we predicted our economic resources in 2002 were not good, therefore we stopped planting at Tlaltizapan and Uxmal and reduced several field assistant positions and cut plantings at Agua Fria to coupe with the budget reduction. Fortunately, in 2003 our budget was not reduced as predicted and we recovered our third testing site in Mexico.

CIMMYT future is uncertain and we are still waiting for the strategic planning process that will address this issue, furthermore this uncertain situation is weakening CIMMYT's scientific capacity (the best two young scientists in the Maize Program Matthew Krakowsky and Slobodan Trifunovic resigned and went to work with USDA and Monsanto Seed Company, they were offered a more brilliant future than CIMMYT) and help us focus more on our core objective - i.e. to develop maize and wheat technologies for the resource poor farmers, we just hope that this definition comes soon.

The tropical lowland maize subprogram staff appreciates all the support received from other sub programs and units and Maize Direction. The Maize Program shows a solid integration with Entomology, Pathology, Physiology, Bank-Pre-breeding, Training, International Testing Unit, Highland and Subtropical. This integration was strongly enhanced in 2002. Special thanks to the Regional Projects R1, R2 and R5, Carlos De León, Fernando Gonzalez, Luis Narro, Salvador Castellanos, Sarvesh Paliwal and Hashis Srivastava for helping us to conduct our trails and promote our germplasm to the farmers in their region and all team members in eastern and southern Africa. We also thank the private seed industry specially Cristiani Burcard and PROSEMILLAS in Guatemala and Messina Beej Co. in India for their support in conducting trials at their experimental sites. We also are grateful to Mario Fuentes,

Carlos Perez, Sergio Mejia, Mauro Sierra, Alejandro Ortega, Ernesto Cervantes, Veronica Machado, Ismael Camargo, Roman Gordon and Dr. N.N. Singh, Project Director, Indian Agricultural Research Institute, for the assistance in conducting trials at their respective stations. We encourage maize scientists in outreach to read this report carefully because it contains recommendations that can be useful for your region and to test the superior germplasm under the production system of farmers planting maize in the developing world.

Hugo Cordova

II. Inbred Line Development, Nurseries and Seed Increases

Four types of nurseries were planted at Agua Fria, 2002B, Cotaxtla, 2002 A&B and Tlaltizapan 2002 A cycle. With a total of 18,700 lines evaluated and selected in 21,300 five meters long nursery rows and approximately 300,000 pollination nurseries described as follows:

1. Germplasm Development Nursery.

Consisted of 161 elite x elite F_2 pedigree populations (yellow and white endosperm), QPM and normal. Every F_2 population was planted in 20 rows bulk in low (42,000 plants/hectare) and high density (84,000 plants/hectare). Self pollinations are executed only in high density, only plants with good ASI are selected, while low density are left without glassine bags and are inoculated with *B. maydis* and Fusarium stalk rots. Information on husk cover and response to disease is collected in low density before harvest time and used at harvest to eliminate bad populations or lines. The selection criteria in high density includes the selection of plants with good ASI and good roots (good standability).

2. Breeding Nursery (S_2 to S_5).

More than 6440 S_2 to S_5 lines (early and late, yellow and white) were planted in Agua Fria 2002B in the same faction explained before. Selection criteria includes resistance to *B. maydis*, Fusarium ear/stalk rot, standability and yield and response to high density, root and stalk quality. Selection pressure is 10 to 20%.

3. Advanced Nursery (S_5 to S_8).

Near 628 lines were planted at Agua Fria 2002B, including late, early, white and yellow. Selection criteria includes resistance to *B. maydis*, Fusarium ear/stalk rot, standability and yield and response to high density, root and stalk quality. Selection pressure is 10 to 20%.

4. Elite Lines Nursery (S_8 to S_{10}).

This nursery includes the elite lines (47 late early white and yellow) were planted at Agua Fria 2002B, that have been selected on the basis of the response to GCA and SCA in crosses for yield, ear rot and other biotic and abiotic stresses and are CML's candidates.

Ten ears of each selected line are harvested from the advanced line nursery and are planted ear to row at 66,666 plants/hectare. This nursery is intended to increase seed to be used (Genetic -1) as original seed.

Additional information such as pollen shedding interval, tassel size, tassel structure, yield, stalk quality is collected from this nursery to provide collaboration with the preliminary information for the potential use as male or female in hybrid combinations.

III. Experiments and Results

1. Population Improvement

Population improvement continues to be a high priority in the tropical lowland subprogram. In 2002 we tested 30 experimental varieties originated from the population improvement project and 30 new synthetics, open pollinated varieties derived from the pedigree selection breeding project. Progress from selection was measured in 2000 and 2001 in white and yellow germplasm in the process of population improvement. This information assisted us to enhance our breeding activities and further move to produce new and better products for all clients.

In Cotaxtla 2002A, we practiced intra-family selections in S_1 lines and generated 400 S_2 lines in populations; 21, 25, 32, and 28, 36 improved by HSRRS, and populations 30 and 31 improved S2 x tester selection. The S_2 testcrosses were formed in Agua Fria 2002B, and delivered to ITU to prepare IPTT`s. In the white late populations we are in the fifth cycle and in the yellow late population we are in the middle of the third cycle in the early populations we will complete the second cycle.

2. Hybrid Development and Testing and synthetic formation.

1745 normal and QPM hybrid combinations: early and advanced generation testcrosses from pedigree selection, stage 3 single crosses, three-way crosses early and late maturing, white and yellow endosperm hybrids were tested in 28 different trials. In Mexico, Colombia, Guatemala, India, Honduras, Paraguay. Size varies according to type of trials, one or two row plots separated 75 centimetres between rows, 5.4 meter long rows, fertilization and other agronomic traits varies according to the recommendation at each location to provide a proper management to the trials. Every single trial will provide information to identify lines and form open pollinated varieties, therefore the need to test larger number of hybrids.

Evaluation of early generation tropical late white testcrosses

Early generation testcrosses (made at S_2 or S_3) provide us with the necessary information to select the best performing 10 to 20% lines and eliminate the remnant load of bad performing lines. Early generation testcrosses are made with S_2 or S_3 lines from pedigree selection scheme and crossed to opposite HG testers, only in some cases where the HG from the F_2 populations is unknown, the use of both testers for a group of lines is obligatory.

With the objective of performing crosses among early and advanced generation lines four isolation blocks including the four testers, two white and two yellows, were planted and advanced and early generation testcrosses were formed at harvest time, crosses were separated according to generation tester and color.

In 2002 we conducted three different trials:

TSCLW02-15; TSCLW02-16 and TSCLW02-17. All trials were conducted in the same five tropical sites: Agua Fria, Puebla and Cotaxtla, Veracruz, Mexico, Las Vegas and Cuyuta, Guatemala and Turipana, Colombia. Elevation of the testing sites varies from 0 MASL in Cotaxtla, Veracruz to 900 MASL in Zacapa, Guatemala. Plot size consisted of one five meters long row at 66,666 plants/hectare. Agronomic practice varied according to site recommendation.

2.1 Combining ability and hybrid yield performance of tropical late white inbred lines crossed to testers tolerant to heat (TSCLW02-14)

55 tropical late white inbred lines originally identified in early generation testcrosses (S_3) as heterotic group "A&B" were crossed to two tester lines originally identified as good response to heat conditions. (T39 and T43) and testers CML448 and CML 449

formed 97 hybrids and 8 checks for a total of 105. The 97 advanced testcrosses, six single crosses among tropical white testers and two checks were included in an alpha lattice 15x7 design with two replications and they were evaluated at two locations: Agua Fria, Puebla and Cotaxtla, Veracruz, Mexico. The objectives of this work were to estimate the combining ability of the new lines, identify new single cross hybrids and potential females for TWC hybrid combinations and lines with good CGA to form synthetic varieties. Highly significant statistic differences were detected at individual and across locations.

The ANOVA showed significant differences for yield and agronomic traits at individual locations and across locations, mean yield varies from 6.7 ton/ha at Agua Fria 8.1 t/ha at Cotaxtla, and 7.2 t/ha across locations (Tables A1 to A3)

The interaction locations x hybrids for yield was statistically non-significant. Six hybrids yielded from 3 to 4.6 t/ha more than H-31 and showed resistance to root lodging FSR (Table 1). Root lodging across locations 17% reflects the importance of selection for this trait, at Obregon H-31 outyielded all hybrids and showed resistance to heat.

General combining ability (GCA) plays an important role in hybrid and synthetic formation lines, showing positive and significant GCA are lines: L_7, L_{14}, L_{15}, L_{21}, L_{22}, L_{23}, and L_{24} showing from 1.5 to 6 times the standard deviation for lines. These lines will be used to form synthetics.

SCA large estimates are shown in Table 2, the hybrids T_2 x L_{14}, T_2 x L_{15}, T_2 x L_7, T_2 x L_{21}, T_2 x L_{16}, T_3 x L_{21}, and T_3 x L_{26}, has estimated value from two to four times the SD. Lines with best GCA will form synthetic varieties that will be included in the synthetic formation.

Material selected here has a tremendous yield potential for Eastern and Southern Africa and Latin America. Superior lines and single crosses can be crossed with lines resistant to MSV and for TWC and tested across locations.

Table 1. TSCLW02-14 Top eight tropical late white single crosses across two locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %	HM 1_5
36	(CL-G2407*CML264)-B-8-1-2-B x T-39	**10.64**	**10.65**	**100**	**125**	0.1	52	0.51	0.94	27.4	3.5	3.0	7.3	0.8	5.6	0.5	3.5
17	(CL-04317*CML247)-B-3-2-1-B x T-39	**10.27**	**10.28**	**97**	**121**	0.1	53	0.52	0.95	28.3	2.7	2.2	19.4	0.0	3.4	3.5	2.5
20	(CL-04317*CML247)-B-6-1-2-B x T-39	**9.76**	**9.99**	**92**	**115**	2.2	51	0.55	1.10	23.7	3.2	2.3	12.8	0.3	16.1	20.3	3.8
15	(CML273*CML401)-B-16-1-1-B x CML449	**9.74**	**9.74**	**92**	**115**	0.0	51	0.55	0.98	24.2	3.6	2.0	25.0	2.2	0.0	11.3	2.8
54	(CL-G2407*CML254)-B-22-1-3-B x CML449	**9.28**	**9.28**	**88**	**109**	0.0	50	0.51	0.99	24.4	3.2	2.5	15.7	0.4	4.6	0.9	3.2
21	(CL-04317*CML247)-B-6-1-2-B x CML449	**9.14**	**9.31**	**86**	**108**	1.8	50	0.56	1.09	24.7	3.0	2.5	10.4	7.1	6.2	6.2	2.6
60	(CL-04317*CML254)-B-16-1-2-B x CML449	**9.03**	**9.03**	**85**	**107**	0.0	49	0.52	0.94	23.6	3.0	2.0	18.4	1.3	1.3	2.4	2.0
50	(CL-04317*CML247)-B-6-1-1-B x CML449	**8.94**	**9.05**	**84**	**105**	1.3	50	0.55	1.03	24.7	3.0	2.9	15.8	2.0	5.9	18.8	4.0
98	CML442 x CML444	**7.41**	**7.90**	**70**	**87**	6.3	53	0.58	0.96	22.4	3.1	3.3	6.2	1.1	0.0	1.5	3.0
99	CML448 x CML449	**7.36**	**7.36**	**69**	**87**	0.1	51	0.51	0.91	27.5	3.0	2.5	9.0	0.0	0.1	16.0	2.6
100	CML247 x CML254 RE	**8.37**	**8.48**	**79**	**99**	1.4	52	0.59	0.99	26.5	3.2	2.4	8.2	0.8	5.8	24.8	2.9
101	CML264 x CML269	**8.87**	**8.98**	**84**	**105**	1.3	51	0.51	0.98	24.4	3.2	2.3	14.9	0.5	1.2	1.6	3.2
102	CL-04368 x CL-SPLW04	**10.59**	**10.61**	**100**	**125**	0.2	51	0.58	1.03	20.2	3.3	2.5	28.8	2.0	7.9	0.0	3.0
103	H-431	**5.00**	**5.25**	**47**	**59**	4.8	49	0.55	0.89	22.5	4.0	3.3	30.8	2.0	2.4	5.7	3.3
104	H-431 x Y902213	**5.63**	**5.92**	**53**	**66**	5.0	49	0.52	0.92	20.8	4.1	3.6	23.0	9.0	0.3	14.5	4.8
105	LOCAL CHECK	**8.48**	**8.66**	**80**	**100**	2.1	51	0.51	0.90	23.7	3.6	2.3	8.3	5.7	2.0	1.2	2.7
	Check Mean	**7.71**	**7.90**			2.6	51	0.54	0.95	23.5	3.4	2.8	16.1	2.6	2.4	8.2	3.2
	Grand Mean	**7.41**	**7.53**			1.6	50	0.53	0.96	24.2	3.3	2.9	17.1	2.5	4.0	8.5	3.1
	LSD 5%	**1.35**	**1.39**			2.8	1.2	0.0	0.1	2.9	0.6	0.5	17.2	5.7	7.1	.	.
	CV %		**14.92**			7.7	1.8	6.0	12.5	6.4	16.3	16.7	13.7	9.8	11.4	85.4	15.9
	F value Loc*Entry		**0.77**			0.5	0.9	0.6	0.6	1.8	0.7	0.6	0.8	0.8	0.6	.	.
	P(F>f)		**0.92**			1.0	0.8	1.0	1.0	0.0	1.0	1.0	0.9	0.9	1.0	.	.
	Number of locations		**2**			2	2	2	2	2	2	2	2	2	2	1	1

Table 2. TSCLW02-14 Evaluation of GCA for tropical late white inbred lines

Across two Locations. 2002 B

1. Grain yield and GCA values.

	L1	L2	L3	L4	L5	L6	L7	L8	MEAN	GCA
T1	6.91	5.62	7.22	6.47	6.83	7.11	7.70	6.08	**6.74**	**-0.785**
T2	7.32	7.04	8.17	6.36	8.44	10.29	9.99	7.35	**8.12**	**0.591**
T3	7.91	6.23	7.03	7.32	9.74	6.42	9.31	7.81	**7.72**	**0.193**
MEAN	**7.38**	**6.29**	**7.47**	**6.71**	**8.33**	**7.94**	**9.00**	**7.08**		
GCA	**-0.148**	**-1.231**	**-0.056**	**-0.811**	**0.809**	**0.412**	**1.474**	**-0.446**		

Testers:

T1 T-43
T2 T-39
T3 CML449

	L9	L10	L11	L12	L13	L14	L15	MEAN	GCA
T1	5.91	6.69	6.68	6.61	6.98	6.38	7.54	**6.68**	**-1.011**
T2	8.34	7.44	8.52	8.59	8.07	10.66	9.32	**8.70**	**1.011**
MEAN	**7.13**	**7.06**	**7.60**	**7.60**	**7.52**	**8.52**	**8.43**		
GCA	**-0.568**	**-0.631**	**-0.093**	**-0.096**	**-0.171**	**0.824**	**0.734**		

GCA St.error LINES = 0.311
GCA St.error TESTERS = 0.129

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	MEAN	GCA
T1	6.91	5.62	7.22	6.47	6.83	7.11	7.70	6.08	5.91	6.69	6.68	6.61	6.98	6.38	7.54	**6.71**	**-0.839**
T2	7.32	7.04	8.17	6.36	8.44	10.29	9.99	7.35	8.34	7.44	8.52	8.59	8.07	10.66	9.32	**8.39**	**0.839**
MEAN	**7.11**	**6.33**	**7.69**	**6.41**	**7.63**	**8.70**	**8.84**	**6.71**	**7.13**	**7.06**	**7.60**	**7.60**	**7.52**	**8.52**	**8.43**		
GCA	**-0.439**	**-1.224**	**0.138**	**-1.142**	**0.081**	**1.146**	**1.291**	**-0.839**	**-0.427**	**-0.489**	**0.048**	**0.046**	**-0.029**	**0.966**	**0.876**		

	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	L26	L27	L28	MEAN	GCA
T2	8.55	7.92	7.53	7.95	7.79	8.78	7.59	7.36	8.75	7.54	6.53	6.22	7.89	**7.72**	**-0.047**
T3	7.62	6.83	5.12	6.56	6.52	9.06	8.78	9.28	8.27	8.50	9.04	7.73	8.31	**7.81**	**0.047**
MEAN	**8.09**	**7.37**	**6.32**	**7.25**	**7.15**	**8.92**	**8.18**	**8.32**	**8.51**	**8.02**	**7.78**	**6.98**	**8.10**		
GCA	**0.318**	**-0.397**	**-1.447**	**-0.515**	**-0.615**	**1.150**	**0.413**	**0.553**	**0.740**	**0.248**	**0.013**	**-0.792**	**0.333**		

Lines:

L1	(CL-04345*CL-274)-B-19-1-1-B	**L11**	(CL-04317*CML247)-B-3-2-3-B	**L21**	(CL-04317*CML247)-B-6-1-1-B
L2	(CL-04346*CL-02513)-B-69-1-1-B	**L12**	(CL-04347*CL-04904)-B-111-1-1-B	**L22**	(CL-04317*CML247)-B-15-1-B
L3	(CL-04347*CL-04904)-B-26-1-1	**L13**	(CL-04347*CL-04904)-B-114-1-2-B	**L23**	(CL-G2407*CML254)-B-22-1-3-B
L4	(CL-04347*CL-04904)-B-109-2-1-B	**L14**	(CL-G2407*CML264)-B-8-1-2-B	**L24**	(CL-G2407*CML254)-B-36-1-2-B
L5	(CML273*CML401)-B-16-1-1-B	**L15**	(CML247*CML254)-B-31-3-2-B	**L25**	(CL-02159*CML247)-B-13-2-2-B
L6	(CL-04317*CML247)-B-3-2-1-B	**L16**	(CL-04345*CL-274)-B-15-1-2-B	**L26**	(CL-04317*CML254)-B-16-1-2-B
L7	(CL-04317*CML247)-B-6-1-2-B	**L17**	(CL-04345*CL-274)-B-113-2-1-B	**L27**	(CL-04317*CML264)-B-21-1-3-B
L8	(CL-04317*CML264)-B-15-1-B	**L18**	(CL-04346*CL-02513)-B-53-1-1-B	**L28**	(CML265*CL-00303)-S7*CML264)-B-8-1-3-B
L9	(CL-04347*CL-04904)-B-15-2-1-B	**L19**	(CL-04347*CL-04904)-B-109-1-1-B		
L10	(CL-04347*CL-04904)-B-86-2-B	**L20**	(CML48*CML401)-B-10-1-B		

2.2 Evaluation of early generation tropical white late lines heterotic Group "A" crossed to tester HGB (CML449) (TSCW02-15).

106 S_3 lines were crossed to CML449. The 105 plus four checks were included in an ∝ 11 x 10 lattice design and evaluated in the five sites mentioned above. ANOVA showed significant statistical differences for yield and agronomic traits at each individual location and across locations GxE interaction was not significant and we proceeded to perform the across analysis. In the model the genotypes were considered fixed and sites random effects, location mean yields 6.71 t/ha at Agua Fria, 10.2 t/ha at Zacapa, 6.96 t/ha at Turipana, 5.8 t/ha at Las Vegas, and 8.0 t/ha at Cotaxtla. At this location a storm-hurricane caused severe damage and most of the trial was lodged with root lodging mean of 74% that affected the value of this trial across locations. Nevertheless the yield was not affected by the lodging. The mean yield across locations was 7.7 t/ha.

Table 3 shows the mean performance across locations of the 8 superior crosses. Note that the yield of the superior testcrosses outyielded best seed industry check from 24 to 32% (8.7 t/ha to 9.4 t/ha) while the check yielded 6.9 t/ha.

The maximum yield of (CL02134* CL021101)-B-53-1 x CML449 was showed in Zacapa, Guatemala (Table A5) with 12.6 t/ha yielded 59% more than seed industry check HR-101.

The main yield of the selected lines for further advance in inbreeding for pedigree selection was 7.8 t/ha and the mean of the crosses 7.6 t/ha. 39 lines heterotic group "A" were selected, with good yield potential and superior agronomic traits such as standability, ear rot, stalk lodging, F. stalk rot and resistance to CSD, rust and *B. Maydis* and are being advanced to S_6. Tables A4 to A9 show the performance of testcrosses at individual and across locations. Yield of best hybrids at individual locations is shown in Fig. 1.

Fig. 1. TSCLW02-15 Grain Yield of the best hybrid and the best local check across five locations in 2002B

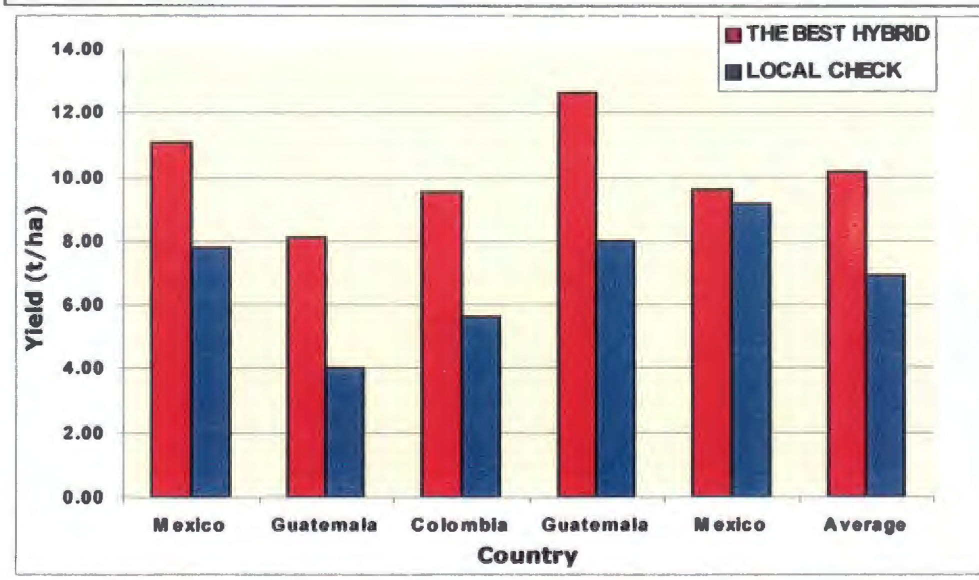


Table 3. TSCLW02-15 Top eight early generation tropical late white single crosses across five locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %	HM 1_5	Css %
27	(CL-02134 *CL-021101)-B-57-1 x CML449	**9.03**	**9.40**	**132**	**137**	4.0	51	0.51	1.05	18.5	2.6	1.9	13.8	2.2	0.2	3.0	3.1	4.7
23	(CL-02134 *CL-021101)-B-46-1 x CML449	**8.77**	**9.28**	**128**	**133**	5.5	50	0.53	1.04	18.6	2.4	2.3	11.2	3.4	0.8	11.6	3.2	6.1
46	(CL-02134 *CL-04351)-B-8-1 x CML449	**8.73**	**8.99**	**127**	**132**	2.9	50	0.49	1.03	18.3	2.7	2.2	22.5	2.3	0.5	16.4	3.4	3.5
33	(CL-02134 *CL-021101)-B-68-1 x CML449	**8.70**	**9.10**	**127**	**132**	4.4	50	0.54	1.03	19.7	2.6	1.9	27.0	3.2	2.0	0.0	2.4	2.9
6	(CL-02134 *CL-021101)-B-12-2 x CML449	**8.63**	**9.11**	**126**	**131**	5.3	50	0.56	1.05	19.8	2.7	2.2	21.3	5.4	0.0	12.5	3.1	7.6
19	(CL-02134 *CL-021101)-B-38-3 x CML449	**8.61**	**8.92**	**126**	**130**	3.4	51	0.53	1.02	17.8	2.7	2.4	18.9	3.1	0.0	7.5	3.2	5.4
9	(CL-02134 *CL-021101)-B-25-1 x CML449	**8.52**	**8.69**	**124**	**129**	2.0	51	0.53	1.01	18.5	2.5	1.9	21.6	4.5	0.0	6.1	2.7	10.0
105	(CML-273*CML-401)-B-9-1-2 x CML449	**8.51**	**8.64**	**124**	**129**	1.5	51	0.52	1.00	17.3	3.2	2.1	25.8	3.1	0.6	6.4	2.8	5.3
107	CML448 x CML449	**6.86**	**7.19**	**100**	**104**	4.6	50	0.49	0.95	19.5	2.6	2.4	25.3	1.2	0.0	15.3	2.6	5.9
108	CML442 x CML444	**4.19**	**5.34**	**61**	**63**	21.6	52	0.58	0.78	16.7	3.4	3.6	15.1	6.7	5.3	3.9	3.4	10.8
109	CML247 x CML254	**6.66**	**6.93**	**97**	**101**	3.8	53	0.57	0.95	19.8	2.7	2.1	8.2	2.2	2.2	0.0	2.6	0.7
110	Local Check	**6.61**	**6.93**	**96**	**100**	4.6	51	0.56	1.00	17.7	2.3	2.4	17.4	7.8	1.9	9.8	3.0	1.4
	Check Mean	**6.08**	**6.60**			8.6	51	0.55	0.92	18.5	2.8	2.6	16.5	4.4	2.3	7.2	2.9	4.7
	Grand Mean	**7.28**	**7.68**			5.2	50	0.52	0.99	18.4	2.9	2.5	21.4	3.5	1.4	13.8	3.2	5.9
	LSD 5%	**0.81**	**0.84**			3.5	0.7	0.0	0.1	1.0	0.6	0.4	9.7	3.9	2.3	.	.	13.9
	CV %		**13.41**			8.5	1.8	6.3	10.2	6.0	15.2	16.9	11.7	10.5	8.4	60.0	12.3	246
	F value Loc*Entry		**0.87**			1.1	0.8	0.6	0.8	1.2	1.8	1.3	0.7	0.8	0.5	.	.	0.5
	P(F>f)		**0.93**			0.3	1.0	1.0	1.0	0.1	0.0	0.0	1.0	1.0	1.0	.	.	1.0
	Number of locations		**5**			5	5	5	5	5	4	5	4	5	4	1	1	2

2.3 Combining ability of early generation tropical late white lines crossed to testers CML448 (A) and CML449 (B) (TSCW02-16).

47 tropical white late S_3 & S_4 lines developed from F_2 pedigree selection Heterotic Groups (AxB) were testcrossed to tester CML448 HG "A" and CML449 HG"B" TL2002A. The 94 crosses and six checks were included in a 10x10 $\propto$ lattice design and were tested in the same five locations mentioned above. The objectives of this study were to estimate the GCA ability of the lines and classify them in heterotic groups, select the outstanding lines to advance and identify lines for synthetic formation.

Mean yield at individual locations was 6.4 t/ha at Agua Fria; 8.6 t/ha at Zacapa, Guatemala, 6.2 t/ha at Turipana, Colombia; 6.5 at Cuyuta, Guatemala, 7.1 t/ha at Cotaxtla, Mexico and 6.95 t/ha across locations. As in trial 15 a severe root lodging (40% mean) was registered at Cotaxtla correlation between yield and ear rot was – 0.44* across locations (Tables A10 to A15). 25 hybrids outyielded the local check with one ton per hectare and 8 hybrids showed resistance to root lodging and Fusarium stalk rot.

New hybrid (CML247*SP49E+F_2-S_5-)B-22-3xCML449 topped the trial across five locations with 9.22 t/ha (Table 4) 47% more yield than the local check and 3.8 t/ha more than CML442 x CML444. This hybrid also outyielded the best check CML448 x CML449 with 23% more yield. Yield potential maximum expression was present at Zacapa, Guatemala 11.9 t/ha 900 MASL and 12.8 t/ha at Cotaxtla, Veracruz 20 MASL (Tables A11 and A14 respectively).

The best 8 performing hybrids across locations are presented in Table 4 CL04368 x CL-SPLW04 continues topping the trial with 10.0 t/ha and resistance to ear rot, root lodging and Fusarium stalk rot while local checks showed susceptibility to those traits Fig. 2.

Testers CML448 HG"A" and CML449 HG"B" effectively classified the new lines in heterotic groups. 13 lines were classified as heterotic group A and 11 lines as belonging to heterotic group "B". $PSGC_1$-1-1-1-3 and (CML247*SP4E+F_2-S_5)-B-11-1 showed the highest value of GCA (Table 5). Selected lines will be used to form advanced crosses and synthetics.

Fig. 2. TSCLW02-16 Grain yield, ear rot, and root lodging for the best three white hybrids and three reference entry hybrids across five locations in 2002B

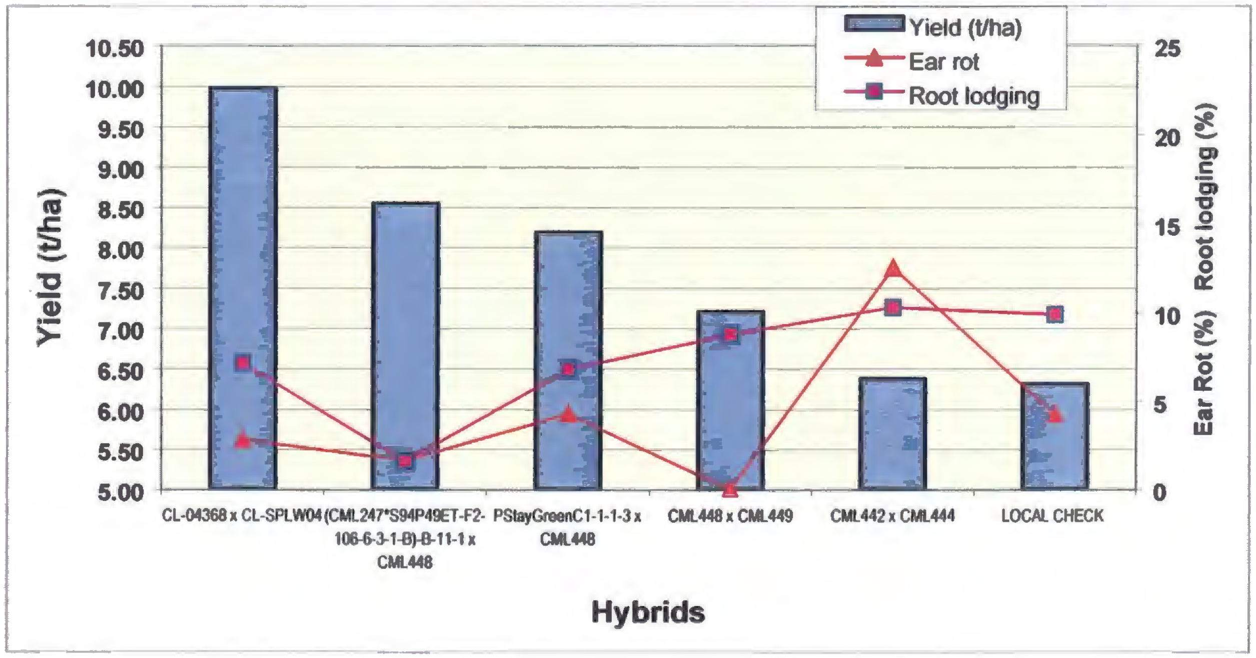


Table 4.TSCLW02-16 Top eight early generation tropical late white lines across five locations in 2002B

Ent no	Pedigree		Yield1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	HM 1_5
8	CL-04368	x CL-SPLW04	9.70	9.98	134	160	2.9	51	0.55	1.15	16.4	2.6	2.3	7.2	2.9	5.5	1.8
34	(CML247*S94P49ET-F2-94-1-1-1-B)-B-22-3	x CML449	8.90	9.22	123	147	3.5	50	0.52	0.93	19.2	2.9	2.5	12.8	2.4	1.7	2.0
90	PStayGreenC1-1-1-3	x CML449	8.55	8.72	118	141	1.9	50	0.52	1.03	18.8	3.1	2.4	13.5	5.5	2.2	1.8
39	(CML247*S94P49ET-F2-106-6-3-1-B)-B-11-1	x CML448	8.41	8.55	116	139	1.7	50	0.48	0.97	20.1	2.4	2.4	1.8	0.9	10.3	1.7
92	PStayGreenC1-3-1-1	x CML449	8.09	8.38	112	134	3.4	50	0.51	0.98	18.3	2.8	2.6	12.3	9.1	16.7	2.2
89	PStayGreenC1-1-1-3	x CML448	7.84	8.20	109	130	4.3	52	0.48	0.91	20.0	2.5	2.6	8.8	1.3	15.8	1.9
75	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-3	x CML448	7.82	7.99	108	129	2.2	51	0.49	0.97	19.9	2.5	2.4	13.8	0.4	12.0	1.5
94	PStayGreenC1-3-2-1	x CML449	7.80	8.00	108	129	2.5	49	0.56	0.97	17.9	3.2	2.8	20.4	5.5	1.8	2.1
96	(CL-04317*CML247)-B-36-2-2-1	x CML449	7.79	7.93	106	129	1.9	50	0.53	1.00	18.7	3.1	2.8	8.3	4.8	5.3	2.2
82	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-4	x CML449	7.76	7.90	108	126	1.7	51	0.50	0.99	18.0	2.8	2.3	19.4	3.8	0.1	1.7
97	CML448	x CML449	7.22	7.22	108	119	0.0	50	0.48	0.98	19.7	3.0	2.7	6.8	1.0	0.7	2.0
98	CML442	x CML444	5.59	6.39	77	92	12.5	53	0.55	0.85	18.5	3.0	2.9	10.3	3.3	2.9	2.0
99	CML247	x CML254	7.55	7.55	105	125	0.0	53	0.54	0.98	19.7	3.1	2.5	7.5	0.3	3.8	2.2
100	LOCAL CHECK		6.06	6.33	84	100	4.3	51	0.53	0.94	17.3	3.1	2.5	9.9	8.0	0.8	2.2
	Check Mean		6.60	6.87			4.2	52	0.52	0.94	18.8	3.1	2.6	9.1	3.1	2.1	2.1
	Grand Mean		6.65	6.95			4.3	51	0.50	0.95	18.8	2.9	2.8	9.9	2.1	9.6	1.9
	LSD 5%		0.95	0.99			3.7	0.7	0.0	0.1	1.4	0.4	0.3	10.7	3.7	7.8	0.4
	CV %			14.34			10.3	1.7	7.4	11.4	7.4	16.8	15.4	11.8	9.2	12.9	19.5
	F value Loc*Entry			1.26			0.8	1.0	0.7	0.6	1.3	0.7	0.8	1.6	1.0	0.6	0.7
	P(F>f)			0.01			5.0	0.5	1.0	1.0	0.0	1.0	1.0	0.0	0.6	1.0	1.0
	Number of locations			5			5	5	5	5	5	4	5	5	5	4	3

Table 5.TSCLW02-16 Evaluation of early generation tropical late white lines across five locations in 2002B

Across 5 locations

Ent no	Pedigree	Yd (t/ha) x CML448	Yd (t/ha) x CML449	Diff. t/ha	GCA t/ha	Erott %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Ear ht Plt ht	# Ear # Plt	Mo %	Erott 1_5	Plt asp	Ear asp	Ridg %	Sldg %	BH %	Ear #	Plt #	Fus %	HM 1_5	EnH 1_5	Dis 1_5	Rust 1_5
	PStayGreenC1-1-1-3	8.196	8.724	-0.53	1.40	3.1	52	51	-0.3	228	111	0.50	0.97	19.4	1.77	2.8	2.5	10.2	3.4	9.0	24	24	11.2	1.8	3.8	2.9	2.2
	(CML247*S94P49ET-F2-106-6-3-1-B)-B-11-1	8.553	7.681	0.87	1.06	1.5	50	50	-0.3	236	120	0.50	0.99	20.4	1.86	2.6	2.6	12.2	1.7	8.9	23	23	2.2	1.7	4.0	3.1	1.7
	(CML247*S94P49ET-F2-94-1-1-1-B)-B-22-3	6.989	9.217	-2.23	1.04	5.0	51	51	0.0	236	117	0.50	0.90	19.4	2.01	2.8	2.7	10.9	1.2	7.9	21	24	19.4	2.0	4.1	3.2	2.1
	(CML254*DEERC2-15-3-1-#2-#1-1-#)-B-B-23-2	7.599	7.780	-0.18	0.63	2.7	52	51	-0.7	234	122	0.52	0.99	19.3	1.64	2.8	2.7	5.6	1.1	4.2	23	23	2.2	2.0	3.7	2.8	2.1
	(CML247*S94P49ET-F2-94-1-1-1-B)-B-24	7.332	7.720	-0.39	0.46	6.0	52	52	-0.2	226	116	0.51	0.92	18.5	2.20	2.9	2.8	10.4	2.0	6.1	22	24	5.8	2.1	4.1	3.4	2.1
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-46-3	6.988	7.897	-0.91	0.38	3.8	53	52	-0.4	245	120	0.49	0.94	19.7	1.82	2.6	2.4	16.0	4.2	1.7	22	23	1.5	1.6	3.0	3.0	1.8
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-25-3	7.155	7.658	-0.50	0.34	2.0	49	49	-0.2	236	113	0.48	0.99	18.0	1.94	3.1	2.8	18.5	6.6	4.3	24	24	16.1	2.2	4.0	3.0	2.3
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-1-2	7.057	7.745	-0.69	0.34	1.9	52	51	-0.6	229	116	0.50	0.86	19.5	1.72	2.6	2.3	9.3	1.8	10.6	20	24	7.6	1.8	2.1	3.0	1.7
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-47-1	7.567	7.081	0.49	0.26	5.9	50	50	-0.2	227	112	0.49	0.96	17.7	2.18	2.9	2.9	11.5	1.4	7.4	23	24	18.4	2.0	4.0	2.7	2.0
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-36-3	6.940	7.645	-0.71	0.23	2.4	52	51	-0.4	223	116	0.52	0.92	20.3	1.62	2.7	2.5	9.2	0.9	2.6	22	24	1.8	1.9	3.5	2.8	1.6
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-36-1	7.237	7.320	-0.08	0.22	2.2	51	51	-0.3	223	114	0.51	0.89	20.3	1.72	2.8	2.5	11.4	0.4	6.6	22	25	2.1	1.8	2.1	2.8	1.5
	(CML247*S94P49ET-F2-131-3-1-2-B)-B-44-1	7.279	7.229	0.05	0.19	6.7	51	50	-0.6	223	119	0.53	0.98	18.8	2.16	2.9	2.8	13.7	2.5	16.6	22	23	10.3	2.0	4.0	3.1	2.1
	(CL-03210*DEERC2-15-3-1-#2-#1-1-#)-B-B-31-2	7.478	6.992	0.49	0.17	2.6	51	51	-0.1	223	112	0.50	0.91	18.0	1.99	3.0	2.4	18.0	2.6	4.9	21	24	13.9	1.8	2.8	3.2	2.1
	(CML247*S94P49ET-F2-131-3-1-2-B)-B-22-1	7.507	6.832	0.67	0.11	4.9	50	50	-0.4	224	112	0.50	0.96	19.2	2.37	2.9	3.0	13.5	4.0	14.4	21	23	16.1	1.8	4.2	3.6	1.8
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-30-2	6.979	7.303	-0.32	0.08	2.2	52	52	0.1	239	119	0.50	0.97	19.6	1.80	2.8	2.4	5.5	2.9	3.7	23	24	4.7	1.7	2.1	3.0	1.6
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-7-1	7.071	7.207	-0.14	0.08	4.7	51	51	-0.2	223	109	0.49	0.97	19.2	2.19	3.1	2.9	14.9	1.6	14.6	24	25	16.5	2.2	5.0	2.9	2.2
	(CML247*S94P49ET-F2-106-6-3-1-B)-B-11-2	7.408	6.866	0.54	0.08	5.5	51	51	-0.1	221	113	0.51	0.94	20.9	2.24	2.9	2.8	12.1	1.5	17.5	21	23	16.4	1.9	4.6	2.8	1.9
	(CML247*S94P49ET-F2-131-3-1-2-B)-B-38-1	7.329	6.918	0.41	0.06	4.9	51	50	-0.2	215	108	0.50	0.90	19.3	2.24	2.8	2.8	9.9	0.5	5.0	20	23	18.4	2.1	4.0	2.5	1.8
	(CML254*DEERC2-15-3-1-#2-#1-1-#)-B-B-23-1	6.900	7.309	-0.41	0.04	4.2	52	51	-0.6	223	115	0.51	0.97	18.5	1.87	2.8	2.8	2.2	0.9	6.4	23	24	11.9	2.1	4.0	2.4	2.3
	(CML247*S94P49ET-F2-111-1-2-2-B)-B-8-1	7.249	6.869	0.38	0.00	1.5	50	50	-0.4	218	108	0.49	0.94	19.3	1.64	2.8	2.7	11.0	4.2	1.3	22	24	16.4	1.9	4.0	3.0	2.0
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-4-1	6.217	7.838	-1.62	-0.03	5.1	51	51	0.2	230	115	0.50	0.88	18.9	2.12	2.7	2.8	12.7	2.0	8.4	21	24	11.2	1.8	4.7	2.7	1.8
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-46-1	6.749	7.247	-0.50	-0.06	8.1	51	51	-0.3	216	101	0.46	0.92	18.1	2.51	2.9	3.0	9.9	1.0	21.3	22	24	6.8	2.0	4.5	2.6	2.0
	(CL-03210*DEERC2-15-3-1-#2-#1-1-#)-B-B-48-2	6.849	7.128	-0.28	-0.07	3.0	49	49	-0.5	227	113	0.50	0.93	18.0	1.65	2.8	2.6	3.3	1.1	1.9	22	24	12.9	1.9	2.5	3.0	1.9
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-1-1	6.741	7.133	-0.39	-0.12	3.3	51	51	-0.5	227	109	0.48	0.89	18.6	1.80	3.0	2.7	10.5	1.8	8.5	20	23	4.8	1.8	2.2	2.9	2.0
	(CML247*S94P49ET-F2-106-6-3-1-B)-B-43-2	6.926	6.758	0.17	-0.22	7.9	51	50	-0.4	221	111	0.50	0.95	18.8	2.77	3.0	3.3	10.2	2.0	51.2	22	23	14.6	2.0	4.5	3.0	2.1
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-36-1	6.672	6.992	-0.32	-0.23	2.6	50	50	-0.4	226	109	0.48	0.93	17.9	2.12	2.8	3.0	9.8	2.7	11.6	20	21	15.3	1.9	4.0	2.8	1.7
	(CL-03210*DEERC2-15-3-1-#2-#1-1-#)-B-B-11	6.555	6.841	-0.29	-0.36	3.7	51	51	-0.1	219	113	0.52	0.96	18.6	1.70	3.0	2.7	10.0	1.4	1.7	22	23	7.5	1.8	2.8	3.1	2.1
	(CML247*S94P49ET-F2-106-6-3-1-B)-B-32-1	5.663	7.520	-1.86	-0.47	9.4	50	50	-0.1	223	108	0.48	0.93	18.5	2.32	2.8	3.2	4.6	1.5	25.4	22	23	9.8	2.1	4.2	2.6	2.1
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-27-1	6.462	6.639	-0.18	-0.51	4.5	51	51	-0.3	217	108	0.50	0.94	18.7	2.18	2.9	3.0	16.9	1.7	10.6	22	23	7.0	1.8	4.0	2.8	2.0
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-31-2	5.238	7.726	-2.49	-0.58	8.2	51	51	-0.2	230	111	0.48	0.86	18.3	2.08	3.0	2.9	9.7	2.6	16.4	21	24	14.6	2.3	3.3	3.0	2.1
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-20-1	5.825	6.866	-1.04	-0.72	7.0	50	50	-0.2	212	102	0.48	0.89	17.2	2.23	3.1	3.2	7.0	4.4	13.4	21	24	20.6	2.1	4.5	3.6	2.2
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-44-1	6.301	5.976	0.32	-0.92	4.3	51	51	-0.2	209	98	0.47	0.91	18.2	2.30	2.8	3.0	9.4	1.3	12.4	20	22	16.7	2.0	4.9	2.8	1.9
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-38-2	5.557	8.645	-1.09	-0.96	3.7	50	50	0.3	228	113	0.50	0.95	17.6	2.43	3.0	3.1	14.1	1.4	12.3	21	22	3.0	2.1	3.2	3.3	2.1
	(CML247*S94P49ET-F2-94-1-1-1-B)-B-28-1	6.660	3.669	2.99	-1.90	5.6	51	51	-0.1	212	106	0.50	0.95	18.9	1.98	3.1	3.1	7.0	0.9	5.6	18	19	31.3	2.1	3.5	2.9	2.2
		6.918	7.205																								
	GCA	-0.143	0.143																								
7	(CML247*S94P49ET-F2-27-1-1-1-B)-B-20-2 x CML448	6.31	7.06			10.6	50	50	-0.2	216	100	0.46	0.92	18.0	2.38	2.6	3.0	2.5	0.7	14.8	22	24	8.9	1.9	4.0	3.0	1.8
8	CL-04368 x CL-SPLW04	9.70	9.98			2.9	52	51	-1.0	247	137	0.55	1.15	16.4	1.60	2.6	2.3	7.2	2.9	5.5	28	25	1.2	1.8	2.0	2.8	1.8
97	CML448 x CML449	7.22	7.22			0.0	51	50	-0.5	225	108	0.48	0.98	19.7	1.99	3.0	2.7	8.8	1.0	0.7	22	22	6.6	2.0	4.0	3.0	2.2
98	CML442 x CML444	5.59	6.39			12.5	53	53	0.0	247	137	0.55	0.85	18.5	3.04	3.0	2.9	10.3	3.3	2.9	20	24	2.6	2.0	4.0	2.5	2.7
99	CML247 x CML254	7.55	7.55			0.0	53	53	-0.3	223	120	0.54	0.98	19.7	1.63	3.1	2.5	7.5	0.3	3.8	22	22	14.3	2.2	4.0	3.0	1.9
100	LOCAL CHECK	6.06	6.33			4.3	52	51	-0.5	223	118	0.53	0.94	17.3	1.76	3.1	2.5	9.9	8.0	0.8	21	22	0.0	2.2	4.0	2.9	1.9
	Check Mean	6.60	6.87			4.2	52	52	-0.3	230	120	0.52	0.94	18.8	2.10	3.1	2.6	9.1	3.1	2.1	21	23	5.9	2.1	4.0	2.9	2.2
	Grand Mean	6.65	6.95			4.3	51	51	-0.3	224	112	0.50	0.95	18.8	2.03	2.9	2.8	9.9	2.1	9.6	21	23	11.1	1.9	3.7	2.9	2.0
	LSD 5%	0.95	0.99			3.7	0.7	0.7	0.5	7.6	5.9	0.0	0.1	1.4	0.5	0.4	0.3	10.7	3.7	7.8	2.6	2.2	.	0.4	.	.	0.6
	CV %		14.34			10.3	1.7	1.7	3.0	4.5	7.8	7.4	11.4	7.4	16.3	16.8	15.4	11.8	9.2	12.9	12.1	8.7	72.9	19.5	12.0	13.3	17.3
	F value Loc*Entry		1.26			0.8	1.0	1.0	0.9	0.7	0.6	0.7	0.6	1.3	1.2	0.7	0.8	1.6	1.0	0.6	1.3	1.7	.	0.7	.	.	1.7
	P(F>f)		0.01			5.0	0.5	0.5	0.8	1.0	1.0	1.0	1.0	0.0	0.2	1.0	1.0	0.0	0.6	1.0	0.0	0.0	.	1.0	.	.	0.0
	Number of locations		5			5	5	5	5	5	5	5	5	5	2	4	5	5	5	4	5	5	1	3	1	1	2

Table 5.TSCLW02-16 Evaluation of early generation tropical late white lines across five locations in 2002B

Across 4 locations

Ent no	Pedigree	Yd (t/ha) x CML448	Yd (t/ha) x CML449	Diff. t/ha	GCA t/ha	Erott %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Ear ht Plt ht	# Ea # Plt	Mo %	Erott 1_5	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Ear #	Plt #	Fus %	HM 1_5	EnH 1_5	Rust 1_5
	PStayGreenC1-3-1-1	7.988	8.803	**-0.81**	**2.01**	6.0	52	51	-0.7	219	107	0.49	0.96	16.6	1.99	2.3	2.5	1.3	0.9	12.3	23	24	14.0	2.0	3.0	1.9
	(CML247*S94P49ET-F2-131-3-1-2-B)-B-44-2	7.870	7.932	**-0.06**	**1.52**	2.0	51	50	-0.7	221	112	0.51	0.93	16.3	1.60	2.6	2.4	4.8	1.4	7.3	22	23	9.7	1.7	4.2	1.7
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-34-1	7.988	7.072	**0.92**	**1.14**	1.3	51	51	-0.3	227	112	0.49	1.04	17.6	1.62	2.4	2.4	2.2	1.8	8.4	21	20	4.1	1.7	2.4	1.8
	PStayGreenC1-3-2-1	6.354	8.403	**-2.05**	**0.99**	2.5	51	50	-0.8	217	109	0.51	1.01	16.2	2.14	2.6	2.5	3.5	2.2	4.7	21	21	6.9	2.0	4.0	1.8
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-36-4	6.199	6.731	**-0.53**	**0.08**	6.9	50	50	-0.3	217	102	0.47	0.95	16.0	2.37	2.8	3.1	3.7	2.1	23.3	22	23	11.4	2.0	3.8	1.9
	(CL-03210*DEERC2-15-3-1-#2-#1-1-#)-B-B-4-1	6.546	6.153	**0.39**	**-0.04**	0.6	51	50	-0.3	213	107	0.50	0.96	17.2	1.52	2.6	2.6	1.7	0.9	2.0	21	22	4.4	1.9	3.0	2.1
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-46-2	5.809	6.831	**-1.02**	**-0.07**	5.9	50	50	-0.2	209	98	0.47	0.94	16.6	2.74	2.4	3.0	1.3	0.9	8.9	22	23	17.4	2.0	4.7	2.1
	(P25C4HC10-B9*[(CAF18*CAFS82-1-4)])-B-B-50-2	8.017	4.603	**3.41**	**-0.08**	2.8	52	51	-0.4	227	114	0.50	1.09	15.9	1.52	2.3	2.5	1.2	0.1	3.4	18	17	6.7	1.7	3.0	1.9
	(CML247*S94P49ET-F2-106-6-3-1-B)-B-32-2	6.511	5.712	**0.80**	**-0.27**	6.7	50	50	0.1	210	99	0.47	0.95	16.3	2.63	2.7	3.0	5.1	1.2	11.6	20	21	1.6	1.9	3.8	1.9
	(CML247*S94P49ET-F2-106-6-3-1-B)-B-44-1	7.010	4.041	**2.97**	**-0.86**	3.8	50	50	0.1	213	103	0.48	1.04	16.6	2.25	2.5	2.8	1.5	2.3	6.2	18	18	17.1	2.0	3.8	2.0
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-44-2	6.362	4.369	**1.99**	**-1.02**	5.5	51	50	-0.5	212	100	0.47	0.97	16.5	2.36	2.7	2.8	2.7	1.7	7.4	16	18	21.8	2.0	4.3	2.0
	(CL-04317*CML247)-B-36-2-2-1	2.739	7.725	**-4.99**	**-1.15**	2.1	51	51	-0.2	211	105	0.50	1.13	16.2	2.27	3.0	2.7	1.0	1.3	2.1	16	16	33.3	2.2	4.0	2.2
	(CML247*S94P49ET-F2-27-1-1-1-B)-B-44-2	5.169	3.079	**2.09**	**-2.26**	8.0	50	50	0.1	203	99	0.49	0.94	17.5	2.64	2.9	2.9	4.9	0.0	13.1	13	15	4.4	1.8	4.0	1.9
		6.505	**6.266**																							
	GCA	**0.120**	**-0.120**																							
97	CML448 x CML449	7.365	7.365			0.0	51	50	-0.4	220	104	0.47	1.01	17.1	2.23	2.8	2.5	4.5	0.7	1.1	22	22	6.6	2.0	4.0	2.2
98	CML442 x CML444	5.483	6.250			12.3	53	53	0.2	242	129	0.53	0.86	16.5	3.04	2.9	2.7	5.5	1.5	3.8	20	24	2.6	2.0	4.0	2.7
99	CML247 x CML254	7.510	7.510			0.0	53	53	-0.2	219	115	0.52	1.01	17.0	1.52	2.8	2.4	1.6	0.3	0.2	22	22	14.3	2.2	4.0	1.9
100	LOCAL CHECK	5.542	5.836			5.0	52	51	-0.5	220	115	0.53	0.94	15.5	1.78	2.9	2.4	3.3	7.1	0.1	20	21	0.0	2.2	4.0	1.9
	Check Mean	6.475	6.740			4.3	52	52	-0.2	225	116	0.51	0.95	16.5	2.14	2.9	2.5	3.7	2.4	1.3	21	22	5.9	2.1	4.0	2.2
	Grand Mean	6.593	6.904			4.5	51	51	-0.2	220	108	0.49	0.96	16.7	2.10	2.7	2.7	2.5	1.7	9.3	21	22	11.1	1.9	3.7	2.0
	LSD 5%	0.925	0.968			4.4	0.8	0.8	0.6	8.6	6.6	0.0	0.1	1.3	.	0.5	0.4	4.2	3.9	8.6	2.5	2.2	.	0.4	.	0.6
	CV %		13.48			10.7	1.7	1.7	3.0	4.8	8.1	7.8	11.3	7.1	17.1	16.8	17.0	10.8	8.4	13.1	12.3	9.3	72.9	19.5	12.0	17.3
	F value Loc*Entry		1.12			0.8	0.9	1.0	0.9	0.7	0.6	0.7	0.6	1.3	.	0.9	0.8	0.6	0.9	0.6	0.9	1.2	.	0.7	.	1.7
	P(F>f)		0.16			1.0	0.9	0.6	0.7	1.0	1.0	1.0	1.0	0.0	.	0.8	1.0	1.0	0.7	1.0	0.8	0.1	.	1.0	.	0.0
	Number of locations		4			4	4	4	4	4	4	4	4	4	1	3	4	4	4	3	4	4	1	3	1	2

No	Set	Location	Country	Local Check
1	1	Agua Fria	México	CML264 x CML269
2	2	Zacapa	Guatemala	HR-101
3	3	Turipana	Colombia	C-343
4	4	Cuyuta	Guatemala	HB-83
5	6	Cotaxtla	México	H-520

2.4 Evaluations of early generation tropical white late lines Heterotic Group "B" crossed with tester CML448 HG"A" (TSCW02-17).

Eighteen tropical white S_3 and S_4 lines derived from F_2 population heterotic group "B" were testcrossed to tester CML448 (HG"A") and 11 remaining testcrosses with CML449 as tester were formed in TL2002A. The 29 early generation testcrosses and six checks were included in a $\propto$ lattice design 5 x 7 and tested in the same five locations mentioned above.

The objective of these trials was to identify superior early generation lines to select in advanced generation superior hybrids to form with the advanced lines and progenitors for synthetic formation at S_5 level of inbreeding.

The ANOVA detected significant statistical differences for yield and main agronomic traits for hybrids at individual and across locations. G*E was significant at 0.10 probability.

Mean yield: 6.43, 10.0, 6.1, 6.7, 7.8 and 7.4 tons per hectare at Agua Fria, Zacapa, Turipana, Cuyuta, Cotaxtla and across locations. The most important constraints to maize yields in these locations were root lodging and F. stalk rot (Tables 16A to 21A).

Five hybrids outyielded the reference entry check CML448 x CML449 new early generation testcross (CLG2407*CML247)-B-25-1-2-2 x CML449 topped the trial across locations (Table 6) showing yield stability ranking fourth at Agua Fria (8 t/ha), first at Zacapa (14.4 t/ha), fourth at Turipana (7.2 t/ha), first at Cuyuta (8.4 t/ha) and first at Cotaxtla (11.4 t/ha) and 10 t/ha across locations with 35% more yield than the check and 50% more than CML 442 x CML444. 10 lines with yields above the mean were identified to continue pedigree selection and the best five hybrids line testers at S_6 generation will be formed in the winter-summer 2003B. Ten lines heterotic group B will be used to form a new synthetic for each location.

2.5 Hybrid yield performance of tropical late maturing yellow endosperm lines with opposite testers (TSCY02-18).

Development of yellow elite maize germplasm is becoming more and more important because developing countries are striving for competition with the use of low quality, highly subsidized maize imported from the USA. Several countries such as Bolivia, Peru, Colombia and Venezuela are providing support to farmers to encourage the production of yellow maize locally and reduce the large imports for animal feeding. Development of hybrids with high yield potential will increase priority in the tropical lowland program, tropical subprogram. In recent years the breeding activities in yellow endosperm tropical maize have oriented to close the differences in yield potential between white and yellow elite germplasm. In the year 2001 new yellow hybrids yielded up to 12 ton/ha at Cotaxtla, Veracruz, Mexico.

The objective of this activity was to identify new single cross combination for testing internationally, use as females and identify superior lines to use as males in TWC hybrid combinations and select superior lines for advanced testcrosses. 107 yellow lines heterotic groups A & B were crossed to the opposite testers, 107 single crosses, two tropical single crosses RE and one seed industry check were evaluated under a $\propto$ lattice design 10x11, 1 row plots 66,000 plants per hectare, two replications per site at six tropical locations: Agua Fria and Cotaxtla, Mexico; La Maquina and Zacapa, Guatemala; Turipana Colombia and Rampur, India.

The ANOVA showed highly significant differences for yield and other agronomic traits such as ear rot and plant height, across and at individual locations. Locations x hybrids interaction for yield, was not significant.

Mean yield trial at individual locations varies: 7.2 t/ha at Agua Fria, 7.3 at Zacapa, 5.7 at Turipana, 2.4 at La Maquina, (this location yield was reduced by severe CS damage) 56% negatively correlated (r = -0.40) with yield 6.2 at Rampur, 7.9 at Cotaxtla and 6.2 t/ha across locations, the maximum yield 10.5 t/ha was detected at Cotaxtla, and Zacapa.

Entries 85, 97, and 84 topped the trial across six locations and showed good stability in the tropical lowland locations ranking first at Agua Fria 10.3 t/ha and in the first 10% in all locations. At Turipana this hybrid Entry 97 yielded 8.5 t/ha and outyielded Pioneer 3041 with 28% more yield (Tables A22 to A28).

Table 7 shows the yield performance of the best 8 hybrids that outyielded the best local checks across six locations.

Eight hybrids were superior in yield from 1.40 to 1.9 t/ha or up to 2 LSD's to the local check and the trial mean yield. Best performing hybrids also showed resistance to ear rot, root lodging damage and foliar diseases. Best hybrids in Table 7 will be tested internationally in 2003-2004.

Table 6. TSCLW02-17 Top eight early generation tropical late white lines across five locations in 2002B

Ent no	Pedigree	Yield1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %	HM 1_5	Css %
2	CL-04368 x CL-SPLW04	**9.90**	**10.16**	**135**	**141**	2.5	52	0.53	1.18	17.4	2.5	2.1	4.3	1.9	3.6	0.0	2.5	2.0
4	(CL-G2407*CML273)-B-25-1-2-2 x CML449	**9.77**	**9.88**	**133**	**139**	1.1	51	0.51	1.04	20.9	2.9	1.8	6.4	0.9	5.2	2.3	2.5	4.6
30	(CL-04317*CML247)-B-36-2-1-2 x CML449	**8.66**	**8.94**	**118**	**124**	3.1	51	0.49	1.16	19.8	2.8	2.2	4.3	2.0	2.9	18.4	2.5	2.4
14	(CML247*S94P49ET-F2-106-6-3-1- x CML448	**8.00**	**8.30**	**109**	**114**	3.6	52	0.49	1.00	22.5	2.3	2.5	1.3	1.5	6.9	0.0	2.0	2.0
28	PStayGreenC1-3-1-2 x CML449	**7.96**	**8.16**	**109**	**114**	2.6	50	0.50	0.95	19.2	2.9	2.1	19.3	5.0	5.3	14.0	3.0	3.2
26	(P25C4HC10-B9*[(CAF18*CAFS82 x CML449	**7.74**	**7.83**	**106**	**110**	1.2	51	0.51	1.03	20.7	2.9	2.2	13.5	2.2	2.8	5.9	1.8	2.9
21	(CL-04352 *CL-02908)-B-8-2 x CML449	**7.67**	**7.77**	**105**	**109**	1.3	49	0.50	1.03	19.2	3.0	2.5	17.2	2.1	5.7	14.8	2.8	4.5
29	(CL-04317*CML247)-B-36-2-1-1 x CML449	**7.61**	**7.70**	**104**	**109**	1.2	51	0.49	1.03	19.3	3.0	2.6	9.0	1.7	4.1	33.8	3.0	4.3
3	(CL-G2407*CML273)-B-25-1-2-2 x CML448	**7.48**	**7.88**	**102**	**107**	5.1	53	0.47	0.95	21.0	2.2	2.1	2.0	0.0	20.3	0.0	1.9	3.2
6	(CL-04352 *CL-02908)-B-24-2 x CML448	**7.44**	7.76	**101**	**106**	4.2	52	0.48	1.00	20.3	2.6	2.5	3.9	1.9	14.3	0.0	2.5	4.1
31	CML448 x CML449	**7.33**	**7.35**	**100**	**105**	0.3	51	0.46	0.97	20.3	3.0	2.4	16.4	1.6	1.8	4.8	2.5	5.4
32	CML442 x CML444	**6.31**	**6.80**	**86**	**90**	7.2	53	0.55	0.94	18.5	3.1	2.9	2.7	4.8	4.3	4.3	2.8	4.9
33	CML264 x CML269	**9.10**	**9.22**	**124**	**130**	1.3	52	0.51	1.04	18.9	2.5	2.3	6.3	0.0	1.3	2.0	2.6	1.4
34	CML247 x CML254	**6.91**	**7.01**	**94**	**99**	1.5	53	0.55	0.96	20.4	2.8	2.2	4.3	1.0	2.3	7.5	2.3	4.2
35	LOCAL CHECK	**7.01**	**7.16**	**96**	**100**	2.1	52	0.54	0.98	19.6	3.2	2.7	5.8	4.5	2.3	0.0	2.2	3.6
	Check Mean	**7.33**	**7.51**			2.5	52	0.52	0.98	19.5	2.9	2.5	7.1	2.4	2.4	3.7	2.5	3.9
	Grand Mean	**7.14**	**7.42**			3.9	51	0.49	0.97	19.8	2.8	2.5	5.7	1.6	8.4	6.9	2.5	3.8
	LSD 5	**0.79**	**0.82**			3.7	0.7	0.0	0.1	1.7	0.5	0.3	7.1	2.3	8.4	.	0.5	3.3
	CV		**11.14**			10.7	1.8	5.3	9.6	6.5	18.9	16.5	12.4	8.8	13.2	108	12.9	64.8
	F value Loc*Entry		**1.26**			0.8	0.8	1.0	0.8	2.3	0.8	0.7	0.7	0.5	0.9	.	1.3	0.8
	P(F>f)		**0.10**			0.9	0.9	0.6	0.9	0.0	0.9	1.0	1.0	1.0	0.6	.	0.2	0.7
	Number of locations		**5**			4	5	5	5	5	4	5	5	5	4	1	2	2

Table 7. TSCLY02-18 Top eight tropical late yellow single crosses across six locations in 2002B

Ent no	Pedigree	Yield1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %	HM 1_5	CSS 1_5	Dis 1_5
85	IBP-4 C3 TLYF-88-2-3-2 x CL-02450	7.47	**7.59**	**96**	**136**	1.6	64	0.55	1.09	17.6	2.7	1.6	3.6	11.2	0.9	21.1	3.1	22.7	2.0
84	IBP-4 C3 TLYF-88-2-1-3 x CL-02450	7.34	**7.45**	**94**	**133**	1.4	65	0.56	1.12	18.2	2.5	1.7	6.1	9.8	2.5	1.2	2.8	11.3	2.3
97	(RCYA99-8)-B-B-2-1 x CL-02450	7.33	**7.49**	**94**	**133**	2.2	63	0.56	1.01	17.6	2.7	2.1	8.9	7.4	1.0	4.4	2.9	14.7	2.0
91	(RCYA99-21)-B-B-17-1 x CL-02450	7.31	**7.63**	**94**	**133**	4.2	64	0.49	0.99	17.6	2.4	2.1	9.1	1.5	6.0	1.5	2.8	22.8	2.0
82	IBP-4 C3 TLYF-88-2-1-1 x CL-02450	7.25	**7.33**	**93**	**132**	1.2	64	0.54	1.01	18.0	2.5	1.8	14.4	4.3	1.7	2.6	2.7	16.1	2.2
80	(LINES P27 & G17* LINES x CL-02450	7.19	**7.44**	**92**	**130**	3.3	64	0.54	1.03	16.5	2.7	1.9	10.4	6.7	1.0	6.5	3.0	31.8	2.0
83	IBP-4 C3 TLYF-88-2-1-2 x CL-02450	7.03	**7.03**	**90**	**128**	0.1	63	0.55	1.02	17.7	2.6	2.2	12.5	3.7	1.1	3.1	2.8	21.8	2.3
92	(RCYA99-21)-B-B-25-1 x CL-02450	6.87	**7.10**	**88**	**125**	3.3	63	0.48	1.06	17.5	2.6	2.4	7.9	1.0	5.7	2.6	2.9	16.9	2.0
108	CML451 x CML287	7.79	**8.02**	**100**	**141**	2.9	63	0.50	1.00	18.0	2.7	2.0	10.0	0.2	4.4	0.0	3.0	26.6	2.0
109	CL-02450 x CML451	6.52	**6.65**	**84**	**118**	1.9	64	0.50	0.96	17.8	2.4	2.3	3.3	2.3	3.7	0.9	2.7	34.9	2.0
110	LOCAL CHECK #1	5.51	**5.70**	**71**	**100**	3.4	63	0.52	1.04	17.3	2.8	2.5	7.1	2.7	5.6	0.0	3.0	16.7	2.8
	Check Mean	6.60	**6.79**			2.7	63.2	0.5	1.0	17.7	2.7	2.3	6.8	1.7	4.6	0.3	2.9	26.1	2.2
	Grand Mean	5.82	**6.12**			5.0	63.4	0.5	1.0	17.6	2.6	2.3	5.8	3.3	5.3	5.0	2.8	29.2	2.2
	LSD 5%	0.78	**0.83**			4.9	1.1	0.0	0.1	1.0	0.3	0.3	5.5	3.5	5.8	.	0.4	12.6	.
	CV %		**16.15**			9.8	1.4	6.5	11.9	5.3	16.6	16.4	12.6	11.4	10.6	151.3	9.5	31.4	16.5
	F value Loc*Entry		**1.08**			1.0	2.4	1.2	0.8	1.9	0.7	0.8	0.6	0.6	0.8	.	1.1	1.0	.
	P(F>f)		**0.18**		.	0.6	0.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	.	0.3	0.6	.
	Number of locations		**6**			5	6	6	6	6	6	6	5	5	4	1	2	2	1

2.6 Combining ability and yield performance of tropical late yellow early generation inbred lines (TSCLY02-19).

The objective of this activity was to estimate the combining ability of new early generation yellow lines and select the superior lines for different uses, identify new single cross combination for advance to stage 3, form synthetic OPV with the lines with outstanding GCA.

68 tropical yellow late S4 lines were crossed with two testers heterotic group A (CL02450) and B (CML 451). 136 single crosses were formed in TL2002A. The 136 crosses, 2 RE checks and 1 seed industry check and tropical single crosses among testers, were evaluated under a $\propto$ lattice design 10x14. One row plots, five meters long, 66,000 plants per hectare, two replications per site at six tropical locations: Agua Fria and Cotaxtla, Mexico, La Maquina, and Zacapa, Guatemala and Turipana, Colombia, and Rampur, India.

The ANOVA showed highly significant differences for yield and other agronomic traits such as ear rot and plant height, across and at individual locations. Locations x hybrids interaction was highly significant, statistical difference reflecting GxE interaction.

The mean yield trial at individual locations was 7.0 ton/ha at Agua Fria, 7.3 t/ha at Cotaxtla, 1.0 t/ha (low yield due to a heavy drought and strong corn stunt damage) at La Maquina, 6.1 t/ha at Turipana, Colombia, 7.1 t/ha at Zacapa, 6.3 at Rampur, India and 6.7 across five locations excluding La Maquina.

Best yielding hybrid at individual locations: (RCYA99-20)-BB-56-1 x CL-02450 = 9.6 t/ha and RCYA99-21)-B-B-47-2 XCML451 = 9.5 t/ha at Agua Fria.

(RCYA99-20)-B-B-47-2xCL02450 = 8.9 t/ha at Zacapa, Entries 114 and 113 topped the trial with 8.2 and 7.7 t/ha at Turipana, Colombia, Entries 68 and 56 showed the highest yields at Bihar, Entries 35 and 116 topped the trial at Cotaxtla. All these hybrids outyielded the local checks at individual and across sites. They also showed resistance to ear rot and lower lodging than the checks (Tables A29 to A35).

(RCYA99-20)B-B-26-3xCL-02450) and (RCYA90-20)-B-B-42-1xCML451 topped the trial across five locations with 8.0 t/ha, yield 23% superior to the checks and showed resistance to ear rot. 8 hybrids outyielded the checks and showed resistance to ear rot (Table 8). 12 yellow lines were classified as Heterotic Group "A" and 17 as Heterotic Group "B". 9 lines were classified as "A&B" and showed positive GCA (Table 9).

Table 8. TSCLY02-19 Top eight early generation tropical late yellow lines across five locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Ear #	Plt #
91	(RCYA99-20)-B-B-26-3 x CL-02450	7.80	8.02	104	123	2.7	67	0.55	1.02	18.0	2.4	2.0	13.4	2.7	0.0	23	23
114	(RCYA99-20)-B-B-41-1 x CML451	7.70	8.09	103	121	4.8	66	0.51	0.97	19.3	2.3	1.9	7.8	0.6	0.0	21	22
116	(RCYA99-20)-B-B-42-1 x CML451	7.66	7.94	102	120	3.5	66	0.52	0.97	19.2	2.2	2.2	3.4	1.7	1.3	22	23
121	(RCYA99-20)-B-B-47-2 x CL-02450	7.64	7.72	102	120	1.1	66	0.58	1.05	18.0	2.8	2.0	8.8	10.6	0.0	23	22
131	(RCYA99-20)-B-B-56-1 x CL-02450	7.63	7.68	102	120	0.6	66	0.53	0.98	18.0	2.5	2.1	7.5	2.7	0.0	22	23
15	(RCYA99-17)-B-B-14-1 x CL-02450	7.60	7.62	101	119	0.4	67	0.55	1.03	17.6	2.4	2.2	2.7	12.6	0.9	22	22
117	(RCYA99-20)-B-B-42-2 x CL-02450	7.53	7.71	101	118	2.3	67	0.53	1.02	19.0	2.5	2.2	1.9	3.4	1.3	23	23
122	(RCYA99-20)-B-B-47-2 x CML451	7.50	7.93	100	118	5.4	67	0.50	1.04	17.7	2.7	2.1	1.1	3.4	0.0	23	22
137	CML451 x CL-MDRY01	7.17	7.27	96	113	1.3	66	0.48	1.03	18.2	2.2	2.0	1.4	1.7	5.1	22	22
138	CML451 x CML287	7.48	7.62	100	118	1.8	66	0.52	1.05	18.5	2.4	1.9	1.7	2.3	1.6	22	21
139	CL-02450 x CML451	6.82	6.96	91	107	2.0	66	0.54	0.96	19.1	2.3	2.1	0.0	1.3	0.6	21	22
140	LOCAL CHECK #1	6.37	6.54	85	100	2.6	66	0.54	1.06	18.3	2.8	2.3	4.5	6.0	1.4	22	21
	Check Mean	6.96	7.10			1.9	65.9	0.5	1.0	18.5	2.4	2.1	1.9	2.8	2.2	21.9	21.6
	Grand Mean	6.54	6.78			3.4	66.1	0.5	1.0	18.1	2.4	2.3	3.7	2.6	1.7	21.4	21.7
	LSD 5%	0.88	0.91			3.6	1.2	0.0	0.1	1.4	0.3	0.3	6.5	3.9	3.1	2.4	2.2
	CV %		14.09			11.2	1.4	7.1	11.2	3.9	17.1	18.7	11.6	10.9	8.5	12.2	9.7
	F value Loc*Entry		1.17			0.6	2.3	0.9	0.7	4.9	0.6	0.7	0.9	0.6	0.7	1.1	1.4
	P(F>f)		0.03			1.0	0.0	0.8	1.0	0.0	1.0	1.0	0.9	1.0	1.0	0.1	0.0
	Number of locations		5			4	5	5	5	5	5	5	4	4	3	5	5

Table 9. TSCLY02-19 Estimation of GCA for early generation tropical late yellow lines across six locations in 2002B

Ent no	Pedigree	Yield CL-02450	Yield CML451	Differ.	Bck %	GCA	Erott %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Ear ht Plt ht	# Ear # Plt	Mo %	Erott 1_5	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Ear #	Plt #	Fus %	HM 1_5	CSS %	Dis 1_5	Rust 1_5
	(RCYA99-20)-B-B-47-2	6.67	6.85	-0.18	107	0.92	3.7	66	65	0.4	227	125	0.55	0.95	17.4	1.88	3.0	2.2	8.3	5.6	0.8	21	22	2.5	2.9	32.1	2.7	3.5
	(RCYA99-20)-B-B-42-1	6.51	6.75	-0.25	105	0.79	4.4	66	65	0.4	215	117	0.54	0.90	18.4	1.63	2.6	2.3	7.2	3.2	13.9	20	22	1.2	2.6	38.0	2.7	2.5
	(RCYA99-20)-B-B-47-1	6.49	6.55	-0.06	103	0.68	4.5	66	65	0.5	223	119	0.54	0.95	17.4	1.44	2.7	2.2	10.3	2.0	3.8	20	22	0.1	2.9	28.1	2.9	3.3
	(RCYA99-21)-B-B-18-1	6.53	6.33	0.20	99	0.59	6.3	65	63	-0.2	221	119	0.54	0.92	17.3	1.88	2.6	2.4	1.0	1.1	11.1	21	24	0.8	2.7	23.8	2.6	3.1
	(RCYA99-20)-B-B-16-1	6.20	6.62	-0.42	101	0.57	4.2	66	64	0.0	222	122	0.55	0.98	17.5	1.71	2.6	2.3	19.3	5.4	4.6	20	20	7.8	3.0	38.9	2.8	2.8
	(RCYA99-20)-B-B-41-1	5.81	6.88	-1.07	99	0.50	5.3	66	65	0.2	227	125	0.55	0.90	18.2	1.46	2.7	2.3	13.5	2.6	5.9	19	21	2.6	2.9	30.6	2.7	3.0
	(RCYA99-20)-B-B-16-2	6.20	6.44	-0.24	100	0.48	4.4	66	65	0.5	220	117	0.53	0.90	18.3	1.57	2.9	2.4	18.7	5.9	6.5	20	22	1.8	3.0	32.3	3.0	3.4
	(RCYA99-21)-B-B-8-1	6.18	6.44	-0.26	99	0.47	5.2	65	63	0.3	223	110	0.49	0.97	17.1	1.57	2.7	2.5	8.8	1.9	2.1	22	23	2.4	2.7	31.0	2.6	3.2
	(RCYA99-21)-B-B-14-1	6.59	5.92	0.67	98	0.42	5.5	66	64	0.4	229	116	0.51	0.95	17.2	1.67	2.7	2.4	4.5	0.7	7.5	21	23	0.2	2.8	25.2	3.0	3.1
	(RCYA99-21)-B-B-8-3	6.20	6.31	-0.11	99	0.41	4.5	65	64	0.3	222	114	0.51	0.98	16.8	1.54	2.8	2.4	9.2	1.0	11.6	21	22	0.2	2.9	27.4	3.0	3.0
	(RCYA99-21)-B-B-12-1	6.02	6.48	-0.46	95	0.41	7.8	64	63	0.3	221	116	0.52	0.91	16.9	1.76	2.8	2.5	3.8	2.2	5.9	21	23	5.1	2.9	24.4	2.8	3.2
	(RCYA99-20)-B-B-47-3	6.52	5.88	0.64	98	0.36	4.5	66	64	0.3	230	126	0.55	0.94	17.8	1.33	2.6	2.2	7.5	2.2	5.8	20	21	4.5	2.8	32.3	3.1	3.1
	(RCYA99-20)-B-B-42-2	6.59	5.79	0.80	96	0.35	6.6	68	65	0.4	217	120	0.55	0.90	18.3	1.71	2.8	2.4	1.9	2.3	20.6	20	22	0.4	2.6	29.9	3.0	2.8
	(RCYA99-13)-B-B-3-1	6.35	6.00	0.35	95	0.34	6.9	64	63	1.0	217	118	0.54	0.91	17.7	1.87	2.8	2.5	9.3	4.4	6.7	20	22	0.9	2.7	26.0	2.6	3.1
	(RCYA99-21)-B-B-20-1	6.48	5.87	0.61	96	0.34	6.3	65	64	0.4	221	111	0.50	0.90	16.6	1.81	2.5	2.3	4.3	1.3	4.4	19	22	0.2	2.7	28.0	2.8	2.8
	(RCYA99-21)-B-B-10-3	5.81	6.48	-0.67	99	0.31	2.7	65	63	0.7	216	112	0.52	0.90	17.6	1.55	2.8	2.4	2.2	1.4	26.9	21	23	0.9	2.7	29.1	2.9	2.4
	(RCYA99-20)-B-B-15-3	6.25	5.95	0.30	89	0.26	12.0	65	64	0.1	221	122	0.55	0.94	18.0	2.02	2.7	2.5	4.3	2.6	7.3	21	23	0.2	3.1	34.0	2.6	3.5
	(RCYA99-20)-B-B-10-2	5.72	6.38	-0.65	89	0.21	11.2	64	63	0.3	210	116	0.55	0.92	18.2	2.04	2.8	2.6	4.4	0.6	11.6	20	22	0.3	2.7	31.4	2.7	3.3
	(RCYA99-20)-B-B-56-1	6.60	5.43	1.17	97	0.18	2.4	66	65	0.8	215	112	0.52	0.93	18.1	1.57	2.7	2.4	7.6	1.2	4.4	20	21	3.6	2.8	41.1	2.9	3.1
	(RCYA99-20)-B-B-6-1	5.99	6.01	-0.02	95	0.16	3.8	66	64	0.2	211	109	0.51	0.84	17.1	1.98	2.8	2.5	6.4	0.7	8.3	19	22	2.6	2.9	27.4	2.9	3.2
	(RCYA99-20)-B-B-32-2	6.28	5.73	0.54	95	0.16	4.1	65	64	0.1	218	119	0.55	0.90	17.1	1.46	2.8	2.4	7.6	1.1	3.4	20	23	0.2	2.8	29.6	2.4	2.7
	(RCYA99-21)-B-B-29-3	6.08	5.91	0.17	92	0.15	7.0	66	64	-0.1	218	110	0.50	0.91	16.7	1.61	2.7	2.4	2.3	3.0	13.7	20	22	1.4	2.9	26.4	2.7	3.2
	(RCYA99-21)-B-B-18-3	6.13	5.84	0.29	93	0.14	6.0	65	63	0.4	218	113	0.52	0.90	17.9	1.77	2.7	2.4	3.9	0.9	7.5	20	23	0.1	2.6	27.3	2.4	3.1
	(RCYA99-8)-B-B-5-2	6.14	5.81	0.33	95	0.13	4.2	65	63	0.2	216	122	0.56	0.98	16.6	1.79	2.5	2.3	9.7	2.2	6.4	20	21	1.6	2.7	22.5	2.5	2.8
	(RCYA99-17)-B-B-14-1	6.56	5.36	1.20	94	0.12	4.5	65	64	0.8	225	123	0.54	0.96	17.6	1.73	2.7	2.4	8.2	6.4	9.0	20	20	1.8	2.8	41.7	2.6	3.3
	(RCYA99-20)-B-B-15-2	6.03	5.87	0.16	95	0.11	3.8	65	63	0.0	214	120	0.56	0.90	17.4	1.83	2.7	2.6	7.8	2.6	14.6	19	22	3.9	2.9	24.1	2.6	2.6
	(RCYA99-21)-B-B-47-1	5.85	6.06	-0.21	96	0.11	2.8	66	64	0.6	216	113	0.52	0.88	17.1	1.93	2.6	2.4	0.0	0.9	11.3	20	23	0.5	2.8	27.5	2.6	2.8
	(RCYA99-13)-B-B-16-1	5.84	6.00	-0.15	90	0.08	8.1	66	65	0.7	216	117	0.54	0.90	17.2	1.94	2.7	2.5	8.3	1.8	7.1	20	22	0.0	2.9	35.0	2.5	2.7
	(RCYA99-21)-B-B-12-3	6.05	5.72	0.33	86	0.04	11.9	65	63	-0.1	222	111	0.50	0.88	17.1	1.86	2.8	2.5	3.1	0.2	20.8	19	22	0.7	2.8	27.6	3.1	3.1
	(RCYA99-13)-B-B-25-1	5.72	5.93	-0.21	84	-0.02	12.5	66	64	0.7	223	121	0.54	0.90	17.8	1.66	2.7	2.5	2.8	1.8	11.3	20	22	0.0	2.8	29.8	2.6	3.1
	(RCYA99-21)-B-B-48-1	5.49	6.11	-0.62	91	-0.04	4.5	65	64	0.1	214	109	0.51	0.88	17.4	1.69	2.7	2.5	5.7	1.7	9.2	19	22	6.3	2.9	28.2	2.9	2.9
	(RCYA99-20)-B-B-10-1	6.05	5.43	0.62	89	-0.11	5.7	66	64	0.0	216	121	0.56	0.93	18.0	1.85	2.9	2.5	5.0	1.4	17.0	20	22	1.0	2.9	28.5	2.9	3.2
	(RCYA99-21)-B-B-16-2	6.46	5.00	1.47	88	-0.11	6.9	66	64	0.3	222	110	0.50	0.94	17.5	1.49	2.6	2.5	4.4	0.6	8.0	19	20	0.2	2.8	37.7	2.5	2.8
	(RCYA99-20)-B-B-17-2	5.69	5.71	-0.01	88	-0.14	6.5	65	64	0.5	215	115	0.54	0.93	17.3	1.78	2.9	2.4	4.6	1.5	10.5	20	21	6.8	2.8	25.5	3.0	3.4
	(RCYA99-20)-B-B-31-2	5.52	5.88	-0.36	90	-0.14	4.8	65	64	0.5	209	116	0.55	0.91	18.0	1.91	2.8	2.6	11.3	1.5	6.0	20	22	3.2	3.1	29.5	3.0	3.3
	(RCYA99-20)-B-B-17-1	5.40	5.95	-0.55	85	-0.17	8.6	65	63	0.4	217	119	0.55	0.89	17.2	1.97	2.7	2.5	4.7	2.3	21.1	19	22	3.8	2.9	23.5	2.7	3.1
	(RCYA99-20)-B-B-26-2	5.54	5.71	-0.18	90	-0.22	3.0	67	65	0.5	212	116	0.55	0.88	18.2	1.68	2.6	2.4	7.9	1.1	10.7	18	20	4.4	2.8	36.0	3.1	2.9
	(RCYA99-20)-B-B-32-1	6.42	4.81	1.61	90	-0.23	2.8	66	65	0.6	227	118	0.52	0.89	17.4	1.62	2.7	2.4	6.4	2.2	6.4	18	20	0.5	2.7	36.0	3.1	3.1
	(RCYA99-21)-B-B-32-1	5.90	5.33	0.57	86	-0.23	7.7	65	64	0.5	220	116	0.53	0.89	17.4	1.60	2.8	2.3	1.4	1.4	14.5	18	21	1.3	2.7	31.8	2.7	3.0
	(RCYA99-20)-B-B-8-1	5.64	5.49	0.15	87	-0.27	5.4	66	65	0.4	215	115	0.53	0.82	18.0	1.82	2.9	2.5	10.2	3.2	23.9	18	23	0.3	2.7	38.5	3.1	2.9
	(RCYA99-13)-B-B-10-1	5.98	5.15	0.84	82	-0.28	10.6	65	64	0.6	215	121	0.56	0.88	17.2	1.88	2.9	2.5	1.6	5.4	6.0	19	22	0.0	2.8	28.9	2.7	3.0
	(RCYA99-14)-B-B-22-1	6.10	5.02	1.08	88	-0.28	4.3	65	64	0.7	215	119	0.56	0.91	17.1	2.08	2.7	2.5	8.8	4.0	26.5	19	21	7.2	2.8	33.1	2.8	2.7
	(RCYA99-20)-B-B-1-3	5.84	5.18	0.66	87	-0.33	4.2	66	65	0.8	222	129	0.58	0.85	18.4	1.87	2.8	2.8	10.8	3.6	13.7	19	22	0.7	2.9	40.4	2.8	3.1
	(RCYA99-20)-B-B-30-1	5.40	5.57	-0.17	83	-0.36	8.3	67	65	0.5	209	109	0.52	0.87	18.4	1.74	2.7	2.4	4.3	2.3	21.0	19	21	1.4	2.8	30.7	2.8	2.9
	(RCYA99-20)-B-B-36-2	5.43	5.52	-0.09	83	-0.37	7.7	66	65	0.8	223	119	0.53	0.85	18.0	1.89	2.8	2.6	8.9	0.6	6.3	18	22	3.2	3.0	33.9	3.1	3.0

Table 9. TSCLY02-19 Estimation of GCA for early generation tropical late yellow lines across six locations in 2002B

Ent no	Pedigree	Yield CL-02450	Yield CML451	Differ.	Bck %	GCA	Erott %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Ear ht Plt ht	# Ear # Plt	Mo %	Erott 1_5	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Ear #	Plt #	Fus %	HM 1_5	CSS %	Dis 1_5	Rust 1_5
	(RCYA99-21)-B-B-7-1	5.88	4.98	0.90	86	-0.41	4.1	65	64	1.0	212	107	0.50	0.89	17.0	1.95	2.8	2.5	5.3	1.5	6.0	20	22	1.5'	2.9	25.4	2.8	2.6
	(RCYA99-20)-B-B-1-1	5.71	5.13	0.58	86	-0.43	4.1	66	64	0.4	220	123	0.56	0.90	17.7	1.79	2.8	2.5	12.5	2.8	5.8	18	20	0.2	2.9	32.4	2.8	3.1
	(RCYA99-20)-B-B-30-2	5.63	5.20	0.43	81	-0.43	9.3	66	65	0.5	209	115	0.55	0.84	18.2	2.06	2.9	2.6	3.6	2.5	14.2	18	22	0.2	2.8	26.6	2.7	3.1
	(RCYA99-20)-B-B-53-1	5.65	5.16	0.48	81	-0.44	9.6	66	64	0.2	209	114	0.54	0.89	16.8	2.08	2.8	2.8	10.4	0.5	6.5	17	20	0.3	2.8	30.7	2.7	3.0
	(RCYA99-20)-B-B-36-1	5.79	4.94	0.85	83	-0.47	6.5	86	64	0.5	216	115	0.53	0.89	18.0	1.93	2.9	2.4	9.5	1.2	7.9	19	22	3.0	3.1	40.1	2.7	3.0
	(RCYA99-20)-B-B-8-2	5.31	5.39	-0.08	81	-0.49	6.2	67	65	0.5	218	114	0.52	0.85	18.2	2.05	2.8	2.6	15.5	1.8	8.5	18	22	1.7	2.7	37.2	3.0	3.1
	(RCYA99-20)-B-B-27-3	5.03	5.59	-0.57	81	-0.53	8.0	67	65	0.4	212	111	0.52	0.92	18.2	2.08	2.8	2.6	6.4	2.9	34.4	19	21	0.0	2.8	28.2	2.8	3.1
	(RCYA99-20)-B-B-27-2	5.35	5.12	0.23	81	-0.61	5.6	69	66	0.7	215	110	0.51	0.89	17.1	2.07	2.7	2.5	6.4	2.9	16.1	19	22	1.1	2.9	26.8	2.8	3.1
	(RCYA99-20)-B-B-29-1	6.03	4.43	1.60	79	-0.61	8.5	67	65	0.6	214	110	0.51	0.85	17.5	1.93	2.8	2.4	5.7	1.9	10.3	17	21	0.3	3.1	30.5	2.6	3.2
	(RCYA99-20)-B-B-1-2	5.47	4.98	0.49	76	-0.62	11.8	68	85	0.4	217	120	0.55	0.85	17.9	2.03	3.0	2.7	13.1	1.2	13.8	18	21	0.3	2.7	30.7	2.8	2.9
	(RCYA99-21)-B-B-6-1	5.15	5.17	-0.02	82	-0.68	3.4	67	66	0.8	217	114	0.52	0.90	17.9	2.06	2.9	2.5	3.4	2.1	9.2	20	22	0.3	2.6	26.2	3.0	2.3
	(RCYA99-20)-B-B-48-3	5.02	5.11	-0.09	81	-0.78	3.6	66	65	0.5	221	124	0.56	0.88	17.6	1.82	2.9	2.6	11.3	3.0	3.2	17	20	2.6	3.0	25.6	2.9	3.2
		5.95	5.73																									
	Across five locations																											
	(RCYA99-21)-B-B-20-2	6.08	6.15	-0.07	105	0.76	6.0	68	65	0.4	213	107	0.50	0.91	16.1	1.45	2.6	2.2	2.6	2.0	9.7	20	22	1.6	2.8	33.4	2.3	2.7
	(RCYA99-21)-B-B-34-1	5.72	6.33	-0.62	105	0.67	4.3	68	65	0.3	217	104	0.48	0.90	15.7	1.34	2.6	2.0	3.7	1.7	15.4	18	20	0.3	3.0	31.3	2.3	2.8
	(RCYA99-20)-B-B-26-3	6.34	5.27	1.08	102	0.45	3.5	70	66	0.5	214	115	0.53	0.90	16.4	1.74	2.6	2.3	14.0	2.6	28.6	19	21	1.3	2.9	27.8	2.9	3.1
	(RCYA99-21)-B-B-10-2	5.44	5.90	-0.46	89	0.32	5.4	65	64	0.4	213	112	0.52	0.90	17.8	1.83	2.6	2.6	4.2	1.9	6.9	19	21	2.6	2.7	30.0	2.7	2.6
	(RCYA99-20)-B-B-55-1	5.78	5.34	0.44	91	0.20	10.5	86	66	1.1	205	112	0.54	0.93	16.6	2.30	2.7	2.4	13.3	0.7	5.5	18	20	1.2	2.7	35.7	2.7	2.7
	(RCYA99-21)-B-B-17-2	5.59	4.94	0.66	88	-0.09	8.2	89	67	0.5	217	106	0.48	0.91	15.4	2.00	2.6	2.4	5.2	2.5	6.7	18	20	2.4	2.7	32.1	2.6	3.1
	(RCYA99-13)-B-B-10-2	5.43	4.97	0.46	83	-0.15	12.9	70	67	0.3	217	126	0.58	0.91	15.9	3.44	2.6	2.5	1.3	5.0	8.6	20	23	13.2'	3.0	24.1	2.5	3.3
	(RCYA99-21)-B-B-18-2	5.77	4.40	1.37	85	-0.26	8.5	69	67	0.7	216	112	0.52	0.94	16.0	2.04	2.7	2.3	6.6	0.5	13.0	18	20	0.2	2.8	28.6	2.6	3.1
	(RCYA99-21)-B-B-7-2	3.93	5.93	-2.00	82	-0.42	8.5	67	65	0.9	208	105	0.51	0.95	16.5	1.99	2.7	2.5	3.7	0.7	12.8	16	18	0.5	2.9	38.3	2.4	2.9
	(RCYA99-17)-B-B-4-3	4.24	5.35	-1.10	80	-0.56	7.5	69	67	0.5	217	117	0.54	0.95	15.6	1.85	2.5	2.1	3.3	2.9	4.4	16	18	8.5	3.1	30.2	2.7	3.0
	(RCYA99-13)-B-B-24-2	5.16	3.67	1.50	74	-0.93	8.7	68	66	0.8	210	113	0.54	0.96	15.5	1.76	2.7	2.3	12.3	2.3	16.5	15	18	2.7	3.1	38.6	2.9	3.3
		5.41	5.29																									
137	CML451 x CL-MDRY01		6.11		94		6.9	66	64	0.3	221	108	0.49	0.89	17.7	1.36	2.6	2.2	8.7	1.4	32.0	19	22	0.0	2.9	38.6	2.3	3.1
138	CML451 x CML287		6.47		100		6.4	65	64	0.6	235	128	0.55	0.92	17.9	1.20	2.6	2.1	5.8	1.9	5.3	20	21	0.6	2.9	31.0	2.5	3.4
139	CL-02450 x CML451		5.91		94		3.6	65	64	0.7	217	119	0.55	0.87	18.4	1.73	2.5	2.3	4.9	1.0	5.8	19	22	0.0	2.6	24.4	2.5	3.2
140	LOCAL CHECK #1		5.66		88		5.9	65	64	0.8	229	129	0.56	0.97	17.8	1.61	3.0	2.5	6.2	4.8	2.7	20	21	0.3	3.1	31.3	3.0	3.2
	Check Mean		6.04				5.7	65	64	0.6	225	121	0.54	0.91	17.9	1.48	2.7	2.3	6.4	2.3	11.4	19	22	0.2	2.9	31.3	2.6	3.2
	Grand Mean		5.81				6.2	65.7	84.1	0.4	218.2	116.3	0.5	0.9	17.6	1.8	2.8	2.5	7.1	2.3	10.6	19.3	21.6	1.8	2.8	30.8	2.8	3.0
	LSD 5%		0.78				6.1	1.2	1.0	0.6	7.5	7.2	0.0	0.1	1.1	0.5	0.3	0.3	7.9	3.3	18.9	2.3	1.9	.	0.4	12.3	.	.
	CV %		15.43				12.8	1.2	1.4	3.4	4.1	7.9	7.0	13.3	3.6	23.2	15.8	16.8	13.8	10.3	18.0	13.5	10.5	191.4	9.2	33.7	12.1	9.9
	F value Loc*Entry		1.17				0.7	3.0	2.0	0.8	1.1	0.9	0.6	0.8	5.0	0.8	0.6	0.7	0.7	0.6	0.5	1.2	1.1	.	1.2	0.7	.	.
	P(F>f)		0.02				1.0	0.0	0.0	1.0	0.1	0.8	1.0	1.0	0.0	0.9	1.0	1.0	1.0	1.0	1.0	0.0	0.1	.	0.2	1.0	.	.
	Number of locations		6				5	5	6	5	6	6	6	6	6	2	6	6	5	5	4	6	6	1	2	2	1	1

No	Set	Location	Country	Local Check #1
1	1	Agua Fria	México	CML287 x CML413
2	2	Zacapa	Guatemala	(L-133 x LSA-297)
3	3	Turipana	Colombia	P-3041
4	4	La Maquina	Guatemala	HB-48
5	5	Kanpur	India	not identified
5	6	Cotaxtla	México	CML433 x CL-02844

2.7 Combining ability and hybrid yield performance of tropical late white advanced inbred lines (TSCW02-10).

51 advanced testcrosses, three single crosses and one check were included in an alpha lattice 5x11 design with two replications and were evaluated at six locations: Agua Fria and Cotaxtla, Mexico; Zacapa and La Maquina, Guatemala; Turipana, Colombia and Bihar Dholi, India. The objectives of this work were to estimate the combining ability of the new lines, identify new single cross hybrids and potential females for TWC hybrid combinations and lines with good CGA to be used as males in TWC hybrids and to form synthetic varieties. Highly significant statistic differences were detected at individual and across locations. The interaction hybrid x location was not significant reflecting the importance stability of performance of some hybrids, trial mean yields: 6.1 t/ha at Agua Fria, 9.1 t/ha at Zacapa, 6.6 t/ha at Turipana, 5.1 t/ha at Las Vegas, 9.7 t/ha at Dholi, 8.0 t/ha at Cotaxtla and 7.4 t/ha across locations.

Table 10 shows the performance of the eight top single cross hybrids yielding from 8.2 t/ha to 8.92 t/ha, 12 to 23 % more yield than the seed industry checks. All hybrids showed resistance to ear rot while CML442XCML444 presented 13% ear rot damage. The best performing hybrid CL04368 x CL-SPLW04 10 t/ha, 34% more yield than checks and CML247xCML254. This hybrid demonstrated good stability ranking first across locations (9.78 t/ha) and first Agua Fria, Zacapa and Cotaxtla, fifth at Turipana, eighth at Las Vegas, Guatemala, and the maximum yield was at Cotaxtla (11.7 t/ha) and 9.7 t/ha across locations. Other stable hybrids were: Entries 59, 60, 104 with the highest yield of 13.3 t/ha at Dholi and 8.7 t/ha at Turipana, Colombia, 10 t/ha at Zacapa and yielded 8.9 t/h across locations. All hybrids showed also resistance to ear rot. The 10 hybrids with superior performance plus the best 3 at individual locations, which are not in the top across locations, will be tested in the third stage trial and internationally in CHTTW in 2003 and 2004 respectively.

Combining ability estimates were performed on the bases of NC design II using 10 females x 5 males mating design and 13 x 3 under a line by tester model analysis.

Superior lines with good GCA are L_2=0.57, L_3=0.354, L_7=0.254 and L_{14}=0.54. These lines will form a new synthetic adding CML448 and CML449.

Same lines can be used as in TWC combination using female single crosses heterotic group "B".

Best SCA: L_{11} x L_5 and L_6 x L_{14}, L_3 x L_{14}, L_5 x L_{14} and L_2 x L_{15} can be used as females in TWC hybrid combination (Tables 11 and 12).

Tables A36 to A42 show the performance of all hybrids at individual and across locations.

Table 10. TSCLW02-10 Top eight tropical late white single crosses across six locations in 2002B

Ent no	Pedigree	Yield1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Css %
60	(CL-04346*CL-02513)-B-62-2-1-B x (CML273*CML401)-B-16-1-	**8.69**	**8.92**	**120**	**123**	2.6	63	0.51	0.99	17.7	2.5	2.0	11.1	0.9	0.5	1.0
104	(CML265*CL-00303)-S7*CML264)-B x CML449	**8.66**	**8.92**	**119**	**122**	2.9	61	0.52	1.06	18.6	2.8	2.3	15.9	0.4	0.2	5.2
59	(CL-04346*CL-02513)-B-62-2-1-B x (CML273*CML401)-B-28-1-	**8.33**	**8.59**	**114**	**118**	3.1	63	0.51	0.95	18.2	2.6	2.4	3.6	1.2	1.2	6.6
73	CL-04365=LPSF7-1-2-2-2-2-BBBB-10 x (CML273*CML401)-B-16-1-	**8.18**	**8.49**	**112**	**116**	3.7	63	0.55	1.00	18.3	2.7	2.6	8.8	2.5	4.7	5.6
94	(CL-04317*CML264)-B-21-1-3-B x CML449	**8.16**	**8.39**	**112**	**115**	2.8	60	0.50	1.18	18.6	2.9	2.3	4.6	0.3	1.4	6.0
99	(CL-04317*CML264)-B-15-1-B x CML449	**8.08**	**8.32**	**111**	**114**	2.9	61	0.48	0.97	17.8	3.0	2.3	10.1	1.6	0.0	6.2
83	CML448=P21(MRRS)C1-430-1-B*10- x (CML273*CML401)-B-16-1-	**8.04**	**8.27**	**111**	**114**	2.7	63	0.48	0.99	18.8	2.5	2.2	2.5	0.2	0.6	5.4
87	CML448=P21(MRRS)C1-430-1-B*10- x CML450	**7.97**	**8.22**	**110**	**113**	3.1	61	0.48	0.90	19.1	2.7	2.3	0.7	0.3	0.0	4.8
105	CML247 x CML254 **RE**	**7.27**	**7.48**	**100**	**103**	2.7	63	0.53	0.94	20.2	2.4	2.2	4.1	4.5	1.2	2.5
106	CML442 x CML444	**5.77**	**6.62**	**79**	**82**	12.8	63	0.54	0.88	17.7	3.0	3.0	7.5	9.5	3.2	14.0
107	CML264 x CML269	**7.87**	**8.01**	**108**	**111**	1.7	61	0.48	1.04	18.0	2.8	2.3	6.1	1.0	1.3	7.6
108	CL-04368 x CL-SPLW04	**9.47**	**9.78**	**130**	**134**	3.2	62	0.53	1.13	16.4	2.7	2.3	11.5	3.0	7.5	2.6
109	LOCAL CHECK 1	**6.76**	**6.92**	**93**	**96**	2.3	62	0.51	1.00	19.7	2.8	2.4	14.1	6.4	1.6	2.4
110	LOCAL CHECK 2	**7.07**	**7.36**	**97**	**100**	3.9	62	0.54	1.01	19.0	3.0	2.7	19.0	4.6	2.2	8.0
	Check Mean	**7.37**	7.70			4.4	62	0.52	1.00	18.5	2.8	2.5	10.4	4.8	2.8	6.2
	Grand Mean	**7.10**	7.44			4.7	62	0.50	0.98	18.7	2.8	2.6	7.5	2.4	4.0	6.6
	LSD 5%	**0.77**	**0.80**			3.3	0.9	0.0	0.1	1.2	0.3	0.3	11.6	3.6	6.4	9.4
	CV %		**13.64**			9.0	2.2	7.6	10.4	7.5	18.2	17.8	9.3	9.3	11.4	69.6
	F value Loc*Entry		**0.96**			0.8	0.7	0.6	0.8	1.2	0.7	0.9	2.6	0.9	1.1	2.1
	P(F>f)		**0.67**			1.0	1.0	1.0	1.0	0.0	1.0	1.0	0.0	0.8	0.1	0.0
	Number of locations		**6**			5	6	6	5	6	6	6	4	6	4	2

Table 11. TSCLW02-10. GCA and standard errors for grain yield for 15 late white tropical inbred lines.

Across six Locations. 2002 B

1. Grain yield and GCA values.

	L11	L12	L13	L14	L15	MEAN	GCA
L1	7.10	6.64	7.38	7.62	6.81	**7.11**	**-0.350**
L2	7.76	7.70	7.89	8.50	8.28	**8.02**	**0.565**
L3	8.01	7.75	7.79	8.19	7.32	**7.81**	**0.352**
L4	6.99	7.49	7.50	8.11	7.14	**7.44**	**-0.016**
L5	8.16	6.99	6.87	8.34	7.11	**7.49**	**0.034**
L6	7.94	6.53	6.89	8.27	6.92	**7.31**	**-0.152**
L7	7.12	7.72	7.32	7.99	8.42	**7.71**	**0.254**
L8	6.28	6.33	7.47	8.09	8.23	**7.28**	**-0.181**
L9	7.95	6.36	7.64	7.94	6.55	**7.29**	**-0.171**
L10	7.49	6.74	7.14	6.93	7.33	**7.12**	**-0.335**
MEAN	**7.48**	**7.03**	**7.39**	**8.00**	**7.41**		
GCA	**0.019**	**-0.434**	**-0.072**	**0.537**	**-0.050**		

GCA St.error for L1 - L10 = 0.138

GCA St.error for L11 - L15 = 0.122

Lines L1 - L10

L1	**(CL-02159*CML247)-B-13-2-2-B**
L2	**(CML273*CML401)-B-16-1-1-B**
L3	**(CML273*CML401)-B-28-1-1-B**
L4	**(CML273*CML401)-B-35-1-1-B**
L5	**CL-PWSD04=PNvaBcoS/DFS301-B-2-B-2-B*4-B-10-10**
L6	**CL-RCW01=[PNvaBco(S/D)xNPH-28]F32-B-1-B-1-2-B*7**
L7	**CML449=CL-03214=P32(MRRS)F2C2-23-2-B*7-1-2-10**
L8	**CML450=(SEGR-6-5-#xNPH28-1)-1-1-1-BB-5-2-B*12**
L9	**P21(MRRS)F2(C2)-179-2-B*8-B-B**
L10	**P390bcoC3/247 F31-1-2-B-B**

2. GCA values by locations

LOC	Inbred lines									
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	GCA SE
LOC 1	-0.439	0.579	0.447	0.171	0.247	0.401	0.019	-0.545	-0.287	-0.589	0.274
LOC 2	-0.835	0.613	0.351	-0.051	0.687	-0.269	0.481	0.247	-0.839	-0.389	0.311
LOC 3	-0.513	0.247	0.687	-0.125	-0.077	-0.249	0.011	0.185	-0.003	-0.165	0.264
LOC 4	-0.314	1.184	-0.460	-0.540	0.238	-0.092	0.470	-0.606	0.664	-0.544	0.273
LOC 5	0.114	-0.430	0.360	-0.338	0.382	-0.728	0.372	-0.280	0.654	-0.110	0.316
LOC 6	-0.112	1.194	0.728	0.788	-1.272	0.024	0.168	-0.090	-1.214	-0.212	0.377

2. GCA values by locations

LOC	Inbred lines					
	L11	L12	L13	L14	L15	GCA SE
LOC 1	-0.051	-0.457	-0.102	0.404	0.208	0.183
LOC 2	0.394	-0.564	0.253	-0.017	-0.068	0.207
LOC 3	-0.102	-0.569	-0.307	0.443	0.534	0.176
LOC 4	-0.675	-0.214	-0.125	0.745	0.269	0.182
LOC 5	0.584	-0.929	-0.454	0.825	-0.028	0.211
LOC 6	-0.034	0.127	0.305	0.820	-1.217	0.251

Lines L11 -L15

L11	**(CL-04346*CL-02513)-B-53-1-1-B**
L12	**(CL-04346*CL-02513)-B-69-1-1-B**
L13	**(CL-04347*CL-04904)-B-55-1-B**
L14	**CL-04365=LPSF7-1-2-2-2-2-BBBB-10**
L15	**CML448=P21(MRRS)C1-430-1-B*10-6-1-1-7-10**

Table 12. TSCLW02-10. GCA and standard errors for grain yield for 16 late white tropical inbred lines.

Across six Locations. 2002 B

1. Grain yield and GCA values.

	L14	L15	L16	MEAN	GCA
L1	7.72	7.25	8.09	**7.69**	**0.204**
L2	8.07	7.35	7.29	**7.57**	**0.090**
L3	7.10	7.49	7.12	**7.24**	**-0.246**
L4	6.64	6.74	7.72	**7.04**	**-0.446**
L5	7.38	7.14	7.32	**7.28**	**-0.204**
L6	7.32	7.12	7.25	**7.23**	**-0.251**
L7	8.20	6.78	7.70	**7.56**	**0.075**
L8	7.69	6.69	7.64	**7.34**	**-0.142**
L9	7.62	6.93	7.99	**7.51**	**0.029**
L10	6.81	7.33	8.42	**7.52**	**0.037**
L11	7.79	7.18	8.40	**7.79**	**0.309**
L12	7.70	6.82	8.33	**7.62**	**0.134**
L13	7.21	7.55	8.92	**7.89**	**0.410**
MEAN	**7.48**	**7.11**	**7.86**		
GCA	**-0.001**	**-0.377**	**0.378**		

GCA St.error for L1 - L13 = 0.174

GCA St.error for L14- L16 = 0.0639

Lines L1 - L13

L1	**(CL-04345*CL-274)-B-15-1-2-B**
L2	**(CL-04345*CL-274)-B-113-2-1-B**
L3	**(CL-04346*CL-02513)-B-53-1-1-B**
L4	**(CL-04346*CL-02513)-B-69-1-1-B**
L5	**(CL-04347*CL-04904)-B-55-1-B**
L6	**(CL-04347*CL-04904)-B-109-2-1-B**
L7	**(CL-04346*CL-02513)-B-62-2-1-B**
L8	**CL-RCW11=(NPH99xNPH101)-1-1-3-2-B-1-B-2-B*8**
L9	**CL-04365=LPSF7-1-2-2-2-2-BBBB-10**
L10	**CML448=P21(MRRS)C1-430-1-B*10-6-1-1-7-10**
L11	**(CL-04317*CML264)-B-21-1-3-B**
L12	**(CL-04317*CML264)-B-15-1-B**
L13	**(CML265*CL-00303)-S7*CML264)-B-8-1-3-B**

2. GCA values by locations

LOC	Inbred lines													
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	GCA SE
LOC 1	6.373	6.550	5.670	5.330	5.767	5.293	5.973	7.347	6.003	6.073	6.097	6.323	6.667	0.359
LOC 2	8.800	8.823	9.533	8.177	9.100	8.813	9.263	8.380	8.097	9.140	10.230	9.503	9.177	0.406
LOC 3	7.090	5.707	6.620	6.253	6.777	5.663	6.183	6.930	6.563	7.090	6.540	6.307	6.253	0.345
LOC 4	5.727	4.030	4.497	5.857	4.850	5.277	5.137	5.167	5.943	5.817	5.643	4.540	5.073	0.357
LOC 5	9.663	11.053	10.000	8.503	9.210	10.287	10.067	9.190	9.750	9.743	9.700	10.980	11.090	0.414
LOC 6	8.463	9.270	7.097	8.093	7.963	8.053	8.720	7.023	8.707	7.250	8.537	8.040	9.093	0.493

2. GCA values by locations

LOC	Inbred lines			
	L14	L15	L16	GCA SE
LOC 1	6.368	5.552	6.419	0.146
LOC 2	8.730	8.749	9.530	0.166
LOC 3	6.359	6.107	6.914	0.141
LOC 4	5.299	4.568	5.723	0.146
LOC 5	9.786	9.542	10.495	0.169
LOC 6	8.342	8.113	8.079	0.201

Lines L14 -L16

L14	**(CL-02159*CML247)-B-13-2-2-B**
L15	**P390bcoC3/247 F31-1-2-B-B**
L16	**CML449**

2.8 Combining ability and hybrid yield performance of tropical late maturing yellow endosperm advanced lines heterotic groups "A" and "B"(TSLCY02-11).

The objective of this activity was to estimate the combining ability of new advanced yellow lines, heterotic groups "A" and "B" and select the best for different uses, identify new single cross combination for testing internationally and identify superior lines to use as males in TWC hybrid combinations and synthetic formation.

14 tropical yellow late lines heterotic group "A" and 12 lines heterotic group "B" were intercrossed in Design II Mating Design in Tlaltizapan 2002A. Only 147 crosses out of the 168 were completed and the 147 plus 3 hybrid checks were included under a 15x10 alpha lattice design with two replication and evaluated at six locations:

Cotaxtla and Agua Fria, Mexico; Zacapa and Las Vegas, Guatemala; Turipana, Colombia and Bihar, India winter planting, representing the tropical lowland from 0 to 700 MASL. The combining ability estimates for yield were made under the NC design II model, 12 female lines heterotic group A and 7 male lines heterotic group B.

Hybrid yield performance at individual and across locations was good presenting high mean yield trials 7.1 t/ha, 8,0 t/ha, 6.0 t/ha, 4.6 t/ha, 8.1 t/ha and 6.5 t/ha at Agua Fria, Zacapa, Turipana, Las Vegas, Bihar and Cotaxtla respectively and 6.7 t/ha across locations. The most important limiting constraint to maize production in the location with lower mean yield (4.6 t/ha) at Las Vegas Guatemala was ear rot with a mean of 17% reducing the clean yield to 3.8 t/ha with r=-0.5 negatively correlated with yield at this location, several hybrids showed resistance to this important disease. The most important constrain that affected yield across locations, was root lodging (22%) severely affecting Cotaxtla's location, nevertheless, they were hybrids that showed resistance to those limiting constraints. Yield potential at individual location of the new hybrid vs. the local checks was impressive from 37% to 127% more yield than the local check. 24 hybrids outyielded the seed industry checks and trial mean yield with up to 29%, more yield or 2.0 t/ha. They also showed resistance to ear rot while the check showed 6% rotten ears. Tables A43 to A49 show the performance of all hybrids at individual and across locations.

Table 13 presents the 8 best yellow endosperm hybrids that outyielded the seed industry checks up to 30% or 2.5 more LSD's up to 1.9 t/ha. Some hybrids also showed resistance to ear rot, tolerance to root lodging. CL-RCY17 x CML452 which yielded 7.9 t/ha and ranked second across locations, CL-RCYX014 x CL02836: ranked first across locations (8.4 t/ha), first at Zacapa, Guatemala (10.6 t/ha), 9.8t/ha at Bihar, India and 8.6 t/ha at Cotaxtla, Mexico.

The estimates of the additives (GCA) and non-additives genetic effects (SCA) play an important role in hybrid breeding. Among the lines HG "A" six lines showed positive and significant estimates L_2= 0.52, L_4= 0.751, L_6= 0.122, L_9= 0.21 L_{10} = 0.41 and L_{12}=0.58 t/ha, 1 to 7 times the SE for GCA, while in the group "B" 2 lines showed positive and significant values for GCA: L_{14}= 0.58, L_{16}= 0.1, L_{17}= 0.23, these values are equivalent 2 to 6 times the SE for GCA.

SCA estimates positive and significant include crosses: L_2 x L_{14}, L_4xL_{14}, L_3xL_{14}, L_{12}xL_{15}, L_2xL_{16}, L_4xL_{16}, L_6xL_{16}=, L_2xL_{17}, L_{12}xL_{19}. These values are equivalent to 1.5 to 3.5 times the SE to SCA effects (Table 14).

The single crosses mentioned above can be used effectively for TWC formation with lines with good GCA considering the participation in SC combinations.

Synthetic formation should be made among the lines with good GCA within and between heterotic groups. Superior hybrids in Table 13 and superior ones at individual locations should be tested internationally and particularly in Asia and Latin America.

The lines with good GCA should participate in new F_2 pedigree populations after executing head to head analysis.

The yield potential of this yellow hybrid combination should be exploited extensively since it is the third year in a row that we achieve those yields, similar to yields of white hybrid combinations at individual locations.

Table 13.TSCLY02-11 Top nine tropical late yellow single crosses across six locations in 2002B

Ent no	Pedigree		Yield1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	CSS 1_5
12	CL-RCY014	x CL-02836	**7.90**	**8.37**	**99**	**130**	5.7	63	0.56	1.10	18.6	3.6	2.2	22.8	4.1	18.9	4.1
106	CL-RCY017	x CML452	**7.68**	**7.86**	**97**	**126**	2.3	62	0.54	0.99	19.2	3.3	1.9	4.5	8.3	3.4	14.0
113	CL-RCY015	x CML452	**7.66**	**7.90**	**96**	**126**	3.0	60	0.52	1.13	18.7	3.0	2.2	19.7	3.5	1.3	17.4
97	CL-RCY018	x CL-02836	**7.63**	**7.98**	**96**	**126**	4.3	64	0.55	0.94	18.6	3.4	2.3	15.4	2.8	4.0	0.0
81	CL-02450	x CL-RCY019	**7.60**	**7.97**	**96**	**125**	4.6	64	0.54	0.93	15.7	3.0	2.1	13.5	9.8	3.0	6.4
38	CL-RCY015	x CML481	**7.57**	**7.89**	**95**	**125**	4.0	64	0.52	0.94	17.8	3.4	2.2	20.6	10.3	1.2	2.6
14	CL-RCY014	x CML451	**7.57**	**7.79**	**95**	**125**	2.8	64	0.50	1.07	19.7	3.2	2.2	10.3	0.1	5.1	10.9
26	CL-RCY017	x CL-02836	**7.50**	**7.95**	**94**	**123**	5.7	63	0.61	1.05	18.8	3.2	2.5	9.0	13.0	4.0	19.1
101	CL-RCY018	x CML451	**7.44**	**7.57**	**94**	**122**	1.8	65	0.52	0.97	19.4	2.8	2.2	15.5	0.0	0.3	2.2
147	CML451	x CML287	**7.95**	**8.41**	**100**	**131**	5.5	63	0.52	0.99	20.0	3.0	2.1	19.6	2.8	0.3	0.1
148	CML451	x CL-MDRY01	**6.86**	**7.23**	**86**	**113**	5.0	63	0.47	1.02	18.0	3.3	2.6	15.3	3.2	4.9	19.5
149	CL-02450	x CL-03618	**7.13**	**7.34**	**90**	**117**	2.7	63	0.54	0.95	18.8	2.9	2.5	30.8	0.9	0.5	0.6
150	LOCAL CHECK #1		**6.07**	**6.47**	**76**	**100**	6.1	62	0.55	0.99	19.4	3.5	2.6	25.1	9.8	2.2	4.7
		Check Mean	**7.01**	**7.36**			4.8	63	0.52	0.99	19.1	3.2	2.4	22.7	4.2	2.0	6.2
		Grand Mean	**6.32**	**6.68**			5.4	63	0.52	0.95	18.3	3.2	2.6	21.6	7.0	3.2	6.2
		LSD 5%	**0.73**	**0.76**			4.2	1.0	0.0	0.1	1.3	0.4	0.3	13.9	7.4	5.0	9.7
		CV %		**15.53**			9.0	1.3	7.6	12.6	7.2	15.3	19.7	11.7	14.2	10.4	98.5
		F value Loc*Entry		**0.84**			0.7	2.5	0.7	0.6	1.4	0.7	0.7	1.0	0.8	0.8	1.3
		P(F>f)		**0.99**			1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.69	0.99	1.00	0.03
		Number of locations		**6**			5	6	6	5	6	5	6	4	5	4	2

Table 14. TSCLY02-11. GCA and standard errors for grain yield for 19 late yellow tropical inbred lines.

Across six Locations. 2002 B

1. Grain yield and GCA values.

	L13	L14	L15	L16	L17	L18	L19	MEAN	GCA
L1	5.71	6.55	5.80	6.41	6.34	6.32	5.38	**6.07**	**-0.667**
L2	6.87	8.37	6.13	7.77	7.79	7.17	6.69	**7.25**	**0.517**
L3	5.83	7.22	7.22	7.04	6.85	6.85	6.68	**6.81**	**0.074**
L4	7.32	7.96	7.31	7.80	7.17	7.55	7.31	**7.49**	**0.751**
L5	6.00	7.52	6.83	5.96	5.99	7.03	5.12	**6.35**	**-0.388**
L6	6.23	6.14	6.98	7.89	7.22	7.11	6.45	**6.86**	**0.122**
L7	5.99	7.14	5.44	4.99	7.07	5.60	5.58	**5.97**	**-0.766**
L8	5.87	7.52	6.87	7.24	7.23	7.18	5.92	**6.83**	**0.096**
L9	6.79	7.08	6.82	7.16	7.21	6.64	6.95	**6.95**	**0.212**
L10	6.97	7.60	7.45	7.22	7.18	6.94	6.60	**7.14**	**0.401**
L11	6.92	7.48	6.00	5.50	6.08	6.49	2.17	**5.81**	**-0.932**
L12	7.06	7.25	7.74	7.03	7.52	6.68	7.97	**7.32**	**0.582**
MEAN	**6.46**	**7.32**	**6.71**	**6.83**	**6.97**	**6.79**	**6.07**		
GCA	**-0.275**	**0.581**	**-0.023**	**0.096**	**0.233**	**0.057**	**-0.670**		

GCA St.error for L1 - L12 = 0.109 GCA St.error for L13- L19 = 0.130

Lines L1 - L12

L1	(CL-02447*CL-02812)-B-19-1-1-B
L2	CL-RCYX13 = (CL-03618*CML287)-B-9-1-3-B
L3	(CL-02439*CML286)-B-1-2-2-B
L4	(CML285*CL-02410)-B-21-1-2-B
L5	IBP-3 C2 TLYD-68-3-2-3-B
L6	CL-RCYX18 = (CML285*CL-00356)-B-1-1-B
L7	CL-RCY004=(CL-02432*CL02821)-B-7-B-5-2-1-B*6
L8	CL-03618=P36C9HC60-B-1-B*11
L9	CL-03622=P36(STE)C2-41-B*15
L10	CL-RCY011=(CGHG2S2-19-1-1F/R)-B*5
L11	CL-RCY007=PIO3011F2-3-5-6-1-B*4
L12	CL-02450

2. GCA values by locations

LOC	Inbred lines												
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	GCA SE
LOC 1	-0.766	0.889	0.217	0.724	-0.978	0.381	-1.021	-0.091	0.295	0.344	-0.669	0.675	0.311
LOC 2	-0.410	0.566	-0.357	0.410	0.131	0.224	-0.564	0.047	0.543	-0.312	-0.827	0.550	0.269
LOC 3	-0.647	0.384	-0.246	0.705	-0.427	0.173	-0.227	0.050	-0.456	0.714	-0.442	0.420	0.198
LOC 4	-0.425	0.038	0.132	0.769	-0.229	0.167	-0.573	0.138	0.079	0.662	-1.022	0.264	0.273
LOC 5	-0.354	0.821	0.827	1.226	-0.497	-0.741	-1.619	-0.221	0.276	0.943	-1.441	0.781	0.237
LOC 6	-1.399	0.401	-0.129	0.671	-0.330	0.527	-0.593	0.652	0.537	0.054	-1.189	0.800	0.289

2. GCA values by locations

LOC	Inbred lines							
	L13	L14	L15	L16	L17	L18	L19	GCA SE
LOC 1	-0.313	0.169	-0.324	0.024	0.280	0.755	-0.592	0.230
LOC 2	-0.452	0.420	0.206	0.314	0.031	0.225	-0.744	0.198
LOC 3	-0.210	0.180	0.415	-0.066	0.222	-0.071	-0.471	0.146
LOC 4	-0.486	0.562	0.079	0.511	-0.191	-0.600	0.126	0.202
LOC 5	-0.220	1.203	-0.210	0.133	-0.117	0.850	-1.639	0.175
LOC 6	0.030	0.952	-0.304	-0.339	1.175	-0.816	-0.699	0.213

Lines L13 -L19

L13	(CL-00344*CML29)-B-46-1-2-B
L14	CL-02836=P28C9F113-3-1-4-B*8
L15	CL-RCYX19 = (CL-00331*CML287)-B-6-2-3-B
L16	CL-SW002=SW1(S)C11-14-1-3-3-B*6
L17	CML451
L18	DTP1YC6F234-2-#-2-2-3-2-BBB
L19	KSX3753F2-5-1-3-B*4

2.9 Hybrid yield performance of tropical late white lines crossed to opposite heterotic group testers (TSCW02-12)

45 tropical late white inbred lines, heterotic groups "A&B" were crossed to the opposite A&B testers.

The 45 advanced testcrosses, four single crosses and one check were included in an alpha lattice 5x10 design with two replications and were evaluated at six locations: Agua Fria and Cotaxtla, Mexico; Zacapa and Las Vegas, Guatemala; Turipana, Colombia and Dholi, India. The objectives of this work were to identify new single cross hybrids and potential females for TWC hybrid combinations and lines to be used as males in TWC hybrids and form synthetic varieties. Highly significant statistic differences were detected at individual and across locations.

The interaction hybrid x location was significant reflecting the importance of the GxE interaction.

Trial mean yields varies from Agua Fria 6.6, Cotaxtla 7.2, Zacapa 10, Las Vegas 5.8, Turipana, 5.7 and Dholi, 13.0 t/ha. and across locations 8.0 t/ha.

Table 15 shows the performance of the ten top single cross hybrids yielding from 10 t/ha to 8.7 t/ha, 13 to 32% more yield than the seed industry checks. All 10 hybrids showed resistance to ear rot while CML442xCML444 presented 13% ear rot damage. The best performing hybrid CL-RCW53 x CML449 yielded 9.5 t/ha, 24 % more yield than checks and CML247xCML254. The RE CL-04368xCL-SPLW04 yielded 10.1 t/ha across locations and demonstrated good stability ranking first across location and first Agua Fria, Zacapa and Cotaxtla, fifth at Turipana; eighth at Las Vegas, Guatemala and the maximum yield was at Cotaxtla and Dholi (13 t/ha), at the last location hybrid CL-RCW63xCML448 yielded 18.1 t/ha, 74 % more yield than the best check. Other stable hybrids were: Entries 8, 2, 28 with yield of 15.5 t/ha at Dholi and 8 t/ha at Turipana, Colombia, 10.5 t/ha at Zacapa, 10.8 t/ha at Cotaxtla, and yielded 9.5 t/h across locations. All hybrids showed also resistance to ear rot. The 10 hybrids with superior performance plus the best 3 at individual locations, which are not in the top across locations, will be tested in the third stage trial and internationally in CHTTW in 2003 and 2004 respectively.

Superior lines will form a new synthetic adding CML448 and CML449. Same lines can be used as in TWC combination using female single crosses heterotic group A and "B" from trial 10.

Tables A50 to A57 show the performance of all hybrids at individual and across locations.

The 10 hybrids with superior performance plus the best 3 at individual locations, which are not in the top across locations, will be tested in the third stage trial and internationally CHTTW in Africa in 2003 and 2004 respectively.

Table 15. TSCLW02-12 Top ten tropical late white single crosses across six locations in 2002B

Ent no	Pedigree		Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %	HM 1_5
3	CL-04368	x CL-SPLW04	**9.83**	**10.11**	**126**	**132**	2.8	57	0.53	1.23	17.4	2.9	2.5	14.0	3.8	5.5	0.0	3.5
8	CL-RCW53	x CML449	**9.20**	**9.53**	**118**	**124**	3.4	57	0.50	0.89	17.8	2.6	2.3	26.3	0.3	8.0	0.0	2.8
11	CL-RCW54	x CML449	**9.04**	**9.25**	**116**	**122**	2.3	57	0.48	1.04	18.2	2.9	2.3	37.9	2.1	5.4	12.3	3.5
16	CL-RCW54	x CML449	**8.84**	**9.19**	**113**	**119**	3.8	58	0.54	1.01	19.0	2.8	2.3	34.8	3.2	0.4	13.7	3.2
18	CL-RCW59	x CML449	**8.83**	**9.36**	**113**	**119**	5.7	58	0.56	1.16	19.2	3.0	2.5	29.0	2.2	0.0	15.8	3.2
7	CL-RCW60	x CML449	**8.64**	**8.77**	**110**	**116**	1.5	57	0.54	0.98	17.5	3.0	2.6	21.7	3.6	0.5	19.3	2.8
5	CL-RCW61	x CML449	**8.61**	**8.91**	**110**	**116**	3.3	56	0.55	0.98	19.1	3.0	2.1	23.8	7.9	2.6	21.5	3.0
19	CL-RCW62	x CML449	**8.57**	**8.84**	**110**	**115**	3.0	58	0.52	0.99	18.3	3.0	2.5	32.2	1.6	0.0	6.8	3.2
10	CL-RCW57	x CML449	**8.47**	**8.82**	**108**	**114**	4.0	57	0.53	1.08	19.6	3.0	2.5	27.3	6.5	0.3	16.1	2.6
17	CL-RCW58	x CML449	**8.44**	**8.95**	**108**	**114**	5.7	58	0.58	1.06	20.1	3.1	2.5	34.1	2.1	0.0	8.0	2.2
12	CL-RCW55	x CML449	**8.37**	**8.71**	**107**	**113**	4.0	57	0.51	1.07	17.6	2.9	2.6	24.2	4.9	2.0	10.9	3.2
47	CML442	x CML444	**6.54**	**7.52**	**84**	**88**	13.1	59	0.54	0.88	17.3	3.2	3.2	17.7	7.9	1.2	7.1	2.9
48	CML448	x CML449	**7.24**	**7.49**	**93**	**97**	3.3	57	0.47	0.92	19.3	3.1	2.5	25.8	3.1	2.0	2.1	2.7
49	CML247	x CML254 **RE**	**7.82**	**8.13**	**100**	**105**	3.8	58	0.55	0.99	20.1	2.3	2.5	17.9	2.9	0.6	6.8	2.8
50	LOCAL CHECK 1		**7.43**	**7.78**	**95**	**100**	4.5	58	0.52	0.97	18.7	3.0	2.6	23.5	8.3	1.3	2.1	3.0
		Check Mean	**7.26**	**7.73**			6.2	58	0.52	0.94	18.9	2.9	2.7	21.2	5.6	1.3	4.5	2.8
		Grand Mean	**7.58**	**8.00**			5.2	57	0.50	0.96	19.1	2.9	2.6	22.0	3.4	3.1	7.1	2.9
		LSD 5%	**1.07**	**1.12**			4.0	0.9	0.0	0.1	1.6	0.4	0.4	14.0	4.7	5.5	.	.
		CV %		**13.68**			10.8	2.0	7.0	11.7	5.2	16.7	19.4	13.9	11.6	10.7	97.3	9.1
		F value Loc*Entry		**1.62**			0.8	1.0	0.7	0.7	4.1	1.1	0.8	1.0	0.9	1.0	.	.
		P(F>f)		**0.00**			1.0	0.5	1.0	1.0	0.0	0.2	1.0	0.6	0.8	0.6	.	.
		Number of locations		**6**			5	6	6	5	6	6	6	4	5	4	1	1

2.10 Hybrid yield performance of tropical late maturing yellow endosperm lines with opposite testers (TSCY02-13).

The objective of this activity was to identify new single cross combinations for testing internationally, use as females and identify superior lines to use as males in TWC hybrid combinations.

41 yellow lines were crossed to the opposite testers, 41 single crosses, two tropical single crosses RE and two seed industry testers were evaluated under a $\propto$ lattice design 5x9. Two row plots 66,000 plants per hectare, two replications per site at six tropical locations: Agua Fria and Cotaxtla, Mexico; Las Vegas, and Zacapa, Guatemala; Palmira, Colombia and Ludhiana, India.

The ANOVA showed highly significant differences for yield and other agronomic traits such as ear rot and plant height, across and at individual locations. Locations x hybrids interaction for yield, was not significant.

Mean yield trial at individual locations varies: 7.2 at Agua Fria, 7.6 at Zacapa, 5.5 at Turipana, 4.6 at Las Vegas, 8.8 at Ludhiana, 7.0 at Cotaxtla and 6.8 t/ha across locations. The maximum yield 11.7 t/ha was detected at Ludhiana, India (Tables A58 to A64).

CL-RCY 007xCL-02450 topped the trial across six locations and showed good stability in the tropical lowland locations ranking first at Ludhiana (11.7 t/ha), and in the first 10% in all locations. At Turipana this hybrid yielded 6.8 t/ha and outyielded Pioneer 3041 with 46% more yield.

Table 16 shows the yield performance of the best 7 hybrids that outyielded the best local checks across six locations. Seven hybrids were superior in yield from 0.84 to 1.5 t/ha or up to 2 LSD's. Best performing hybrids also showed resistance to ear rot and root lodging damage while the check showed 7% and 15% ear rot and root lodging respectively. Best performing hybrids should be tested in Asia and Latin America. Female lines in Entries: 2, 31 and 27 will form single crosses to be used as females in TWC hybrids using CL-02450 as male. Best parent lines will form synthetic varieties.

Table 16. TSCLY02-13 Top eight tropical late yellow single crosses with opposite testers across six locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %	HM 1_5	CSS 1_5
2	CL-RCY007 x CL-02450	7.69	8.05	112	127	4.5	67	0.51	0.97	19.2	2.7	2.6	8.9	8.1	7.4	0.4	3.0	7.4
31	(CML-297*CL-2410)-B-10-1-1-B-B x CL-02450	7.54	7.71	110	124	2.2	68	0.57	0.95	19.9	3.0	2.5	1.5	10.6	0.5	3.6	3.3	6.8
27	IBP-4(TYF)C2S1-66-1-2-1-B-B-B x CL-02450	7.42	7.69	108	122	3.6	68	0.55	0.94	19.3	2.6	2.3	8.0	10.0	0.5	2.4	2.9	2.1
24	P24C10F128-1-B-2-2-2-B x CML451	7.40	7.80	108	122	5.1	70	0.53	1.09	21.4	2.9	2.1	2.8	2.3	2.2	2.9	2.0	8.8
7	(CML-285*CML-27)-B-8-3-1-B-B x CML451	7.36	7.77	108	121	5.2	67	0.47	0.98	19.0	3.0	2.5	1.2	0.9	0.2	3.7	2.7	6.3
9	(CML-285*CML-283)-B-43-1-1-3- x CML451	7.26	7.36	106	120	1.3	68	0.51	0.94	18.7	3.1	2.7	2.1	2.3	0.4	3.1	3.3	8.1
33	P27C11F66-3-B-1-1-B x CL-02450	7.08	7.40	103	117	4.3	68	0.48	0.91	21.0	2.9	2.3	8.1	6.2	0.0	0.6	2.1	6.0
42	CML451 x CL-02450	7.49	7.94	110	124	5.6	68	0.50	0.94	20.5	3.1	2.5	9.8	4.1	0.6	0.0	2.4	7.4
43	CML287 x CML451	6.84	7.27	100	113	5.9	68	0.50	0.90	20.4	2.8	2.5	3.5	4.3	0.7	0.5	3.0	5.3
44	LOCAL CHECK 1	6.07	6.49	89	100	6.6	67	0.51	1.04	19.0	3.6	2.7	14.6	8.7	4.0	0.0	3.8	13.8
45	LOCAL CHECK 2	6.03	6.47	88	99	6.8	67	0.51	0.95	19.0	2.9	2.4	3.1	4.0	1.3	2.7	1.1	7.0
	Check Mean	6.61	7.04			6.2	68	0.51	0.96	19.8	3.1	2.5	7.8	5.3	1.6	0.8	2.6	8.4
	Grand Mean	6.44	6.79			5.2	68	0.51	0.93	19.5	2.9	2.6	5.1	4.2	1.8	3.4	2.8	10.9
	LSD 5%	0.81	0.84			3.2	0.9	0.0	0.1	1.4	0.3	0.3	8.3	4.9	4.0	.	.	9.3
	CV %		14.60			8.3	1.4	6.2	13.0	7.4	15.8	15.1	10.2	10.9	9.8	130.4	11.0	75.7
	F value Loc*Entry		1.10			0.9	1.3	0.9	0.6	1.5	0.7	0.9	2.3	0.9	0.5	.	.	0.6
	P(F>f)		0.25			0.8	0.1	0.9	1.0	0.0	1.0	0.8	0.0	0.7	1.0	.	.	1.0
	Number of locations		6			5	6	6	6	6	5	5	5	5	4	1	1	2

2.11 Yield performance of tropical white single cross hybrids (TSLW02-01).

50 new tropical single cross hybrids formed with the combination of lines selected from advanced testcrosses trial evaluation were tested at six locations in Mexico, Guatemala, Colombia and India.

The ANOVA showed significant differences for yield and agronomic traits at individual locations and across locations, mean yield varies from 5.3 t/ha at Las Vegas, Guatemala and Turipana to 8.9 t/ha at Bihar, India, at Cotaxtla, and Agua Fria, Mexico, mean yield was 7.3 t/ha. Zacapa also presented high mean yield 8.7 t/ha. The interaction locations x hybrids for yield was statistically significant showing nevertheless, the importance of GxE interaction of hybrids.

CL-021103xCML449 yielded 8.8 t/ha across six locations and performed first across locations at Zacapa, Las Vegas and Turipana; fourth at Agua Fria and Cotaxtla, and sixth at Bihar (Tables A65 to A71), showing adaptation to the tropical environment. This hybrid outyielded seed industry local checks with 30% more yield and resistance to ear rot and some hybrids also showed tolerance to root lodging and yielded 23% more than the RE CML247 x CML254. Eight more hybrids outyielded checks (Table 17), Fig. 3. Table 17 shows the performance of the best 8 hybrids. Single cross hybrid CL-021103 x CML449 yielded 8.8 t/ha, 52% more than CML442xCML444 Low N check. Eight hybrids outyielded the Low N check hybrid and should be tested in Africa in AMS project. Best 10 hybrids will be tested internationally in 2003 and 2004 in CHTTW they also offer potential for African lowlands and mid-altitude under stresses.

Fig. 3. TSCLW02-01 Grain yield and ear rot for five advanced tropical late white single crosses and two reference entries evaluated across six locations in 2002B

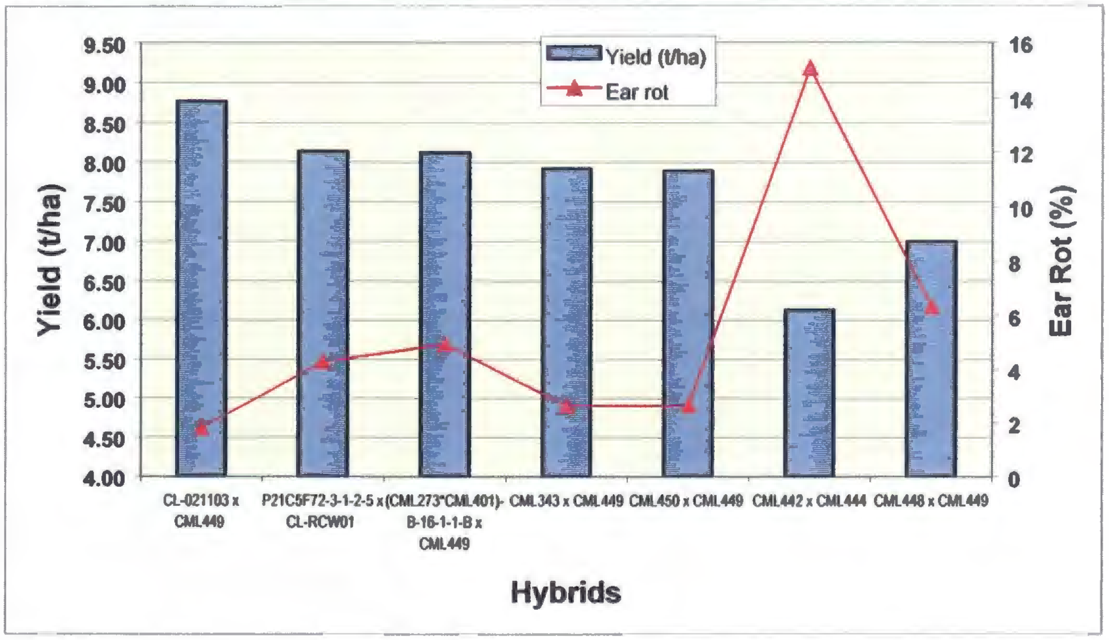


Table 17. TSCLW02-01 Top eight tropical late white single crosses across six locations in 2002B

Ent no	Pedigree		Yield1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Plt ht cm	Ear ht cm	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	CSS 1_5
5	CL-021103	x CML449	8.61	8.77	131	120	1.8	63	241	127	0.52	1.05	20.7	2.9	2.1	20.2	3.0	2.1	2.6
38	(CL-04317*CML247)-B-6-1-2-B	x CML449	7.80	8.32	119	109	6.3	62	231	124	0.53	1.08	20.2	3.3	2.5	16.0	7.6	2.1	2.6
30	CL-FAWW08	x CML254	7.79	8.14	119	109	4.3	65	251	152	0.60	1.23	19.0	3.5	2.6	11.7	3.3	0.4	1.8
8	CL-04365	x CML449	7.72	8.12	118	108	4.9	62	230	125	0.55	0.99	19.2	3.0	2.4	19.0	6.8	1.6	1.3
12	P21C5F72-3-1-2-5-BBB-##-1-BBB-4	x CL-RCW01	7.66	7.87	117	107	2.7	63	246	116	0.47	1.04	20.0	2.7	2.5	10.7	5.1	2.0	3.8
29	CML340	x CML254	7.63	7.82	116	106	2.5	64	242	131	0.54	1.08	19.3	2.7	2.8	7.5	0.2	0.3	1.3
7	CL-04365	x CML448	7.51	7.86	114	105	4.5	62	230	120	0.52	0.95	19.2	2.7	2.5	3.8	2.3	1.0	0.9
18	CML343	x CML448	7.45	7.78	114	104	4.2	65	230	101	0.44	1.06	20.4	2.7	2.4	3.7	0.6	2.4	4.5
44	CML449	x CL-RCW01	6.78	6.98	103	94	2.9	61	216	109	0.50	0.98	20.1	3.2	2.5	15.4	4.9	0.1	7.3
45	CL-04362	x CML258	6.74	7.92	103	94	14.9	63	242	138	0.57	0.99	19.6	3.0	3.0	9.3	9.4	0.5	1.4
46	CML339	x CML344	7.80	8.07	116	106	5.8	64	240	124	0.51	1.08	18.2	3.2	2.4	6.6	5.3	0.2	3.3
47	CML442	x CML444	5.21	6.14	79	73	15.1	64	237	126	0.52	0.88	18.7	3.5	3.2	20.7	9.1	0.1	4.9
48	CML448	x CML449	6.66	7.01	100	91	6.3	62	224	106	0.47	0.91	21.4	3.4	2.3	22.7	1.9	1.1	2.3
49	CML247	x CML254	7.06	7.24	106	98	2.5	65	223	124	0.56	0.96	20.8	2.5	2.1	18.5	3.9	0.5	0.9
50	Local check		7.18	7.42	109	100	3.3	63	237	130	0.55	1.04	19.6	3.0	2.4	14.8	6.4	2.4	0.6
		Check Mean	6.73	7.26			7.3	63	231	122	0.53	0.98	19.7	3.1	2.5	15.4	5.8	0.7	2.9
		Grand Mean	6.90	7.22			4.5	63	231	119	0.51	1.00	19.5	3.0	2.6	15.3	3.8	1.2	4.6
		LSD 5%	0.78	0.81			3.2	0.8	7.7	7.7	0.0	0.1	1.1	0.5	0.4	12.3	4.1	2.6	6.0
		CV %		11.17			6.8	1.6	5.1	8.7	7.3	13.0	6.5	17.2	16.0	8.9	9.9	8.2	61.9
		F value Loc*Entry		1.54			1.3	0.9	0.7	0.9	0.9	0.7	1.2	1.0	1.6	1.8	0.8	1.0	2.2
		P(F>f)		0.00			0.07	0.70	1.00	0.86	0.85	1.00	0.09	0.43	0.00	0.00	0.98	0.51	0.00
		Number of locations		6			5	6	6	6	6	5	6	5	6	4	5	4	2

2.12 Evaluation of tropical late yellow endosperm single cross hybrids across eight locations 2002B (TSCLY02-02).

TSCLY-2 is the trial that includes yellow hybrids in the third stage of testing, the superior top performing hybrids are promoted to international testing in CHTTY.

25 tropical late yellow endosperm single cross hybrids were included in a 5x5 alpha lattice design with two replications evaluated at eight environments in Mexico, Guatemala, Colombia, Venezuela, India and Vietnam.

Mean yield trial at individual locations varies from 7.4 t/ha in Cotaxtla, 7.10 t/ha at Agua Fria, 1.9 t/ha at Colombia, 4.8 t/ha at Maracay, Venezuela, 2.9 t/ha at Villa de Cura, Venezuela, 4.6 t/ha at Guatemala, 9.1 t/ha at India and 6.6 t/ha at Vietnam and 5.5 t/ha across locations (Table 19).

The ANOVA showed statistically significant differences among hybrids for yield and some important agronomic traits at individual and across locations, the highly significant difference location x hybrids reflects the importance of GxE interaction.

The maximum yield was reached at Jalna, India with the hybrid CML287 x CML451 = 10.9 t/ha, 3.2 t/ha more than the seed industry check. This new hybrid also showed resistance to ear rot and root lodging. Same hybrid yielded 7.4 t/ha at Agua Fria, Mexico and topped the trial across eight locations with 6.6 t/ha (Table 19).

Table 18 shows the performance of all hybrids across 8 locations. The best four hybrids CML287 x CML451, RCY0011 x CML451, CML451 x CL-SW002 and CL-RCY008 x CML451 outyielded the seed industry check with 12 to 20% more yield and resistance to ear rot.

The superior 8 hybrids across locations plus the best two at individual locations will be tested in international trials and should be tested in farmers' fields in Colombia, Peru, Indonesia, Nepal and Philippines or included in the regional trials in Asia. Fig. 4 shows the performance of the best hybrids across locations.

Fig. 4. TSCLWOY-02. Grain yield for the best hybrid and the best local check across eight environments

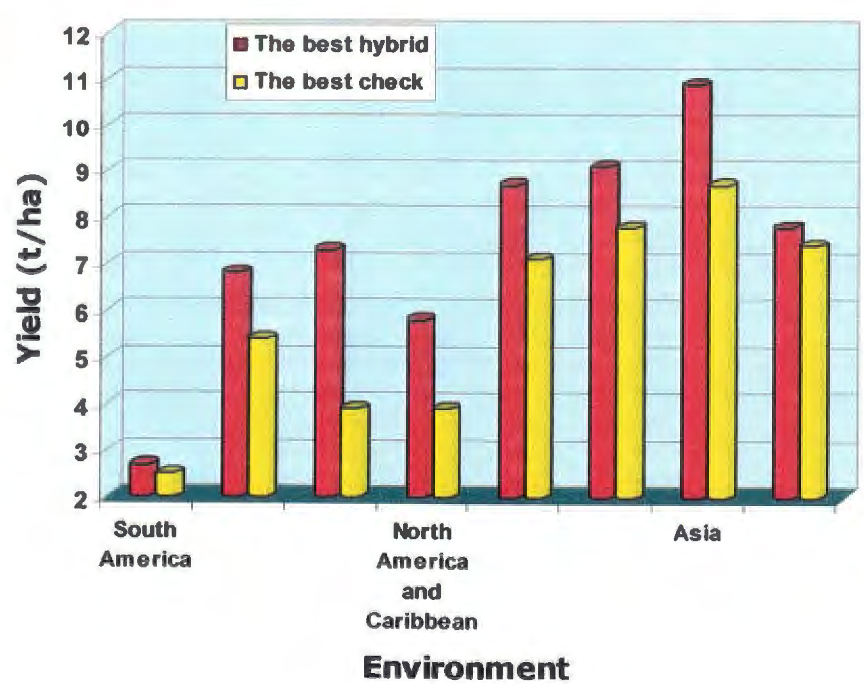


Table 18. TSCLY02-02. Mean for different traits across eight environments

Ent no	Pedigree	Yield t/ha	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott %	Erott 1_5	Plt asp 1_5	Ear asp 1_5	Rldg %	Rldg 1_5	Sldg %	Stkldg 1_5	BH %	BH 1_5	Fus %	Stunt %	P.P. 1_5	B.M. 1_5	Virus %	EPP %
22	CML-287 x CML-451	6.6	56	57	-1.1	247	129	13	4.3	2.1	2.5	2.4	15.9	1.0	1.3	1.5	1.6	1.6	0.0	1.1	2.8	2.3	9	0.88
5	CL-RCY0011 x CML-451	6.1	53	54	-1.2	224	109	13.3	7.0	1.6	2.4	2.4	8.8	1.0	0.9	1.0	0.8	1.5	0.0	0.0	2.8	2.8	25.8	0.83
11	CML-451 x CL-SW002	6.1	55	56	-1.8	224	114	12.4	4.8	2.4	2.1	2.3	3.5	1.0	3.2	1.5	1.3	1.4	0.0	0.0	3.0	3.0	9.4	0.84
2	CL-RCY008 x CML-451	6.0	54	55	-0.9	224	114	12.6	4.9	2.1	2.5	2.3	9.4	1.0	9.2	2.0	0.7	1.4	0.0	1.0	3.3	3.3	17.1	0.89
20	CL-02455 x CML-226	5.9	54	56	-1.2	263	128	13.8	2.7	1.8	2.8	2.2	27.8	1.0	9.5	2.0	2.2	1.6	3.1	0.0	3.0	3.0	13.7	0.85
4	CL-RCY0011 x CL-02450	5.9	54	55	-1.4	233	123	13.6	5.7	2.8	2.5	2.6	12.4	1.0	1.3	1.5	16.3	1.8	1.1	4.3	2.8	2.8	30.8	0.81
3	CL-RCY009 x CML-451	5.7	53	55	-1.7	220	114	12.1	6.4	2.3	2.7	2.6	5.1	1.0	3.5	1.0	2.6	1.4	3.2	1.1	3.3	3.8	34.5	0.87
21	CML-452 x CML-287	5.7	53	54	-0.5	238	124	12.6	2.9	1.9	2.7	2.3	17.6	1.0	1.9	2.0	3.2	1.5	0.0	1.1	3.0	3.0	22.0	0.97
23	CML-451 x CL-02450	5.6	56	58	-1.8	225	118	13.3	2.2	1.8	2.3	2.6	0.5	1.0	3.8	2.5	0.8	1.4	2.1	1.0	2.3	2.3	16.6	0.80
18	CL-02838 x CML-451	5.5	56	58	-1.6	235	111	13.7	6.0	1.8	2.5	2.6	5.0	1.0	1.2	2.0	0.0	1.4	0.0	3.2	2.5	2.5	13.8	0.81
15	CL-G2621 x CML451	5.5	56	57	-1.4	238	124	13.4	4.8	2.6	2.5	2.9	0.5	1.0	2.6	1.0	4.0	1.6	0.0	2.1	2.8	2.8	15.2	0.79
6	CL-PY39104 x CML-451	5.4	54	56	-1.5	230	119	12.4	2.9	1.8	2.7	2.6	14.5	1.0	1.9	2.0	0.0	1.4	0.0	0.0	3.0	2.5	8.6	0.83
16	CL-PY39102 x CML-451	5.4	53	54	-1.7	223	108	12.2	5.0	2.0	2.6	2.9	6.3	1.0	1.2	1.5	1.2	1.9	0.0	0.0	2.8	3.0	8.5	0.86
7	CL-SCBY03 x CML-451	5.4	55	57	-2.0	221	112	13.7	4.6	1.8	2.4	2.7	3.7	1.0	1.7	1.0	1.8	1.8	1.1	1.0	2.8	2.8	19.5	0.85
12	CML-451 x CML-454	5.4	55	55	-0.7	217	103	12.5	3.2	1.8	2.2	2.5	1.1	1.0	1.2	1.5	0.4	1.4	1.0	0.0	2.8	2.5	14.4	0.82
14	CL-DTPY03 x CML-451	5.3	54	55	-1.7	224	114	13.3	5.7	2.5	2.5	3.1	12.1	1.0	2.8	1.5	2.6	1.7	0.0	1.1	3.0	2.5	24.2	0.82
9	CML-451 x CL-02843	5.3	54	56	-1.9	232	113	12.4	4.5	2.1	2.6	2.5	15.6	1.0	3.7	3.0	0.0	1.4	0.0	0.0	3.3	3.0	12.0	0.86
8	CL-G2621 x CML-413	5.3	56	57	-1.4	232	133	13.8	4.4	2.4	2.6	2.8	9.2	1.0	3.1	1.0	1.1	1.6	0.0	0.0	3.3	3.0	10.9	0.88
10	CML-451 x CML-413	5.2	56	58	-1.6	230	122	13.2	2.5	1.8	2.5	2.5	4.4	1.0	1.4	2.5	1.6	1.6	0.0	1.0	2.8	2.8	18.7	0.80
17	CL-PY39103 x CML-451	5.2	53	55	-1.5	225	111	12.2	9.8	2.1	2.6	3.0	3.2	1.0	1.5	1.5	8.3	1.9	2.0	0.0	3.3	3.3	10.4	0.76
1	CL-RCY007 x CML-451	5.2	55	56	-1.8	221	110	13.0	5.1	2.4	2.4	2.6	10.0	1.0	3.0	2.0	3.3	1.3	0.0	1.0	2.8	2.5	14.4	0.78
19	CL-G2609 x CML-287	4.8	55	56	-1.0	241	128	13.9	3.7	2.9	2.7	2.7	10.3	1.0	3.8	1.0	7.7	1.9	0.0	6.4	4.0	3.8	17.8	0.80
13	CL-02836 x CML-413	4.6	55	57	-1.9	233	133	13.3	5.7	2.5	3.1	3.1	18.2	1.0	4.2	1.5	16.5	2.3	9.4	0.0	3.5	3.3	13.0	0.83
24	Local Check	5.5	53	54	-1.2	233	126	13.3	2.3	1.9	2.6	2.4	22.3	1.0	3.2	3.0	6.6	1.6	0.0	0.0	3.3	3.3	19.3	0.92
25	Local Check	5.4	53	54	-1.1	226	122	12.8	3.3	1.9	2.5	2.3	3.1	1.0	5.0	1.5	5.5	1.8	0.0	0.0	2.8	2.5	20.2	0.85
	Check Mean	5.5	53	54	-1.1	230	124.0	13.0	3	1.9	2.6	2.3	12.7	1.0	4.1	2.25	6.1	1.7	0.0	0.0	3.0	2.9	19.7	0.89
	Grand Mean	5.5	54	56	-1.4	230	118.4	13.0	5	2	2.5	2.6	9.4	1.0	2.9	1.65	3.4	1.6	1.0	1.1	3.0	2.9	16.5	0.84
	LSD 5%	0.94	1.1	1.2		16.9	9.8	0.9																
	CV %	13.3	1.6	1.7		8.9	7.3	9.9																
	F value Loc*Entry	1.69	1.5	1.6		0.7	1.3	0.5																
	P(F>f)	0.00	0.01	0.00		0.99	0.05	1.00																
	Number of locations	8	8	8		8	8	7	7	2	8	8	4	1	6	1	3	4	1	1	1	1	1	8

No	Country	Location
1	Colombia	Villavo
2	Venezuela	Maracay, Estado Aragua
3	Venezuela	Villa de Cura, Aragua
4	Guatemala	Las Vegas, Tequisate
5	Mexico	Agua Fria
6	Mexico	Cotaxtla
7	India	Jalna
8	Vietnam	Binh Duong

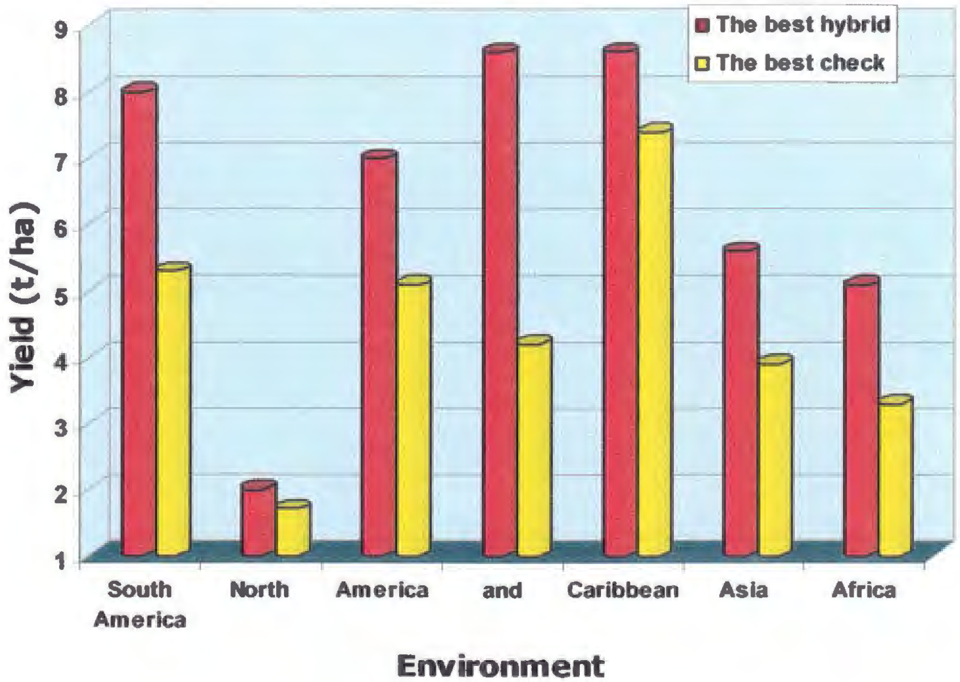
Table 19. CIMMYT Mean for different traits across environments (TSCLY02-02)

No. Locations: 8

Ent. No.	Entry Name	South America			Central America, North America			Asia		Overall means		
		1	2	3	4	5	6	7	8	Grain yield t/ha	Days to silk	Plant ht (cm)
22	CML-287 x CML-451	2.7	6.8	4.4	5.4	7.4	7.4	10.9	7.5	6.6	57	247
5	CL-RCY0011 x CML-451	2.3	3.8	6.1	5.0	8.7	7.3	9.2	6.4	6.1	54	224
11	CML-451 x CL-SW002	2.1	5.7	5.0	3.9	7.0	7.1	10.0	7.7	6.1	56	224
2	CL-RCY008 x CML-451	1.7	5.0	5.0	4.9	7.2	6.7	9.9	7.8	6.0	55	224
20	CL-02455 x CML-226	2.1	5.2	4.3	4.9	7.3	7.2	9.8	6.8	5.9	56	263
4	CL-RCY0011 x CL-02450	1.7	4.8	7.3	5.0	5.5	7.8	8.7	6.1	5.9	55	233
3	CL-RCY009 x CML-451	1.6	4.6	4.8	4.2	6.9	7.3	8.7	7.7	5.7	55	220
21	CML-452 x CML-287	2.5	4.3	2.1	4.9	7.6	7.0	9.5	7.4	5.7	54	238
23	CML-451 x CL-02450	2.0	4.8	1.6	3.9	7.7	9.1	10.4	5.1	5.6	58	225
18	CL-02838 x CML-451	2.2	4.6	2.7	4.2	5.8	7.3	9.7	7.3	5.5	58	235
15	CL-G2621 x CML451	1.1	5.7	1.2	5.1	5.3	7.4	10.7	7.1	5.5	57	238
6	CL-PY39104 x CML-451	1.1	5.0	1.1	5.3	7.1	8.4	8.9	6.6	5.4	56	230
16	CL-PY39102 x CML-451	1.6	5.4	2.4	4.8	7.4	6.8	8.0	7.0	5.4	54	223
7	CL-SCBY03 x CML-451	1.2	4.8	2.0	3.8	8.1	8.8	9.4	5.0	5.4	57	221
12	CML-451 x CML-454	2.3	5.9	1.9	4.7	7.4	7.4	7.7	5.7	5.4	55	217
14	CL-DTPY03 x CML-451	2.1	4.4	2.7	4.4	7.8	7.6	7.8	6.0	5.3	55	224
9	CML-451 x CL-02843	1.8	4.0	2.3	4.1	6.9	7.6	9.6	6.4	5.3	56	232
8	CL-G2621 x CML-413	2.1	3.9	1.0	5.8	7.3	7.6	7.7	6.7	5.3	57	232
10	CML-451 x CML-413	2.4	3.1	1.6	5.5	7.4	7.2	8.8	5.9	5.2	58	230
17	CL-PY39103 x CML-451	1.6	5.7	1.7	3.8	5.2	7.4	9.5	6.7	5.2	55	225
1	CL-RCY007 x CML-451	1.9	4.7	2.1	4.4	6.0	7.0	8.2	7.2	5.2	56	221
19	CL-G2609 x CML-287	2.1	4.7	2.1	4.5	3.0	6.8	8.8	6.5	4.8	56	241
13	CL-02836 x CML-413	1.3	3.9	1.3	4.3	6.7	6.7	7.3	5.3	4.6	57	233
24	Local Check-1	2.5	5.4	3.9	3.8	7.1	7.2	6.9	7.3	5.5		
25	Local Check-2	1.8	2.5	3.9	3.9	7.0	7.8	8.7	7.4	5.4		
MEANS		1.9	4.8	2.9	4.6	6.8	7.4	9.1	6.6	5.5		
	C.V.%	18	23	23	15	15	11	5	7	15		

No.	Country	Location
1	Colombia	Villavo
2	Venezuela	Maracay, Estado Aragua
3	Venezuela	Villa de Cura, Aragua
4	Guatemala	Las Vegas, Tequisate
5	Mexico	Agua Fria
6	Mexico	Cotaxtla
7	India	Jalna
8	Vietnam	Binh Duong

Fig. 5. TTWCW02-03. Grain yield for the best hybrid and the best local check across eight environments.



2.13 Hybrid performance of white tropical three-way cross hybrids (TTWC02-3).

Six single crosses among lines heterotic groups A&B were selected as females and crossed to 10 parents heterotic groups A&B, tropical and subtropical with good GCA.

17 three way-crosses, 6 single crosses used as females and two seed industry checks were tested under an $\propto$ alpha lattice design 5x5, with two replications and evaluated at 7 locations: Cotaxtla, Ver., and Agua Fria in Mexico, La Maquina and Nueva Concepcion in Guatemala, Turipana, Colombia, Mtuapa, Kenya and New Delhi, India. The mean yield trial across locations was 4.9 t/ha. Root lodging affected the trial severely at Cotaxtla with a mean of 25% damage.

The five best performing hybrids yielded 5.5 t/ha and outyielded the local checks with 30% and lower ear rot damage (Table 20). The best performing hybrid (CML449xCML448)CL-PWSD05 yielded 5.7 t/ha across seven locations in Africa, Asia and Latin America. Best performing hybrids at individual locations are shown in Table 21, Fig. 5.

Table 20. TTWCW02-03. Mean for different traits across seven environments

Ent no	Pedigree	Yield t/ha	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott %	Erott 1_5	Plt asp	Ear asp. 1_5	Rldg %	Sldg %	BH %	BH 1_5	Plt #	Fus %	Stunt %	EnH 1_5	P.P. 1_5	B.M. 1_5	Virus %	EPP %	Stem borer 1_5	Com. rust 1_5	Curv. 1_5	Bare tips %
5	(CML-449 x CML-448) x CL-PWSD05	**5.7**	54	54	-0.3	241	129	16	11.4	1.8	3.2	2.7	22.6	6.3	5.7	2.5	41.1	3.1	0.0	2.8	3.5	2.6	18.7	0.98	1.5	1	3	26.2
18	(CML-448 x CL-02199) x CML-449	**5.6**	52	52	0.1	222	114	16.1	7.5	1.5	3.6	2.6	24.2	7.6	1.5	2.0	41.7	3.4	0.0	2.0	3.0	2.3	19.3	0.92	1.5	1.0	2.5	21.1
4	(CML-449 x CML-448) x CL-PWSD03	**5.6**	54	54	-0.1	241	122	16.8	11.0	1.9	3.2	2.5	22.0	5.2	3.6	3.0	41.3	2.0	0.0	3.0	3.5	2.3	14.3	0.88	1.5	1.0	3.0	15.1
7	(CML-449 x CML-448) x CML-450	**5.4**	53	53	-0.4	227	117	15.7	9.6	1.6	2.9	2.8	18.4	7.9	1.5	3.0	40.6	1.0	0.0	2.0	3.0	2.5	20.2	0.94	1.8	1.0	2.0	19.6
3	(CML-449 x CML-448) x CL-RCW01	**5.4**	53	53	-0.3	226	108	16.5	9.3	1.8	3.4	2.6	15.7	2.4	2.7	2.5	42.2	0.0	0.0	2.8	3.0	2.5	25.4	0.85	1.3	1.0	3.0	8.8
2	(CML-449 x CML-448) x CL-RCW08	**5.3**	54	54	-0.2	231	133	15.5	6.5	2.0	3.2	2.8	18.3	6.8	5.2	2.5	41.4	0.0	3.1	2.5	3.3	2.3	18.1	0.91	1.3	1.0	2.0	6.4
16	(CML-449 x CL-RCW01) x CL-RCW08	**5.3**	54	54	-0.4	228	124	14.3	10.6	1.9	3.5	2.9	22.7	9.4	4.4	2.5	41.2	1.1	2.1	2.8	3.8	2.6	16.5	0.90	1.0	1.0	2.5	8.5
15	CML-449 x CL-RCW01	**5.2**	52	52	-0.3	221	110	16.3	7.8	1.6	3.6	2.7	27.5	8.2	1.3	2.0	39.4	3.1	0.0	2.0	3.8	2.8	27.6	0.95	1.3	1.0	3.0	21.8
14	(CL-RCW01 x CML-447) x CML-449	**5.2**	52	52	0.0	222	110	15.0	10.8	2.0	3.8	2.8	37.9	12.9	2.0	2.0	38.2	0.0	1.0	2.0	4.0	2.8	29.2	1.00	1.0	1.0	3.0	11.8
1	CML-449 x CML-448	**5.1**	52	53	-0.2	219	104	16.2	8.4	1.6	3.0	2.8	19.0	6.3	1.6	2.0	38.4	3.2	0.0	2.0	3.5	2.7	20.9	0.92	1.5	1.0	3.0	24.3
9	(CML-449 x CML-447) x CL-RCW08	**5.1**	54	55	-0.5	237	134	16.1	10.4	2.4	3.5	3.0	29.4	7.5	1.8	2.5	39.8	0.0	0.0	2.5	3.0	2.3	22.4	0.92	1.3	1.0	2.5	23.3
8	CML-449 x CML-447	**5.0**	53	53	-0.1	229	112	16.3	7.6	1.5	3.8	2.5	32.5	11.6	3.4	3.0	35.2	8.3	0.0	1.8	3.8	2.8	27.3	1.02	1.3	1.0	2.5	7.9
22	CML-247 x CML-254	**5.0**	56	55	0.1	215	127	15.8	5.8	1.5	2.8	2.5	17.3	6.6	2.1	2.5	38.8	6.5	0.0	3.8	2.5	2.2	11.6	0.96	1.0	1.0	2.5	10.0
20	(CL-021102 x CL-021110) x CML-449	**5.0**	53	53	0.0	229	120	15.3	10.0	1.8	3.8	2.6	21.1	13.3	4.1	3.0	39.7	1.0	1.0	2.0	4.0	2.7	13.6	1.01	1.8	1.0	2.5	14.3
21	(CL-021110 x CL-02199) x CL-RCW01	**4.9**	54	54	0.0	231	116	14.9	12.0	1.9	2.9	2.8	8.6	3.4	4.2	2.5	40.6	3.1	0.0	3.5	3.0	2.5	16.6	0.92	1.8	1.0	3.0	13.6
19	(CML-448 x CL-02199) x CL-RCW01	**4.9**	55	55	-0.1	238	113	16.7	7.9	2.1	3.0	2.8	8.0	2.7	3.8	2.0	43.2	0.0	0.0	3.3	3.0	2.5	19.0	0.90	1.3	1.0	3.0	7.1
17	CML-448 x CL-02199	**4.8**	55	55	-0.2	226	118	16.2	9.1	2.8	3.2	3.1	8.8	1.6	8.2	2.0	40.5	0.0	2.0	4.0	4.0	2.6	15.5	0.87	1.3	1.0	2.5	11.4
11	(CML-449 x CML-447) x CML-450	**4.7**	54	54	-0.1	224	119	15.3	13.4	1.9	3.3	2.8	13.7	9.6	2.8	2.0	38.2	2.1	2.1	2.0	3.5	2.7	30.2	0.95	1.5	1.0	2.0	19.9
24	(CML-247 x CML-254) x CL-R1	**4.7**	54	54	-0.1	238	130	14.4	7.7	1.9	3.5	2.9	22.4	17.0	5.8	2.0	39.4	4.2	1.0	3.0	4.0	2.7	10.1	0.96	1.3	1.0	3.0	9.2
23	(CL-021102 x CL-021110) x CML-450	**4.6**	55	55	-0.3	231	116	15.6	8.5	2.4	3.1	3.0	6.3	10.3	6.5	3.0	38.6	3.1	0.0	3.3	3.3	2.5	14.0	0.93	1.5	1.0	2.0	18.5
6	(CML-449 x CML-448) x CML-446	**4.6**	54	55	-0.3	231	124	16.0	7.7	2.4	3.7	2.9	43.5	6.1	1.9	2.0	36.7	3.2	1.1	3.3	3.8	2.8	29.0	0.89	1.5	1.0	3.0	7.3
13	(CL-RCW01 x CML-447) x CL-RCW08	**4.4**	56	56	-0.1	229	123	15.6	14.7	2.4	3.0	3.1	10.9	2.2	2.7	2.5	39.3	0.0	1.0	2.5	3.0	2.4	14.2	0.88	1.0	1.0	2.5	12.3
10	(CML-449 x CML-447) x CML-446	**3.9**	54	55	-0.2	239	133	15.9	10.5	3.0	4.1	3.2	44.5	13.4	0.0	2.0	35.6	6.4	4.3	2.3	3.8	2.8	21.4	0.95	1.3	1.0	3.0	11.6
12	CL-RCW01 x CML-447	**3.5**	56	56	0.0	210	100	16.7	17.3	2.0	3.6	3.6	7.9	2.1	2.1	2.0	40.1	1.1	0.0	2.0	3.8	2.8	23.2	0.88	1.8	1.0	3.0	7.9
25	Local Check	4.4	53	53	-0.1	228	122	14.6	15.1	2.9	3.3	3.1	19.5	9.4	0.3	2.5	39.0	2.0	1.0	3.0	3.5	2.4	12.5	0.90	2.0	1.0	2.5	14.1
	Check Mean	**4.4**	53	53.4	-0.1	228	121.7	15	15	2.9	3.3	3.1	19.5	9.4	0.3	2.5	39.04	2.0	1.0	3.0	3.5	2.4	12.5	0.90	2.0	1.0	2.5	14.1
	Grand Mean	**4.9**	54	54.1	-0.2	228	119.0	16	10	2	3.4	2.8	21.0	7.5	3.3	2.4	39.6	2.3	0.8	2.6	3.4	2.6	19.9	0.93	1.4	1.0	2.7	14.1
	LSD 5%	**0.85**	1.0	1.0		9.9	7.9	1.8																				
	CV %	**12.79**	1.6	1.5		4.4	7.5	9.8																				
	F value Loc*Entry	**1.61**	1.0	1.3		0.7	0.6	1.2																				
	P(F>f)	**0.00**	0.56	0.07		0.95	1.00	0.19																				
	Number of locations	**7**	6	7		6	6	7	6	2	6	6	6	7	4	1	7	1	1	1	1	3	2	7	1	1	1	1

No	Country	Location
1	Colombia	Turipana
2	Guatemala	La Maquina
3	Guatemala	Nueva Concepcion
4	Mexico	Agua Fria
5	Mexico	Cotaxtla
6	Kenya	Mtwapa
7	India	New Delhi

Table 21: CIMMYT Mean for different traits across environments (TTWCW02-03)

No. Locations: 7

Ent. No.	Entry Name	South America	Central America, North America and Caribbean				Asia	Africa	Overall means: Grain yield (t/ha)	Overall means: Days to silk	Overall means: Plant ht (cm)
		1	2	3	4	5	6	7			
5	(CML-449 x CML-448) x CL-PWSD05	6.9	1.3	6.0	8.6	8.2	3.7	5.1	5.7	54	241
18	(CML-448 x CL-02199) x CML-449	8.0	1.4	6.6	7.7	8.0	4.9	2.9	5.6	52	222
4	(CML-449 x CML-448) x CL-PWSD03	6.6	1.8	6.7	7.7	7.2	5.6	3.8	5.6	54	241
7	(CML-449 x CML-448) x CML-450	6.7	1.6	7.0	7.8	6.7	4.4	3.7	5.4	53	227
2	(CML-449 x CML-448) x CL-RCW08	7.3	1.3	6.5	7.2	7.1	5.5	2.5	5.3	54	231
16	(CML-449 x CL-RCW01) x CL-RCW08	6.4	2.0	6.6	7.9	7.2	4.6	2.3	5.3	54	228
3	(CML-449 x CML-448) x CL-RCW01	7.0	1.3	6.0	8.1	7.0	3.4	4.0	5.3	53	226
15	CML-449 x CL-RCW01	6.8	2.0	6.6	7.8	6.7	3.7	2.9	5.2	52	221
14	(CL-RCW01 x CML-447) x CML-449	5.5	1.7	6.4	6.7	8.6	4.5	2.9	5.2	52	222
1	CML-449 x CML-448	6.1	1.5	6.7	7.5	6.2	4.6	3.3	5.1	53	219
9	(CML-449 x CML-447) x CL-RCW08	5.8	1.6	6.5	7.3	7.6	4.5	2.2	5.1	55	237
8	CML-449 x CML-447	5.1	1.8	7.0	6.8	7.2	3.5	3.7	5.0	53	229
20	(CL-021102 x CL-021110) x CML-449	6.8	1.9	6.7	6.5	7.1	4.0	1.9	5.0	53	229
22	CML-247 x CML-254	7.0	1.5	5.7	6.7	6.3	4.4	3.3	5.0	55	215
21	(CL-021110 x CL-02199) x CL-RCW01	6.3	1.5	6.2	5.7	7.3	3.8	3.6	4.9	54	231
19	(CML-448 x CL-02199) x CL-RCW01	6.8	1.6	6.0	5.2	6.3	3.9	4.2	4.9	55	238
17	CML-448 x CL-02199	6.4	1.2	6.1	4.6	6.8	5.6	2.9	4.8	55	226
11	(CML-449 x CML-447) x CML-450	5.3	1.4	5.5	6.6	7.5	3.6	3.4	4.7	54	224
24	(CML-247 x CML-254) x CL-R1	5.7	1.1	6.6	6.5	6.5	3.2	3.2	4.7	54	238
6	(CML-449 x CML-448) x CML-446	5.6	1.1	6.6	4.3	6.4	5.1	3.4	4.6	55	231
23	(CL-021102 x CL-021110) x CML-450	6.2	1.0	6.4	6.4	6.9	3.9	1.6	4.6	55	231
13	(CL-RCW01 x CML-447) x CL-RCW08	5.0	1.3	5.3	6.5	4.8	4.9	3.0	4.4	56	229
10	(CML-449 x CML-447) x CML-446	4.3	1.3	6.2	4.6	3.8	3.9	3.3	3.9	55	239
12	CL-RCW01 x CML-447	4.8	0.8	4.0	3.9	3.3	3.1	4.3	3.5	56	210
25	Local Check	5.3	1.7	5.1	4.2	7.4	3.9	3.3	4.4		
MEANS		6.2	1.5	6.2	6.6	6.7	4.3	3.2	5.0		
	C.V.%	10	23	7	8	14	17	18	14		

No	Country Pais	Location Localidad
1	Colombia	Turipana
2	Guatemala	La Maquina
3	Guatemala	Nueva Concepcion
4	Mexico	Agua Fria
5	Mexico	Cotaxtla
6	Kenya	Mtwapa
7	India	New Delhi

2.14 Yield performance of yellow three –way cross hybrids (TTWCY02-04).

Tropical yellow TWC hybrids with high yield potential are still difficult to form. The genetic characteristic related with plant and ear placement is difficult to manipulate, as a consequence most of the TWC hybrid appearance looks tall and ear placement inadequate.

Most developing countries in Latin America plant hybrid seed use TWC or double cross hybrids. Therefore, it is very important to develop the proper germplasm adapted to maize growing conditions. A three-way cross hybrid should meet three important conditions: 1) Good yield potential and standability in farmers' fields. 2) Good yield and standability of the single cross female in seed production fields. 3) Good plant height, pollen shedding and standability of the male parent and ability to compete with single cross female.

The selection of the parents in each progenitor should be planned well in advance apart from good GCA. The parents must be carefully selected according to heterotic response, yield *per se*, good standability, ear rot resistance, lower ear placement and general foliar disease and husk cover. Particularly important is ear placement located in the lower half of the plant, height and good roots, a male or female parent susceptible to lodging is the most undesirable The criteria mentioned above was strictly applied in the selection of parents involved in the TWC hybrid formation of the present work.

In this study we selected five yellow single crosses that we used as females and twelve yellow lines with good GCA. 47 yellow TWC five single crosses used as females and 3 checks were evaluated under ∝ lattice 5x11 design and tested in five tropical locations in Mexico, Colombia, Guatemala and India.

Highly significant statistical differences for yield and agronomic traits were found at individual and across locations. Hybrid x location interaction revealed the importance of GxE. Best 7 TWC hybrids yielded from 6.3 to 7.0 t/ha, 1.2 to 2.3 t/ha more than the local checks (1 to -2 LSD). Table 22 shows the performance of superior hybrids at individual locations. TWC yellow hybrids (CML451 x CML287)xCL-RCYX18 and (CML451xCML287)xCL-RCY005 topped the trial and outyielded the best single cross hybrid female CML451 x CML287 (Tables A72 to A73).

Table 22. TTWCW02-04. Tropical Three Way Crosses Yellow across five locations in 2002.

Ent no	Pedigree	Yield t/ha	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott 1_5	Erott %	Plt asp	Ear asp 1_5	Rldg %	Sldg %	P.P. 1_5	B.M. 1_5
8	(CML451*CML287) x CL-RCYX18	**7.01**	55	55	0.1	249	136	12.8	1.8	4.6	2.4	2.5	13.0	0.8	2.5	2.9
3	(CML451*CML287) x CL-RCY005	**6.99**	55	55	-0.3	236	131	14.7	1.5	5.4	2.6	2.3	12.4	1.4	2.8	2.9
28	(CL-02450*CML451) x CL-02836	**6.64**	56	55	0.6	231	130	14.8	2.8	10.0	2.8	2.8	5.5	2.2	3.0	3.0
37	(CL-02450*CL-03618) x CL-02836	**6.50**	55	55	0.1	241	135	13.6	1.8	4.5	3.1	2.5	8.4	1.2	3.3	2.5
15	(CL-02450*CL-02836) x CL-RCY005	**6.43**	55	55	0.2	229	137	14.2	2.0	5.2	3.0	2.5	11.8	1.8	3.3	2.5
31	(CL-02450*CML451) x POB.45c8-76-1-	**6.32**	54	54	-0.4	220	116	13.8	1.8	8.9	2.9	2.6	6.6	0.8	2.8	2.9
25	(CL-02450*CML451) x CL-RCY005	**6.27**	54	55	-0.9	216	118	14	1.6	5.3	2.8	2.2	13.9	1.5	2.5	2.8
33	CL-02450 x CL-03618	**5.74**	54	54	-0.2	242	134	13.6	1.5	4.7	2.6	2.6	21.0	0.9	2.5	2.5
20	(CL-02450*CL-0283[illegible] x [CATETO DC 1	**5.59**	55	55	-0.4	246	138	13.3	2.3	9.2	3.0	2.6	9.3	2.0	3.5	3.0
22	CL-02450 x CML451	**5.44**	55	56	-0.7	225	120	14.2	1.6	3.6	2.6	2.5	4.7	0.6	2.5	2.5
54	Local Check	**4.90**	53	53	-0.3	233	128	12.2	1.9	5.5	3.1	2.7	10.2	4.1	3.3	3.1
55	Local Check	**4.94**	54	54	-0.5	232	134	12.5	1.8	4.3	3.2	2.5	18.8	3.8	3.5	3.1
	Check Mean	**4.92**	53	53.7	-0.4	232	131	12	1.8	5	3.2	2.6	14.5	3.9	3.4	3.1
	Grand Mean	**5.43**	55	55	-0.3	232	130	14	2	7	2.9	2.7	13.4	2.4	3.1	2.8
	LSD 5%	**1.12**	1.4	1.1		20.1	10.7	1.7								
	CV %	**13.91**	1.4	1.6		9.4	7.9	12.5								
	F value Loc*Entry	**1.41**	1.5	1.0		0.5	0.7	0.7								
	P(F>f)	**0.01**	0.00	0.50		1.00	1.00	1.00								
	Number of locations	**5**	4	5		5	5	4	2	4	5	5	4	5	1	2

2.15 Hybrid yield performance of tropical white Three-Way Crosses (TTWC02-5).

Six tropical late white single crosses among lines heterotic groups A&B were selected as females and crossed to 10 parents heterotic groups A&B, tropical and subtropical with good GCA.

55 three way-crosses, 5 single crosses used as females and five seed industry checks were tested under an ∝ alpha lattice design 13x5, with two replications and evaluated at 2 locations: Cotaxtla, Ver., and Agua Fria, Mexico. The mean yield trial across locations was 7.3 t/ha, 7.4 and 7.1 at Cotaxtla and Agua Fria, respectively. Root lodging affected the trial severely at Cotaxtla with a mean of 25% damage.

The 9 best performing hybrids yielded from 8.0 to 9 t/ha and outyielded the local checks with up to 34% and lower ear rot damage, and showed good standability (Table 23). The best performing TWC hybrid (CL-RCW18 x CML254)CL02119 yielded 8.6 t/ha across locations, 8.9 t/ha (Table A74) at Cotaxtla and 8.2 t/ha (Table A75) at Agua Fria and 8.6 t/ha across locations (Table A76).

The top performing hybrids at individual locations are:

(CLRCW18xCML254) CL-PWSD05 = 9.7 t/ha, (CL-04262 x CML254) = 9.7 t/ha at Cotaxtla, Mexico and (CL04368xCl-SPLW04) x (CML265xCL-00303-S7 = 8.0 t/ha, at Agua Fria.

9 hybrids selected in this study will be tested in Latin America and Africa in the CHTTW 03. It is recommended to initiate on-station testing in Central America and South America with the flint, white endosperm hybrids which can be effectively tested in on-farm trials in Colombia and Venezuela.

Table 23. TTWCW02-05 Top nine tropical late white TWC across two locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %
1	CL-04368 x CL-SPLW04	**8.65**	**8.82**	**129**	**136**	2.0	51	0.56	0.95	22.0	3.5	2.8	20.7	3.6	9.1
2	(CL-04368 x CL-SPLW04) x (CML265*CL-00303)-S7*CML264)-B-3	**8.55**	**8.71**	**128**	**134**	1.8	52	0.55	1.00	23.4	4.0	2.5	13.1	10.0	0.4
49	(CL-RCW18 x CML254) x CL-021119	**8.26**	**8.61**	**124**	**130**	4.1	52	0.51	0.98	23.8	3.9	2.7	29.5	2.9	10.0
23	CL-04362 x CML254	**8.22**	**8.47**	**123**	**129**	3.0	51	0.61	1.07	22.2	3.8	2.8	13.4	1.1	3.3
34	CL-FAWW11 x CML343	**8.15**	**8.38**	**122**	**128**	2.7	53	0.53	1.00	23.0	2.8	2.6	9.0	3.9	0.6
51	(CL-RCW18 x CML254) x CL-04377	**7.99**	**8.73**	**120**	**125**	8.5	51	0.52	0.99	24.9	4.2	3.0	18.5	4.7	17.8
50	(CL-RCW18 x CML254) x CL-PWSD05	**7.94**	**8.19**	**119**	**125**	3.0	53	0.53	1.04	24.2	4.1	2.7	4.3	6.1	5.3
3	(CL-04368 x CL-SPLW04) x CML264	**7.86**	**8.20**	**118**	**123**	4.1	53	0.51	0.98	26.7	3.4	2.7	14.2	0.4	4.6
46	(CL-RCW18 x CML254) x (CML265*CL-00303)-S7*CML264)-B-3	**7.83**	**7.97**	**117**	**123**	1.7	53	0.54	1.00	21.8	2.9	2.5	4.7	0.9	1.5
61	(CML247 x CML254) x R1	**5.41**	**5.79**	**81**	**85**	6.4	50	0.56	0.87	24.1	4.7	3.1	38.4	11.5	5.7
62	CML448 x CML449	**5.44**	**5.96**	**81**	**85**	8.8	50	0.47	0.95	26.0	4.4	3.4	45.1	3.2	0.5
63	CML442 x CML444	**5.18**	**6.22**	**78**	**81**	16.8	53	0.56	0.91	24.5	3.9	3.8	18.2	7.5	0.0
64	CML247 x CML254 RE	**6.68**	**6.75**	**100**	**105**	1.1	53	0.55	0.93	27.8	2.5	2.5	7.1	0.9	2.5
65	LOCAL CHECK	**6.37**	**6.85**	**95**	**100**	7.0	51	0.55	1.02	24.3	4.2	3.3	31.1	14.2	0.0
	Check Mean	**5.81**	**6.31**			8.0	51	0.54	0.94	25.3	3.9	3.2	28.0	7.5	1.7
	Grand Mean	**6.84**	**7.26**			5.7	52	0.55	0.96	23.9	3.9	3.0	20.2	4.9	4.6
	LSD 5%	**1.18**	**1.24**			4.7	1.1	0.0	0.1	2.7	0.6	0.4	18.9	7.6	7.1
	CV %		**9.73**			7.1	2.1	5.6	9.3	10.9	13.1	10.5	10.9	8.6	8.7
	F value Loc*Entry		**1.55**			1.0	0.5	0.4	0.7	0.5	0.8	1.0	1.2	1.1	1.0
	P(F>f)		**0.03**			0.4	1.0	1.0	0.9	1.0	0.9	0.6	0.2	0.4	0.5
	Number of locations		**2**			2	2	2	2	2	2	2	2	2	2

2.16 Combining ability of single cross females and male lines and hybrid yield performance (TTWCW02-6).

A three-way cross hybrid should meet three important conditions: 1) Good yield potential and standability in farmers' fields. 2) Good yield and standability of the single cross female in seed production fields. 3) Good plant height, pollen shedding and standability of the male parent and ability to compete with single cross female.

The selection of the parents in each progenitor should be planned well in advance apart from good GCA. The parents must be carefully selected according to heterotic response, yield *per se*, good standability, ear rot resistance, lower ear placement and general foliar disease and husk cover. Particularly important is ear placement located in the lower half of the plant, height and good roots, a male or female parent susceptible to lodging is the most undesirable. The criteria mentioned above was strictly applied in the selection of parents involved in the TWC hybrid formation of the present work.

10 single crosses among lines heterotic groups A&B were selected as females and crossed to 9 parents with good GCA.

48 three way-crosses, 10 single crosses used as females, two single crosses reference entry and five seed industry checks were tested under an $\propto$ alpha lattice design 5x13, with two replications and evaluated at 7 locations: Cotaxtla, Ver., Agua Fria and Tampico, in Mexico; Turipana, Colombia; Cuyuta, Guatemala; Comayagua, Honduras and Bihar, India.

A design II NC analysis was applied to estimate combining ability in crosses among five single crosses, female parents and five lines male parents, in the model the genotypes were considered fixed and sites at random.

The mean yield trial across locations was 7.7, 6.8 and 7.6 t/ha at Agua Fria and Cotaxtla, respectively. Root lodging affected the trial severely at Cotaxtla with a mean of 52% damage. Mean yield at Turipana was 6.1, with 6.9 at Cuyuta, 6.7 at Tampico where ear rot showed the highest mean (16.4) with negative correlation with yield (r=-0.47), at Bihar, India, 8.4 t/ha and the highest mean yield (10.7 t/ha) and an ear rot mean of 16 % was obtained at Comayagua, Honduras, that is reflected in reduction of the mean clean yield to 9.3 t/ha, nevertheless, some hybrids such as (CML269 x CL-02181)CLRCW42 and (CML264 x CML269)xCML449 showed resistance to ear rot and the reduction in yield was only 4.8 and 6.7% respectively. The complete information on the performance of hybrids at individual and across locations is showed in Tables A77 to A84. Fig 6 shows the performance of the best hybrids at each individual location.

Seven new TWC hybrids outyielded the local checks from 2.5 to 1 t/ha or up 35% more yield, some of the new hybrids were resistant to ear rot, root lodging, and FSR while the checks showed susceptibility to these important economic traits (Table 24). (CML398xCML269)CL-RCW42 topped the trial across location and ranked first to sixth at individual locations demonstrating good yield stability, (CML 269xCL-02181)CL-RCW42 also showed stability with 9.0 t/ha across locations (Table 24).

GCA is a statistic frequently used by plant breeders to identify new lines as parents in hybrid combinations, but GCA for single crosses is very seldom used with the same objectives. The GCA estimates for single crosses and lines is presented in Table 25. CML448xCML449 showed the highest positive and significant GCA =0.317 three times the SE of GCA, L_6, L_8 and L_9 showed the best GCA estimates among lines.

CML448xCML449 will be now used extensively in TWC hybrid formation. The superior TWC yielded 40% more than CML442xCML444 and CML247xCML254 with 20 % showing good yield stability across seven locations, therefore they should be tested in Africa, and Latin America provide farmers the opportunity of increase productivity in their maize growing systems. CML247xCML254 has been used extensively as female in TWC hybrid combinations by the seed industry in Latin America with good success, therefore, it is expected that the new TWC will play an important role in increasing maize productivity after they are accepted by farmers because they fulfill the characteristics of good TWC mentioned above.

Table 24. TTWCW02-06 Top eight tropical late white TWC across six locations in 2002B

Ent no	Pedigree		Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Css 1_5
49	CML269	x CL-02181	**9.39**	**9.71**	**113**	**135**	3.3	64	0.52	1.01	20.2	3.3	2.3	14.5	3.9	2.2	2.2
50	(CML269 x CL-02181)	x CL-RCW42	**8.74**	**8.98**	**105**	**126**	2.7	66	0.53	1.04	22.2	3.5	2.2	11.6	2.9	3.2	0.7
53	(CML398 x CML269)	x CL-RCW42	**8.70**	**9.00**	**104**	**125**	3.3	65	0.51	0.94	19.8	3.6	2.5	18.5	3.8	1.5	2.1
8	(CML448 x CML449)	x CL-RCW36	**8.57**	**8.93**	**103**	**124**	4.0	66	0.53	0.96	20.9	3.1	2.1	4.5	1.8	3.9	2.5
46	(CML264 x CML269)	x CML449	**8.50**	**8.67**	**102**	**122**	2.0	62	0.52	1.04	21.4	3.5	2.8	20.5	2.9	0.0	3.2
16	(CML449 x CML447)	x CL-RCW49	**8.16**	**8.82**	**98**	**118**	7.4	64	0.51	1.02	21.3	3.4	2.6	9.2	2.6	8.3	7.9
51	(CML269 x CL-02181)	x CL-RCW43	**8.14**	**8.53**	**98**	**117**	4.6	65	0.52	1.01	21.3	3.4	2.7	4.4	4.4	6.0	4.7
5	(CML448 x CML449)	x CL-RCW37	**8.09**	**8.28**	**97**	**117**	2.3	64	0.50	0.99	22.0	3.4	2.3	7.4	2.6	2.9	3.5
60	CML442	x CML444	**6.13**	**6.91**	**74**	**88**	11.2	66	0.52	0.89	21.2	3.5	3.0	3.7	6.0	2.4	6.3
61	CL-04368	x CL-SPLW04	**8.36**	**9.11**	**100**	**120**	8.2	65	0.55	1.09	20.2	3.3	2.1	13.6	11.0	6.2	5.0
62	CL-FAWW11	x CML343	**8.34**	**8.65**	**100**	**120**	3.6	67	0.52	0.98	21.4	3.1	2.5	3.6	3.6	1.6	7.7
63	CL-04362	x CML254	**7.77**	**8.10**	**93**	**112**	4.1	66	0.59	1.11	20.9	3.1	2.9	5.6	4.3	2.0	4.6
64	LOCAL CHECK 1		**6.38**	**6.88**	**76**	**92**	7.3	64	0.53	0.97	19.8	3.6	2.8	15.7	8.2	1.2	5.2
65	LOCAL CHECK 2		**6.94**	**7.25**	**83**	**100**	4.3	64	0.55	0.96	20.6	3.3	2.8	17.0	5.9	2.4	6.5
		Check Mean	**7.32**	**7.82**			6.4	65	0.54	1.00	20.7	3.3	2.7	9.9	6.5	2.6	5.9
		Grand Mean	**7.29**	**7.73**			5.7	64	0.51	0.98	21.1	3.4	2.6	12.4	3.4	3.1	4.0
		LSD 5%	**0.69**	**0.71**			3.6	0.9	0.0	0.1	1.3	0.5	0.3	10.6	3.6	2.5	3.3
		CV %		**10.45**			7.2	1.6	8.0	7.5	5.2	14.3	14.8	8.3	7.8	7.8	52.5
		F value Loc*Entry		**1.21**			1.1	1.2	0.7	0.6	2.2	0.8	1.0	2.3	1.4	0.8	1.2
		P(F>f)		**0.06**			0.2	0.0	1.0	1.0	0.0	0.9	0.5	0.0	0.0	1.0	0.2
		Number of locations		**6**			5	6	6	5	6	3	5	5	5	5	2

Table 25. TTWCW02-06. GCA and standard erors for grain yield estimates for females (single cross hybrids) and males (inbred lines).

Across five Locations. 2002 B

1. Grain yield and GCA values.

	L6	L7	L8	L9	L10	MEAN	GCA
SC1	8.17	7.57	7.72	8.47	6.57	7.70	**0.317**
SC2	7.63	7.29	7.52	7.44	6.29	7.23	**-0.150**
SC3	7.57	7.19	7.52	7.23	7.59	7.42	**0.039**
SC4	6.47	7.45	6.72	7.32	6.98	6.99	**-0.396**
SC5	8.24	6.08	7.94	7.82	7.80	7.57	**0.191**
MEAN	7.62	7.12	7.48	7.66	7.05		
GCA	**0.232**	**-0.269**	**0.100**	**0.274**	**-0.338**		

GCA St.error female SC hybrids = 0.140

GCA St.error inbred lines = 0.137

2. GCA values by locations

LOC	Female (SC hybrids)						Inbred lines					
	L1	L2	L3	L4	L5	GCA SE	L6	L7	L8	L9	L10	GCA SE
LOC 1	-0.227	0.083	0.327	-0.272	0.087	0.164	0.538	-0.505	0.313	-0.115	-0.233	0.164
LOC 2	0.511	-0.493	-1.021	0.171	0.833	0.314	-0.927	0.165	-0.051	0.673	0.141	0.314
LOC 3	0.608	-0.224	0.076	-0.716	0.256	0.148	0.754	0.068	-0.322	0.038	-0.538	0.148
LOC 4	0.474	-0.354	0.184	-0.630	0.326	0.144	0.070	-0.230	0.170	0.436	-0.446	0.144
LOC 5	0.220	0.236	0.626	-0.534	-0.550	0.301	0.726	-0.842	0.390	0.336	-0.612	0.301

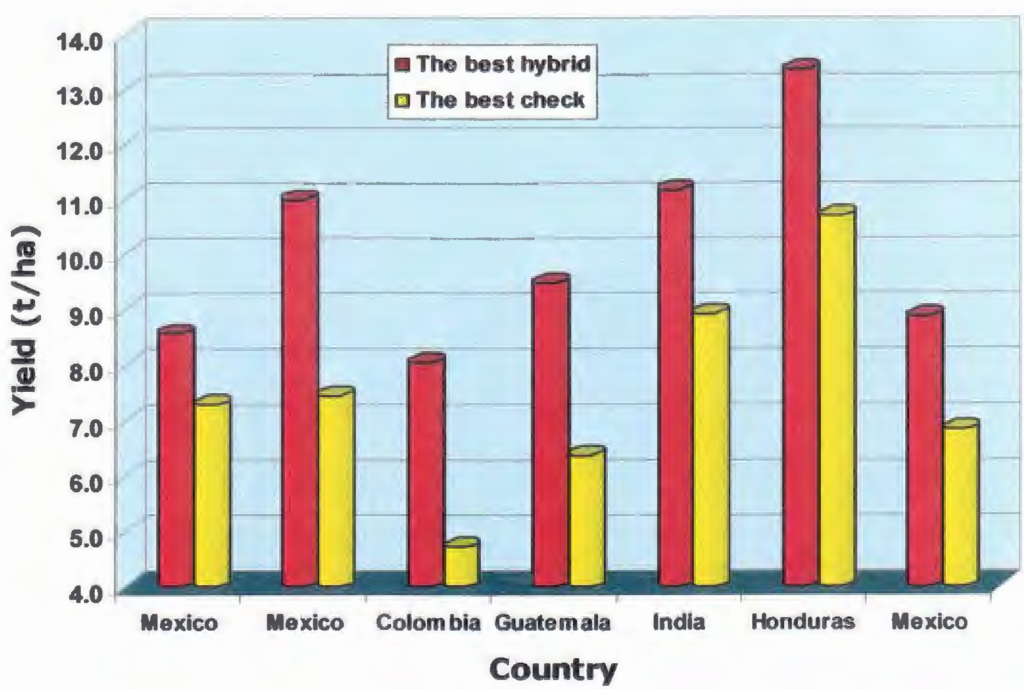
Females (single-cross hybrids)

SC1 (CML448 x CML449)
SC2 (CML449 x CML447)
SC3 (CML449 x CL-RCW01)
SC4 (CL-RCW01 x CML447)
SC5 (CML264 x CML269)

Males (inbred lines)

SC6 (CL-04345*CL-274)-B-113-2-1-B
SC7 (CL-04346*CL-02513)-B-69-1-1-B
SC8 (CL-04347*CL-04904)-B-55-1-B
SC9 (CL-04347*CL-04904)-B-109-2-1-B
SC10 (CL-04345*CL-274)-B-15-1-2-B

Fig. 6. TTWCW02-06. Grain yield for the best hybrid and the best local check across seven environments



2.17 Combining Ability of Tropical Yellow single Crosses and Lines and Yield performance of Three Way Cross Hybrids (TTWCY02-07).

Tropical yellow TWC hybrids with high yield potential are still difficult to form. The genetic characteristic related with plant and ear placement is difficult to manipulate, as a consequence most of the TWC hybrid appearance look tall and ear placement inadequate.

Most developing countries in Latin America plant hybrid seed use TWC or double cross hybrids. Therefore, it is very important to develop the proper germplasm adapted to maize growing conditions. A three-way cross hybrid should meet three important conditions: 1) Good yield potential and standability in farmers' fields. 2) Good yield and standability of the single cross female in seed production fields. 3) Good plant height, pollen shedding and standability of the male parent and ability to compete with single cross female.

The selection of the parents in each progenitor should be planned well in advance apart from good GCA. The parents must be carefully selected according to heterotic response, yield *per se*, good standability, ear rot resistance, lower ear placement and general foliar disease and husk cover. Particularly important is ear placement located in the lower half of the plant, height and good roots, a male or female parent susceptible to lodging is the most undesirable. The criteria mentioned above was strictly applied in the selection of parents involved in the TWC hybrid formation of the present work.

In this study we selected 4 yellow tropical late single crosses among lines selected within and between heterotic groups to be used as females and ten lines with good GCA that combine well with both parents, selected to make up the single cross females, to be used as male parents. The 39 TWC's, the 4 single crosses used as females, plus 2 checks were tested under a $\propto$ lattice design 5x9 with two replications and were shipped to twelve locations in Mexico, Guatemala, Colombia, Honduras, Panama and India. The estimates GCA and SCA effects were based in a 4x8 NC design II using single crosses as female parents and lines as male parents. The objectives of this work are to estimate GCA and SCA effects for yield as a mean of selecting the best SC for female in future TWC formation and the best parents lines for males, identify superior yellow TWC hybrids for testing internationally and lines to form synthetics.

Highly significant statistical differences were detected at variables studied in the ANOVA at individual and across locations. Mean yields: 8, 7, 9.6, 6.2 t/ha at Agua Fria, Zacapa, Guatemala, Turipana, Colombia, respectively and 3.4 t/ha at La Maquina, the lowest mean yield at La Maquina, Guatemala was due to severe CS damage (43% with a correlation with yield r= - 0.30) affecting the yield. The tallest plant height mean, 254 cm with the highest root lodging mean 22 % was obtained at Cotaxtla, Veracruz, Mexico and mean yield 7.5 t/ha. The superior mean yield was record at Comayagua , Honduras 10.2 t/ha followed by Bihar winter planting at India with 8.5 t/ha. Mean yields at El Ejido, Panama 5.6 t/ha was the second lower and 6.7 t/ha at Tampico, Mexico. In Paraguay we planted 3 locations and the mean yields were 5.04, 8.1 and 5.8 t/ha at Capitan Miranda, Paraguay and San Juan Bautista respectively and 7 t/ha across twelve locations in Latin America and Asia. The most important disease affecting yield at individual locations was ear rot that showed 16%

ears damaged reducing the mean yield from 6.7 to 5.6 t/ha at Tampico, Mexico, nevertheless, the best new TWC hybrid yielded 8 t/ha and showed resistance to ear rot (5.7 % damage) the most susceptible material was the seed industry check A7573 that showed 29 % ear rot damage the correlation with yield of this disease was r= 0-.55*. Similar response was noted at Capitan Miranda where the best performing hybrid yielded 7 t/ha and only 5% ear damage, while the seed industry check DK350 showed 21 % ear rot damage and yielded only 2.6 t/ha (poor stand also).

Table 26 shows the best performing 11 entries across 12 locations. Nine hybrids were one LSD above the trial mean and 11 hybrids outperformed the local check across locations. Plant height and ear placement in the new yellow TWC hybrids and SC female parents is very acceptable coinciding with the description of good TWC hybrid discussed above, confirming that the selection of the parents performed initially worked effectively (Picture 1). The yield of the single cross parents is also very good and guarantee attractive seed yield for seed growers.

Eleven hybrids are three-way crosses, and two are the single crosses used as females, all 10 hybrids outyielded the seed industry check with 20 up to 30% more grain yield than the local checks. The best TWC hybrids yielded 7.5 t/ha while its female parent also yielded good (CML451 x CL-SW002) CL-RCY017 7.5 t/ha while CML451 x CL-SW002 single cross parent yielded 6.7 t/ha, (CML451xCL-02450)CL-RCY015 =7.4 t/ha and CML451xCL-02450, 7.1 t/ha.

This performance will permit to provide new TWC attractive for both the seed producers and the commercial farmers. The selected hybrids also showed good yield stability.

Tables A85 to A98 show the performance of all TWC and single cross hybrids at individual and across locations (Fig. 7).

GCA and SCA estimates for single crosses will assist us in selecting the best SC parents for future use in TWC formation CML451xCL-02450 and CML451xCL-SW002 presented the best GCA effects for SC parents, up to four time SE for GCA for single crosses, they will be used as female parents in TWC hybrids formation while lines: L_8, L_{10} and L_{11}, showed the best GCA estimates for lines they will be used as males in TWC combinations (Table 27).

For three consecutive years the tropical lowland subprogram has been searching for appropriate germplasm to develop yellow TWC hybrids with good yield potential and stability and attractive to farmers and seed producers. We believe that today we have accomplished this task and developed such type of hybrids that will definitively assist the public and private seed industry to provide farmers with high quality germplasm to improve maize productivity in the developing world. The selected hybrids also showed good yield stability and should be tested extensively in Latin America and Asia.

Picture 1. CL02450 x CML451

Table 26. TTWCY02-07 Top eight tropical late yellow TWC across 12 locations in 2002B

Ent no	Pedigree		Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Css 1_5
20	(CML451 x CL-SW002)	x CL-RCY017	**7.05**	**7.48**	**103**	**129**	5.8	65	0.54	0.99	17.4	2.4	2.4	4.2	11.6	4.3	17.0
10	(CML451 x CL-02450)	x CL-RCY015	**7.02**	**7.44**	**103**	**129**	5.6	65	0.53	1.01	16.6	2.6	2.4	5.9	19.7	2.3	18.4
6	(CML451 x CL-02450)	x CL-RCY014	**6.98**	**7.50**	**102**	**128**	6.8	65	0.52	0.99	17.5	2.8	2.2	11.1	16.0	9.1	10.5
21	(CML451 x CL-SW002)	x CL-RCY015	**6.98**	**7.48**	**102**	**128**	6.6	64	0.51	1.00	16.6	2.7	2.4	10.1	17.2	3.7	15.4
17	(CML451 x CL-SW002)	x CL-RCY014	**6.97**	**7.67**	**102**	**128**	9.2	64	0.51	0.98	16.7	2.6	2.3	13.2	12.2	11.0	14.4
22	(CML451 x CL-SW002)	x CL-RCY016	**6.87**	**7.45**	**101**	**126**	7.8	64	0.53	0.99	16.9	2.8	2.4	7.5	15.9	4.1	13.3
11	(CML451 x CL-02450)	x CL-RCY016	**6.81**	**7.40**	**100**	**125**	7.9	65	0.55	0.99	17.1	2.5	2.4	10.7	19.1	3.6	17.6
33	CML451 x CL-02844)	x CL-RCY016	**6.78**	7.31	**99**	**124**	7.3	65	0.51	1.01	17.1	2.7	2.4	9.6	20.5	3.7	19.0
28	CML451 x CL-02844)	x CL-RCY014	**6.71**	**7.26**	**98**	**123**	7.6	64	0.50	0.99	16.6	2.7	2.3	16.5	14.0	11.3	12.3
29	CML451 x CL-02844)	x CL-RCY005	**6.71**	**7.07**	**98**	**123**	5.1	66	0.55	0.95	17.2	2.6	2.2	7.0	17.9	2.8	18.4
18	(CML451 x CL-SW002)	x CL-RCY005	**6.70**	**7.17**	**98**	**123**	6.6	65	0.54	0.94	17.9	2.8	2.3	10.9	12.8	3.9	18.1
1	CML451	x CL-02450 RE	**6.58**	7.14	**97**	**121**	7.8	66	0.52	0.95	17.4	2.5	2.4	7.7	16.7	4.3	14.5
43	CML451	x CML287	**6.82**	**7.48**	**100**	**125**	8.9	66	0.52	0.95	17.4	2.5	2.2	9.2	15.9	6.4	18.9
44	CML451	x CL-MDRY01	**6.03**	**6.93**	**88**	**111**	13.0	65	0.50	0.96	15.8	2.8	2.4	5.2	14.8	12.1	30.2
45	LOCAL CHECK 1		**5.46**	**6.11**	**80**	**100**	10.6	64	0.53	1.03	17.4	3.1	2.7	13.7	16.2	9.2	21.2
	Check Mean		**6.22**	**6.91**			10.1	65.4	0.5	1.0	17.0	2.8	2.4	8.9	15.9	8.0	21.2
	Grand Mean		**6.35**	**6.89**			8.0	65.1	0.5	1.0	17.0	2.8	2.5	10.6	16.0	5.4	17.5
	LSD 5%		**0.36**	**0.37**			2.3	0.6	0.0	0.0	0.8	0.2	0.5	5.7	5.0	2.8	5.0
	CV %		**9.52**	**10.27**			7.3	1.4	8.2	9.5	6.5	14.8	42.7	11.0	10.2	7.9	34.2
	F value Loc*Entry			**0.84**			0.8	1.2	0.6	0.8	1.5	0.7	0.6	0.9	1.1	1.0	0.9
	P(F>f)			**0.95**			1.0	0.0	1.0	1.0	0.0	1.0	1.0	0.9	0.2	0.5	0.8
	Number of locations			**12**			11	10	12	11	12	9	10	11	11	9	5

Table 27. TTWCY02-07. GCA and standard errors for grain yield, estimated for females (single cross hybrids) and males (inbred lines).

Across nine Locations. 2002 B

1. Grain yield and GCA values.

	L5	L6	L7	L8	L9	L10	L11	L12	MEAN	GCA
SC1	6.87	6.56	6.98	7.15	6.97	7.63	7.42	6.53	**7.01**	**0.024**
SC2	7.09	7.03	6.90	7.40	6.84	7.85	7.47	6.64	**7.15**	**0.162**
SC3	6.93	6.44	7.00	7.27	6.66	7.28	7.51	6.72	**6.98**	**-0.011**
SC4	6.76	6.50	6.37	7.48	7.10	7.05	7.13	6.12	**6.81**	**-0.176**
MEAN	**6.91**	**6.63**	**6.81**	**7.33**	**6.89**	**7.45**	**7.38**	**6.50**		
GCA	**-0.076**	**-0.357**	**-0.176**	**0.337**	**-0.097**	**0.465**	**0.393**	**-0.489**		

GCA St.error female SC hybrids = 0.0476

GCA St.error inbred lines = 0.0885

2. GCA values by locations

LOC	Female (SC hybrids)					(Males) Inbred lines								
	L1	L2	L3	L4	GCA SE	L5	L6	L7	L8	L9	L10	L11	L12	GCA SE
LOC 1	-0.390	0.050	0.378	-0.038	0.106	-0.883	-0.413	-0.820	0.743	0.155	0.858	0.315	0.045	0.163
LOC 2	0.165	0.378	-0.100	-0.443	0.176	0.543	-0.967	0.123	0.623	-0.592	0.438	0.580	-0.747	0.269
LOC 3	0.037	0.269	-0.013	-0.293	0.134	-0.159	-0.327	-0.342	0.003	-0.074	0.446	0.718	-0.264	0.205
LOC 4	-0.117	0.080	0.142	-0.105	0.087	-0.638	-0.108	-0.478	-0.371	0.437	0.662	0.847	-0.348	0.133
LOC 5	0.023	0.088	0.149	-0.259	0.141	0.026	-0.319	-0.234	1.121	-0.234	0.309	0.151	-0.821	0.215
LOC 6	0.256	0.243	-0.400	-0.099	0.231	-0.555	-0.305	0.170	0.147	0.367	0.107	0.050	0.020	0.353
LOC 7	0.068	0.224	-0.350	0.058	0.117	0.257	-0.406	-0.306	0.297	-0.166	0.322	0.329	-0.326	0.179
LOC 8	0.015	0.298	0.138	-0.451	0.175	0.365	-0.055	-0.155	0.333	-0.602	0.815	0.060	-0.762	0.268
LOC 9	0.160	-0.170	-0.039	0.050	0.166	0.365	-0.315	0.455	0.137	-0.163	0.227	0.487	-1.193	0.253

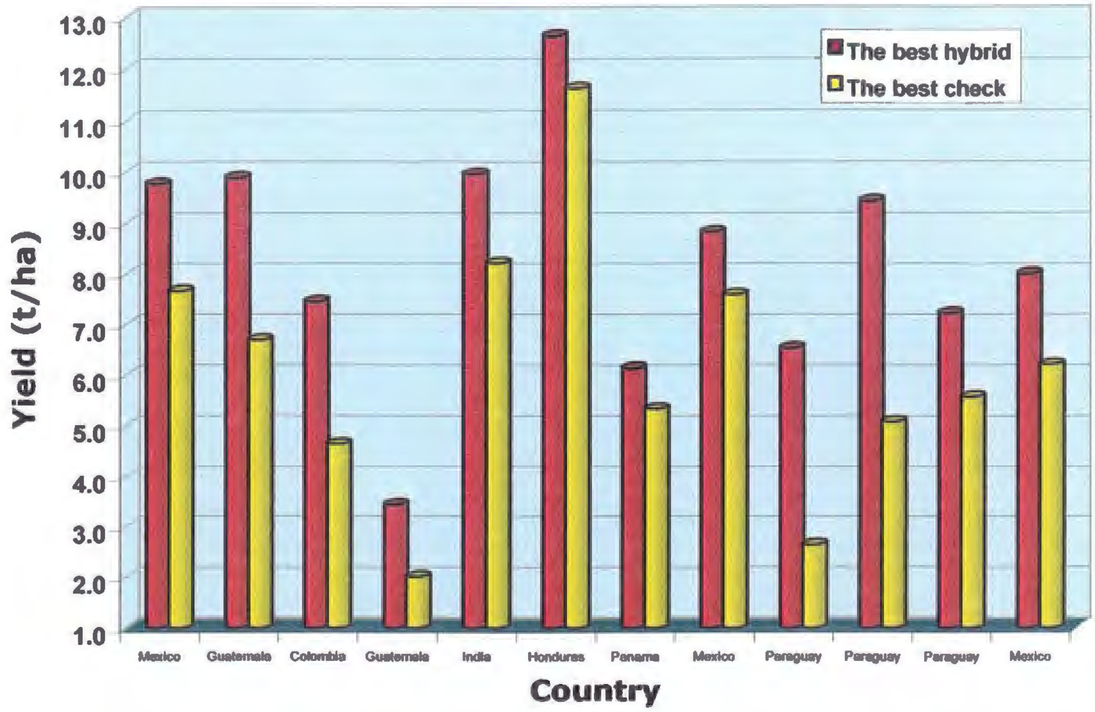
Females (single-cross hybrids)

SC1	**(CML451 x CL-02450)**
SC2	**CML451 x CL-SW002)**
SC3	**CML451 x CL-02844)**
SC4	**CML451 x CL-02420)**

Males (inbred lines)

L5	**(CL-03618*CML287)-B-13-1-1-B**
L6	**CL-00392=SinAmTSRC2-86-2-1-B*6-7-10**
L7	**CL-RCY004=(CL-02432*CL02821)-B-7-B-5-2-1-BBBB-10-10**
L8	**CL-RCY005=(CL-02709*v)-BBB-1-1-BBBB-10-10**
L9	**CL-RCY007=PIO3011F2-3-5-6-1-BBB-B**
L10	**CL-RCYX13 = (CL-03618*CML287)-B-9-1-3-B**
L11	**CL-RCYX19 = (CL-00331*CML287)-B-6-2-3-B**
L12	**IBP-3 C2 TLYD-68-3-2-3-B**

Fig. 7. TTWCY02-07. Grain yield for the best hybrid and the be across 12 environments



2.18 Combining ability and hybrid yield performance of tropical and subtropical late white advanced inbred lines (TSCW02-08).

10 tropical late white inbred lines, were crossed to 5 subtropical lines .in a partial design II.

51 advanced testcrosses, three single crosses and one check were included in an alpha lattice 5x11 design, with two replications and were evaluated at six locations: Agua Fria and Cotaxtla, Mexico; Zacapa and La Maquina, Guatemala; Turipana, Colombia and Bihar, India. The objectives of this work were to estimate the combining ability of the new lines, identify new single cross hybrids and potential females for TWC hybrid combinations and lines with good CGA to be used as males in TWC hybrids and to form synthetic varieties. Highly significant statistic differences were detected at individual and across locations. The interaction hybrid x location for yield, was significant reflecting the importance of GxE interaction.

Trial mean yields varies from 8.3 t/ha at Zacapa and Bihar to 1.3 t/ha at La Maquina, location affected severely by CS, because germplasm lacked adaptation to tropical environment, therefore this location was not included in combined analysis.

Table 28 shows the performance of the eight top single cross hybrids across five locations yielding from 7.6 t/ha to 9.2 t/ha, 17 to 40% more yield than the seed industry checks and 32% more yield than CML442xCML444. All hybrids showed resistance to ear rot and the checks 20% root lodging. The best performing hybrid Entry 18 yielded 9.2 t/ha, 53% more yield than CML247xCML254. Hybrid (Entry 18) demonstrated good stability ranking first across location (9.2 t/ha) and first at Bihar

(15 t/ha), third at Agua Fria, and in the top 10% at: Zacapa and Cotaxtla, at Turipana, La Maquina, Guatemala. Other stable hybrids were: Entries, 20, 16, 4, with a highest yield of 11.3 t/ha at Bihar and 8.0 t/ha at Turipana, Colombia, 12 t/ha at Zacapa. Best hybrids showed also resistance to ear rot (Tables A99 to A105 and Fig. 8). Combining ability estimates were performed on the bases of NC design II using 8 females x 4 males mating design under a line by tester model analysis.

Among the subtropical lines L_2 and L_4 showed the highest GCA estimates. The tropical lines presented L_5, L_6, L_8, and L_{12} with the best GCA estimates L_2xL_5 and L_2xL_8 showed the best SCA estimates (Table 29). The yield potential demonstrated in the new tropical x subtropical hybrids show the exploitation of heterosis in tropical x subtropical germplasm. The 8 hybrids in Table 28 should be tested in the subtropical areas especially in the winter planting in India, Mexico, Vietnam and mid-altitude elevation in Southern Africa. Lines with best GCA will be used to form synthetic varieties. Best SCA crosses will be used as females in TWC hybrids, with best GCA lines as males.

The 10 hybrids with superior performance plus the best 3 at individual locations, which are not in the top across locations, will be tested in the third stage trial and internationally in CHTSW in 2003 and 2004 respectively.

Table 28. TSCLW02-08 Top eight advanced tropical x subtropical white single crosses across five locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	HM 1_5
18	P501c1#-500-2-1-2-2-2-1-2-B-B- x CL-FAWW11=FAWGCAWhite-	**9.06**	**9.22**	**132**	1.8	68	0.56	1.07	19.6	2.8	2.4	14.6	9.0	1.3	1.8
16	P501c1#-500-2-1-2-2-2-1-2-B-B- x CML339=LPSEQC3-H297-2-1-1	**8.89**	**9.29**	**130**	4.3	67	0.50	1.22	19.3	2.6	2.2	9.3	10.3	1.8	1.9
20	P501c1#-500-2-1-2-2-2-1-2-B-B- x CML444 P43C9-1-1-1-1-1-B*5	**8.79**	**9.10**	**128**	3.4	67	0.55	1.07	21.0	2.7	2.4	7.3	3.8	0.7	2.1
4	(CML277*CML269)-B-18-1-B x P501c2-280-2-1-2-2-B-1-B	**7.63**	**7.86**	**111**	2.9	66	0.51	1.05	19.1	2.8	2.2	6.6	3.0	0.7	1.9
5	(CML265*CL-00303)-S7*CML2 x P501c2-280-2-1-2-2-B-1-B	**7.63**	**7.93**	**111**	3.8	68	0.54	1.02	20.2	2.9	2.4	17.8	3.9	0.9	2.1
15	P501c1#-500-2-1-2-2-2-1-2-B-B- x CML254=TUX.SEQ149-2-BBB-	**7.57**	**7.87**	**110**	3.8	68	0.54	1.15	21.7	2.8	2.7	4.9	0.2	6.6	1.5
12	(CML273*CML401)-B-35-1-1-B x P501c1#-500-2-1-2-2-2-1-2-B-B-	**7.55**	**7.88**	**110**	4.1	67	0.51	0.99	18.4	2.8	2.5	0.4	1.7	5.8	2.1
17	P501c1#-500-2-1-2-2-2-1-2-B-B- x CML247=(G24F119*G24F54)-6	**7.45**	**7.55**	**109**	1.4	67	0.53	1.01	21.8	2.7	2.5	16.2	2.6	6.9	1.8
52	CML448 x CML449	**6.35**	**6.61**	**93**	3.9	66	0.46	0.92	20.3	2.8	2.5	8.4	5.8	5.7	1.8
53	CML247 x CML254 RE	**5.43**	**5.55**	**79**	2.2	67	0.54	0.92	22.5	3.0	2.6	17.1	8.8	1.0	1.8
54	CML442 x CML444	**6.86**	**7.12**	**100**	3.7	66	0.52	0.90	22.2	2.7	2.5	7.2	5.1	1.3	1.8
55	LOCAL CHECK	**6.28**	**6.37**	**92**	1.4	65	0.51	1.03	18.9	2.7	2.6	19.3	4.3	0.9	1.6
	Check Mean	**6.23**	**6.41**		2.8	66.1	0.5	0.9	21.0	2.8	2.6	13.0	6.0	2.2	1.7
	Grand Mean	**6.72**	**7.07**		4.9	66.4	0.5	0.9	20.5	2.9	2.5	14.5	6.9	2.3	1.8
	LSD 5%	**1.05**	**1.11**		5.6	1.2	0.0	0.1	1.6	0.4	0.3	11.6	8.0	4.5	0.4
	CV %		**13.03**		11.3	1.6	7.0	11.3	7.0	14.8	15.8	12.4	12.7	8.5	16.9
	F value Loc*Entry		**1.88**		1.0	1.6	0.7	0.9	1.6	0.8	0.9	0.9	1.2	1.4	0.9
	P(F>f)		**0.00**		0.46	0.00	1.00	0.78	0.00	0.92	0.73	0.72	0.14	0.06	0.58
	Number of locations		**5**		4	5	5	4	5	4	5	4	4	3	2

Table 29. TSCLW02-08. GCA and standard errors for grain yield, estimated for subtropical and tropical inbred lines.

Across five Locations. 2002 B

1. Grain yield and GCA values.

	L5	L6	L7	L8	L9	L10	L11	L12	MEAN	GCA
L1	6.09	5.82	5.95	6.06	5.23	4.78	5.05	6.40	**5.67**	**-0.386**
L2	7.93	6.52	5.99	7.77	5.88	6.14	6.44	6.23	**6.61**	**0.556**
L3	6.48	5.67	6.31	6.07	6.03	4.77	5.54	5.83	**5.84**	**-0.221**
L4	6.70	7.13	5.73	6.67	5.67	5.32	5.70	5.95	**6.11**	**0.051**
MEAN	**6.80**	**6.28**	**6.00**	**6.64**	**5.70**	**5.25**	**5.68**	**6.10**		
GCA	**0.741**	**0.226**	**-0.063**	**0.585**	**-0.355**	**-0.805**	**-0.377**	**0.047**		

GCA St.error subtropical lines = 0.1571 GCA St.error tropical lines = 0.2417

2. GCA values by locations

LOC	Female (SC hybrids)					(Males) Inbred lines								
	L1	L2	L3	L4	GCA SE	L5	L6	L7	L8	L9	L10	L11	L12	GCA SE
LOC 1	-0.739	0.691	-0.330	0.378	0.153	0.291	0.096	0.526	0.896	-0.749	-0.504	-0.412	-0.144	0.234
LOC 2	0.175	0.464	-0.366	-0.273	0.224	0.311	0.544	-0.639	1.106	-0.839	-0.271	-0.966	0.754	0.343
LOC 3	0.144	0.719	-0.610	-0.253	0.169	-0.481	1.047	-0.408	1.009	-0.681	-0.301	-0.708	0.524	0.258
LOC 4	-0.273	-0.418	0.343	0.349	0.149	0.703	0.168	0.440	-0.135	-0.555	-0.522	0.313	-0.412	0.227
LOC 5	-1.236	1.326	-0.142	0.052	0.182	2.881	-0.724	-0.232	0.048	1.051	-2.424	-0.112	-0.487	0.278

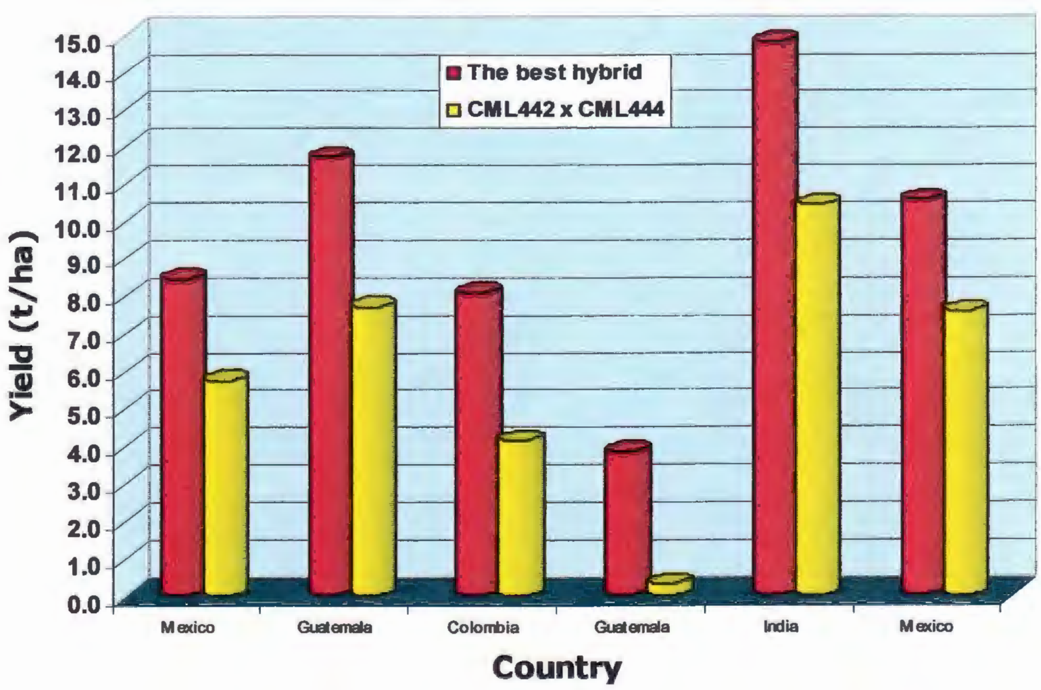
Subtropical lines

L1 **P501c2-280-2-1-2-2-B-1-B**
L2 **P501c1#-500-2-1-2-2-2-1-2-B-B-2-B**
L3 **P502c2-185-3-4-1-3-B-1-B**
L4 **HG88"A" S2-204-1-3-2-3-3-6-B-B-2-B**

Tropical lines

L5 **CL-FAWW11=FAWGCAWhite-3-3-1-2-2-B*6**
L6 **CML247=(G24F119*G24F54)-6-4-1-1-BB-f-##-B*6**
L7 **CML254=TUX.SEQ149-2-BBB-##-1-BB-f-##-BB-B*4**
L8 **CML339=LPSEQC3-H297-2-1-1-1-3-##-BB**
L9 **CML442 M37W/ZM607#BF37SR-2-3-SR-6-2-X]-8-2-X-1-B*5**
L10 **(CML247*CML37)-B-6-3-2-B**
L11 **(CML254*CML78)-5-1-1-3-B**
L12 **(CML273*CML401)-B-35-1-1-B**

Fig. 8. TSCLW02-08. Grain yield for the best hybrid and CML442 x CML444 across six environments



2.19 Hybrid yield performance of tropical and subtropical yellow late advanced inbred lines (TSCLY02-09).

The 17 crosses, among tropical x subtropical yellow lines two RE checks and one seed industry check were included in an alpha lattice 4x5 design with two replications and they were evaluated at three locations: Turipana, Colombia, Zacapa, Guatemala and Bihar, India. The objectives of this work were to identify new single cross hybrids and potential females for TWC hybrid combinations and lines with good potential to form synthetic varieties. Highly significant statistic differences were detected at individual and across locations. The interaction hybrid x location was not highly significant reflecting the importance of yield stability.

Mean yield across three locations 7.3 t/ha and 8.7 t/ha at Zacapa, 5.4 at Turipana and 7.6 t/ha at Bihar.

Table 30 shows the performance of the outstanding 8 single cross hybrids identified from this experiment, across three locations. The yield of the 8 entries ranked from 6.8 t/ha to 8.3 t/ha, 16 to 44% more yield than Pioneer 3041 that yielded 5.8 t/ha.

CL-RCYX18 x 90(SPMATC4/P500SELY#-B-54-4-B-B topped the yield trial, showing yield stability. It performed well ranking first in Zacapa (11.0 t/ha), third in Bihar (9.0 t/ha), fifth in Turipana (5.2 t/ha) and first across three locations 8.3 t/ha (Tables A106 to A112). This hybrid also outyielded the RE check CL-02450 xCML451 by 1.0 t/ha.

This new hybrid also showed resistance to root lodging and ear rot. CML451xCML 287 yielded 9.1 t/ha across location and showed yield stability.

Best hybrids should be tested in winter planting maize areas in Asia.

Table 30. TSCLY02-09 Top eight advanced tropical x subtropical yellow single crosses across three locations in 2002B

Ent no	Pedigree		Yield 1 t/ha	Yield t/ha	Bck %	Bck %	Erott %	Silk days	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Fus %
1	CL-RCYX18 = (CML285*CL-0	x 90[SPMATC4/P500(SELY)]#-	**8.21**	**8.28**	**90**	**142**	0.8	76	0.56	1.45	16.5	2.2	2.3	3.1	37.6	0.0	1.3
17	CL-RCYX16 = P390amC3/285x	x CL-02836=P28C9HC113-3-1-4	**8.20**	**8.30**	**90**	**142**	1.2	77	0.54	0.97	17.0	2.2	1.4	0.2	7.7	3.6	0.0
7	CL-RCYX18 = (CML285*CL-0	x POB.45c8-76-1-2-1-2-B-B-B	**8.11**	**8.19**	**89**	**140**	1.0	74	0.50	1.07	15.4	2.0	2.0	1.1	3.1	3.3	1.1
12	POB.45c8-76-1-2-1-2-B-B-B	x CL-RCY004 (CL-02432*CL-02	**7.96**	**8.03**	**88**	**138**	0.8	76	0.51	0.94	16.9	2.5	2.1	1.2	1.0	0.0	1.8
4	90[SPMATC4/P500(SELY)]#-B-	x CL-02450=P24STEC1F16-1-3-	**7.50**	**7.88**	**83**	**130**	4.8	75	0.55	1.02	17.3	2.5	1.8	0.0	30.1	0.0	0.0
6	90[SPMATC4/P500(SELY)]#-B-	x CL-RCY004 (CL-02432*CL-02	**6.81**	**6.81**	**75**	**118**	-0.1	75	0.50	1.06	16.4	2.2	2.2	0.5	17.3	0.0	2.4
8	CL-RCYX16 = P390amC3/285x	x POB.45c8-76-1-2-1-2-B-B-B	**6.71**	**6.79**	**74**	**116**	1.2	75	0.52	1.04	15.3	2.0	1.8	1.2	1.0	13.0	0.9
9	POB.45c8-76-1-2-1-2-B-B-B	x CML413=SIN AM TSR-23-3-2	**6.65**	**6.82**	**73**	**115**	2.5	75	0.49	0.96	15.6	2.5	2.2	0.0	1.2	0.0	0.3
18	CML287	x CML451	**9.08**	**9.17**	**100**	**157**	0.9	76	0.54	1.09	16.5	2.5	1.5	0.0	7.5	0.0	0.5
19	CL-02450	x CML451 RE	**7.66**	**7.68**	**84**	**132**	0.3	76	0.50	0.97	16.3	2.8	2.2	1.0	11.5	0.0	5.3
20	LOCAL CHECK		**5.78**	**5.79**	**64**	**100**	0.0	75	0.55	0.95	16.0	2.5	2.2	9.7	7.8	0.0	0.3
		Check Mean	**7.51**	**7.54**			0.4	76	0.53	1.00	16.2	2.6	1.9	3.6	8.9	0.0	2.0
		Grand Mean	**7.14**	**7.27**			1.8	75	0.53	1.04	16.2	2.4	2.0	1.1	17.1	2.4	-0.6
		LSD 5%	**1.14**	**1.22**			6.3	2.2	0.0	0.1	1.3	0.4	0.5	5.3	23.9	.	0.4
		CV %		**14.04**			9.7	1.9	5.5	9.9	3.4	11.8	18.3	6.0	10.3	13.8	0.5
		F value Loc*Entry		**1.04**			0.6	1.6	0.7	0.8	4.1	0.7	1.2	2.8	1.8	.	5.4
		P(F>f)		**0.45**			0.8	0.1	0.7	0.7	0.0	0.8	0.3	0.0	0.1	.	0.8
		Number of locations		**3**			2	3	2	2	3	2	3	2	2	1	1

2.20 Yield performance of CIMMYT tropical white late single cross hybrids across 12 locations in the tropical mega-environment.

CHTTW02 includes the evaluation of 18ropical late maturing white endosperm single cross hybrids and two seed industry checks under a ∝ lattice design 4x5with three replications. 45 trials were shipped by the ITU to 20 countries planting maize in the tropical environment.

At the closing of this report, international testing has collected information from 12 locations in 9 countries.

Table 31 includes the yield performance of all hybrids at each individual location: CMS003001 = CL04368xCL-SPLW04 showed excellent yield stability and ranked first in 8 locations and in the best 10% at other 4 locations (Fig. 9). This hybrid also topped the trial across 12 locations with 7.1 t/ha outperforming all seed industry checks across locations and at 10 individual locations. The mean of the best seed industry local checks across 12 sites was 5.9 t/ha and the trial mean yield 6.0 t/ha. Hybrids
CL-04377xCML264, and CL-0436xCML254 outyielded our best last year hybrid CMS993037 one t/ha yield and CML247xCML254 with 20% more yield. The best 3 new hybrids were superior in yield to the seed industry checks and the trial mean with 1.5 LSD, 20 % more yield. Resistance to ear rot, *B. maydis* corn stunt and rust (Table 32).

This increase in yield represents 3.25 % per year or 200 kg/ha per year.

The superior hybrids should be extensively tested in Africa and Latin America to help farmers planting maize in developing countries. Venezuela and Colombia should extensively test the 3 new hybrids since flint endosperm is essential for adoption.

Table: 31. CHTTW02. Mean Hybrid Trial - Tropical White in 2002, across 12 locations.

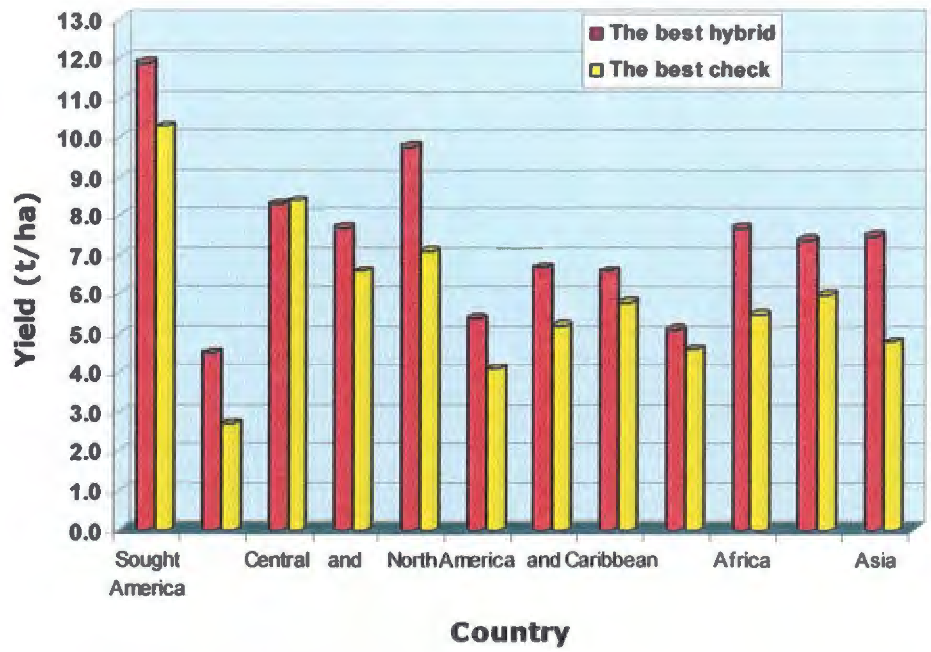
Ent. No.	Entry Name	South America		Central America, North America and Caribbean							Eastern & S. Africa		Asia	Overall means		
		1	2	3	4	5	6	7	8	9	10	11	12	Grain yield t/ha	Days to silk	Plant ht (cm)
1	CL-04368xCL-SPLW04	11.3	3.3	8.3	7.7	9.8	5.3	6.6	6.6	4.8	6.6	7.3	7.5	7.1	55	230
9	CL-04377xCML-264	11.9	3.1	5.4	6.3	8.0	5.1	6.3	6.6	4.3	7.3	7.4	7.0	6.6	57	224
2	CL-04362xCML-254	10.7	4.0	6.6	5.9	8.7	4.5	6.6	5.5	4.1	7.0	6.9	7.3	6.5	57	230
15	CML-264xCML-269	10.5	4.5	6.9	6.5	8.8	5.3	5.3	6.2	4.3	7.2	7.3	4.3	6.4	55	212
13	CL-SPLW05xCML-264	10.7	3.5	6.4	6.1	8.4	4.7	5.8	6.1	5.1	6.2	6.7	6.2	6.3	55	216
16	CML-36xCML-384	10.6	3.7	6.2	4.8	7.9	4.2	4.8	6.4	4.7	7.7	6.1	7.3	6.2	56	229
4	CL-FAWW11xCML-343	10.8	4.1	5.2	5.4	7.7	4.5	4.8	6.2	3.9	6.8	7.0	6.3	6.1	58	216
6	CL-RCW18xCML-254	10.3	3.3	6.9	6.1	8.6	4.3	4.8	5.1	3.8	6.8	6.1	6.4	6.0	58	232
10	CL-04367xCML-258	9.8	2.7	6.0	5.7	9.1	4.1	5.0	6.1	3.2	6.1	7.5	6.3	6.0	57	247
5	CML-341xCL-RCW01	10.3	3.2	7.5	6.0	7.2	4.4	5.6	6.4	3.7	5.9	5.7	5.2	5.9	55	227
8	CL-021119xCML-254	9.3	2.7	5.6	5.5	7.6	4.0	6.7	5.8	4.1	5.7	6.3	6.1	5.8	59	235
7	CML-342xCML-254	10.9	3.8	5.3	5.3	8.0	4.0	5.1	5.6	3.6	6.4	5.4	5.8	5.8	57	228
12	CL-FAWW11xCML-264	10.3	3.9	5.9	5.7	7.3	3.7	4.8	6.4	3.6	5.3	5.8	6.1	5.7	57	206
17	CML-448xCML-449	9.6	2.9	4.1	5.7	5.8	4.8	6.7	6.1	5.0	6.7	6.5	3.4	5.6	54	209
14	CML-339xCL-02143	9.4	3.0	5.3	3.3	6.6	5.4	5.4	5.6	3.8	5.6	5.9	7.5	5.6	55	223
11	CL-PHYW03xCML-254	9.6	3.3	6.1	5.6	6.6	4.3	5.5	4.6	3.5	5.4	6.6	5.6	5.6	58	219
18	CML-247xCML-254	10.5	3.0	4.3	6.8	7.2	4.3	5.0	5.5	3.4	6.3	5.2	4.9	5.6	57	206
3	CML-339xCML-247	10.6	3.4	6.3	4.3	5.5	3.9	5.0	6.0	4.5	6.0	4.4	6.1	5.5	57	223
20	Local Check-2	10.3	2.7	8.4	6.6	6.8	4.1	4.8	5.8	4.6	5.5	6.0	4.8	5.9		
19	Local Check-1	9.6	1.9	4.4	5.2	7.1	3.8	5.2	5.7	4.6	4.3	4.6	3.5	5.0		
	MEANS	10.4	3.2	6.0	5.7	7.7	4.5	5.5	5.9	4.1	6.4	6.3	6.1	6.0		
	C.V.%	5.0	18.8	12.1	10.3	11.3	7.7	11.0	8.7	16.9	18.9	13.9	13.6	12.3		

No.	Country	Location
1	Tocorón - Edo. A	Venezuela
2	Villavo	Colombia
3	Agua Fria	Mexico
4	Azuer	Panama
5	Cotaxtla	Mexico
6	Las Acacias, Ja	Honduras
7	Las Vegas Tiquis	Guatemala
8	Nueva Concepci	Guatemala
9	San Andres	El Salvador
10	Mtwapa	Kenya
11	MTWAPA (2)	Kenya
12	New Delhi	India

Table 32. CHTTW02. Mean for different traits across 12 environments.

Ent no	Pedigree	Yield t/ha	Bck %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott %	Erott 1_5	Plt asp	Ear asp 1_5	Ear as 1_9	Rdg %	Fus %	Stunt %	Rust 1_5	B.M 1_5	Virus 1_5	EPP	Stemborer 1_5	Bare tips %	Common rust 1_5
1	CL-04368xCL-SPLW04	**7.1**	120	56	56	0.0	230	121	18	5.7	1.7	2.7	2.4	6.7	9.2	2.8	5.8	2.0	1.9	2	1	2	2.7	1.0
9	CL-04377xCML-264	**6.6**	112	56	57	-0.8	224	117	20.1	13.9	2.6	2.4	3.2	6.0	16.7	9.2	3.3	2.0	1.8	3.9	1.0	1.3	7.9	1.0
2	CL-04362xCML-254	**6.5**	110	56	57	-0.6	230	135	19.7	7.1	1.9	2.8	3.0	5.0	7.1	2.8	4.2	2.3	2.1	1.6	1.1	1.8	3.3	1.0
15	CML-264xCML-269	**6.4**	110	54	55	-1.0	212	107	19.8	3.1	1.7	2.7	2.6	8.2	4.9	0.7	1.0	2.0	1.7	2.4	1.0	1.4	4.5	1.0
13	CL-SPLW05xCML-264	**6.4**	108	55	55	-0.4	216	115	19.3	8.9	1.9	2.3	3.2	5.2	10.0	0.0	4.5	2.0	1.9	1.6	1.0	2.7	0.9	1.0
16	CML-36xCML-384	**6.2**	105	55	56	-1.2	229	128	19.2	7.7	1.6	2.9	2.6	7.2	10.3	8.5	7.8	2.0	1.9	6.8	1.1	1.8	1.7	1.0
4	CL-FAWW11xCML-343	**6.1**	103	58	58	0.0	216	112	20.3	11.1	2.3	2.9	2.9	8.3	10.5	11.2	7.7	2.0	1.9	6.1	1.1	1.4	0.0	1.0
6	CL-RCW18xCML-254	**6.1**	103	57	58	-0.8	232	123	19.7	12.2	5.2	2.7	2.8	7.0	6.3	4.3	5.3	1.8	1.7	5.5	1.1	1.3	5.9	1.0
10	CL-04367xCML-258	**6.0**	103	56	57	-0.8	247	133	19.0	12.6	2.1	3.2	2.8	5.7	24.8	0.8	6.7	2.0	1.8	7.2	0.9	1.4	0.0	1.0
5	CML-341xCL-RCW01	**6.0**	102	54	55	-0.3	227	108	20.0	10.6	1.9	2.7	2.9	6.0	4.8	1.4	8.2	2.3	2.1	4.8	1.0	1.3	3.5	1.0
12	CL-FAWW11xCML-264	**5.8**	98	57	57	-0.2	206	112	20.0	6.5	2.0	2.7	2.9	5.2	5.4	4.2	2.8	2.0	1.8	1.2	1.0	1.9	0.9	1.0
8	CL-021119xCML-254	**5.8**	98	58	59	-0.7	235	130	20.9	6.9	1.8	2.9	2.4	5.8	11.8	5.6	3.8	2.0	1.6	1.3	1.0	1.6	9.4	1.0
7	CML-342xCML-254	**5.7**	98	57	57	0.0	228	128	20.4	9.9	1.9	2.8	2.8	6.8	11.8	5.6	6.5	2.0	1.8	2.8	1.2	1.5	0.9	1.0
17	CML-448xCML-449	**5.6**	96	53	54	-0.7	209	100	21.1	5.4	2.8	3.1	2.6	5.7	15.1	6.1	3.5	2.0	1.8	1.7	1.0	1.6	8.7	1.0
14	CML-339xCL-02143	**5.6**	96	54	55	-0.7	223	117	17.9	13.6	1.9	3.0	3.0	6.2	15.7	7.0	5.7	2.3	2.0	2.5	1.1	1.5	1.0	1.0
18	CML-247xCML-254	**5.6**	95	57	57	-0.5	206	114	20.6	4.2	1.8	2.5	2.5	6.5	6.6	8.5	1.7	2.0	1.8	2.1	0.9	2.2	3.8	1.0
11	CL-PHYW03xCML-254	**5.6**	95	56	58	-1.2	219	118	20.9	5.1	1.7	2.6	2.5	5.8	7.0	2.0	5.8	2.3	1.9	3.1	1.0	1.9	2.5	1.0
3	CML-339xCML-247	**5.5**	94	57	57	-0.2	223	122	19.2	10.2	2.1	2.7	2.8	5.7	12.8	1.5	3.8	2.2	1.8	4.1	1.0	1.8	5.9	1.0
19	Local Check	5.0	85	54	55	-0.9	217	116	18.9	14.8	2.7	2.8	2.9	5.0	13.0	5.1	4.2	2.3	2.1	1.0	0.9	3.0	3.9	1.0
20	Local Check	5.9	100	54	55	-0.6	224	118	18.6	8.3	2.0	2.8	2.7	5.3	10.4	0.0	3.7	1.8	1.7	2.9	1.0	2.4	8.8	1.0
	Check Mean	**5.4**		54	55	-0.7	221	117	18.7	12	2.3	2.8	2.8	5.2	11.7	2.5	3.9	2.1	1.9	1.9	1.0	2.7	6.3	1.0
	Grand Mean	**6.0**		56	56		223	119	18.1															
	LSD 5%	**0.59**		0.9	0.9		6.0	6.2	0.9															
	CV %	**11.9**		1.9	1.9		3.6	7.6	7.7															
	F value Loc*Entry	**1.06**		1.04	1.09		0.80	0.66	0.68															
	P(F>f)	**0.30**		0.36	0.23		0.94	0.99	0.99															
	Number of locations	**12**		12	12	12	11	11	12	10	2	7	9	2	9	1	2	1	2	2	12	2	1	1

Fig. 9. CHTTW02. Grain yield for the best hybrid and the best local check across 12 environments



2.21 Yield performance of tropical late maturing yellow endosperm hybrids tested across 15 locations (CHTTY02)

CHTTY02 includes the evaluation of 18 tropical late maturing yellow endosperm single cross hybrids and two seed industry checks under a ∝ lattice design 4x5 with three replications. 40 trials were shipped by the ITU to 19 countries planting maize in the tropical environment.

At the closing of this report, international testing has collected information from 15 locations in 10 countries in Asia and Latin America.

Table 33 includes the mean yield of all hybrids at individual locations: CMS983002 (CML287 x CML451) topped the trial across locations and at several individual locations with 6.6 t/ha mean yield, 25% more yield than the seed industry check across locations (Table 33) Fig 10. This hybrid showed good yield stability ranking first at 12 locations and in the top 10% at 5 locations.

This hybrid also showed resistance to root lodging, foliar diseases and root lodging and better ear placement than the checks. CML451xCML287, CL-SCBY06xCML287 and CML287xCL-02841 respectively, outyielded the seed industry checks across locations with 0.5 to 1.5 t/ha, more yield and superior agronomic traits (Table 34). These hybrids also showed good yield stability in Asia, Bolivia, Peru, Colombia, Ecuador and Paraguay they should be tested extensively and promoted to help farmers to increase maize productivity and reduce maize imports.

Table: 33. CHTTY02. Mean for different traits across 15 environments in 2002.

Ent. No.	Entry Name	South America				Central America, North America and Caribbean							Asia				Overall means		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Grain yield (t/ha)	Days to silk	Plant ht (cm)
1	CML451xCML287	7.7	2.1	5.2	11.2	4.6	5.8	9.1	4.1	7.7	8.8	6.9	7.8	10.7	2.4	4.6	6.6	57	228
18	CL-G2621 xCML451	6.3	2.0	5.3	9.9	3.3	5.5	8.2	3.8	7.4	8.0	6.1	6.3	9.0	3.1	5.0	5.9	57	224
5	CL-G2620xCML287	7.7	2.5	4.2	10.4	4.2	4.3	9.1	4.2	7.2	8.5	7.3	5.4	8.5	1.3	3.6	5.9	57	235
11	CL-02838xCML451	7.7	2.9	5.0	10.0	2.5	4.3	7.0	3.8	7.2	7.7	5.4	6.3	9.5	1.8	5.8	5.8	58	222
15	CL-02450xCML226	9.1	2.6	4.1	9.5	3.9	4.6	7.4	3.9	5.7	5.7	4.9	6.2	9.3	3.0	6.8	5.8	56	216
16	CML287xCML413	7.6	3.1	4.3	9.7	3.5	5.1	9.0	3.4	5.5	7.0	7.6	6.6	7.0	3.0	4.5	5.8	58	229
13	CL-02450xCL-03618	7.7	2.4	4.6	9.7	4.1	5.2	8.0	3.6	5.9	8.1	4.8	5.4	9.6	1.3	5.5	5.7	56	222
12	CL-02450xCL-02836	7.9	2.5	4.3	10.2	3.8	4.5	7.3	3.0	6.3	7.5	5.1	5.8	8.9	2.7	5.2	5.7	57	217
17	CL-02450xCML451	7.5	2.7	4.0	10.3	2.1	4.4	7.3	3.2	6.8	7.6	5.9	7.2	8.8	2.5	5.1	5.7	58	215
6	CL-RCY005xCML287	7.0	2.8	3.4	9.9	3.2	3.2	8.1	3.4	5.7	7.4	5.7	7.2	9.7	2.3	5.2	5.6	58	222
3	CML287xCL-02841	7.1	1.5	3.4	11.0	1.9	4.5	8.3	4.9	5.6	7.5	3.6	5.8	9.4	1.6	6.7	5.5	58	243
10	CML451xCL-MDRY01	5.9	1.7	4.1	9.4	2.9	3.8	7.8	4.6	7.6	6.7	5.0	4.8	9.1	2.3	5.1	5.4	57	212
7	CML413xCL-03613	7.5	3.4	3.1	8.9	3.7	3.7	7.3	3.5	6.0	5.8	5.9	5.8	7.5	2.1	4.0	5.2	57	210
14	CL-02450xCL-G2618	8.1	2.7	4.1	10.0	3.3	4.0	8.3	3.9	4.5	6.4	4.7	3.4	6.6	2.1	5.8	5.2	56	219
4	CL-SCBY07xCML287	7.9	2.5	3.2	9.2	3.5	4.5	7.4	3.7	4.9	5.8	5.9	5.3	8.1	1.6	4.1	5.2	57	236
2	CL-SCBY06xCML287	7.7	2.5	2.8	9.4	4.2	3.6	8.4	3.2	6.0	5.3	5.7	4.8	8.3	2.3	2.7	5.1	57	236
9	CL-DTPY03xCML413	6.0	3.6	3.8	8.6	4.3	4.3	6.4	3.7	8.2	5.8	4.5	4.7	8.0	2.9	4.1	5.1	56	220
8	CML413xCL-SCBY06	6.5	3.0	2.2	8.8	4.0	2.3	8.0	4.0	6.0	7.0	5.2	5.5	8.3	3.3	2.3	5.1	58	217
20	Local Check-2	8.4	2.1	2.5	10.7	3.1	2.5	5.9	3.6	6.2	7.3	4.6	3.8	8.6	2.7	5.7	5.2		
19	Local Check-1	8.1	1.0	2.0	9.8	3.5	2.4	5.8	3.0	7.1	8.5	2.0	4.3	9.5	3.3	7.1	5.2		
MEANS		1.2	1.1	1.6	0.7	0.9	1.5	1.2	0.8	1.4	1.7	1.1	1.0	0.5	1.0	1.2	1.2		
C.V.%		9.9	27.3	25.8	4.6	16.1	22.4	9.4	13.2	13.2	14.5	12.7	11.1	3.6	25.7	14.7	14.9		

No.	Country	Location	No.	Country	Location
1	Bolivia	Cotoca (Santa Cruz)	10	Mexico	Cotaxtla
2	Colombia	Villavo	11	Panama	Azuer
3	Venezuela	Maracay, Edo. Aragua	12	India	Hyderabad
4	Venezuela	Tocorón - Edo. Aragua	13	India	Jalna
5	El Salvador	San Andres	14	India	New Delhi
6	Guatemala	Las Vegas Tiquisate	15	Vietnam	Binh Duong
7	Guatemala	Zacapa			
8	Honduras	Danli			
9	Mexico	Agua Fria			

Fig. 10. CHTTY02. Grain yield for the best hybrid and the best local check across 15 environments.

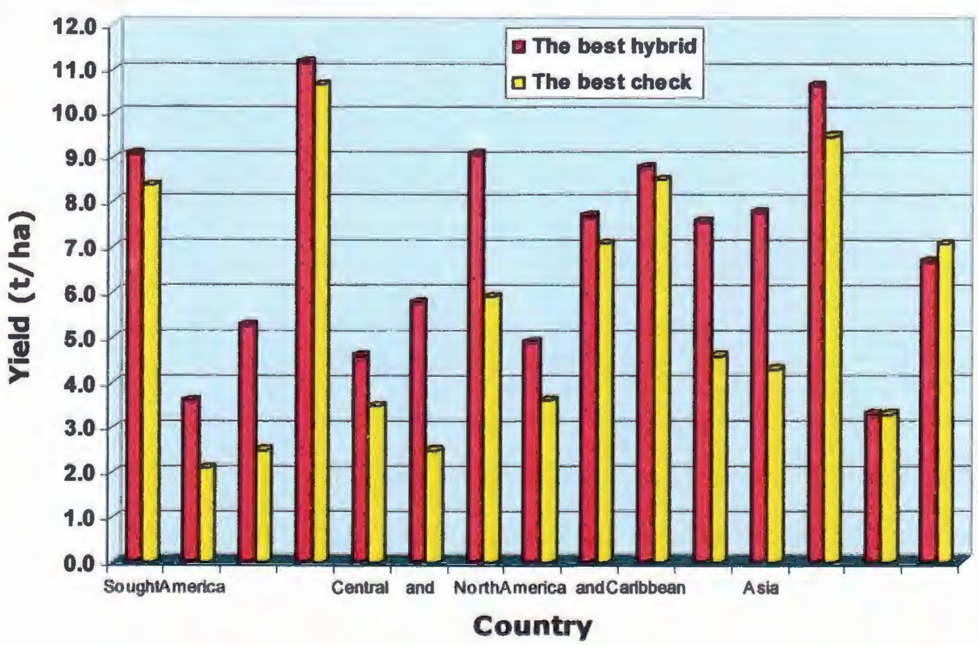


Table 34. CHTTY02. Mean for different traits across 15 environments.

Ent no	Pedigree	Yield t/ha	Bck %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott 1_5	Erott %	Plt asp	Ear asp 1_5	Rldg %	Sldg %	BH %	BH 1_5	Fus %	Stunt %	Rust 1_5	B.M. 1_5	Virus 1_5	EPP	Leaf spot 1_5
1	CML451xCML287	**6.5**	**126**	56	57	-1.2	217	114	16.4	1.5	5.7	2.5	2.2	2.4	12.0	5.107	1.72	0.0	6.9	2.0	2.0	3.8	1.0	1
2	CL-SCBY06xCML287	**5.2**	**99**	56	57	-1.4	225	132	16.6	1.8	4.9	3.3	2.7	33.0	10.9	2.6	1.9	8.1	2.7	3.0	3.2	2.5	0.9	1.0
3	CML287xCL-02841	**5.5**	**105**	56	58	-1.7	231	134	16.0	1.9	12.6	3.2	2.8	29.8	11.4	3.7	2.3	5.1	3.2	3.3	3.3	2.5	0.9	1.2
4	CL-SCBY07xCML287	**5.2**	**99**	56	57	-1.5	223	126	15.9	1.8	6.5	3.1	2.6	15.9	12.3	2.0	1.7	2.3	3.5	2.7	3.0	0.3	1.0	1.0
5	CL-G2620xCML287	**5.9**	**113**	56	63	-7.2	218	120	17.5	1.5	4.7	2.9	2.5	6.2	16.1	2.4	2.2	1.4	4.0	2.7	3.0	4.4	1.0	1.2
6	CL-RCY005xCML287	**5.6**	**108**	56	57	-1.5	212	120	16.6	1.8	5.4	2.9	2.5	25.3	9.5	2.6	1.9	1.4	2.3	3.0	3.0	1.4	0.9	1.2
7	CML413xCL-03613	**5.2**	**100**	55	57	-1.4	200	113	16.3	2.1	1.6	2.9	2.6	13.0	12.1	3.6	1.8	0.7	0.8	2.7	3.0	1.9	0.9	1.0
8	CML413xCL-SCBY06	**5.1**	**97**	56	58	-2.0	206	118	17.2	1.8	3.9	3.1	2.6	16.6	10.9	3.0	1.8	0.7	2.3	2.8	3.0	2.2	0.9	1.0
9	CL-DTPY03xCML413	**5.2**	**99**	54	56	-1.5	209	117	15.4	2.2	8.8	3.0	2.9	19.5	9.2	19.3	2.4	1.5	2.7	2.3	3.0	6.1	1.2	1.2
10	CML451xCL-MDRY01	**5.4**	**103**	55	57	-1.8	199	97	15.7	1.7	8.3	2.7	2.8	9.3	6.7	5.4	2.0	0.0	7.2	2.0	2.0	13.4	0.9	1.0
11	CL-02838xCML451	**5.8**	**111**	56	58	-2.0	212	111	17.2	1.5	4.8	2.5	2.3	3.9	11.0	1.7	1.7	0.7	6.7	2.2	2.2	5.0	0.9	1.0
12	CL-02450xCL-02836	**5.7**	**110**	56	57	-1.5	208	121	15.9	1.6	5.5	2.9	2.5	16.4	9.9	5.3	2.0	8.6	5.4	3.0	2.8	8.9	0.9	1.0
13	CL-02450xCL-03618	**5.7**	**109**	55	56	-1.5	212	114	16.5	1.5	3.8	2.7	2.6	20.8	6.0	0.3	1.6	0.7	2.5	2.7	2.3	2.5	0.9	1.0
14	CL-02450xCL-G2618	**5.2**	**99**	54	56	-1.6	208	116	15.3	1.8	6.8	3.1	2.6	26.8	11.8	5.9	1.8	2.3	1.3	2.7	2.7	5.7	0.9	1.2
15	CL-02450xCML226	**5.8**	**111**	55	56	-1.3	206	116	15.7	1.9	6.3	2.7	2.4	14.4	14.3	2.1	1.7	6.5	3.8	3.0	3.2	4.1	0.9	1.2
16	CML287xCML413	**5.8**	**110**	57	58	-1.5	219	127	16.6	1.7	3.1	2.9	2.4	18.4	11.3	7.0	2.0	3.6	0.7	2.5	3.0	1.1	1.0	1.0
17	CL-02450xCML451	**5.7**	**109**	56	57	-1.7	203	106	16.7	1.8	4.4	2.6	2.5	0.5	10.7	1.0	1.4	0.7	4.2	1.7	1.7	6.0	0.9	1.0
18	CL-G2621 xCML451	**5.9**	**114**	55	57	-1.1	212	112	16.7	1.8	7.8	2.6	2.6	0.4	6.7	2.6	1.8	0.0	7.9	2.0	2.0	10.5	0.9	1.0
19	Local Check	5.1	**99**	55	57	-1.6	206	113	15.5	1.4	7.2	2.8	2.7	19.3	6.5	2.3	1.7	0.7	3.0	2.7	3.0	3.0	0.9	0.8
20	Local Check	**5.2**	**100**	54	56	-1.5	207	110	15.7	1.7	6.5	2.7	2.5	12.1	10.8	4.1	1.9	3.1	3.5	2.5	2.7	6.2	1.0	1.0
	Check Mean	**5.2**		55	56	-1.6	206	112	16	1.5	7	2.7	2.6	15.7	8.6	3.2	1.79	1.9	3.3	2.6	2.8	4.6	0.9	0.9
	Grand Mean	**5.5**		55	57	-1.8	212	117	16	2	6	2.9	2.6	15.1	10.7	4.2	1.87	2.5	3.8	2.6	2.7	4.6	0.9	1.1
	LSD 5%	**0.63**		0.8	4.1		7.2	7.0	1.1															
	CV %	**13.0**		2.1	3.0		4.5	7.4	11.3															
	F value Loc*Entry	**1.49**		0.93	10.8		1.08	1.28	0.72															
	P(F>f)	**0.0**		0.72	0.0		0.22	0.01	0.99															
	Number of locations	**15**		15	15	15	15	15	14	2	10	12	14	9	13	5	6	1	2	1	1	2	15	1

No	Country	Location
1	Mexico	Cotaxtla
2	Guatemala	Las Vegas Tiquisate
3	El Salvador	San Andres
4	Mexico	Agua Fria
5	Honduras	Danli
6	Colombia	Villavo
7	India	New Delhi
8	Venezuela	Tocorón - Edo. Aragua
9	India	Jalna
10	Vietnam	Binh Duong
11	Panama	Azuer
12	Venezuela	Maracay, Estado Aragua
13	Guatemala	Zacapa
14	India	Hyderabad
15	Bolivia	Cotoca (Santa Cruz)

2.22 Tropical white late synthetics (EVT-12S)

23 synthetics, resistant to foliar diseases, low N, drought, CSS and high quality protein and two local checks were tested under an alpha lattice design 5x5 with 3 replications per site. International Testing Unit shipped 42 sets to different countries, at the closing of this report we have received results from only 8 locations.

Although the majority of the checks used by national programs as seed are OPV's or hybrids developed using CIMMYT germplasm. All locations with low or high mean yield trial, in all locations a new synthetic variety resistant to stresses outyielded the best check (Fig. 11). Synthetic S99TLW BNSEQ(1) outyielded the local checks and mean trial by 1 t/ha (one LSD) resistant to foliar diseases ranked first across locations 5.6 t/ha, (Table 36).

At individual locations, it also showed more resistance to CSS and root lodging than the local checks. Synthetic S98 TLW-2B topped the trial at Guatemala, Mexico, Nicaragua, India and Indonesia. Synthetic S99 TLW BN-SEQ(1) tolerant to low N and drought, performed at the top 10% yield at each location. The best QPM synthetic
S99 TLWQ-AB yielded well at Mexico, India and Indonesia (Table 35). Best synthetics should be tested on-farm.

Fig. 11. EVT12S. Grain yield for the best EVT's and the best local check across seven environments

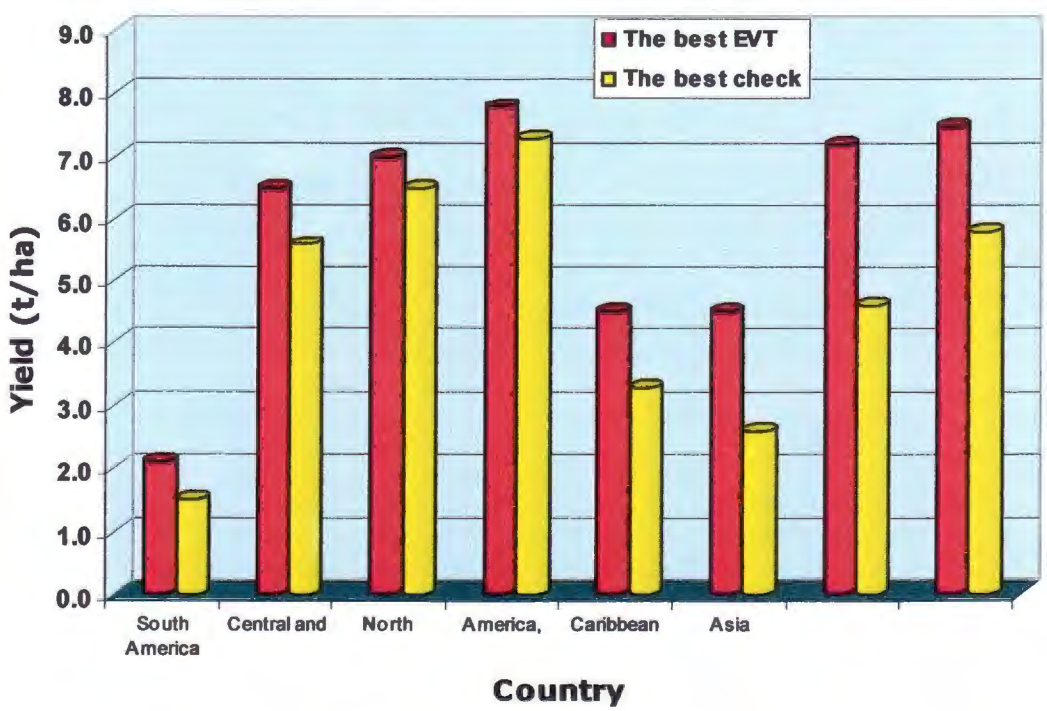


Table. 35.EVT12S.Mean for different traits across seven environments in 2002.

Ent. No.	Entry Name Entradas	South America	Central America, North America and Caribbean				Asia			Overall means Grain yield (t/ha)	Days to silk	Plant ht (cm)
		1	2	3	4	5	6	7	8			
21	S99TLW BNSEQ (1)	1.9	6.5	7.0	6.9	4.5	4.0	6.4	7.5	5.6	65	218
22	S98TLW-2 B	1.9	6.0	6.8	6.9	4.4	4.0	6.7	7.0	5.4	65	218
20	ACROSS S9643	1.6	5.9	6.6	7.1	3.9	4.5	5.9	6.7	5.3	67	236
19	S97 TLW GH "A y B" (2)	1.5	6.1	6.1	7.8	3.8	3.0	7.0	6.4	5.2	66	223
17	S99TLWQ-AB	1.7	5.8	5.6	5.8	3.5	4.2	7.2	7.1	5.1	64	213
14	S99TLWQ HG"AB"	1.4	5.9	6.0	6.2	3.9	3.1	6.6	6.8	5.0	64	214
23	POZA RICA 8763 RE	1.7	5.9	6.5	4.4	4.2	2.6	6.9	7.5	5.0	63	212
18	POZA RICA 9443 RE	1.8	5.5	5.9	6.4	3.3	2.5	7.3	6.7	4.9	67	234
13	S99TLWQ HG"B"	2.1	5.5	5.5	5.5	3.8	2.7	7.6	6.6	4.9	64	208
6	S00TLWQ-A	1.3	5.3	5.3	6.5	2.2	4.1	7.2	7.0	4.9	66	213
16	S99TLWQ-B	1.7	5.6	6.0	5.7	3.4	2.9	6.7	6.6	4.8	64	206
8	S00TLWQ-B	2.1	5.7	5.9	5.4	3.7	3.4	5.5	6.8	4.8	65	214
7	S00TLWQ-A1	1.7	5.0	6.7	5.6	3.2	2.9	6.3	5.8	4.6	65	206
9	S00TLWQ-AB	1.9	5.8	5.5	5.7	3.1	2.2	6.1	6.7	4.6	66	207
12	S99TLWQ HG"A"	1.6	5.9	5.9	4.9	4.0	1.6	6.0	6.2	4.5	64	218
15	S99TLWQ-A	1.3	5.6	6.1	5.5	2.9	2.5	5.5	6.7	4.5	65	217
10	S99TLWQ-1	1.1	5.1	5.0	5.6	3.1	4.2	5.7	5.7	4.4	66	207
11	S99TLWQ	1.6	5.4	5.0	5.9	2.4	3.2	5.8	6.1	4.4	65	209
4	SIN-1 P73 NICOP	1.8	5.4	4.8	3.9	3.1	3.2	5.1	7.1	4.3	64	219
2	SIN-1 P73 COT-1	2.1	4.7	3.7	3.7	3.4	3.6	6.2	6.5	4.2	65	213
5	SIN-1 P73 PR-5	1.5	4.5	3.6	4.1	3.9	2.6	5.1	5.7	3.9	64	210
3	SIN-1 P73 NIC-3	1.7	4.2	3.3	2.7	3.4	2.5	4.9	5.6	3.5	64	211
1	P73NISA1	1.2	4.3	2.6	2.5	2.9	1.9	3.9	5.2	3.1	65	207
24	Local Check-1	1.3	5.6	5.5	7.3	3.3	2.3	4.6	5.8	4.5		
25	Local Check-2	1.5	4.5	6.5	6.4	3.1	2.6	4.1	5.8	4.3		
	MEANS	1.7	5.5	5.4	5.4	3.5	3.1	6.2	6.5	4.7		
	C.V.%	23.3	9.1	13.5	18.8	12.0	29.0	11.3	9.4	15.8		

No.	Country	Location
1	Colombia	Villavo
2	Guatemala	Ovejero, Jutiapa
3	Mexico	Agua Fria
4	Mexico	Cotaxtla
5	Nicaragua	Santa Rosa
6	India	Dholi
7	India	Dholi (2)
8	Indonesia	Takalar, South Sulawesi

Table 36. EVT12S. Lowland Tropical white Normal and QPM Synthetics across seven locations in 2002.

Ent no	Pedigree	Yield t/ha	Bck %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Ear ht Plt ht	Mo %	Erott %	Pltasp 1_5	Earasp 1_5	Rldg %	Sldg %	BH %	Earro 1_5	Plt #	Stunt %	EnH 1_5	BH 1_5	Stunt %	Leafspor 1-5	Rust 1_5	B.M. 1_5
21	S99TLW BNSEQ (1)	5.45	122	56	56	0.3	218	113	1.0	19	9	2.56	2.79	21	3.3	9.1	1.92	42	0.0	1.8	1.4	1.2	1.2	2.5	1.9
22	S98TLW-2 B	5.25	118	55	56	1.0	218	111	1.0	22	8	2.31	2.81	9	5.4	4.1	1.83	44	0.9	2.0	1.5	0.4	1.5	2.3	1.7
20	ACROSS S9643	5.13	115	58	58	0.9	236	124	0.9	21	16	2.56	2.93	15	9.2	2.3	2.00	43	0.0	1.8	1.4	4.7	1.2	2.0	1.5
19	S97 TLW GH "A y B" (2)	5.05	113	56	58	1.1	223	121	0.9	22	10	2.42	2.74	13	3.8	4.4	1.92	42	0.0	1.5	1.4	1.4	1.0	2.3	1.7
23	POZA RICA 8763 RE	4.79	107	53	55	1.3	212	102	0.9	19	17	2.72	3.14	17	4.8	8.0	2.58	43	0.0	2.5	1.5	2.1	1.0	2.7	2.1
17	S99TLWQ-AB	4.79	107	54	55	1.2	213	107	0.8	19	15	2.50	3.17	16	7.4	9.3	2.33	43	0.0	2.5	1.3	4.0	1.3	2.7	1.8
14	S99TLWQ HG"AB"	4.75	106	55	56	1.0	214	111	0.9	21	13	2.61	3.14	23	5.8	11.2	2.33	44	0.0	2.3	1.8	2.0	1.2	2.0	1.5
8	S00TLWQ-B	4.72	106	56	57	0.9	214	112	0.9	21	8	2.69	2.69	18	9.0	2.1	1.92	43	0.0	1.8	1.5	1.2	1.3	2.2	1.6
18	POZA RICA 9443 RE	4.64	104	58	59	1.0	234	128	0.9	23	13	2.67	3.21	17	6.1	3.6	2.58	43	1.1	2.2	1.5	1.6	1.2	2.3	1.8
16	S99TLWQ-B	4.57	102	55	55	0.9	206	106	0.9	19	13	2.44	3.19	18	8.1	5.4	2.17	42	0.0	2.3	1.3	2.5	1.0	2.3	1.7
6	S00TLWQ-A	4.50	101	55	57	1.6	213	103	0.8	20	18	2.44	3.19	9	2.7	15.3	2.42	42	0.0	2.2	1.4	3.4	1.0	2.2	1.8
9	S00TLWQ-AB	4.48	100	56	57	1.4	207	100	0.8	21	14	2.75	2.95	18	6.6	9.0	2.42	43	0.0	2.7	1.5	3.2	1.2	2.2	1.7
12	S99TLWQ HG"A"	4.46	100	55	56	0.8	218	106	0.9	21	12	2.69	2.90	19	6.1	7.8	2.08	43	1.1	2.5	1.3	3.3	1.3	2.5	1.8
13	S99TLWQ HG"B"	4.43	99	55	56	1.5	208	108	0.9	20	13	2.50	3.02	22	9.7	5.3	2.17	43	0.0	2.0	1.5	2.9	1.3	2.3	1.8
15	S99TLWQ-A	4.43	99	55	56	1.1	217	101	0.8	20	16	2.53	3.24	17	6.9	11.9	2.50	44	0.0	2.7	1.3	5.1	1.0	2.3	1.7
7	S00TLWQ-A1	4.42	99	55	56	1.3	206	97	0.8	21	20	2.42	3.19	16	4.5	11.0	2.50	42	0.0	2.5	1.3	3.4	1.0	2.3	1.9
10	S99TLWQ-1	4.26	95	56	57	1.2	207	105	0.8	21	12	2.33	3.10	14	6.2	3.9	2.25	42	0.0	2.5	1.4	4.4	1.2	2.7	2.0
11	S99TLWQ	4.20	94	56	57	0.9	209	101	0.8	20	14	2.53	3.29	14	8.2	4.5	2.50	43	0.0	2.0	1.3	4.3	1.2	2.3	2.0
4	SIN-1 P73 NICOP	4.01	90	55	56	1.1	219	115	0.8	18	15	2.97	3.38	32	6.7	6.1	2.83	43	0.0	2.0	1.4	3.2	1.2	2.3	2.2
2	SIN-1 P73 COT-1	3.90	87	55	56	1.3	213	117	0.9	19	13	3.03	3.24	38	9.7	3.5	2.25	41	0.0	1.8	1.3	4.5	1.3	2.7	2.3
5	SIN-1 P73 PR-5	3.66	82	54	55	1.0	210	109	0.8	19	17	2.69	3.26	37	6.5	5.6	2.42	43	0.0	1.8	1.3	2.6	1.3	2.8	2.6
3	SIN-1 P73 NIC-3	3.30	74	54	55	1.3	211	109	0.8	19	11	2.81	3.36	42	5.5	5.7	2.50	40	0.0	2.0	1.3	5.3	1.0	3.0	2.5
1	P73NISA1	2.95	66	55	56	1.0	207	107	0.8	18	20	2.89	3.50	39	7.1	1.3	3.17	41	0.0	2.0	1.3	3.1	1.5	3.3	2.8
24	Local Check-1	4.47	100	55	55	0.6	217	113	0.9	20	9	2.8	3.0	17.8	6.3	2.2	1.92	38	0.0	1.8	1.3	2.9	1.0	2.2	1.5
25	Local Check-2	4.35	97	54	55	1.2	214	112	0.9	19	10	2.8	3.2	18.8	5.7	6.8	2.33	39	0.0	2.0	1.3	1.1	1.0	2.7	2.3
	Check Mean	4.41		54	55		216	112	0.9	20	9	2.8	3.1	18.3	6.0	4.5	2.13	38	0.0	1.9	1.3	2.0	1.0	2.4	1.9
	Grand Mean	4.44		55	56		215	110	0.9	20	14	2.6	3.1	21.0	6.5	6.5	2.33	43	0.1	2.2	1.4	3.0	1.2	2.4	1.9
	LSD 5%	0.68		1.2	1.3		9.3	8.4		1.9															
	CV %	15.45		1.8	1.9		4.9	9.5		10.5															
	F value Loc*Entry	0.88		1.3	1.1		0.6	0.5		0.7															
	P(F>f)	0.80		0.04	0.19		1.00	1.00		0.99															
	Number of locations	7		7	7	7	6	6	6	7	6	6	7	5	5	5		7	1	1	2	2	1	1	2

No	Country	Location
1	Colombia	Villavo
2	Guatemala	Ovejero, Jutiapa
3	India	Dholi
4	Indonesia	Takalar, South Sulawesi
5	Mexico	Agua Fria
6	Mexico	Cotaxtla
7	Nicaragua	Santa Rosa

2.23 Evaluation of tropical late yellow synthetics in 6 locations in the tropical environment 2002 (EVT-13S).

18 yellow tropical synthetic varieties including QPM and normal were included in a 4x5 alpha lattice design with 3 replications. ITU shipped 42 sets to 20 countries at closing of this report. We have received results from 6 locations in five countries.

As in the case of the white varieties in several locations the local check was a hybrid, nevertheless, in 6 out of 6 locations one or two yellow synthetics outyielded the best checks.

Yellow synthetic PR S9627 topped the trial across locations with 5.6 t/ha, 1000 kg more than the best checks (Table 37). This synthetic also showed similar maturity, lower plant height, excellent ear placement, resistance to root lodging, lower ear rot, resistance to corn stunt, *B. maydis* and showed good yield stability, ranking first at Mexico, Nicaragua and Indonesia (Table 38) Fig. 12.

Some synthetics with specific adaptation outyielded the best checks at individual locations: S0128, S0124, TAKFA-S9624, in Asia and Mexico.

Fig. 12. EVT13S. Grain yield for the best EVT's and the best local check across seven environments

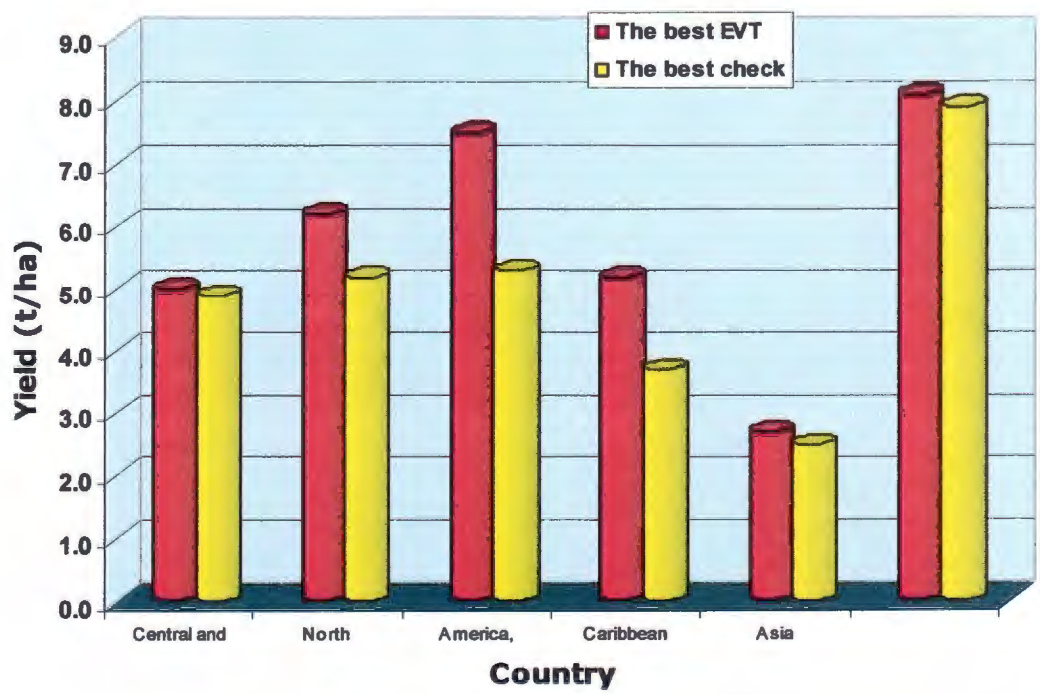


Table 37. EVT 13S. Lowland Tropical yellow Normal and QPM Synthetics across six locations in 20

Ent no	Pedigree	Yield t/ha	Bck %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Ear ht Plt ht	Mo %	Erott 1_5	Erott 1_5	Pltasp 1_5	Earasp 1_5	Rldg %	Sldg %	BH %	BH 1_5	Plt #	Fus %	Stunt %	Rust 1_5	B.M. 1_5	Virus %
14	POZA RICA S9627	**5.6**	**122**	58	59	-1.5	220	110	1.0	23	7	5.1	3.0	2.4	17	5.1	5.0	2.7	41.6	5.7	2.0	2.5	1.8	8
1	S0128	**5.4**	**117**	58	59	-1.0	223	122	1.0	24	5	1.9	3.2	2.4	27	8.1	3.9	2.7	40.1	12.6	1.1	2.3	1.8	4
15	TAKFA S9624	**5.0**	**109**	57	58	-1.4	223	120	0.9	25	10	1.8	3.4	2.8	19	5.2	8.0	2.7	40.0	8.0	3.5	2.5	1.9	7
16	S98TLY-1 B	**5.0**	**109**	57	59	-1.3	215	115	1.0	26	7	1.9	3.0	2.6	19	5.0	5.4	2.3	40.1	2.1	1.5	2.3	1.7	4
3	S0124	**5.0**	**108**	57	58	-1.2	225	113	1.0	24	6	1.9	3.3	2.8	31	7.1	7.3	3.0	38.1	7.8	4.4	2.2	1.8	3
17	ACROSS S9624-1	**4.9**	**107**	56	58	-1.4	225	117	1.0	23	8	2.0	3.2	2.9	16	6.5	14.7	2.7	40.2	4.9	4.1	2.0	1.8	7
13	S97 TLY GH "A y B" (1) (RE)	**4.8**	**105**	58	59	-1.5	211	117	1.0	24	5	2.0	3.1	2.8	15	10.0	8.8	2.7	38.4	9.2	1.9	2.3	1.9	5
11	S99TLYQ-AB	**4.8**	**105**	55	57	-1.5	214	110	0.9	23	8	2.0	3.3	3.1	23	9.5	12.0	2.7	38.7	2.9	2.0	3.0	2.5	5
2	S0136	**4.7**	**102**	58	60	-1.3	218	114	0.9	24	7	1.6	3.1	2.7	20	7.5	8.2	2.3	39.2	11.3	1.6	2.0	1.5	3
8	S99TLYQ GH"AB"	**4.7**	**102**	55	56	-1.0	211	113	0.9	23	8	2.0	3.2	2.9	20	7.7	8.6	2.7	40.3	6.3	2.7	2.0	2.0	2
7	S99TLYQ GH"B"	**4.5**	**98**	55	56	-1.1	210	111	0.9	22	5	1.9	3.3	3.0	20	5.4	9.4	2.7	40.2	4.8	2.7	2.7	2.3	1
6	S99TLYQ GH"A"	**4.5**	**97**	55	56	-1.2	210	111	0.9	23	6	2.3	3.3	2.8	25	6.6	9.0	2.3	38.4	11.0	3.9	2.0	2.0	4
9	S99TLYQ-A	**4.4**	**97**	55	56	-1.1	215	113	0.9	23	8	1.9	3.5	2.9	34	6.6	7.7	3.0	37.7	6.8	2.5	2.2	2.3	3
5	S00TLYQ-AB	**4.3**	**94**	56	58	-1.6	212	110	0.9	24	8	2.0	3.4	3.0	28	8.2	8.9	2.7	38.7	5.7	2.5	2.7	2.2	1
10	S99TLYQ-B	**4.2**	**91**	56	57	-1.1	219	116	0.9	22	7	2.4	3.5	3.1	17	5.5	13.0	2.7	38.9	8.5	3.0	2.7	2.4	2
18	COTAXTLA S9627-1	**4.1**	**90**	57	59	-1.8	221	111	1.0	23	10	1.8	3.5	2.8	37	7.6	4.6	2.7	37.3	6.0	7.0	2.3	2.0	10
4	S00TLYQ-B	**4.1**	**88**	56	57	-1.2	213	110	0.9	22	6	2.2	3.4	2.9	17	4.7	7.5	2.3	38.5	9.1	2.0	2.5	2.0	4
12	IBOPERENDA 8666 (RE)	**4.0**	**87**	56	57	-1.9	209	105	0.9	24	12	2.8	3.4	3.5	22	7.4	8.5	2.3	37.1	6.5	3.9	2.7	2.3	10
19	Local Check	**4.6**	**99**	57	59	-1.9	225	121	0.9	23	10	2.1	3.5	2.9	27	10.4	7.5	3.0	37.6	5.0	3.3	2.3	1.8	3
20	Local Check	**4.6**	**100**	56	57	-1.1	218	113	0.9	23	7	1.6	3.4	2.7	30	7.9	7.1	3.0	37.7	7.7	2.5	2.2	2.1	2
	Check Mean	4.6		56.6	58.1	-1.5	221	117	0.9	23	8	1.8	3.5	2.8	28	9.1	7.3	3.0	37.7	6.4	2.9	2.3	1.9	2
	Grand Mean	4.7		56	58	-1.3	217	114	0.9	23	8	2.2	3.3	2.8	23	6.9	8.4	2.6	39.1	7.2	2.9	2.4	2.0	5
	LSD 5%	0.57		1.2	1.3		8.5	7.5		1.6														
	CV %	13.0		1.7	2.1		5.1	9.4		7.2														
	F value Loc*Entry	0.68		1.3	0.8		0.5	0.4		0.7														
	P(F>f)	0.98		0.08	0.88		1.00	1.00		0.97														
	Number of locations	6		6	6		6	6	6	6	5	2	5	6	5	6	5	1	6	1	2	1	2	1

No	Country	Location
1	Guatemala	San Pedro Pinula, Jalapa
2	India	New Delhi
3	Indonesia	Takalar, South Sulawesi
4	Mexico	Cotaxtla
5	Mexico	Agua Fria
6	Nicaragua	Santa Rosa

Table. 38. EVT13S. Mean for different traits for Lowland Tropical yellow Normal and QPM Syntheticsacross six environments in 2002.

Ent. No.	Entry Name	Central America, North America and Caribbean				Asia		Overall means		
		1	2	3	4	5	6	Grain yield (t/ha)	Days to silk	Plant ht (cm)
14	POZA RICA S9627	4.5	6.1	7.5	4.9	2.5	8.1	5.6	59	220
1	S0128	5.0	5.9	6.3	5.2	2.6	7.2	5.4	59	223
15	TAKFA S9624	4.0	6.2	5.8	4.3	2.4	7.5	5.0	58	223
16	S98TLY-1 B	4.3	5.6	6.0	5.0	2.6	6.6	5.0	59	215
3	S0124	4.7	5.5	6.9	4.7	1.4	6.6	5.0	58	225
17	ACROSS S9624-1	4.2	5.5	5.4	4.3	2.7	7.5	4.9	58	225
13	S97 TLY GH "A y B" (1) (RE)	4.1	5.5	5.4	5.2	1.9	7.0	4.8	59	211
11	S99TLYQ-AB	4.5	5.6	5.3	4.5	1.6	7.4	4.8	57	214
2	S0136	3.5	5.2	6.1	4.2	1.9	7.2	4.7	60	218
8	S99TLYQ GH"AB"	4.1	5.8	5.2	3.7	2.6	6.7	4.7	56	211
7	S99TLYQ GH"B"	4.3	5.4	5.0	4.0	2.7	5.7	4.5	56	210
6	S99TLYQ GH"A"	4.0	5.0	4.8	3.7	2.2	7.1	4.5	56	210
9	S99TLYQ-A	4.5	5.3	5.1	3.7	1.6	6.6	4.4	56	215
5	SOOTLYQ-AB	3.7	5.1	4.9	4.2	1.7	6.2	4.3	58	212
10	S99TLYQ-B	4.4	4.7	3.6	3.6	2.2	6.6	4.2	57	219
18	COTAXTLA S9627-1	3.0	4.7	5.3	3.5	1.7	6.7	4.1	59	221
4	SOOTLYQ-B	3.5	4.8	4.3	3.1	2.3	6.4	4.1	57	213
12	IBOPERENDA 8666 (RE)	3.7	4.6	4.4	2.8	1.9	6.5	4.0	57	209
20	Local Check-2	4.9	5.2	5.3	3.7	2.3	6.1	4.6		
19	Local Check-1	4.1	5.2	4.3	3.3	2.5	7.9	4.6		
	MEANS	4.1	5.4	5.4	4.1	2.1	6.9	4.7		
	C.V.%	12.4	9.7	17.5	12.1	22.9	7.8	13.7		

No.	Country	Location
1	Guatemala	San Pedro Pinula, Jalapa
2	Mexico	Agua Fria
3	Mexico	Cotaxtla
4	Nicaragua	Santa Rosa
5	India	New Delhi
6	Indonesia	Takalar, South Sulawesi

2.24 Evaluation of tropical late maturing synthetics tolerant to biotic and abiotic stresses in the tropical environment.

Open pollinated varieties with good yield potential and extended adaptation to marginal environments that possess the capacity to buffer the different limiting constraints to maize production and enhance yield stability provided by resistance to biotic and abiotic stresses. Another important factor is that more than 60% of the farmers planting corn in the tropical environments do not use improved varieties or hybrids because the seed costs have gone sky high in recent years, therefore development of good synthetics OPV varieties is of prime importance in the tropical lowland subprogram. In 1999 we started to develop synthetic varieties that possess more uniformity, resistant to foliar diseases, lower ear placement to be more attractive to farmers.

2.25 Evaluation of 14 synthetics resistant to biotic and abiotic stresses in 30 locations in Central America.

Synthetics: QPM and Normal

New tropical white QPM synthetics. We have developed a range of new QPM synthetics for tropical environments. These possess good yield potential, intermediate plant height, low ear placement and uniformity, tolerance to root lodging and foliar diseases, resistance to ear rot, semi-flint kernel texture, high milling percentage, and twice the lysine and tryptophan of normal maize. Since they are open pollinated varieties, the cost of seed is lower and farmers can save seed from progeny for planting in subsequent seasons. Some of the synthetics were developed with an eye to heterotic response, and can thus be used as parents in non-conventional hybrids.

Evaluation of synthetics resistant to biotic and abiotic stresses. On-farm test and promotion of the new synthetic varieties in marginal areas such as the project carried out by PRM where near 30 trials were conducted in 2001 in farmer's fields is strongly recommended. In 2001 fourteen OPV synthetics resistant to different stresses were tested in 29 locations in Central America, Synthetic CTS-1 (resistant to insects), and S97 TLW HG"A&B" outyielded the best local check with up to 30%. The best synthetic yielded 5.8 ton/ha and the local checks 4.4 ton/ha. In 2002 more than 200 strip test validation trials were planted on poor resource farmer fields growing corn in Central America. Community based seed production systems is associated to on-farm validation tests.

With the information collected from the strip tests: Synthetic S97TLW-AB was released in Guatemala and two more synthetics will be released in Nicaragua and El Salvador.


New released QPM line CML492

3. Quality Protein Maize Project

Since 1997, when the Nippon Foundation helped CIMMYT to reactivate Quality Protein Maize (QPM) research, 21 developing countries have released dozens of QPM hybrids and varieties for use by farmers, while more than 30 countries annually request CIMMYT QPM trials. These encouraging results and continuation of Nippon found set up QPM program as priority in tropical lowland research activities.

The total number of rows planted with QPM material in 2002A season was 1,710 - 5m long (122 at Cotaxtla and 1,588 at Tlaltizapan). In 2002B season we planted 6,681 rows at Agua Fria breeding station and 1,076 rows at Cotaxtla (Table 39). All activities performed were related with: seed increase of hybrids, synthetics, pools, and populations; selection of inbred lines; evaluation of hybrids and synthetics; and conversion of normal lines to QPM.

Table 39. Number of 5 m long rows in QPM breeding activities at Tropical Lowland subprogram in 2002.

	Cotaxtla	Tlaltizapán	Cotaxtla	Agua Fría	
Breeding material	2002A	2002A	2002B	2002B	**Totals**
Recycling F_1 to F_2 white		185		307	492
Recycling F_1 to F_2 yellow		126		65	191
F2 populations white				190	190
F2 populations yellow				190	190
S2 to S4 nurseries white				442	442
S2 to S4 nurseries yellow				178	178
S5 to S8 nurseries white				142	142
S5 to S8 nurseries yellow				61	61
CML, seed increase		102		400	502
Backcrossing & MAS	36			96	96
Hybrid formation		1,037		716	1,753
Seed increase of pools, populations, synthetics and EV		35		1,770	1,805
Seed increase of hybrids				925	925
Formation of new synthetics				60	60
Formation of F_1 populations	86	103			103
Trials			1,076	1,139	2,215
Totals	**122**	**1,588**	**1,076**	**6,681**	**8,269**

Tropical lowland QPM project could be separated in several components:

- Incorporation of stress resistance in QPM
- Pedigree breeding (QPM)
- Conversion of normal lines to QPM
- Formation of QPM synthetics
- QPM hybrids development and testing

3.1 Incorporation of stress resistance in QPM

Lowland tropics is well known as very stressful environment, with many biotic and abiotic constrains. Knowing those stresses and incorporation of resistance for the most important constrains could greatly improve yield and dependability of QPM materials for certain areas. As the NIPPON-foundation is focused in Africa, we oriented our strategy in HQ to include in the process of selection all the limiting constrains prevailing in this part of the world. We crossed tropical germplasm with material resistant to maize streak virus (MSV) and gray leaf spot (GLS) to form F2 pedigree breeding populations, we are also creating new heterotic populations with resistance to both stresses.

In 2002 season 87 white and 120 yellow S2 lines developed from QPM line cross with some donors for resistance were grown and selected at Agua Fria location extremely favorable for different biotic stresses. One hundred and seventeen white and 85 yellow ears were selected for advancement. Total 20 F2 populations (QPM x source of stress resistance) were grown at Agua Fria, and 409 (293 white and 116 yellow) the best ears were selected based on tolerance to diseases, insects, and other important agronomic characteristics to be advanced in next season. In addition 185 white new F1's and 65 yellow F1 crosses between elite QPM germplasm and stress resistant source material were planted at Agua Fria in 2002B season.

Another important way to incorporate stress resistance in QPM material is to create opposite heterotic populations. These populations should have as many as possible donors for resistance while maintaining significant % of elite germplasm. Crosses for making these populations were selected and will be planted at Agua Fria in 2003A season. The next possible steps are to start some type of reciprocal recurrent selection from these populations, or half-sib selection using opposite inbred line as tester.

3.2 QPM pedigree breeding

QPM pedigree breeding program is the most important breeding method for development of new lines at tropical lowland subprogram. The objective of this part of tropical program is to develop the new QPM inbred lines that produce high grain yields and superior agronomic performance in hybrid combination.

Based on carefully selected parents and with the idea to develop stress tolerant QPM material 492 rows of white and 191 rows of yellow F1's were grown in 2002 for pedigree selection (Table 39). All F1's were screened for major diseases (maydis, rust, ear rot) and lodging. The susceptible ones were discarded from further use in pedigree breeding, because of low probability that new good lines can be developed from weak hybrids. Total 380 rows of F2 plants were grown at Agua Fria in 2002B. Selection in the former was performed at flowering and based on plants free of diseases, with no lodging, with favorable ear placement, and with no silk delay. The best 30-40% of the plants were selfed and selected again at harvest time for ear rot and good presents of QPM modifiers genes.

At QPM early generation nurseries S_2 to S_4 442 tropical, intermediate-to-late maturing, white QPM lines and 178 tropical, intermediate-to-late, yellow QPM lines were planted at Agua Fría in 2002B (Table 39). The selection we performed is based on rows performance, and then we selected the best plants within rows. The most resistant rows (plants) were selfed and at the harvest time selection was done based on low incidence of root lodging and resistance to ear rot. The best lines will be advanced to next generation. These lines will be forwarded to regional CIMMYT offices in Africa, where they could be selected under local environment, and crossed with local testers. After evaluation, the best lines can be used for hybrid formation as well as for formation of new high yielding synthetics for resource poor farmers.

Based on yield trials data from 2001B the most promising lines S_5 to S_8 white (142 rows) and yellow (61 rows) were planted at Agua Fria in 2002B (Table 39). They were planted ear-to-row in five-meter plots at a density of 66,666 plants per hectare. All healthy plants were selfed. The best lines will be designated as "elite" and sent to Africa, Latin America and Asia.

3.3 Conversion of normal lines to QPM

As mentioned in 2001 annual report conversion process of two CIMMYT elite lines CML264 and CML273 is completed. Preliminary results of these two lines in crosses with other QPM elite germplasm are very encouraging. Converted line CML264Q in single-cross and three-way cross combinations made hybrids with excellent performance and topped many yield trials. Also protein quality data confirmed that conversion process was successfully completed.

Table 40 shows head-to-head analysis of CML264 x CML273 (normal hybrid) versus CML264Q x CML273Q (QPM hybrid from converted lines) and the best local checks from 2001 and 2002 yield trials. It is very clear that there is no differences in any of studied traits between normal and converted version, while new QPM hybrid outyielded the best local check for more than 800 kg/ha across 28 locations and had much better standability (stalk and root lodging) and plant scores.

Table 40. Head-to-head analysis of CML264Q x CML273Q vs. CML264 x CML273 and the best local check based on data from 28 locations in 2001B and 2002B.

Hybrid	Yield (t/ha)	End Hard	ER %	RL %	SL %	Mo %	BH %	Silk	Poll.	PH cm	EH cm	EA asp.	Plt. asp.	Try %
CML264Q x CML273Q	6.68	2.20	6.1	10.9	3.7	20.3	5.2	56.0	56.3	235	120	2.77	2.70	0.083
CML264 x CML273	6.60	2.14	5.9	13.8	3.3	19.6	7.1	55.9	56.1	231	118	2.79	2.58	0.050
Local Check	5.85	1.82	6.2	31.2	10.8	20.2	5.5	54.4	54.4	232	124	2.78	3.40	0.050
Number of locations	28	24	28	24	28	28	25	27	28	28	28	28	22	
Prob. QPM vs. Normal	0.68	0.47	0.83	0.23	0.40	0.08	0.17	0.33	0.38	0.07	0.21	0.83	0.32	
Prob. QPM vs. Check	0.00	0.02	0.94	0.00	0.02	0.78	0.80	0.00	0.00	0.14	0.12	0.88	0.00	

Yield=Grain Yield t/ha; End Hard.= Score for endosperm hardness (1-5); ER= % of Ear Rot; RL=% of Root Lodging; SL=% of Stalk Lodging; Mo=% of Grain Moisture; Silk=Days to Silk; Poll.= Days to flowering; Plt= Plant height; EH=Ear Height; EA asp.=Ear Aspect (1-5); Plt. Asp.= Plant Aspect (1-5); Try=Tryptophan in the whole kernel (average of the parents)

In 2002B cycle we planted 56 rows for conversion of another seven elite normal lines (R1, CML247, CML254, CL-RCW01, CML451, CL-02450, and CML287). Based on the data from DNA analyses homozygous recessive (o2o2) plants were used for making backcrosses with recurrent parents. The selected ears (BC1F1) will be planted in next cycle and two different conversion-breeding schemes will be used for this purpose (see chapter "additional work on tropical lowland subprogram" for the new scheme).

3.4 Formation of QPM synthetics

Development of quality protein maize synthetics with excellent yields, uniformity, tolerance to pests and diseases, and high values of essential amino-acids is very important task at tropical lowland subprogram. Developed synthetics can be used directly by resource poor farmers for stable yields, as female parents in creation of non-conventional hybrids, as opposite synthetics in reciprocal - recurrent breeding scheme, and as source population for inbred lines development.

Based on 2001B yield trials the best-inbred lines were selected for formation of five white and two yellow QPM synthetics. Lines were planted in 2002B cycle and all possible crosses between selected lines were made. Series of single cross hybrids will be planted in next cycle to complete formation of synthetics (i.e. syn.1 to syn.2). In 2002B season tropical lowland subprogram increased seeds of S99TLWQ-1, one of the best QPM synthetics. This synthetic was planted on 1110 rows and more than 1.500 kg of seeds were harvested.

3.5 QPM hybrids development and testing

Close to 300 new white and around 140 yellow crosses between advanced and elite QPM lines were made in year 2002. Crosses made in season 2002A were grown in yield trials in 2002B. Total 16 new white and 14 yellow superior hybrids were grown in international (CHTTWQ and CHTTYQ) yield trials in 2002B. In addition others 280 hybrids, and 12 new QPM synthetics were evaluated in yield trials managed by tropical lowland subprogram on 4-5 locations. Trials from these locations are analyzed, data stored in database, and based on results we planed our new crosses and breeding nursery plantings for 2003A cycle.

Table 41. Mean grain yields (without reduction for ear rot), CV's, and LSD's for seven locations across eight QPM experiments in 2002B.

	Experiment									
Location	21	22	23	24	25	26	27	28	AVG	
	7.09	6.60	6.72	6.28	6.34	5.12	7.05	5.49	**6.34**	GRAND MEAN
	1.43	1.38	1.25	1.29	1.70	1.49	1.59	1.03	**1.40**	LSD 5 %
Aqua Fria - Mexico	9.58	9.26	9.27	9.52	13.33	14.06	10.77	8.99	**10.60**	CV %
	6.99	6.12	6.29	6.73	6.85	7.49	7.63	5.65	**6.72**	GRAND MEAN
	2.29	1.64	2.15	2.04	2.62	2.44	1.36	1.00	**1.94**	LSD 5 %
Cotaxtla - Mexico	15.52	11.85	17.01	14.07	19.02	15.74	8.49	8.55	**13.78**	CV %
					6.16	6.08			**6.12**	GRAND MEAN
					2.50	2.34			**2.42**	LSD 5 %
Guadalajara - Mexico					20.13	18.58			**19.36**	CV %
	5.41	4.78	5.62	4.04	5.44	5.27		3.89	**4.92**	GRAND MEAN
	2.00	1.10	1.32	1.14	1.47	2.66		1.06	**1.54**	LSD 5 %
Turipana - Colombia	17.49	10.20	11.72	13.08	13.46	24.34		13.05	**14.76**	CV %
	6.46	6.02	6.73	5.78	5.79	6.33		5.27	**6.05**	GRAND MEAN
	0.98	1.29	0.87	1.11	1.35	1.13		0.81	**1.08**	LSD 5 %
Cuyuta - Guatemala	7.19	9.46	6.45	8.88	11.54	8.63		7.38	**8.50**	CV %
	3.08	3.77	1.97	3.15	3.87	4.22		2.49	**3.22**	GRAND MEAN
	1.39	1.15	1.15	1.72	2.28	2.14		0.84	**1.53**	LSD 5 %
New Delhi - India	21.46	13.53	29.12	25.31	29.32	24.43		16.28	**22.78**	CV %
	3.41								**3.41**	GRAND MEAN
	1.36								**1.36**	LSD 5 %
San Andres - El Salvador	18.93								**18.93**	CV %

Total eight yield trials were grown on seven different locations. Three locations were in Mexico and one in Colombia, Guatemala, India and El Salvador. Grand mean, coefficient of variations (CV), and least significant difference (LSD) for grain yield for each experiment-locations are shown in table 41. The smallest values of CV, and LSD were observed at location Cuyuta – Guatemala (8.50 % and 1.08t/ha) and Agua Fria – Mexico (10.60% and 1.40t/ha) confirming the best management of yield trials in these two locations. At location Cotaxtla - Mexico probably high lodging caused by several storms decreased preciseness of the evaluated experiments, but this location again confirmed high yielding potential (average yield for all experiment 6.72 t/ha) in 2002B season. Highest values of CV and LSD were estimated at location New Delhi – India due to severe drought conditions during growing season.

The results of all trials are discussed below. In further discussion mean grain yield is expressed as clean yield i.e. yield decreased for % of ear rot (in Tables Yield 1), unless it is pointed out different. The trypthopan data for QPM hybrids were calculated using average values for tryptophan from inbred lines, parents of the observed hybrid. Due to expensive chemical analyses and high correlation coefficient between tryptophan and lysine (0.954 in our case based on more than 300 samples) only tryptophan content for QPM lines was requested and obtained from the laboratory.

3.5.1 TSCWQ02-21. Evaluation of advanced tropical QPM white single crosses

Crosses between released white late QPM CIMMYT lines and with advanced QPM lines were evaluated at six locations with two replications in 4x8 α-lattice design with goal to identify the best hybrids for CHTT's. The 27 crosses between QPM lines, two QPM reference hybrids, one normal hybrid, and two commercial checks made total 32 entries. Plots consisted of one row plot 0.75m apart and 5m long. Scores and counts were taken for several important traits and results are presented in tables 42 and A113 to A119.

Analysis of variance (ANOVA) showed that there is no significant interaction between genotypes and environment, while at each individual location significant differences were observed between entries for grain yield (Tables A113 to A119).

The highest mean grain yield for this experiment was achieved at Agua Fria (7.09 t/ha), following by Cotaxtla (6.99 t/ha), while the lowest yield had New Delhi-India (3.08 t/ha), respectively. The highest yielding hybrids were CLQ-RCWQ50 x CML144 with 5.99 t/ha and CLQ-RCWQ01 x CLQ-6316 (5.98 t/ha). These hybrids outyielded the best local checks for 24% percent and were better than QPM reference hybrid (CML144 x CML159) for more than 40% (Table 42). Also endosperm hardness scores, ear rot and standability of these hybrids were at high level confirming their high agronomic performance. Almost all advanced hybrids had higher yield performance than QPM reference hybrid, and 2/3 of them higher yield than the best normal endosperm local checks (Table A119).

Table 42. TSCWQ02-21. Means for top ten tropical QPM white single crosses, reference entries, and local checks across six locations in 2002.

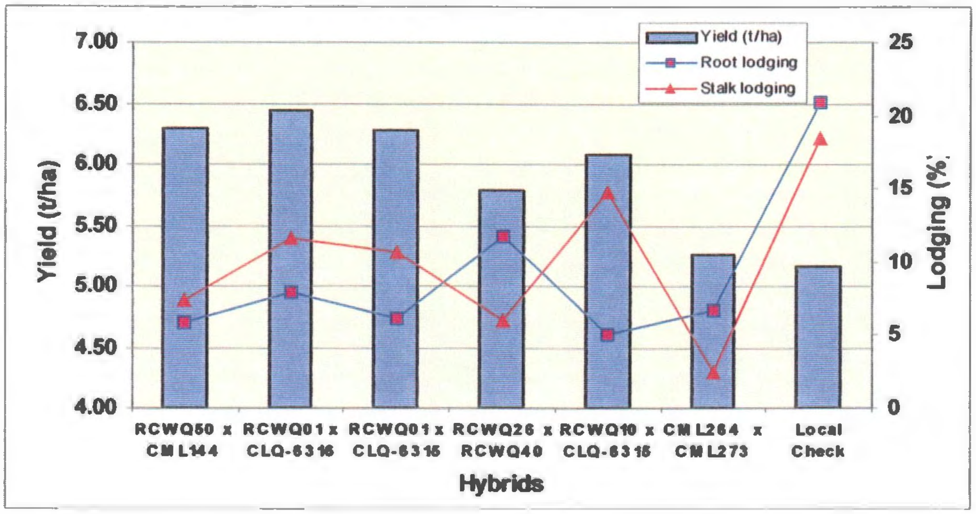
Ent no	Pedigree			Yield 1 t/ha	Yield t/ha	Bck N %	Bck Q %	EnH 1_5	Erott %	Silk days	ASI	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	Ear #	Plt #	Stunt 1_5	Try %
13	CLQ-RCWQ50	x	CML144	**5.99**	**6.30**	**124**	**141**	1.9	4.8	54	0.4	0.50	0.99	20.4	2.8	2.5	5.9	7.4	44	45	2.7	0.108
5	CLQ-RCWQ01	x	CLQ-6316	**5.98**	**6.44**	**124**	**140**	1.5	7.1	56	0.6	0.54	0.93	21.6	3.1	2.5	7.9	11.6	42	46	3.8	0.099
6	CLQ-RCWQ01	x	CLQ-6315	**5.77**	**6.27**	**120**	**135**	1.7	8.0	55	0.7	0.54	0.96	21.6	3.1	2.7	6.1	10.6	46	48	13.6	0.105
9	CLQ-RCWQ26	x	CLQ-RCWQ40	**5.61**	**5.79**	**116**	**132**	1.5	3.1	53	-0.2	0.49	0.91	20.4	3.4	2.5	11.7	6.0	41	45	4.7	0.089
4	CLQ-RCWQ10	x	CLQ-6315	**5.53**	**6.08**	**115**	**130**	2.0	8.9	52	-0.3	0.49	0.95	21.5	3.3	2.7	5.1	14.8	42	44	4.1	0.096
14	CML142	x	CLQ-RCWQ11	**5.48**	**5.93**	**114**	**128**	1.6	7.7	55	0.2	0.54	0.94	19.6	3.4	2.7	9.3	6.3	43	46	3.1	0.094
2	CLQ-RCWQ13	x	CLQ-6316	**5.41**	**5.77**	**112**	**127**	2.5	6.3	56	0.2	0.52	0.88	20.9	3.2	2.8	6.8	5.8	39	43	7.4	0.091
1	CLQ-RCWQ15	x	CLQ-6316	**5.23**	**5.76**	**108**	**123**	2.3	9.3	53	0.5	0.50	0.90	20.1	3.1	3.3	6.2	9.8	42	47	3.2	0.097
3	CLQ-RCWQ10	x	CLQ-6316	**5.22**	**5.64**	**108**	**122**	2.2	7.5	54	0.3	0.51	0.92	21.9	3.6	2.8	15.6	4.0	37	41	7.1	0.091
18	CML142	x	CML147	**5.19**	**5.71**	**108**	**122**	1.6	9.2	55	0.7	0.52	0.96	20.5	3.3	2.7	10.4	7.2	44	47	4.6	0.101
28	CML144	x	CML159	**4.26**	**4.57**	**88**	**100**	1.9	6.8	55	0.5	0.50	0.87	19.6	3.5	2.8	15.5	17.5	35	41	4.8	0.096
29	CML264	x	CML273	**5.06**	**5.27**	**105**	**119**	2.2	3.8	56	1.1	0.52	0.96	20.2	2.8	2.9	6.6	2.4	36	37	4.3	0.050
30	CML264Q	x	CML273Q	**4.97**	**5.29**	**103**	**117**	2.4	6.0	57	0.8	0.49	1.01	21.3	2.7	2.8	3.0	3.2	38	38	2.8	0.091
31	Local Check #1			**4.82**	**5.16**	**100**	**113**	2.2	6.7	54	0.3	0.55	0.95	21.4	3.8	3.1	20.9	18.4	40	42	3.8	0.050
32	Local Check #2			**4.76**	**5.31**	**99**	**112**	1.7	10.3	53	0.4	0.54	0.90	20.8	3.6	2.8	17.5	4.1	39	44	5.7	0.050
			Check Mean	**4.78**	**5.12**			2.1	6.7	55	0.6	0.52	0.94	20.7	3.3	2.9	12.7	9.1	38	40	4.3	
			Grand Mean	**5.02**	**5.41**			2.0	7.2	54	0.3	0.52	0.93	20.4	3.4	2.9	14.1	12.3	40	44	5.3	
			LSD 5%	**0.62**	**0.65**			0.5	4.5	0.8	0.5	0.0	0.1	1.3	0.5	0.3	10.4	8.9	3.7	2.8	4.4	
			CV %		**13.27**			12.7	8.3	1.8	2.7	5.5	12.4	8.5	12.2	14.6	9.8	10.1	12.4	9.7	54.3	
			F value Loc*Entry		**1.24**			4.8	0.7	1.0	0.8	1.0	0.7	0.9	1.4	1.1	2.2	2.0	0.8	0.7	1.1	
			P(F>f)		**0.12**			0.0	1.0	0.6	0.8	0.5	1.0	0.7	0.1	0.3	0.0	0.0	0.8	1.0	0.4	
			Number of locations		**6**			5	5	6	6	6	6	6	4	6	5	6	6	6	2	

No	Set	Location	Country	Local Check-1	Local Check-2
1	1	Agua Fria	México	CML156xCML159	CML448xCML449
2	2	Cotaxtla	México	H520	CML448xCML449
3	3	Turipana	Colombia	C-343	V-156
4	4	Cuyuta	Guatemala	HB-83	NEB-0001
5	5	New Delhi	India	Pro311	Ganga Safed - 2
6	6	San Andres	El Salvador	HQ-61	H-59

Besides statistically significant yield performance of several top hybrids, all QPM hybrids had almost double content of tryptophan in comparisons with the best local checks (Table 42). These values were from 0.089% up to 0.108%. The advantages of new generation of QPM hybrids over local check can be easily seen at Figure 13.

The data clearly showed that QPM hybrids could compete with the best normal hybrids for grain yield and most other quality traits. Based on this study the biggest concern in QPM material is root and stalk lodgings, which in aggregate were higher than 25% for whole experiment. The fewer incidences in lodging had normal CML264 x CML273 hybrid (Fig. 13) and QPM version of the same hybrid. This means that in the future more attention should be put on improvement of this trait and some favorable alleles from normal endosperm germplasm should be identified and introduced into QPM.

Fig. 13. TSCWQ02-21. Average grain yield (t/ha) and root and stalk lodgings (%) for top five QPM hybrids, the best normal hybrid, and local check.



Some of the best hybrids from individual locations are already requested from national programs and seed will be increased. Seeds of the best hybrids across locations will be also increased and sent to CIMMYT hybrid tropical trials (CHTT). The best lines will be used together with other very good (advanced and early generations) QPM lines to form synthetics as one of the best solutions for resource poor farmers.

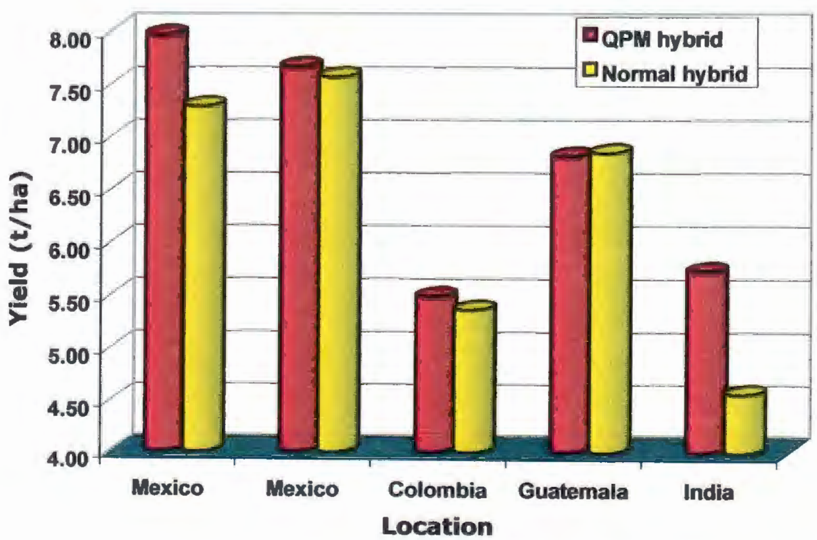
3.5.2 TSCYQ02-22. Evaluation of advanced tropical QPM yellow single crosses

Advanced generation of tropical yellow QPM hybrids were evaluated at five locations during 2002B season. Total 13 QPM hybrids, reference entry, and two local checks were grown in 4x4 α-lattice design with two replications per location and in 5 m long rows. The goals of this experiment were to identify the best hybrids for CHTT's as well as females for the TWC hybrids. Also the best lines will be used for formation of new sources for pedigree breeding selection. The results of the experiment are presented in tables 43 and A120 to A125.

Analysis of variance (ANOVA) across five locations showed significant interaction between genotypes and environment for grain yield, ear and plant aspects, lodgings, *helminthosporium maydis*, and bad husk coverage (Table A125). These findings will make general conclusions, across locations, less dependable.

Six out of thirteen studied hybrids outyielded reference QPM hybrid CML161 x CML165 (Table 43) and will be sent to CHTTQ04. The highest yielding QPM hybrid CML161 x CLQG2404 with 5.93 t/ha (11% higher than reference entry), showed excellent endosperm hardness scores, low incidence of ear rot, good resistance to observed diseases with lodgings at the same level as reference entry. Hybrids CML161 x CLQ-S89YQ06 and CML161 x CLQ-RCYQ22 besides high yield, had the highest standability in experiment, and showed more resistance to *fusarium moniliforme*, corn stunt, and general diseases than reference entry. Although across performance of the best QPM hybrids did not outyielded the best local check, it was possible to identify at individual locations (except Cuyuta - Guatemala) at least one QPM hybrid with higher yield performance than the best local check (Tables A120 - A124). These findings are getting more importance especially in the case when G x E interaction is significant (Fig. 14). Additional advantages of QPM hybrids are higher content of tryptophan and lysine, two essentially important amino-acids. Top QPM hybrids showed from 0.083 to 0.101 % of tryptophan, while estimation for normal endosperm hybrid is around 0.050%.

Figure 14. TSCYQ02-22. The grain yields performance of the best QPM hybrids and the best local check hybrids across five locations.



The same conclusion about resistance to root and stalk lodgings from white QPM program can be applied for yellow program. Generally QPM hybrids showed more lodgings and new sources of favorable alleles from normal endosperm germplasm should be identified and introduced into programs.

Studied yellow QPM hybrids in this experiment did not show higher yield across locations than selected the best local check hybrids. This means that further work is necessary to improve yield of yellow QPM hybrids. Maybe one of the main reasons is absence of the yellow normal lines converted to QPM (in white QPM programs CML264Q is one of the most useful line). Conversion of three the most important yellow normal lines to QPM are underway, and yellow QPM program should benefit from these conversions.

Table 43. TSCYQ02-22. Means for top six tropical QPM yellow single crosses, reference entries, and local checks across five locations in 2002.

Ent no	Pedigree			Yield 1 t/ha	Yield t/ha	Bck Q %	Erott %	EnH 1_5	Silk days	ASI	Ear ht cm	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rlodg %	Slodg %	Bh %	Try %
13	CML161	x	CLQ-G2604	**5.93**	**6.09**	**111**	2.5	1.8	52	0.9	127	0.54	0.99	20.0	3.4	2.5	21.4	11.5	2.3	0.092
4	CLQ-RCYQ28	x	CLQ-RCYQ12	**5.83**	**5.96**	**110**	2.2	2.5	51	0.6	125	0.52	0.98	19.7	3.4	2.8	17.4	15.1	3.2	0.101
7	CML161	x	CLQ-S89YQ06	**5.81**	**6.06**	**109**	4.2	1.8	53	0.8	134	0.54	0.95	18.8	3.7	2.4	10.8	5.3	2.1	0.083
3	CLQ-RCYQ28	x	CLQ-RCYQ31	**5.50**	**5.64**	**103**	2.5	2.6	50	-0.8	130	0.51	0.90	21.4	3.8	2.9	16.5	18.4	1.2	0.100
8	CML165	x	CLQ-RCYQ07	**5.47**	**5.70**	**103**	4.0	1.9	54	1.0	123	0.52	0.94	21.0	3.3	2.8	17.4	12.8	4.8	0.099
9	CML161	x	CLQ-RCYQ22	**5.43**	**5.58**	**102**	2.7	1.7	52	0.4	118	0.50	0.96	19.4	2.9	3.1	5.5	6.2	17.3	0.094
14	CML161	x	CML165 (RE)	**5.33**	**5.53**	**100**	3.7	2.0	53	0.6	125	0.53	1.02	19.4	3.4	2.7	17.9	13.8	7.0	0.095
15	Local Check # 1			**6.07**	**6.33**	**114**	4.0	1.6	54	0.4	138	0.54	0.98	20.3	3.6	2.4	25.5	11.0	7.6	0.050
16	Local Check # 2			**5.26**	**5.46**	**99**	3.7	1.5	55	0.7	124	0.53	0.96	19.5	2.9	2.8	6.3	6.2	1.9	0.050
			Check Mean	**5.55**	**5.77**		3.8	1.7	54	0.6	129	0.53	0.98	19.7	3.3	2.6	16.6	10.3	5.5	
			Grand Mean	**5.26**	**5.46**		3.7	1.9	53	0.7	129	0.53	0.95	19.8	3.5	2.8	18.4	10.8	4.9	
			LSD 5%	**0.75**	**0.77**		2.7	0.3	1.1	0.8	6.7	0.0	0.1	1.6	0.5	0.4	11.3	9.6	6.3	
			CV %		**10.13**		5.6	12.9	1.6	8.2	6.8	5.9	9.7	9.6	8.5	11.7	8.7	8.9	6.8	
			F value Loc*Entry		**2.42**		1.5	1.7	1.9	0.7	0.7	0.5	0.6	0.9	2.3	1.7	1.9	2.1	2.8	
			P(F>f)		**0.00**		0.1	0.1	0.0	0.9	0.9	1.0	1.0	0.6	0.0	0.0	0.0	0.0	0.0	
			Number of locations		5		4	4	5	5	5	5	5	5	4	5	4	5	4	

No	Set	Location	Country	Local Check-1	Local Check-2
1	1	Agua Fria	México	CML161xCLQ-6603	CML451xCL-02450
2	2	Cotaxtla	México	CML161xCLQ-6604	CML451xCL-02450
3	3	Turipana	Colombia	P-3041	V-109
4	4	Cuyuta	Guatemala	CML287xCML451	HA-48
5	5	New Delhi	India	Pro 311	Bio 9601

3.5.3 TTWCWQ02-23. Evaluation of tropical QPM late white Three-Way crosses

In this experiment 48 new developed three-way cross (TWC) hybrids were evaluated together with their female components (single cross hybrid). The objective of this experiment was to find the best TWC hybrids for CHTT's as one of solutions for resource poor farmers. Total 64 entries were grown at six locations in 8x8 α-lattice design with two replications per location. Results from this study are presented in tables 44 and A126 to A132.

Analysis of variance across locations revealed significant genotype x environment interaction for grain yield, ear rot, plant aspect, stalk lodging, bad husk coverage, and endosperm hardness (Table 44). At all individual locations significant differences were observed between entries for grain yield. The highest yield for this experiment was achieved at Cuyuta - Guatemala (6.73 t/ha), while location New Delhi – India had the lowest average grain yield (1.97 t/ha) due to severe drought conditions (Table 44).

Two reference entry hybrids were used as standards to compare new developed TWC hybrids. QPM reference entry was (CML144 x CML159) x CML176 hybrid, which was released in several developing countries and normal single cross hybrid CML448 x CML449 regular check in normal trials. Results obtained from this experiment are very encouraging. More than half of the studied new TWC hybrids outyielded QPM reference entry. The best ones had more than 20% yield advantage. Also many other important agronomic characteristics were on the side of new TWC hybrids (Fig. 15).

Figure 15. Average grain yields, aggregate lodgings, and corn stunt for the best five TWC hybrids and two reference entries across six locations in 2002B season.

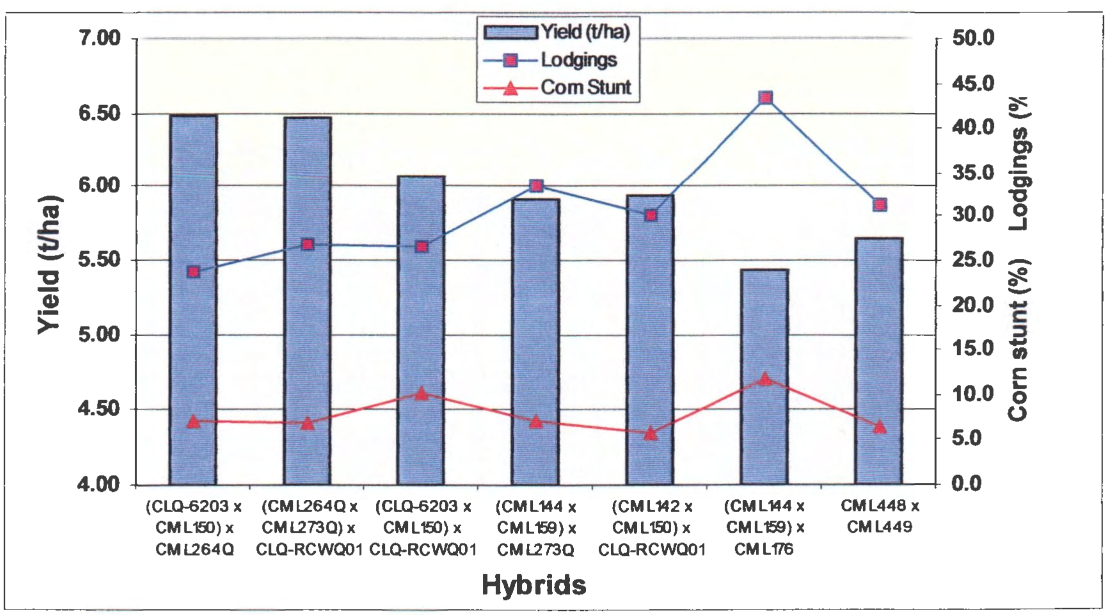


Table 44. TTWCWQ02-23. Means for top five tropical QPM white TWC, reference entries, and local check across six locations in 2002.

Ent no	Pedigree			Yield 1 t/ha	Yield t/ha	Bck Q %	Bck N. %	EnH 1_5	Erott %	Ear ht Plt ht	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Stunt %	Try %
51	(CLQ-6203 x CML150)	x	CML264Q	**6.12**	**6.48**	**124**	**110**	2.2	5.6	0.50	2.8	2.7	6.6	17.1	6.6	7.0	0.095
61	(CML264Q x CML273Q)	x	CLQ-RCWQ01	**6.09**	**6.47**	**123**	**109**	1.9	5.9	0.53	2.9	2.6	7.6	19.2	3.4	6.8	0.095
24	(CLQ-6203 x CML150)	x	CLQ-RCWQ01	**5.77**	**6.06**	**117**	**104**	1.7	4.8	0.52	3.1	2.7	9.5	16.9	3.0	10.2	0.097
46	(CML144 x CML159)	x	CML273Q	**5.63**	**5.91**	**114**	**101**	2.6	4.7	0.52	3.2	2.9	9.8	23.5	4.9	7.2	0.092
58	(CML142 x CML150)	x	CLQ-RCWQ01	**5.56**	**5.94**	**113**	**100**	1.6	6.3	0.56	3.0	2.5	9.8	20.4	4.2	5.8	0.094
31	CML144	x	CML159 (RE)	**4.79**	**4.98**	**97**	**86**	2.2	3.9	0.51	3.7	3.0	13.4	28.3	7.2	16.3	0.096
37	(CML144 x CML159)	x	CML176	**4.94**	**5.44**	**100**	**89**	1.9	9.2	0.51	3.6	2.8	10.1	33.3	2.1	11.8	0.089
62	CML448	x	CML449	**5.57**	**5.64**	**113**	**100**	1.4	1.2	0.51	3.7	2.7	14.0	17.2	7.0	6.4	0.050
63	CML264	x	CML273	**5.23**	**5.59**	**106**	**94**	2.4	6.5	0.51	2.9	2.9	5.1	13.6	8.5	3.4	0.050
64	Local Check			**5.12**	**5.40**	**104**	**92**	1.9	5.3	0.54	3.5	2.8	16.9	27.2	8.6	7.5	0.050
			Check Mean	**5.13**	**5.41**			1.9	5.3	0.52	3.5	2.8	11.9	23.9	6.7	9.1	
			Grand Mean	**4.95**	**5.41**			2.0	8.4	0.52	3.4	2.9	13.8	19.8	8.6	9.2	
			LSD 5%	**0.55**	**0.58**			0.5	4.6	0.0	0.4	0.3	9.4	9.5	6.5	5.4	
			CV %		**11.62**			17.0	7.6	6.8	10.7	14.2	11.2	10.2	7.9	61.1	
			F value Loc*Entry		**1.30**			2.5	1.0	0.6	1.4	1.1	0.8	1.2	1.8	0.7	
			P(F>f)		**0.01**			0.0	0.4	1.0	0.0	0.3	0.9	0.0	0.0	1.0	
			Number of locations		**6**			5	5	6	5	6	5	6	4	3	

No	Set	Location	Country	Local Check
1	1	Agua Fria	México	(CML247xCML254)xR1
2	2	Cotaxtla	México	H520
3	3	Turipana	Colombia	C-343
4	4	Cuyuta	Guatemala	(CML247xCML254)xR1
5	5	New Delhi	India	Ganga Safed - 2
6	6	El Ejido	Panama	(CML247 x CML249) x P23(STE)C2-1703-61-3-3

Even comparing TWC hybrids with normal single cross tester was possible to find several of them who showed higher yield performance and higher standability (Table 44). The highest yielding TWC hybrids across six locations were (CLQ-6203 x CML150) x CML264Q with 6.12 t/ha, (CML264Q x CML273Q) x CLQ-RCWQ01 with 6.09 t/ha, and (CLQ-6203 x CML150) x CLQ-RCWQ01 with 5.77 t/ha. It was 10, 9, and 4 % better than normal single cross hybrid (CML448 x CML449). All three hybrids also had above average performance in drought conditions at location in India. The female parents of these hybrids also had high yield performance (4.38 t/ha and 5.13 t/ha) and should secure cheap seed production. All lines in these three hybrids are by performance data unrelated and our guess is that hybrids mentioned above can play important role in developing countries and should replace old (CML144 x CML159) x CML176 hybrid. Estimated tryptophan values for top TWC hybrids were from 0.092 to 0.097 %, what is much higher than in normal endosperm hybrids (Table 44). All five new three-way cross hybrids, include new QPM lines in the make up, and outyielded (CML144 x CML159) x CML176, normal seed industry checks and reference entry checks. This confirms the potential of new QPM hybrids to increase maize productivity and alleviate malnutrition in Africa and Latin America, where maize is staple food. These hybrids should be tested extensively, while the new synthetics from promising lines will provide new alternatives for small farmers.

3.5.4 TTWCYQ02-24. Evaluation of tropical QPM late yellow Three-Way crosses

Thirteen yellow TWC hybrids together with their female parents and the best local checks were grown at nine locations in 4x6 α-lattice design with two replications per location. Results from this study are presented in tables 45 and A133 to A142.

ANOVA revealed significant interaction between genotypes and environment for grain yield, flowering dates, plant aspect, and endosperm hardness (Table A142). At individual locations significant differences were observed between entries for grain yield.

The best hybrid in this experiment was (CML161 x CML165) x CLQ-S89YQ07 with 5.17 t/ha (3% higher than the best check). Also, this hybrid showed the fewer incidences in ear rot and bad husk coverage, with also good other agronomic characteristics (Table 45). As female parent for this TWC hybrid is widely accepted high yielding single cross hybrid, we believe that mentioned TWC hybrid could play an important role in developing world. Farmers could benefit by buying cheaper seed of TWC hybrid, but with no yield penalty in field. Another promising TWC hybrids in this experiment were (CML165 x CML172) x CML161 with 5.09 t/ha and (CML161 x CML165) x CLQ-S89YQ01 with 4.96 t/ha and good other agronomic characteristics. The QPM single cross hybrid CML172 x CLQ-6601 (new CML493) outyielded the best local checks as well as reference QPM hybrid and showed the least incidence of ear rot and lodgings in the experiment. Also, this hybrid had other good agronomic characteristics and the highest values of Tryptophan.

Mentioned QPM-TWC hybrids had more then 0.080 % of tryptophan content, what makes them much more nutritionally suitable for animal consumption than normal endosperm hybrids (Table 45). As results for this experiment came from very diverse nine locations across Latin America, all hybrids that performed well should be sent to Africa for their evaluations on farmers field.

Table 45. TTWCYQ02-24. Evaluation of tropical QPM late yellow TWC across nine locations in 2002 B

En no	Pedigree			Yield 1 t/ha	Yield t/ha	Bck %	Erott %	Silk days	ASI	Ear ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Stunt 1_5	EnH 1_5	Try %
4	(CML161 x CML165)	x	CLQ-S89YQ07	**5.17**	**5.63**	**103**	8.3	59	0.9	0.54	0.98	18.0	3.1	2.7	15.6	19.8	5.2	7.4	2.2	0.084
21	CML172	x	CLQ-6601	**5.10**	**5.45**	**102**	6.4	59	1.1	0.52	0.95	16.1	3.0	2.5	9.3	12.3	7.1	6.5	1.4	0.097
17	(CML165 x CML172)	x	CML161	**5.09**	**5.68**	**102**	10.4	58	0.8	0.52	0.97	17.0	2.9	2.6	13.1	21.0	19.5	11.4	1.8	0.080
3	(CML161 x CML165)	x	CLQ-S89YQ01	**4.96**	**5.46**	**99**	9.1	59	1.2	0.55	1.02	16.7	3.0	2.6	4.9	18.9	9.3	11.4	2.0	0.084
10	CML161	x	CML172	**4.79**	**5.35**	**96**	10.4	59	0.9	0.53	0.97	16.3	3.1	2.9	15.8	11.5	20.7	8.4	1.8	
2	(CML161 x CML165)	x	CLQ-RCYQ01	**4.76**	**5.44**	**95**	12.6	59	1.2	0.50	0.96	16.8	3.3	2.7	25.2	10.9	16.2	8.2	2.4	
8	CML161	x	CML169	**4.75**	**5.37**	**95**	11.7	59	1.3	0.55	1.01	16.0	3.6	2.9	32.7	12.3	12.8	10.2	2.4	
22	(CML172 x CLQ-6601)	x	CML170	**4.73**	**5.15**	**95**	8.2	57	0.6	0.55	0.99	16.9	3.2	2.7	7.6	21.7	8.7	11.9	2.0	
20	(CML169 x CML172)	x	CML161	**4.72**	**5.33**	**95**	11.3	58	0.8	0.52	0.96	16.6	3.1	2.8	28.2	12.7	8.5	11.2	2.3	
5	(CML161 x CML165)	x	CML170	**4.67**	**5.20**	**94**	10.2	58	0.9	0.56	0.97	17.1	3.3	2.8	16.3	26.9	10.2	12.3	2.1	
9	(CML161 x CML169)	x	CML172	**4.65**	**5.10**	**93**	8.8	59	1.3	0.54	0.91	16.5	3.3	2.8	20.7	19.6	15.5	10.3	2.1	
7	(CML161 x CML170)	x	CML172	**4.65**	**5.05**	**93**	7.8	58	0.8	0.53	0.97	16.2	3.3	4.5	21.5	11.0	16.1	9.2	1.9	
12	CML161	x	CLQ-G2602	**4.57**	**4.99**	**92**	8.4	59	0.8	0.53	0.98	17.2	3.0	2.8	24.0	13.0	13.4	11.5	2.0	
15	(CML164 x CML172)	x	CML170	**4.55**	**5.00**	**91**	9.0	57	0.6	0.56	0.98	16.7	3.4	2.9	15.1	22.3	7.9	7.0	2.1	
14	CML164	x	CML172	**4.50**	**5.05**	**90**	11.0	58	1.2	0.55	0.95	17.1	3.1	2.8	17.7	10.4	11.2	7.7	2.6	
16	CML165	x	CML172	**4.47**	**4.92**	**90**	9.1	60	1.1	0.51	0.96	16.2	3.1	3.0	12.3	15.7	25.0	10.0	1.8	
6	CML161	x	CML170	**4.47**	**4.98**	**90**	10.2	58	0.5	0.56	0.96	16.3	3.0	2.9	26.9	15.9	6.8	7.2	1.9	
13	(CML161 x CLQ-G2602)	x	CML172	**4.42**	**4.96**	**88**	11.0	59	1.5	0.55	0.91	16.7	3.2	3.0	16.5	14.5	19.9	9.9	2.2	
11	(CML161 x CML172)	x	CML169	**4.41**	**5.13**	**88**	14.0	59	1.0	0.53	0.96	16.2	3.7	3.0	33.4	15.3	13.7	10.4	2.5	
18	CML169	x	CML172	**4.27**	**4.67**	**85**	8.6	59	1.1	0.53	0.88	17.5	3.4	2.9	33.2	14.6	16.3	7.0	2.1	
19	(CML169 x CML172)	x	CLQ-S89YQ01	**4.21**	**4.86**	**84**	13.4	59	1.5	0.53	0.97	17.2	3.5	2.9	21.3	11.7	7.8	6.6	1.7	
1	CML161	x	CML165	**4.75**	**5.38**	**95**	11.7	59	1.2	0.52	0.98	17.6	3.1	2.6	11.2	17.9	8.4	10.0	1.8	0.095
23	Local Check #1			**4.99**	**5.43**	**100**	8.1	60	1.2	0.54	0.98	18.2	3.2	2.6	13.2	18.5	10.4	10.4	1.5	
24	Local Check #2			**4.94**	**5.48**	**99**	9.9	59	0.6	0.51	0.97	17.9	2.5	2.6	10.1	11.0	5.9	8.4	1.2	
			Grand Mean	**4.69**	**5.21**		10.0	58.7	1.0	0.5	1.0	16.9	3.2	2.9	18.6	15.8	12.4	9.4	2.0	
			LSD 5%	**0.47**	**0.49**		3.5	0.7	0.4	0.0	0.0	0.8	0.4	0.7	10.3	8.0	6.2	3.7	0.4	
			CV %	**10.93**	**11.83**		7.6	1.4	2.7	7.5	7.9	6.7	12.7	52.3	15.1	14.2	9.3	49.0	14.8	
			Number of locations		**9**		8	9	9	9	9	9	8	9	8	9	7	5	5	

3.5.5 TSCWQ02-25. Evaluation of tropical QPM white single crosses in Design II mating scheme.

Design II mating scheme was applied to estimate general combining abilities (GCA) for five white QPM lines HG "A" and nine white QPM lines HG "B". Forty five design II crosses, 14 additional QPM crosses, QPM reference entry, one normal hybrid and two local checks were grown at six locations in 7x9 α-lattice design with two replications per location. Results from this study are presented in tables 46, 47 and A143 to A149.

The best S_4 QPM lines based on testcross performance from 2001B season yield trials (tested as S_3 lines) were used for formation of this design II experiment. The main objective in this study was to identify new high yielding hybrids and overcome deficit in QPM hybrids caused by termination of CIMMYT QPM programs in 1991. Later in 1996, CIMMYT reinitiated QPM programs but it could not result in fast development of QPM hybrids with involvement of second cycle lines. Most of the advanced hybrids reported in previous parts of QPM annual reports were based on lines developed before 1991.

Except for root lodging, ANOVA did not show for any other trait significant genotype x environment interaction (Table A149), while at each individual location significant differences were observed between entries for grain yield (Tables A143 – A149).

Only six new QPM hybrids outyielded the best QPM reference entry hybrid CML144 x CML159, while no one had better performance than normal hybrid CML448 x CML449 (Table 46). Entries 2 and 37, which had better performance than reference entry showed also better endosperm hardness scores, lower ear position, and the best standability in experiment. The majority of the studied new QPM hybrids had ear height over plant height less than 0.50, indicating that previous selection for inbred lines ear position was successful. The main idea for this type of selection was to decrease lodgings. Indeed if we look at root and stalk lodging data for this experiment there is 14.1 % less incidence than in experiment 21. Parents of the hybrids, which showed the smallest root and stalk lodging could be used as sources of favorable alleles for these traits.

The general combining ability studies revealed that the best combiner from heterotic group "A" was (CML147xCL-RCW01)-B-4-1-2 inbred line. This line had positive GCA at each individual location and estimated 0.448 t/ha across locations (Table 47). The highest breeding values from HG "B" showed (CLQ-6203xCL-04321)-B-21-1-2 inbred line. Also this line had positive GCA at each location and 0.590 t/ha across locations. Both lines were used for formation of white QPM synthetics, for formation of new QPM crosses, and as parents in pedigree breeding program.

All studied lines in this experiment came from pedigree selection of QPM x normal parent. Laboratory data for tryptophan content for these lines showed high values making new QPM hybrids more valuable than normal endosperm hybrids for developing world (Table 46).

Disappointing grain yield results from design II experiment suggest that one testing of early generation inbred lines is not enough for estimation of their breeding values, and their widely use in hybrid combinations. Second testing of good performing lines should follow with two – three testers and after that the best lines should be used for making promising hybrid combinations.

Table 46. TSCWQ02-25. Means for top six tropical QPM white single crosses, reference entries, and local checks across six locations in 2002.

Ent no	Pedigree			Yield 1 t/ha	Yield t/ha	Bck %	Erott %	EnH 1_5	ASI	Ear ht Plt ht	# Ear # Plt	Plt asp	Ear asp	Rldg %	Sldg %	BH %	Try %
2	(CML147xCL-RCW01)-B-4-1-2	x	(CLQ-6203xCL-04321)-B-21-1-2	**6.04**	**6.77**	**105**	10.8	2.0	0.7	0.49	0.98	3.2	2.7	4.4	1.1	20.5	0.093
11	(CML147xCL-RCW01)-B-10-2-1	x	(CLQ-6203xCL-04321)-B-21-1-2	**5.98**	**6.61**	**104**	9.6	2.6	0.3	0.47	0.97	3.1	2.7	9.5	4.8	7.3	0.092
37	(CML147xCL-RCW01)-B-61-2-1	x	(CLQ-6203xCL-04321)-B-21-1-2	**5.94**	**6.44**	**104**	7.8	2.0	0.4	0.47	0.98	2.6	2.7	1.5	2.3	11.1	0.095
29	(CML147xCL-RCW01)-B-53-1-3	x	(CLQ-6203xCL-04321)-B-21-1-2	**5.81**	**6.39**	**101**	9.0	2.1	0.3	0.48	0.94	3.2	2.9	12.6	2.9	12.0	0.097
59	(CML146xCL-RCW01)-B-27-1-2	x	(CLQ-6203xCL-04321)-B-7-1-2	**5.76**	**6.13**	**101**	5.9	1.4	0.5	0.48	0.93	2.9	2.3	19.2	2.9	5.5	0.093
7	(CML147xCL-RCW01)-B-4-1-2	x	(CLQ-6203xCL-04321)-B-15-1-1	**5.76**	**6.40**	**100**	10.0	2.1	0.5	0.48	1.00	3.1	2.8	11.4	0.7	11.6	0.089
60	CML144	x	CML159	**5.73**	**6.01**	**100**	4.6	2.4	0.2	0.50	0.94	3.4	2.8	8.2	14.1	6.9	0.096
61	CML448	x	CML449	**6.13**	**6.63**	**107**	7.6	2.3	0.6	0.47	1.03	2.8	2.7	6.8	1.9	5.0	
62	Local Check #1			**6.11**	**6.58**	**107**	7.1	2.5	1.1	0.51	0.96	3.0	2.9	12.6	6.7	6.3	
63	Local Check #2			**5.30**	**5.84**	**92**	9.3	2.3	0.4	0.49	0.98	2.9	3.0	6.1	8.4	9.0	
			Check Mean	**5.82**	**6.26**		7.1	2.4	0.6	0.49	0.98	3.0	2.9	8.4	7.8	6.8	
			Grand Mean	**5.10**	**5.74**		11.1	2.2	0.6	0.48	0.98	3.0	3.0	9.1	3.2	9.5	
			LSD 5%	**0.65**	**0.69**		5.6	0.4	0.5	0.1	0.2	0.4	0.3	10.4	3.9	7.1	
			CV %		**16.7**		9.9	21.4	3.5	32.3	30.9	16.8	16.0	10.5	11.1	11.2	
			F value Loc*Entry		**0.81**		0.5	0.9	0.5	0.5	0.6	0.8	0.7	1.5	0.7	1.0	
			P(F>f)		**0.96**		1.0	0.7	1.0	1.0	1.0	0.9	1.0	0.0	1.0	0.5	
			Number of locations		**6**		5	5	6	6	6	5	6	5	6	5	

No	Set	Location	Country	Local Check-1	Local Check-2
1	1	Agua Fria	México	CML156xCML159	CMLQ-6203xCML150
2	2	Cotaxtla	México	CML156xCML159	H520
3	3	Turipana	Colombia	Lo Trajo	ICHY-156
4	4	Cuyuta	Guatemala	CML156xCML159	HEB-0001
5	5	New Delhi	India	CML156xCML159	Ganga Safed - 2
6	6	Gudalajara	México	not identified	not identified

Table 47. TSCWQ02-25. GCA estimates of QPM tropical late white lines across six locations.

1. Grain yield and GCA values.

	L8	L9	L10	L11	L12	L13	L14	L15	L16	MEAN	GCA
L1	5.15	6.40	6.07	6.77	6.04	5.93	6.42	6.38	5.81	6.11	0.448
L2	6.01	6.19	6.34	6.61	5.74	5.62	5.80	5.89	5.04	5.91	0.254
L3	5.08	5.53	5.42	5.61	5.25	5.99	4.92	4.66	5.19	5.29	-0.366
L4	5.96	5.59	6.15	6.44	6.01	6.12	5.88	5.36	5.27	5.86	0.204
L5	4.97	4.57	5.24	5.82	5.22	5.00	5.66	5.22	4.39	5.12	-0.539
MEAN	5.43	5.65	5.84	6.25	5.65	5.73	5.74	5.50	5.14		
GCA	-0.227	-0.005	0.183	0.590	-0.011	0.070	0.076	-0.159	-0.518		

GCA St.error LINES = 0.079 GCA St.error TESTERS = 0.091

2. GCA values by locations

LOC	Group 1						Group 2									
	L1	L2	L3	L4	L5	GCA SE	L8	L9	L10	L11	L12	L13	L14	L15	L16	GCA SE
LOC 1	0.160	0.262	-0.079	0.299	-0.643	0.163	-0.768	0.284	-0.136	0.508	0.056	0.450	0.142	-0.414	-0.126	0.231
LOC 2	0.909	0.231	-0.670	0.385	-0.855	0.266	-0.104	-0.496	0.578	0.852	-0.294	0.236	-0.164	0.102	-0.708	0.377
LOC 3	0.516	0.293	-0.636	0.198	-0.371	0.146	-0.537	-0.095	0.235	0.911	0.031	0.351	-0.111	-0.199	-0.589	0.206
LOC 4	0.204	0.609	-0.298	-0.101	-0.414	0.133	-0.148	-0.154	0.214	0.066	0.170	0.362	-0.052	-0.124	-0.336	0.188
LOC 5	0.338	-0.136	0.037	0.567	-0.807	0.216	-0.443	0.363	0.029	0.495	0.049	-0.145	0.497	-0.087	-0.755	0.306
LOC 6	0.559	0.262	-0.554	-0.125	-0.142	0.246	0.636	0.068	0.180	0.710	-0.076	-0.834	0.142	-0.232	-0.596	0.349

LINES		LINES			
L1	(CML147xCL-RCW01)-B-4-1-2	L8	(CLQ-6203xCL-04321)-B-10-1-1	L13	(CLQ-6203xCL-04321)-B-24-1-2
L2	(CML147xCL-RCW01)-B-10-2-1	L9	(CLQ-6203xCL-04321)-B-15-1-1	L14	(CLQ-6203xCL-04321)-B-26-3-2
L3	(CML147xCL-RCW01)-B-39-1-1	L10	(CLQ-6203xCL-04321)-B-18-1-2	L15	(CLQ-6203xCL-04321)-B-7-1-2
L4	(CML147xCL-RCW01)-B-61-2-1	L11	(CLQ-6203xCL-04321)-B-21-1-2	L16	(CLQ-6203xCL-04374)-B-7-2
L5	(CML173xCL-RCW01)-B-15-3-1	L12	(CLQ-6203xCL-04321)-B-23-1		

3.5.6 TSCWQ02-26. Evaluation of tropical QPM white single crosses.

Total 35 hybrids were evaluated in this experiment using 5x7 α-lattice design at six locations with two replications per location. Several new crosses with advanced and released lines were evaluated while 16 entries were part of small design II crosses (2x8) with S_4 lines. The objective of this experiment was to identify the best hybrids for advancement in CHTT's or advance tropical trials. Results from this study are presented in tables 48, 49 and A150 to A156.

Analysis of variance across locations revealed no significant interaction between genotype and environment for studied traits (Table A156), while differences between entries at individual locations for grain yield were higher than one LSD values. This experiment showed the highest average grain yield at location Cotaxtla (7.49 t/ha). The smallest yield (4.22 t/ha) was observed at New Delhi – India, however for that location 4.22 t/ha was the highest yield of all studied QPM experiments (Table A154).

The highest yielding hybrid in experiment was CLQ-RCWQ01 x CML264Q with 6.70 t/ha across six locations (Table 48). This hybrid outyielded the best local check and QPM reference entry for 23 and 36 % and had better standability, corn stunt resistance, and much more attractive plant and ears. The hybrid topped the trial in Cotaxtla with maximum grain yield of 11.73 t/ha and 0.0% ear rot. Seven other QPM hybrids outyielded local check, while fourteen had better performance than QPM reference entry. Advantages for top five hybrids in this experiment over QPM reference entry and local check are shown in figure 16. Besides higher yield, new QPM hybrids showed better standability than reference entries.

Figure 16. Average grain yields, stalk and root lodgings for the best five QPM hybrids, reference entry, and local check across six locations in 2002B.

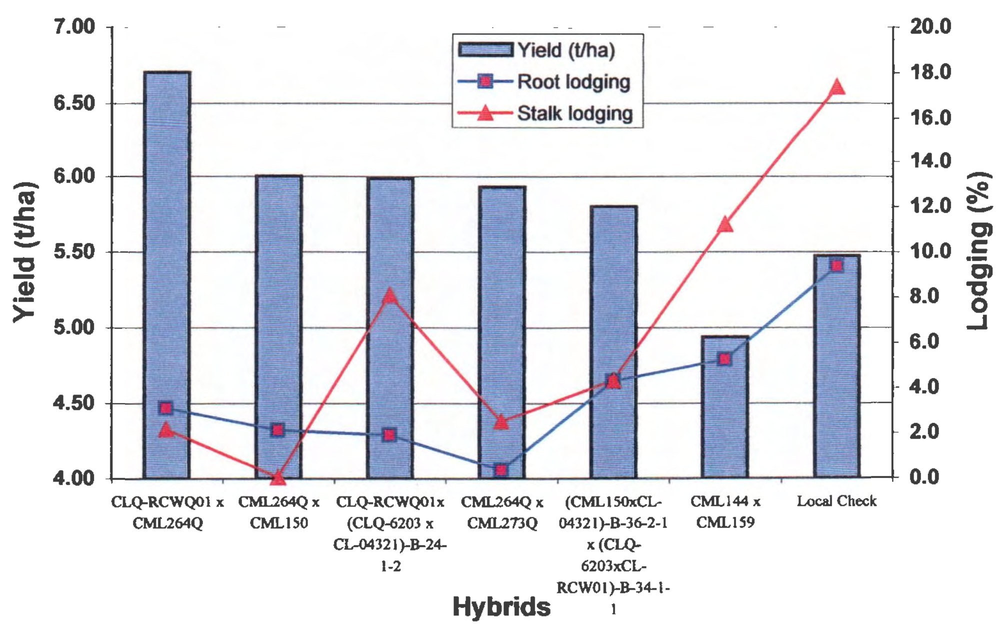


Table 48. TSCWQ02-26. Evaluation of tropical QPM white single crosses across six locations in 2002.

E. no	Pedigree			Yd 1 t/ha	Yd t/ha	Bck %	Erott %	EnH 1_5	ASI	E ht Plt ht	# Ear # Plt	Mo %	Plt asp	Ear asp	Rldg %	Sldg %	BH %
28	CLQ-RCWQ01	x	CML264Q	**6.70**	**7.27**	**123**	7.9	2.5	0.7	0.50	1.03	22.8	2.4	2.4	3.1	2.2	4.1
25	CML264Q	x	CML150	**6.00**	**6.83**	**110**	12.1	2.5	0.7	0.48	1.05	23.4	2.8	2.7	2.1	0.1	12.8
30	CLQ-RCWQ01	x	(CLQ-6203 x CL-04321)-B-24-1-2	**5.99**	**6.63**	**109**	9.7	2.3	0.9	0.48	0.97	22.5	2.5	2.9	1.9	8.1	4.3
22	CML264Q	x	CML273Q	**5.93**	**6.54**	**108**	9.4	2.3	0.5	0.53	0.94	22.1	2.8	2.7	0.4	2.5	4.4
20	CML264Q	x	(CML146 x CML150)-B-32-1-2-B	**5.84**	**6.64**	**107**	12.0	2.1	0.3	0.49	1.04	22.4	2.8	2.6	4.9	0.7	3.2
11	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-34-1-1	**5.80**	**6.47**	**106**	10.4	2.3	0.7	0.47	1.03	22.0	2.8	2.9	4.3	4.3	3.9
26	CML264Q	x	CML159	**5.65**	**6.32**	**103**	10.5	2.4	1.2	0.48	0.92	22.8	3.0	3.1	5.3	5.3	10.9
21	CML264Q	x	CML273Q	**5.54**	**5.95**	**101**	6.9	2.5	1.8	0.49	0.95	22.8	2.4	3.0	1.9	4.7	4.5
29	CLQ-RCWQ01	x	CML273Q	**5.31**	**5.77**	**97**	8.1	2.4	0.6	0.46	0.91	24.1	2.6	3.0	0.6	2.4	5.4
14	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-43-3-1	**5.22**	**5.81**	**95**	10.1	2.7	1.3	0.50	0.97	22.5	2.9	3.1	3.8	6.3	5.2
2	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-17-2-1	**5.22**	**5.70**	**95**	8.5	2.6	0.5	0.51	0.98	22.7	3.3	2.9	6.6	3.5	5.1
16	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-46-2-1	**5.22**	**5.70**	**95**	8.5	2.5	-0.2	0.49	0.98	22.6	2.7	3.1	1.9	0.2	3.9
18	CML264Q	x	(CML146 x CL-RCW01)-B-27-1-2-B	**5.18**	**6.25**	**95**	17.1	2.4	0.4	0.50	0.97	22.5	2.6	2.9	2.8	6.2	14.6
8	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-46-2-1	**5.10**	**5.84**	**93**	12.7	2.6	0.6	0.50	0.99	22.5	3.3	2.9	14.0	0.7	15.1
13	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-40-1-11	**5.09**	**5.74**	**93**	11.4	2.2	0.1	0.47	0.95	21.9	3.3	2.9	9.5	2.6	3.2
4	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-36-2-3	**4.80**	**5.59**	**88**	14.1	2.6	0.2	0.49	0.99	22.7	3.1	2.9	10.0	6.3	8.8
10	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-17-2-1	**4.70**	**5.19**	**86**	9.5	2.4	0.6	0.50	0.92	22.9	2.7	2.9	3.9	1.2	3.9
27	CML264Q	x	CML273Q	**4.68**	**5.27**	**85**	11.2	2.3	0.8	0.48	0.98	24.4	2.9	3.0	3.7	2.1	5.1
17	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-48-1-1	**4.60**	**5.25**	**84**	12.2	2.7	0.6	0.47	1.14	22.0	2.9	2.8	0.9	2.2	5.4
3	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-34-1-1	**4.52**	**5.70**	**83**	20.7	2.9	0.7	0.47	1.02	21.5	3.1	3.2	18.7	4.3	7.9
1	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-14-1-2	**4.51**	**5.26**	**83**	14.1	2.7	0.0	0.48	0.97	23.5	3.2	3.1	3.8	3.3	17.9
5	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-40-1-11	**4.50**	**5.25**	**82**	14.2	2.1	0.6	0.49	0.98	21.2	3.2	3.0	12.9	6.5	13.7
15	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-44-1-1	**4.50**	**5.30**	**82**	15.2	2.6	0.3	0.49	0.96	23.9	3.1	3.4	1.5	6.8	8.6
9	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-48-1-1	**4.46**	**5.69**	**81**	21.6	2.7	0.0	0.47	1.02	21.5	3.2	3.3	6.9	6.8	14.4
19	CML264Q	x	(CLQ-6203 x CL-04321)-B-26-3-2	**4.44**	**5.12**	**81**	13.2	2.1	0.1	0.45	0.98	23.5	2.7	3.1	2.2	0.6	4.6
7	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-44-1-1	**4.31**	**5.23**	**79**	17.5	2.4	0.2	0.49	0.98	22.3	3.1	3.3	6.6	3.8	19.0
23	CML264Q	x	(CLQ-6203 x CL-04374)-B-7-2-2-B	**4.27**	**4.76**	**78**	10.2	1.9	0.5	0.45	1.14	22.8	2.7	3.1	6.3	1.4	7.8
24	CML264Q	x	(CLQ-6203 x CL-04321)-B-13-2-2-B	**4.21**	**4.89**	**77**	14.0	2.1	0.2	0.46	1.00	22.8	3.1	3.2	2.0	0.9	5.7
6	(CML150xCL-04321)-B-19-1-3	x	(CLQ-6203xCL-RCW01)-B-43-3-1	**4.21**	**5.10**	**77**	17.5	2.0	0.8	0.48	0.98	22.5	3.2	3.2	15.4	1.5	10.3
12	(CML150xCL-04321)-B-36-2-1	x	(CLQ-6203xCL-RCW01)-B-36-2-3	**3.96**	**4.63**	**72**	14.5	2.6	0.3	0.46	1.02	21.8	3.1	3.1	4.7	3.4	7.3
31	CML144	x	CML159 (RE)	**4.94**	**5.50**	**90**	10.3	2.1	0.9	0.49	0.96	21.1	3.4	2.9	5.3	11.2	4.8
32	CML264	x	CML273	**5.10**	**5.78**	**93**	11.7	2.5	0.7	0.48	0.96	21.3	2.2	3.2	2.9	1.9	14.4
33	CML264Q	x	CML273Q	**5.27**	**5.89**	**96**	10.4	2.3	0.6	0.50	0.99	21.5	2.6	3.1	3.1	5.8	8.2
34	CML448	x	CML449 (RE)	**6.26**	**6.55**	**114**	4.4	1.8	0.6	0.48	0.98	23.1	2.7	2.5	5.0	7.0	4.8
35	Local Check #1			**5.47**	**5.91**	**100**	7.4	2.0	0.9	0.50	0.95	21.2	2.9	2.7	9.4	17.4	7.0
			Grand Mean	**5.06**	**5.75**		12.0	2.4	0.6	0.48	0.99	22.5	2.9	3.0	5.4	4.1	8.0
			LSD 5%	**0.76**	**0.81**		6.1	0.5	0.6	0.0	0.1	1.4	0.5	0.4	7.4	5.8	4.7
			CV %		**17.51**		11.7	26.6	3.4	7.6	12.7	7.9	17.4	16.9	13.9	11.2	8.2
			Number of locations		**6**		5	5	6	6	6	6	5	6	5	6	5

One part of this experiment was design II (2x8) study of new S_4 lines. Two lines from heterotic group "A" were crossed with eight lines from HG"B". Inbred lines HG "A" did not show any differences for grain yield in crosses with opposite lines (Table 49). The best combiner from HG "B" was line (CLQ-6203xCL-RCW01)-B-34-1-1 (GCA = 0.570 t/ha) and will be extensively used in QPM breeding program.

Table 49. General combining abilities for QPM lines in design II (2x8) across six locations in 2002B.

Line	3	4	5	6	7	8	9	10	Mean	GCA
1	5.70	5.70	5.59	5.25	5.10	5.23	5.84	5.69	5.51	**0.00**
2	5.19	6.47	4.63	5.74	5.81	5.30	5.70	5.25	5.51	**0.00**
Mean	5.45	6.08	5.11	5.49	5.45	5.26	5.77	5.47		
GCA	**-0.06**	**0.57**	**-0.40**	**-0.02**	**-0.06**	**-0.25**	**0.26**	**-0.04**		

Lines

1 (CML150xCL-04321)-B-19-1-3
2 (CML150xCL-04321)-B-36-2-1
3 (CLQ-6203xCL-RCW01)-B-17-2-1
4 (CLQ-6203xCL-RCW01)-B-34-1-1
5 (CLQ-6203xCL-RCW01)-B-36-2-3
6 (CLQ-6203xCL-RCW01)-B-40-1-11
7 (CLQ-6203xCL-RCW01)-B-43-3-1
8 (CLQ-6203xCL-RCW01)-B-44-1-1
9 (CLQ-6203xCL-RCW01)-B-46-2-1
10 (CLQ-6203xCL-RCW01)-B-48-1-1

3.5.7 TSCYQ02-27. Evaluation of tropical QPM yellow single crosses in design II mating scheme.

Two design II type of crosses (three lines HG"B" x seven lines HG "A" and two lines HG "A" x three lines HG 'B") with QPM reference entry and two local checks were grown in 5x6 α-lattice design at two locations with two replications per location. Results from this study are presented in tables 50, 51 and A157 to A159.

The best S_4 QPM lines based on testcross performance from 2001B season yield trials (tested as S_3 lines) were used for formation of these two design II. The same reasons for making design II crosses mentioned for experiment TSCWQ02-25 can be applied here. The main objective in this study was to identify new high yielding yellow QPM hybrids for CHTT's.

Analysis of variance showed significant genotype x environment interaction for grain yield only (Table A159). At individual locations differences between entries were higher than one LSD. The highest yielding entry had 9.68 t/ha at Cotaxtla (10% higher than the best local check).

The best hybrid in experiment was (CML150xCL-03618)-B-16-1-2 x (CML165xCLQ-6203)-B-9-1 with 9.02 t/ha across two locations. This hybrid showed 0.0% ear rot, only 2.1% total lodgings, and very good scores for other agronomic characteristics (Table 51). Unfortunately other studied hybrids did not had yield advantages over the QPM reference entry CML161 x CML165, while only four of them had slightly higher yield than the best local check. As the data of design II crosses from previous experiment (TSCWQ02-25) were also discouraging, it means that design II crosses should be eliminated from the regular breeding procedure. The breeding procedure for new developing lines should be organized on the most economic way. First testing with 1-2 testers on 3-5 locations and second testing with 2-4 testers on 4-8 locations. Design II crosses can be used only for special studies due to high expenses for making this type of crosses (hand pollination).

Table 50. TSCYQ02-27. GCA estimates of QPM tropical late yellow lines across two locations in 2002.

1. Grain yield and GCA values.

	L4	L5	L6	L7	L8	L9	L10	MEAN	GCA
L1	6.39	7.08	7.67	7.59	4.81	9.15	5.98	6.95	-0.434
L2	6.46	8.69	7.76	8.96	6.99	9.05	7.03	7.85	0.464
L3	5.83	8.53	8.50	7.62	6.17	8.79	6.04	7.35	-0.030
MEAN	6.23	8.10	7.98	8.06	5.99	8.99	6.35		
GCA	-1.158	0.717	0.592	0.672	-1.398	1.610	-1.035		

GCA St.error LINES = 0.137 GCA St.error TESTERS = 0.366

2. Grain yield and GCA values.

	L9	L7	MEAN	GCA
L11	7.10	6.68	6.89	0.079
L12	5.80	5.65	5.72	-1.088
L13	7.69	7.95	7.82	1.009
MEAN	6.86	6.76		
GCA	0.052	-0.052		

GCA St.error LINES = 0.271

GCA St.error TESTERS = 0.067

1. GCA values by locations

LOC	Group 1				Group 2							
	L1	L2	L3	GCA SE	L4	L5	L6	L7	L8	L9	L10	GCA SE
LOC 1	-0.441	0.179	0.263	0.154	-1.124	0.632	-0.201	0.569	-0.304	1.432	-1.004	0.267
LOC 2	-0.426	0.750	-0.323	0.141	-1.192	0.801	1.385	0.775	-2.492	1.788	-1.065	0.244

2. GCA values by locations

LOC	Group 1				Group 2		
	L11	L12	L13	GCA SE	L9	L7	GCA SE
LOC 1	-0.463	-0.808	1.272	0.289	-0.043	0.043	0.204
LOC 2	0.622	-1.368	0.747	0.264	0.147	-0.147	0.186

LINES	
L1	(CML150xCL-03618)-B-6-2-1
L2	(CML150xCL-03618)-B-16-1-2
L3	(CML150xCL-03618)-B-17-2-2
L4	(CML159xCL-G2501)-B-16-5-1

LINES	
L5	(CML165xCLQ-6203)-B-11-2
L6	(CML165xCLQ-6203)-B-20-1-1
L7	(CML165xCLQ-6203)-B-54-1-1
L8	(CML165xCLQ-6203)-B-57-1-1

LINES	
L9	(CML165xCLQ-6203)-B-9-1
L10	(CML173xCL-G2501)-B-36-2-1
L11	(CML176xCL-G2501)-B-9-1-1
L12	(CML176xCL-G2501)-B-41-1-1
L13	(CML176xCL-G2501)-B-55-1-2

Table 51. TSCYQ02-27. Evaluation of tropical QPM yellow single crosses across two locations in 2002B

Ent no	Pedigree	Yield 1 t/ha	Yield t/ha	Bck N %	Erott %	EnH 1_5	Ear ht Plt ht	# Ear # Plt	Plt asp	Ear asp	Rtldg %	Stldg %	Try %
10	L2 x L9	**9.04**	**9.04**	**106**	0.0	2.5	0.54	0.94	2.4	2.4	0.0	2.1	0.087
3	L1 x L9	**8.69**	**9.15**	**102**	5.1	2.3	0.49	0.95	2.7	2.4	5.2	0.0	0.093
17	L3 x L9	**8.60**	**8.79**	**101**	2.1	2.2	0.51	0.99	3.6	2.7	0.0	6.6	0.087
11	L2 x L5	**8.58**	**8.69**	**101**	1.2	2.2	0.52	0.83	3.2	2.4	1.2	1.7	0.090
13	L2 x L7	**8.56**	**8.96**	**100**	4.5	1.9	0.54	0.97	3.0	1.9	0.0	2.0	0.087
28	CML161 x CML165	**8.85**	**8.85**	**104**	0.0	1.5	0.55	0.94	3.6	2.0	0.0	9.1	0.095
29	Local check #1	**6.72**	**6.83**	**79**	1.7	2.0	0.56	0.90	3.6	2.9	13.8	7.6	0.092
30	Local check #2	**8.52**	**8.69**	**100**	2.0	1.2	0.53	0.96	2.4	2.0	0.3	2.2	0.050
	Grand Mean	**7.01**	7.34		4.6	2.3	0.52	0.93	3.3	2.9	3.8	4.7	
	LSD 5%	**1.33**	**1.40**		5.1	0.5	0.03	0.11	0.9	0.4	10.1	8.9	
	CV %		**9.24**		9.9	13.0	5.04	11.39	14.7	10.4	11.8	10.3	
	Number of locations		**2**		2	2	2	2	2	2	2	2	

LINES

L1	**(CML150xCL-03618)-B-6-2-1**	L5	**(CML165xCLQ-6203)-B-11-2**
L2	**(CML150xCL-03618)-B-16-1-2**	L7	**(CML165xCLQ-6203)-B-54-1-1**
L3	**(CML150xCL-03618)-B-17-2-2**	L9	**(CML165xCLQ-6203)-B-9-1**

Estimation of GCA from design II crosses revealed that the best combiner from HG "A" are lines (CML165xCLQ-6203)-B-9-1, (CML165xCLQ-6203)-B-11-2, and (CML165xCLQ-6203)-B-54-1-1, while the highest values of GCA from HG "B" had (CML150xCL-03618)-B-16-1-2 and (CML176xCL-G2501)-B-55-1-2 (Table 50). These lines will be used more extensively in QPM breeding program. Estimation of GCA values from design II crosses and their use for CIMMYT inbred line releases can be replaced in breeding scheme with head-to-head analysis of lines. Head-to-head analysis can provide breeding values of compared inbred lines as well as show strengths or disadvantages of new lines over the best tester line.

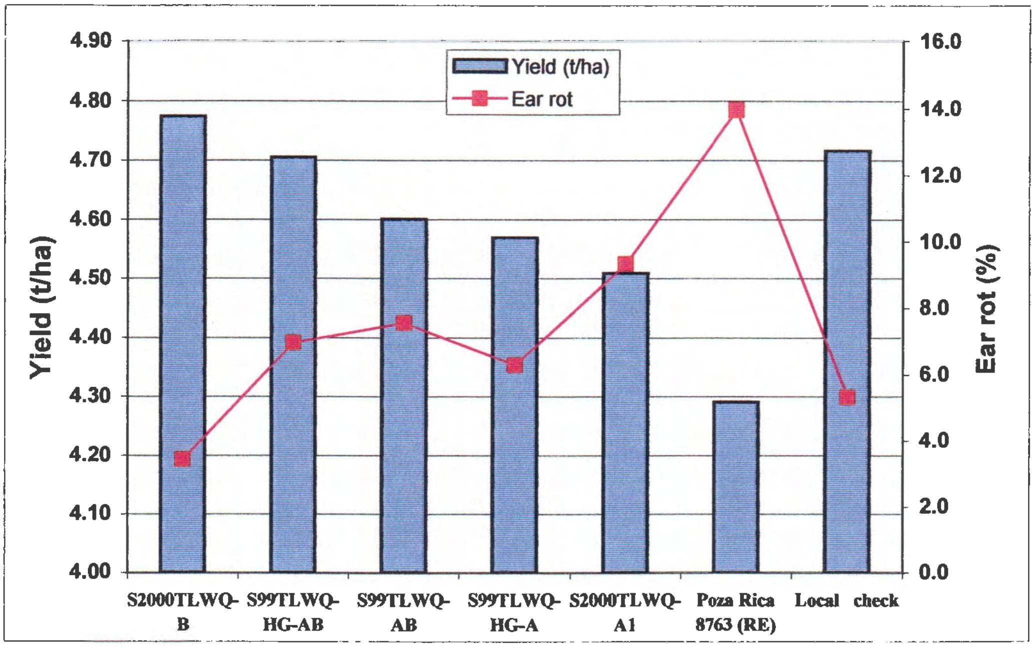
3.5.8 EVTWQ02-28. Evaluation of tropical QPM white synthetics

Twelve new white QPM synthetics, two reference QPM synthetics, and two local checks were grown in 4x4 α-lattice design at five locations with two replications per location. Lines, which formed new QPM synthetics, were selected based on the good GCA values (and other good characteristics) from 1999 and 2000-year yield trials. Results from this study are presented in table 52 and A160 to A165.

Analysis of variance showed that except for corn stunt there was no genotype x environment interaction for other traits (Table A165). At each individual location significant differences were observed between entries. The highest mean grain yield (5.65 t/ha) for experiment was achieved at location Cotaxtla (Table A161).

Seven out of 12 new QPM synthetics had equal or better yield performance than the best reference entry POZA RICA 8763 (Table 52). The highest yielding synthetics were S2000TLWQ-B with 4.77 t/ha and S99TLWQ-HG-AB with 4.70 t/ha across five locations with less incidence of ear rot (figure 17) and other agronomic characteristics not significantly different than reference entry. As addition these synthetics had even same or slightly better performance than the best normal local check hybrids (figure 17).

Figure 17. Grain yield and Ear rot for the best five QPM synthetics reference entry and the best local check across five location in 2002B.



Additional benefits of new QPM synthetics are almost double content of trypthopan and lysine than in normal endosperm material. The best of them will be tested *per se* in next years in Africa and Latin America and used as female parents for non-conventional hybrids.

3.5.9 CHTTWQ02. CIMMYT Hybrid Tropical Trial White QPM

Ten newly developed QPM hybrids, four well-known QPM hybrids and two local checks (normal endosperm hybrids) were grown in 4x4 alpha lattice design, with 3 replications per locations. These trials were sent on more than 30 locations. Up to know, the data are returned from 12 locations.

All evaluated QPM hybrids outyielded the best local check across 12 locations (Table 53). Three newly developed hybrids (CML144 x CLQ-RCWQ26 with 6.02 t/ha, CLQ-6203 x CML159 with 5.91 t/ha, and CLQ-6203 x CML147 with 5.78 t/ha) topped the trial with more that 20% yield advantages over the local checks and good other agronomic characteristics. All ten newly developed QPM hybrids showed better yield performance than reference QPM hybrid (CML144 x CML159), indicating progress in white tropical lowland QPM research program.

Table 53. CHTTWQ02 Mean for different traits across 12 environments in 2002.

Ent no	Pedigree	Yield t/ha	Bck %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott %	Erott 1_5	Plt asp	Ear asp 1_5	Rldg %	Sldg %	BH %	BH 1_5	Plt #	Fus %	Stunt %	EnH 1_5	Bipolaris 1_5	Virus %	Ears/pant	Leaf spot 1_5
11	CML144 x CLQ-RCWQ26	**6.02**	**129**	56	57	-0.4	224	110	16.9	4.3	1.8	2.7	2.0	8.1	9.7	0.2	1.4	45	11.3	2.9	1.8	2.9	6.2	0.97	1.5
6	CLQ-6203 x CML159	**5.91**	**127**	55	55	-0.3	213	101	15.2	7.1	2.4	2.5	2.2	15.2	10.0	5.5	1.5	44	35.8	0.0	1.7	3.0	21.3	0.99	1.5
5	CLQ-6203 x CML147	**5.78**	**124**	55	55	-0.3	214	95	15.7	5.7	2.3	2.6	2.4	13.5	3.1	8.1	1.3	44	15.4	2.5	1.9	2.1	17.7	0.94	1.5
10	CML144 x CML147	**5.75**	**123**	57	57	-0.3	219	102	15.7	4.6	1.8	2.1	2.4	5.7	3.8	7.6	1.5	45	0.7	10.6	1.8	2.0	7.0	0.96	1.0
13	CML142 x CML144	**5.71**	**123**	56	57	-0.3	225	122	14.8	3.8	1.8	2.7	2.4	6.9	6.8	0.6	1.5	44	3.0	2.3	1.7	2.5	5.5	0.98	1.2
7	CML142 x CLQ-RCWQ03	**5.70**	**122**	56	56	-0.3	222	119	15.4	6.5	1.8	2.6	2.1	8.6	6.4	4.5	1.6	44	0.9	2.6	1.5	2.2	6.7	0.91	1.3
3	CLQ-6203 x CLQ-RCWQ50	**5.70**	**122**	55	55	-0.2	226	106	14.9	7.2	2.3	2.7	2.4	11.2	5.8	0.4	1.4	45	19.7	0.7	2.0	2.2	10.8	0.97	1.5
1	CLQ-6203 x CLQ-RCWQ01	**5.68**	**122**	56	56	-0.4	208	101	16.2	5.2	1.9	2.5	2.2	7.0	9.0	0.5	1.4	45	4.4	7.8	1.4	2.3	16.6	0.96	1.5
8	CML142 x CML147	**5.58**	**120**	56	56	-0.2	236	121	15.2	5.8	1.9	2.5	2.3	7.2	1.8	6.5	1.2	44	1.0	4.7	1.8	2.2	4.7	0.99	1.3
12	CML150 x CLQ-RCWQ31	**5.42**	**116**	54	55	-0.3	209	96	14.7	4.7	1.8	2.3	2.3	7.1	2.6	7.9	1.4	44	3.0	0.7	1.9	2.3	8.2	0.95	1.5
2	CLQ-6203 x CLQ-RCWQ04	**5.39**	**116**	56	56	-0.1	207	100	15.2	4.8	2.3	3.0	2.5	12.7	9.3	0.2	1.6	44	23.3	3.7	1.4	3.3	12.6	0.96	1.2
9	CML143 x CLQ-6313	**5.24**	**112**	54	54	-0.4	221	116	15.0	4.2	1.5	3.1	2.3	18.0	9.2	4.4	1.4	43	16.5	0.0	1.8	2.4	7.0	0.96	1.3
4	CLQ-6203 x CLQ-RCWQ36	**5.18**	**111**	55	55	-0.4	220	101	14.8	6.7	1.8	2.8	2.2	12.5	9.0	2.6	1.4	43	19.7	0.0	1.7	2.3	23.1	0.93	1.2
14	CML144 x CML159 RE	**4.88**	**105**	57	57	-0.3	222	102	15.1	4.1	2.3	2.8	2.2	9.8	11.6	2.0	1.3	42	14.8	4.5	1.8	2.8	5.5	0.88	1.3
15	Local Check	4.83	104	55	55	-0.5	217	105	15.5	4.6	1.6	2.6	2.3	10.1	4.1	1.9	1.5	37	8.4	1.5	1.5	2.3	7.6	0.94	1.3
16	Local Check	4.50	96	56	56	-0.1	232	121	15.3	5.4	2.3	2.6	2.5	13.1	3.5	4.4	1.3	42	0.0	3.3	1.6	2.3	8.7	0.93	1.2
	Check Mean	**4.66**		55	56	-0.3	225	113	15.4	5	2.0	2.6	2.4	11.6	3.8	3.12	1.4	40	4.2	2.4	1.5	2.3	8.1	0.93	1.25
	Grand Mean	**5.45**		55	56	-0.3	220	107	15.4	5	2.0	2.7	2.3	10.3	7.0	3.6	1.4	44	12.1	3.1	1.7	2.5	10.9	0.95	1.35
	LSD 5%	0.64		1.0	1.0		6.3	5.3	1.0																
	CV %	13.2		2.0	2.1		4.4	7.5	6.8																
	F value Loc*Entry	1.21		1.35	1.20		0.58	0.61	1.2																
	P(F>f)	0.08		0.01	0.09		1.00	0.99	0.12																
	Number of locations	12		12	12	12	11	11	11	10	2	7	10	10	10	4	4	12	1	1	4	2	1	11	1

Three QPM hybrids (CML144 x CML147, CML142 x CML147, CML150 x CLQ-RCWQ31) had total lodgings less than 10% (average for the experiment 17.3%) confirming that some progress has been made in this direction. As CML147 was parent in two out of these three stable hybrids, the line probably posses favorable alleles for stability and should be used as donor in QPM breeding programs.

3.5.10 CHTTYQ02. CIMMYT Hybrid Tropical Trial Yellow QPM

Eight newly developed tropical late yellow QPM hybrids, four well-known QPM hybrids, and two reference entries were grown in 2x7 alpha lattice design with three replications and two rows per plot. Trial was sent to more than 30 locations, but up to the data of writing this report information's from 15 locations were returned.

Two newly developed QPM hybrids (CML 161 x CLQ-6603 with 5.96 t/ha, and CML 161 x CLQ-S89YQ06 with 5.79 t/ha) and two well-know hybrids (CML 161 x CML 172 with 5.91 t/ha, and CML 161 x CML 163 with 5.56 t/ha) outyielded the best QPM reference entry CML161 x CML165 and two local checks (Table 54). The first three hybrids also had low incidence of ear rot, while CML 161 x CLQ-S89YQ06 showed high standability in the experiment with other good agronomic characteristics.

All top yielding hybrids had CML161 as one of the parent, indicating that new lines have been identified to replace CML165 from QPM reference hybrid. Additional efforts are necessarily at the tropical lowland program in order to develop new inbred lines, which will successfully replace CML161 in new hybrid combinations.

Table 54. CHTTYQ02. Mean for different traits across 15 environments in 2002.

Ent no	Pedigree	Yield t/ha	Bck %	Ant days	Silk days	ASI	Plt ht cm	Ear ht cm	Mo %	Erott %	Plt asp	Ear asp 1_5	Rldg %	Sldg %	BH %	BH 1_5	Plt #	Plt germ #	Fus %	Stunt %	EnH 1_5	P.P. 1_5	B. M. 1_5	Virus 1_5	Ea/plt %	GLS 1_5	Faw 1_5	Msv %
2	CML 161 x CLQ-6603	5.96	109	54	55	-1.4	232	123	21.1	2.8	2.7	2.3	13.6	4.5	17.1	1.8	45	46	1.4	0.0	1.6	1.6	2.0	2.5	0.92	3.0	1.2	1.2
10	CML 161 x CML 172	5.91	108	55	56	-1.5	243	126	21.4	3.5	2.6	2.4	14.8	4.5	29.2	1.9	45	45	0.0	0.0	1.7	1.6	2.1	2.5	0.95	3.3	1.7	1.2
1	CML 161 x CLQ-S89YQ06	5.79	106	54	56	-1.7	232	121	20.7	3.4	2.7	2.2	5.4	5.3	6.4	1.6	46	46	4.2	0.4	2.0	1.5	1.9	2.5	0.93	3.0	1.4	1.2
11	CML 161 x CML 163	5.56	102	55	57	-1.7	229	123	23.2	9.0	2.7	2.5	20.4	6.7	3.7	2.1	45	46	7.7	1.2	2.1	1.5	2.1	2.7	0.89	3.5	1.4	1.2
12	CML 161 x CML165 RE	5.55	101	54	56	-1.4	219	110	21.3	6.2	2.7	2.5	10.5	5.9	7.3	1.8	45	45	7.0	0.4	1.8	1.7	2.2	2.5	0.96	3.3	1.2	1.2
7	CML 161 x CLQ-RCYQ11	5.49	100	55	57	-1.5	241	128	21.7	4.0	2.7	2.2	14.4	5.2	5.7	1.6	44	46	0.0	1.0	1.8	1.3	2.3	2.7	0.94	3.5	1.5	1.5
5	CML 172 x CLQ-RCYQ09	5.45	100	54	56	-1.3	226	111	21.6	8.1	2.7	2.6	13.6	2.2	36.6	2.4	46	46	2.1	0.9	2.0	1.5	2.0	2.2	0.90	3.2	1.5	1.3
4	CML 172 x CLQ-RCYQ08	5.40	98	55	57	-1.4	232	119	22.2	7.4	2.7	2.9	5.1	4.7	29.4	2.2	45	45	0.0	0.0	1.9	1.7	2.3	2.8	0.93	3.3	1.9	1.2
9	CML 161 x CLQ-6601	5.37	98	54	55	-1.3	226	114	21.2	4.1	2.4	2.4	9.6	4.3	7.7	1.8	45	46	3.5	1.6	1.8	1.9	2.2	2.5	0.96	3.8	1.7	1.3
6	CML 161 x CLQ-RCYQ22	5.36	98	53	55	-1.1	218	106	20.6	4.3	2.5	2.5	5.8	2.7	26.5	2.1	46	46	2.1	0.8	1.9	1.4	2.0	3.0	0.94	3.5	1.4	1.3
3	CML 161 x CLQ-RCYQ01	5.35	98	55	56	-1.8	234	114	21.0	7.9	3.2	2.7	14.6	4.0	28.6	2.2	45	46	0.0	0.0	2.2	1.9	2.1	3.0	0.90	3.2	1.4	1.2
8	CML 170 x CML 171	4.96	91	54	55	-1.0	216	113	20.9	5.0	2.9	2.5	7.8	4.7	12.9	2.0	46	46	10.9	0.4	1.6	1.8	2.7	3.2	0.91	3.2	1.2	1.2
13	Local Check	5.07	93	54	55	-0.9	224	116	20.4	4.1	2.7	2.3	10.5	4.2	5.4	2.1	38	45	0.0	0.4	1.4	1.8	2.2	2.3	1.00	3.0	1.4	1.7
14	Local Check	5.47	100	55	56	-1.1	220	111	21.3	4.1	2.4	2.3	7.9	4.5	4.5	1.8	43	45	0.0	1.4	1.6	1.4	1.8	1.7	0.96	3.2	1.2	1.7
	Check Mean	5.27		54	55.5	-1.0	222	114	20.9	4	2.5	2.3	9.2	4.3	5	2.0	40.7	45	0.0	0.9	1.5	1.6	2.0	2.0	0.98	3.1	1.25	1.7
	Grand Mean	5.48		54	56	-1.4	229	117	21.3	5	2.7	2.5	11.3	4.6	17.6	2.0	45	46	3.2	0.6	1.9	1.6	2.2	2.7	0.93	3.3	1.4	1.2
	LSD 5%	0.53		0.7	0.8		5.6	4.8	1.1																			
	CV %	12.12		1.3	1.4		4.1	6.7	5.9																			
	F value Loc*Entry	1.21		1.6	1.7		0.7	0.7	1.5																			
	P(F>f)	0.07		0.00	0.00		0.99	0.98	0.00																			
	Number of locations	15		14	15		15	15	15	12	11	14	13	13	7	5	15	3	1	2	4	3	5	2	15	1	2	1

3.6 ADDITIONAL WORK AT THE CIMMYT TROPICAL LOWLAND SUBPROGRAM

3.6.1 CIMMYT tropical lowland database

In 2002-year tropical subprogram completed a small project with idea to develop useful database system. The database was developed in Microsoft access program. With this database we were able to store all data related with breeding program in one place, to join similar types of data and allow analysis across them, to get additional data related with breeding program, and at the end to facilitate selection and save some time and money.

The main advantage of this database system is that enables simultaneous examination of data from different years and experiments. It means that we could easily compare two (or more) hybrids in any experiments where they were grown together i.e. apply head-to-head analysis. The idea and database itself had excellent appraisal from other CIMMYT scientists and the main function, as well as all stored data, will be incorporated into the new version of MaizeFinderPC the future CIMMYT maze application (GIS and database system) for internet and personal computes. At the end of 2002, we had stored tropical lowland yield trials data from 1999-2002.

3.6.2 The new method for estimation of inbred line breeding value

Alongside with development of tropical lowland database, we developed the new tool for estimation of the genetic merit of inbred lines relative to the best tester line. This method we called "head-to-head analysis of inbred lines".

Head-to-head analysis of inbred lines uses similar principles as in head-to-head analysis of hybrids. The main difference is that head-to-head analysis of inbred lines considers the lines (usually two, but can be more) in crosses with the same other lines or other genotypes, such as hybrids. The requirements for both analyses are that the crosses were grown in the same experiment. One comparison of lines in crosses with the same other parent in one experiment was considered to be one data point. The higher number of data points, the higher the confidence in the results obtained. The significance of the differences could be compared with paired *t*-test.

The general combining abilities of compared lines could be calculated using following equation:

$$GCA_n = \bar{l}_n - \bar{\bar{x}} \quad , \qquad (1)$$

where $\bar{l}_n$ is average yield of line *n* and $\bar{\bar{x}}$ is average yield of all crosses in the analysis.

Also, stability analysis could be shown for each inbred line using the same data as for head-to-head analysis. Grain yield of inbred line crosses (expressed as % of experiment mean) could be regressed on the test location yield. Similar regression but for hybrids ("stability head-to-heads") was reported by TROYER (1983). As the lines we want to compare were grown in the same experiment, location, and years this stability analysis is valid for comparison of the two (or more) lines.

Head-to-head analysis enables pooling of results for the same lines across different years, experiments, and locations and could be potential tool for selection and advancement of new developed lines. The tester lines in any breeding programs are usually the best lines for a heterotic group. Head-to-head analyses of the new lines with the tester would enable breeders to select the superior performing material. With appropriate computer software, all lines compared with the same tester could be sorted and presented in one table, which would facilitate selection.

Use of stability analysis to select lines for pedigree breeding would allow breeders to develop lines suitable for specific or wider adaptation. For example grain yield of the line crosses can be regressed on environments sorted by average growing degree units (GDU); i.e., maturity group. This can provide information of line performance in short-season vs. full-season environments. In the case when compared lines come from the same pedigree, significant differences between regression lines could indicate presents of different alleles for grain yield in the two lines, and justify initiation of pedigree projects with crosses between them. An advantage of this type of analysis is that breeders do not need to grow special experiments at a large number of locations to perform stability analysis.

Application of these tools can be extended to comparisons between testers from the same heterotic group. That analysis would help with decisions of which tester to use for the first screening of breeding materials, and which for the second screening. In the case of comparing testers, number of data points can be very high enhancing confidence in results. Public institutions can also benefit from these analyses, using them as main criteria (tools) for releasing superior lines.

The head-to-head and stability analysis of inbred lines could be easily applied in any breeding program and used for determination of the breeding value of inbred lines in a more cost- and time-efficient manner than using diallel or design II methods.

The manuscript, which explains the head-to-head analysis of inbred lines will be published in Maydica in 2004. Finally, this analysis will be incorporated into the new version of MaizeFinder.

3.6.3 The new conversion breeding scheme

The 2002 year marked the first year since we started to use the new conversion breeding scheme to convert elite normal line to QPM. The main idea came from Hans Gevers (South Africa), who participated as the trainees at the CIMMYT first advanced training course with emphasis on QPM, held at CIMMYT headquarters, Mexico, from 26 August to 20 September. This is just one more confirmation that not CIMMYT is only one who is giving knowledge to the others, but training courses are equally useful for trainees and CIMMYT researchers, for the exchange of information, knowledge, and experience.

The short outline of the new conversion scheme

Cycle:

1. Germplasm: QPM x Normal
   Locus: (o_2o_2) (NN)

2. Germplasm: F1 x Normal
   Locus: (No_2) (NN)

3. Germplasm: BC_1
   Locus: (50% NN and 50% No_2)

a) **Without markers:** Self all BC_1 plants and make cross with normal – recurrent parent (i.e. make BC_2). On the selfed ears at harvest time look for segregation. Expectations are: 50% ears will be complete normal (discard those ears and the crosses with those plants), 50% should have segregations on ears (select QPM part of the seeds with good modification and grow next cycle as new S_1 line). Write plants/ears with the best modified QPM seeds (based on light table) and advance only BC_2 seeds, for further conversion process, from selected the best-modified ears.

b) **With markers:** Screen all BC_1 plants with molecular markers (phi057 or umc1066) self only BC_1 plants which are heterozygous (No_2) and use pollen to make cross with normal – recurrent parent (i.e. make BC_2). Then again look for the best modifications (light table) on those segregating ears (selfed ears), and advance only BC_2 seeds from the best-modified ears. Also, seeds from the selfed ears could be grown in nursery as new S_1 line.

4. Repeat procedure as in Cycle 3., and make BC_3.

5. Use markers to select self-heterozygous (No_2) BC_3F_1 plants. At pollination self only selected plants (No_2), while at harvest look for the best modified kernels (light table) and plant them next season.

6. BC_3F_2 plants. Use markers (optional) and self only (o_2o_2) plants (should be high % of BC_3F_2 plants homozygous for opaque-2 gene based on light table selection in previous cycle). Self the best plants and send seeds for laboratory analysis (Try, Lys). Again select on light table and advance the best modified ears (kernels).

The advantages on the new conversion breeding scheme are: i) it will speed up the process and we should be able to save two cycles (one year), ii) by selfing segregating plants (for o2o2 genes) and looking into their modifications we will have during all stages of conversion full control for presence of good modifiers, iii) the self (selected) seeds could be used for planting as the new developed S_1 line, making whole process more useful. As main disadvantage of the new conversion scheme is that all segregating plants need to be tagged (numbered) and during pollination these numbers should be written on pollinating bas (either self or crosses).

3.6.4 QPM pedigree breeding scheme

One of our ideas on the tropical lowland subprogram was to develop and implement a new pedigree breeding scheme, which will take into account the new developed tools for estimation of inbred lines breeding values (head-to-head analysis of inbred lines) and implement our past experience in work with QPM germplasm. This new scheme should help us to organize our QPM research activities on more efficient, cost effective, and product oriented manner. In the same time this scheme can bring benefits to the other QPM programs as well as be used as new training material.

The first version of QPM pedigree breeding scheme (presented below) has the list of basic steps (in the appropriate order), timing, and instructions for successful development of the new QPM inbred lines. In the second version, each step written in the scheme will be elaborated with scientific references (where are possible) or practical data from QPM breeding programs.

QPM pedigree breeding scheme

Cycle	Start Cycle A (off season)	Start Cycle B (main season)
Year 1		
Cycle A	Make crosses (F1's or BC's) **Make crosses based on pedigree data, lines per se, and head-to-head analysis.**	
Cycle B	Self F1's Self at least 15-20 plants Discard bad looking F1's Select F2 seeds under light table. From QPM x QPM cross select the best modifications (scale 2) 1-normal type; 5-opaque From QPM x Normal cross. Segregation 3:1. Select QPM part, scale 3 (2-4)	Make crosses (F1's or BC's) **Make crosses based on pedigree data, lines per se, and head-to-head analysis.**
Year 2		
Cycle A	Grow F2's in higher density. Grow at least 400 F2 plants. Select the best plants. Select at harvest 50-100 the best ears with good modifications. Select under light table S2 seeds. Look for segregation. If present, select QPM part of the seeds scale 3 (2-4). If not, select the best modifications. Write down complete QPM lines.	Self F1's Self at least 15-20 plants Discard bad looking F1's Select F2 seeds under light table. From QPM x QPM cross select the best modifications (scale 2) 1-normal type; 5-opaque From QPM x Normal cross. Segregation 3:1. Select QPM part, scale 3 (2-4)

Cycle	Start Cycle A (off season)	Start Cycle B (main season)
Cycle B	Grow ear per row S2 lines. Advancing to S3. Grow at high density. Screen for major diseases and pests. Select the best rows, and the best plants within rows. Select at harvest the best ears (1-3) with good modifications. Select under light table S3 seeds. Look for segregation. Most of the ears should be complete QPM. Select the best modifications. Prepare seeds for Lab. Analysis. (only Try.)	Grow F2's in higher density. Grow at least 400 F2 plants. Select the best plants. Select at harvest 50-100 the best ears with good modi Select under light table S2 seeds. Look for segregation. If present, QPM part of the seeds scale 3 (2-4). If not, select the best modifica Write down complete QPM lines.
Year 3		
Cycle A	Grow S3 lines in testcross isolation. Use one tester from opposite heterotic group. Discard the lines that do not satisfy agronomic criteria. Harvest only rows that perform well in isolation, nursery and have high % of Try (Lab. Anal.) Grow the same S3 lines in nursery. Advancing to S4. Select the best rows, and plants within rows. Harvest only rows (the best ear(s) (1-2) within row) that perform well in isolation, nursery and have high % of Try (Lab. Anal.) Select under light table S4 seeds. All ears should be complete QPM. Select the best modifications.	Grow ear per row S2 lines. Advancing to S3. Grow at high density. Screen for major diseases and pests. Select the best rows, and the best plants within Select at harvest the best ears (1-3) with good modifica Select under light table S3 seeds. Look for segregation. Most of th should be complete QPM. Select the best modifications. Prepare s Lab. Analysis. (only Try.)

Cycle	Start Cycle A (off season)	Start Cycle B (main season)

Year 3

Cycle B

Start Cycle A (off season)	Start Cycle B (main season)
Evaluate S3 x tester testcrosses. Grow trials on 3-5 locations, 2 reps, 1 row/plot. **Grow S4 lines in nursery. Advancing to S5** Select the best rows, and plants within rows. Harvest the best ear (1) within the best rows. Based on yield trials data, select the best 10-30% inbred lines. Select under light table S5 seeds of those lines. Select the best modifications.	**Grow ear per row S3 lines. Advancing to S4.** Grow at high density only lines with high values of tryptophan. **Screen for major diseases and pests.** Select the best rows, and the best plants within rows. Select at harvest the best ear(s) (1-2) with good modifications.

Year 4

Cycle A

Start Cycle A (off season)	Start Cycle B (main season)
Grow S5 lines in testcross isolation. Use the same tester as in stage S3. Most of the lines should be good per se, but discard some that do not tolerate inbreeding. Harvest only rows that perform well in isolation, and nursery. **Grow the same S5 lines in crossing block.** Make crosses with one or two additional tester lines. If there is possibility do that in isolation. Make crosses for pedigree breeding with some promising S5 lines. **Grow the same S5 lines in nursery. Advancing to S6.** Select the best rows, and plants within rows. Harvest only rows (the best ear within row) that perform well in isolation, and nursery.	**Grow S4 lines in testcross isolation.** Use one tester from opposite heterotic group. Harvest only rows that perform well in isolation, and nursery. **Grow the same S4 lines in nursery. Advancing to S5.** Select the best rows, and plants within rows. Harvest only rows (the best ear within row) that perform well in isolation, and nursery.

Cycle	Start Cycle A (off season)	Start Cycle B (main season)

Cycle B

Start Cycle A (off season)

Evaluate S5 lines x testers crosses.

Test on 4-8 locations, 2 reps, 2 rows/plot.

Grow S6 lines in nursery. Advancing to S7.

If line is uniform self all plants.

Harvest ears in bulk.

Based on yield trials data, select the best inbred lines. Select crosses with new lines for CIMMYT trials.

Start Cycle B (main season)

Evaluate S4 lines x tester testcrosses.

Grow trials on 3-5 locations, 2 reps, 1 row/plot.

Grow S5 lines in nursery. Advancing to S6

Select the best rows, and plants within rows.

Harvest the best ear (1) within the best rows.

Based on yield trials data, select the best 10-30% inbred lines. Select under light table S6 seeds of those lines. Select the best modifications.

Year 5

Cycle A

Start Cycle A (off season)

Make S7 lines crosses using isolation block

If new line make good hybrids with tester lines, grow 5 - 10 rows in isolations for seed increase for CIMMYT hybrid trials.

Grow the same S7 lines in crossing block.

Make crosses with four to six additional tester lines. If there is possibility do some crosses in isolation.

Make crosses for pedigree breeding based on pedigree data, lines per se, and head-to-head analysis.

Make seed increase for crosses for CIMMYT hybrid trials.

Based on yield trials data, select the best inbred lines to grow in line evaluation trial (for releasing inbred lines).

Start Cycle B (main season)

Grow S6 lines in testcross isolation.

Use the same tester as in stage S3.

Most of the lines should be good per se, but discard some that do not tolerate inbreeding.

Harvest only rows that perform well in isolation, and nursery.

Grow the same S6 lines in crossing block.

Make crosses with one or two additional tester lines. If there is possibility do that in isolation.

Make crosses for pedigree breeding with some promising S6 lines.

Grow the same S6 lines in nursery. Advancing to S7.

Select the best rows, and plants within rows.

Harvest only rows (the best ear within row) that perform well in isolation, and nursery.

Cycle	Start Cycle A (off season)	Start Cycle B (main season)

Year 5

Cycle B

Evaluate S7 lines in CIMMYT and subprogram yield trials.

Subprogram trials: Test on 6-10 locations, 2 reps, 2 rows/plot.

Evaluate lines for releasing in LET trials.

Grow lines in nursery.

Self and harvest at least ten ears.

Evaluate S6 lines x testers crosses.

Test on 4-8 locations, 2 reps, 2 rows/plot.

Grow S7 lines in nursery. Advancing to S8.

If line is uniform self all plants.

Harvest ears in bulk.

Based on yield trials data, select the best inbred lines. Select crosses with new lines for CIMMYT trials.

Year 6

Cycle A

Grow lines in nursery.

Grow ten rows of each selected line for releasing. If uniform harvest in bulk.

The best lines use as new testers (based on head-to-head analysis).

Make S8 lines crosses using isolation block

If new line make good hybrids with tester lines, grow 5 - 10 rows in isolations for seed increase for CIMMYT hybrid trials.

Grow the same S8 lines in crossing block.

Make crosses with four to six additional tester lines. If there is possibility do some crosses in isolation.

Make crosses for pedigree breeding based on pedigree data, lines per se, and head-to-head analysis.

Make seed increase for crosses for CIMMYT hybrid trials.

Based on yield trials data, select the best inbred lines to grow in line evaluation trial (for releasing inbred lines).

Grow lines in nursery.

Self and harvest at least ten ears.

Cycle	Start Cycle A (off season)	Start Cycle B (main season)
Cycle B		Evaluate S8 lines in CIMMYT and subprogram yield trials. Subprogram trials: Test on 6-10 locations, 2 reps, 2 rows/plot. Evaluate lines for releasing in LET trials.
Year 7		
Cycle A		Grow lines in nursery. Grow ten rows of each selected line (based on yield trials) for releasing. If uniform harvest in bulk. The best lines use as new testers (based on head-to-head analysis).

3.7 CIMMYT Maize Global Line Evaluation Trials

Evaluation of maize inbred lines in yield trials is not a common procedure in breeding programs (Vasal et al., 1999). Except for specific studies, these types of trials are rare. The correlation coefficients for yield and other traits were significant in many studies between inbred lines and their hybrids (Gurrath et al., 1991; Bolaños and Edmeades, 1996), but they were still too low to be of appreciable predictive value. These conclusions probably were the main staple for establishment of inbred line trials in regular breeding programs. But in order to determine economics of hybrid maize seed production or to obtain complete information on inbred lines for their releases, the line evaluation trials could be the best solution.

At CIMMYT, the various types of line evaluation trials (LET's) had an important role in maize breeding programs (Vasal et al., 1999). But all these trials were handled separately for each subprogram and carried out on limited number of locations. In such circumstances field evaluation of inbred lines from different subprograms was limited as well as between other CIMMYT stations and scientists. The unified yield trials on significant number of locations around the world should bring benefits to the CIMMYT HQ and regional breeding programs.

The objectives of this study were to: provide information of inbred lines grain yields and other important agronomic traits; provide stability of performance and adaptation in specific locations and across-locations; evaluate inbred lines for traits and stresses not screened previously; identify donor-inbred lines for various traits.

3.7.1 MATERIAL AND METHODOLOGY

The CIMMYT maize inbred lines developed at different regions and breeding subprograms were used for this study. The eighty late, 48 early and 20 highland lines were grown in three different experiments. The experiments were grown at the CIMMYT breeding stations around the world, making a total of 13 sites at six different countries (Table 56). Total 27 traits were scored. The list of traits and used scales are given in Table 55.

Table 55. The list of traits and used scales.

The general traits are:

- Female Flowering (days)
- Male Flowering (days)
- ASI (days)
- Plant Height (cm)
- Ear Height (cm)
- Plant Aspect (1-5; 1-good, 5-poor)
- Yield (t/ha)
- Ear Aspect (1-5; 1-good, 5-poor)
- Ear Rot (1-5; 1-clean, 5-severely ear rot)
- % Ear Rot (%)
- Grain Moisture (%)
- Stalk Lodging (%)
- Root Lodging (%)
- Poor Husk Cover (%)

The specific traits are:

A) Biotic

- Maydis Leaf Blight (1-5; 1-clean, 5- severely)
- Turcicum leaf blight (1-5; 1-clean, 5- severely)
- Polysora Rust (1-5; 1-clean, 5- severely)
- Common Rust (1-5; 1-clean, 5- severely)

- Ear rot (1-5; 1-clean, 5- severely)
- Maize Streak Virus (1-5; 1-clean, 5- severely)
- Gray Leaf Spot (1-5; 1-clean, 5- severely)
- Fall armyworm (1-5; 1-clean, 5- severely)
- Corn earworm (1-5; 1-clean, 5- severely)
- Sugarcane Borer (1-10; 1-clean, 10- severely)

B) Abiotic
- Drought Tolerance
- Low Nitrogen
- Soil Toxicity (1-5; 1-tolerant, 5- susceptible)

Field experiments were conducted in 2002 at the northern hemisphere, and in 2003 at the southern hemisphere. All three experiments were grown in α- lattice designs, with two replications. The plot consisted of two rows, 5 m long, with 0.75 m distance between rows, and 21 plants per row (~53,000 plants per ha). Only in cases of physiology, entomology and fitopathology smaller plots were used for germplasm screening. Data was analyzed for each individual location as well as combined over environments and replications. For this purpose the SAS MIXED procedure (SAS Institute, 1997) was used.

Table 56. Country, program and the trial grown.

		Trial		
Country	Program	GLET-L02	GLET-E02	GLET-H02
Colombia	CIMMYT-Colombia	X	X	X
Guatemala	CIMMYT-Guatemala	X		X
Ethiopia	CIMMYT-Ethiopia	X	X	X
Kenya	CIMMYT- Kenya	X	X	
Kenya	CIMMYT- Kenya	X	X	
Zimbabwe	CIMMYT- Zimbabwe	X	X	X
Mexico	Highland	X	X	X
Mexico	Subtropical	X	X	
Mexico	Tropical	X	X	X
Mexico	Entomology	X	X	X
Mexico	Fitopathology	X	X	X
Mexico	Physiology - Low N	X	X	
Mexico	Physiology - Drought	X	X	

GLET-L02 – Global line evaluation trial (Late inbred lines);
GLET-E02 – Global line evaluation trial (Early inbred lines);
GLET-H02 – Global line evaluation trial (Highland inbred lines);

3.7.2 RESULTS

The results from the conducted experiments will be reported by traits and then by experiments.

Grain Yield

The grain yield results reported here should be taken with respect due to competition, which had existed between entries with different plant height. Limited amount of seed withhold us from using border rows for each plot. As a result grain yield of the evaluated lines in most cases was positively correlated with plant height.

These correlation coefficients were from -0.03 up to 0.63, depending on experiment (Tables A166- A201).

The average grain yields across 12 locations were: for GLET-L 1.52 t/ha (Table A179), GLET-E 1.47 t/ha (Table A192), and GLET-H02 2.03 t/ha (Table A201). The highest yielding locations were Tlaltizapan (Mexico) with 2.77 t/ha for GLET-L (Table A168), Harare (Zimbabwe) with 3.23 t/ha for GLET-E (Table A186), and Ambo (Ethiopia) with 3.79 t/ha for GLET-H (Table A200).

In the experiment GLET-L the highest yielding lines across 12 sites were: P502c2-185-3-4-1-3-B-1-B-B-B, (CML-265*CL-00303)-BBB-6-1-3-B*5-B-B, and MBR-ET(W) C1 F139-2-1-B-2-B*9 with more than 2.2 t/ha (Table A179). Only these three lines were better than the best check lines CML451 and CML384. Other 18 lines had grain yield higher than average yield of the checks. Surprisingly, 17 tested lines had average grain yield less than 1.0 t/ha.

More than twenty best performing early lines (GLET-E) had grain yield higher than the best check line CML423 (Table A192). The grain yields for these lines were in range from 1.20 to 2.06 t/ha, respectively. In this experiment 12 lines yielded less than 1.0 t/ha.

No highland lines had better performance than check line CML463 across seven locations (Table A201), but ten (71 %) of them performed better than the average values of the checks. All highland lines had grain yield above 1.1 t/ha, and if we take into account that the highest yielding experiment across and at individual locations was highland (GLET-H) it is possible to conclude that these lines posses good potential as female parents in seed industry.

3.7.3 Biotic constrains

Rust

For rust no satisfactory inoculation techniques are yet available. Therefore, the inbreds were evaluated under natural conditions. Two different species of rust has been monitored: polysora rust (*Puccinia polysora*) and common rust (*Puccinia sorghi*), each was scored on two different locations. Despite natural infestation evaluated inbred lines have showed good variability in their resistance (tolerance) to rust.

In GLET-L only inbred line CL-PWSD04 could be considered as resistant source (Table A202) for polysora rust, but many other lines showed good tolerance (scores 2.0 and less). Two white and four yellow lines showed higher tolerance to polysora rust in GLET-E (Table A203), while as expected only one highland line had good tolerance to polysora rust (which is not common type of rust for highlands; Table A204).

Seven late lines showed tolerance to common rust (Table A202), while majority of the lines in GLET-L were rather susceptible. As expected, only four early lines could be considered as tolerant (Table A203), while more than half of the new highland lines had good tolerance to common rust (Table A204). Based on these results it is clear that some progress has been done in development of resistant breeding material in each ecology where specific type of rust is predominant.

Maize Streak Virus (MSV)

The inbred line evaluation for resistance to MSV has been carried out in Harare (Zimbabwe) and for GLET-L in Alupe (Kenya), under natural infestation. Correlation coefficient between scores from Alupe and Harrare was 0.27 (data not shown). Again as expected the most promising lines with resistance to MSV came from the program were natural infestation is present in breeding nursery. The most resistant late lines are Zimbabwe lines, but two lowland-tropical lines also showed good resistance to

MSV (Table A202). These lines could be potentially used as donor of favorable alleles for MSV. Only two early lines from Asia program could be considered as lines with some tolerance to MSV, while all other lines from GLET-E were rather susceptible (Tables A203 and A198). Similarly only two highland lines had some tolerance to MSV (Table A204).

Ear Rot

Ear rot is one of the biotic constrains present in the most tropical and subtropical environments, consequently for this trait the highest number of scores has been taken. Since pathogens were not specified all scores were analyzed and reported together.

Sixteen white and 15 yellow late lines had average ear rot scores (across ten locations) less than 10 % and could be considered as sources of resistance (tolerance) to the pathogens of ear rot (Table A202). In GLET-E (across nine locations) four white and one yellow lines had the scores less than 10 % (Table A203), while no one highland line showed less than 10 % of ear rot infection based on average value across six locations (Table A201).

Gray Leaf Spot (GLS)

The data for gray leaf spot (*Cercospora zea maydis*) has been collected from Alupe (Kenya), under natural infestation. Since the highest score for this disease was 3.0 our assumption is that natural infestation was not good enough to effectively screen evaluated inbred lines. Anyway, several potentially resistant lines to GLS are given in tables A175 and A202.

Turcicum Leaf Blight

Similar to GLS, Turcicum leaf blight (*Exserohilum turcicum*) data were collected in Alupe (Kenya), under natural infestation for GLET-L, and in Agua Fria cycle A for GLET-H. The scores for the late lines (GLET-L) were from 1.0 to 5.0 indicating high pressure of the pathogens as well as good variability between the lines. Thirteen white and eight yellow lines showed scores less than 1.5 (Table A202), while majority of evaluated lines also showed relatively good resistance to turcicum leaf blight (Table A175). In the case of highland lines less variability were observed and only one line showed susceptibility to turcicum leaf blight (Table A196).

Maydis Leaf Blight

Maydis Leaf Blight (*Bipolaris maydis*) has been scored under natural infestation on three locations (four for GLET-H) and data were analyzed across locations. Unfortunately, no one of the evaluated inbred lines had scores less than 2.1, and consequently we were unable to identify resistant lines. In the late lines (GLET-L) several of them (Table A202) could be considered as source of tolerance (scores 2.3 and less), but generally low variability between lines was present (Table A179). Only two white and three yellow early lines (GLET-E) had scores 2.3 and less (Table A203), while only one line from highlands could be considered as source of tolerance to maydis leaf blight (Table A204).

Sugarcane Borer

Late and early inbred line trials were infested, at Agua Fria – Mexico, with larvae of Sugarcane Borer (*Diatraea saccharalis [fabricius]*). Good variability was present between lines. Six white and two yellow late lines could be considered as tolerant to sugarcane borer (Table A202), while in early trial seven white and three yellow lines posses some tolerance to this pest and had scores below 6.0 (Table A203). These lines could be potentially used as donor of favorable alleles for tolerance to sugarcane borer.

Fall Armyworm and Corn Earworm

Only highland inbred lines were inoculated with these pathogens in El Batan with larvae of *Spodoptera frugiperda* (Fall armyworm) and *Heliothis Zea* (Corn earworm). The majority of the lines showed good tolerance to these two pathogens (Table A195), while two inbred lines from Pool 9B (POOL 9B C1 TSR-8P-2P-1P-2P-1P-3-B-B-B-B and POOL 9B C0 R.L.23-1P-2P-3-2P-1P-B-B-B-B) could be considered as resistant to fall armyworm and corn earworm. Both lines should be used as donors of favorable alleles even for subtropical and tropical lines.

3.7.4 Abiotic constrains

Low Nitrogen

Late and early inbred line trials were grown in Tlaltizapan - Mexico during 2002 summer season and exposed to the low nitrogen fertility soils. The good variability between the lines was observed and grain yield ration varied from 0.20 t/ha to 2.26 t/ha for GLET-L (Table A177), and from 0.31 to 1.36 for GLET-E trial (Table A190).

Ten late lines had yield performance above 1.50 t/ha and could be considered as tolerant to low nitrogen fertility, while eight lines yielded less than 0.50 t/ha, indicating their susceptibility to low N soils. Similarly, six early lines with yield performance above 1.0 t/ha could be considered as tolerant, while six lines with less than 0.50 t/ha susceptible to low nitrogen fertility. The correlation coefficients between grain yield in low N trial and grain yield in normal management trials across locations were 0.50 for GLET-L and 0.41 for GLET-E, respectively.

Drought

Evaluation of late and early inbred lines under severe drought conditions were carried out in Tlaltizapan – Mexico, during dry season (winter). Similar to the low N trials we observed good variability between the lines. Grain yields in late experiment were from 0.0 t/ha to 1.04 t/ha, with average values of only 0.14 t/ha, respectively (Table A178). The grain yields of early lines were in range from 0.0 t/ha to 0.90 t/ha, with grand mean of 0.28 t/ha, respectively (Table A191). The higher yield of early trial could be explained with earlier flowering and some escape of severe drought conditions.

Only three late lines could be considered as resistant/tolerant to drought conditions, while more than half evaluated lines had grain yield less than 100 kg/ha, indicating their susceptibility to severe drought environments. Two late inbred lines (CL-04362 and P502c2-185-3-4-1-3-B-1-B-B-B) tolerant to drought are the same one, which performed well under low nitrogen and should be extensively used in breeding programs for marginal environments. Eleven early lines showed tolerance to severe drought conditions, while more than 15 could be considered as susceptible. Estimated correlation coefficients between grain yield in drought conditions and yield across normal management environments were, positive and low, 0.22 (GLET-L) and 0.32 (GLET-E), respectively.

3.7.5 Agronomic characteristics

Lodgings

Plants with root and stalk lodgings were counted and results were expressed in % of total plants almost at each location where inbred line trials were grown. Analysis across locations showed that excellent variability were present between inbred lines, and that ration were from 0.7 % up to 37.9 %, respectively. Some stable lines were identified in each inbred line trial. In GLET-L average root lodgings were 8.9 % (Table A179), and more than 20 lines showed good root strengths (less than 5.0 % lodging). Consequently only seven lines could be considered as susceptible with more than 20 % of lodgings. In GLET-E, three lines had very good root strengths and less than 5 % of lodgings, while thirteen of them showed poor roots (Table A192). Average lodging in this experiment was 15.2 %, what is almost two times higher than in late inbred line trial. Four highland lines showed good roots, while three lines expressed poor roots strengths, with 11.5 % as average lodgings for the experiment (Table A201).

Much smaller variability was observed between lines for stalk lodgings (data not shown). The maximal values were not higher than 10 % of lodgings. Consequently, many lines in each experiment could be considered as tolerant i.e. with less than 5 % of lodgings. Since this trait is highly correlated with stalk diseases or insects pressure (i.e low repeatability across locations), probably the best option would be to look at individual locations and identify for each ecology the resistant inbred lines.

Poor Husk Coverage

The same as for lodgings, the number of plants with poor husk cover was counted and expressed as % of total number of plants almost at each location were trials were grown. Good variability was present between lines. Most of the lines in each experiment showed good husk coverage, however in each experiment it was possible to identify several susceptible inbred lines. Anyway, low to intermediate repeatability of this trait for GLET-L and GLET-E suggests that data from individual locations should be also considered.

3.7.6 CONCLUSIONS

Total 33 (thirteen late, twelve early, and eight highland) inbred line trials were evaluated in six different countries, and more than 25 different traits were observed. In each experiment it was possible to identify lines with good yield potential at individual and across locations. These lines could be successfully used as female components in hybrid seed production. We identified lines, which could be considered as resistant and used as donors of favorable alleles in pedigree selection procedures, except for maydis leaf blight and sugarcane borer (identified lines only with tolerance). Since majority of the lines has been selected for these trials based on good general combining abilities (GCA), synthetic formation among superior lines is recommended as well as hybrid formation between tropical and subtropical i.e. subtropical and highland lines to better exploit heterosis. These new synthetics and hybrids should be tested in subtropical and mild altitude, and transition zone ecologies.

Looking across all traits that we scored or measured the most promising late lines would be:

GLET-L

CL-04362 (with good yield in normal conditions, drought, low N, with resistance to turcicum, ear rot, and MSV);

P502c2-14-3-1-4-B-B-1-B-B-B (with good yield in normal conditions, low N, with resistance to turcicum, ear rot, common rust, and tolerance to maydis);

P502c2-185-3-4-1-3-B-1-B-B-B (with good yield in normal conditions, drought, low N, with resistance to ear rot, common rust, and tolerance to sugarcane borers);

CL-G2617 (with good yield in normal conditions, low N, with resistance to turcicum, ear rot, and tolerance to maydis);

CML384 (with good yield in low N, low lodgings, with resistance to turcicum, ear rot, and tolerance to maydis);

Cl-02450 (with resistance to turcicim, GLS, and tolerance to maydis and sugarcane borers).

GLET-E

89[G32/DRSTEW]#-31-1-2-B-B-3-5-2-B-1-1-3-B*6 (with good yield in normal conditions, drought, with resistance to GLS, both rusts, and tolerance to maydis and sugarcane borers);

89[G32/DRSTEW]#-31-1-2-B-B-3-5-2-B-1-2-6-B*5 (with good yield in normal conditions, drought, with resistance to GLS, and tolerance to sugarcane borers);

Pob. SEW-HG"B"C0F39-1-1-1-1-B (with good yield in normal conditions, low N, with resistance to common rust, and tolerance to sugarcane borers).

GLET-H

A.T.V.C. 119-B-3-2-2-1-B-B-B (with good standability, with resistance to common rust and tolerance to maydis);

POOL 9B C1 TSR-8P-2P-1P-2P-1P-3-B-B-B-B (with good yield in normal conditions, with resistance to MSV and FAW).

All these lines should be extensively used in CIMMYT maize breeding programs directly or as donors of favorable alleles

Since lines involved in this study were already tested for GCA, the best performing lines should be to form synthetic DPV's.

IV. Seed Shipments and Distribution

The tropical lowland subprogram collaborated extensively with national programs and the seed industry and maize outreach staff providing seed of CML, CL lines, open pollinated varieties, synthetics, populations, hybrids, a total 1105 kg. of seed, 479 hybrids, 3513 lines, 315 experimental varieties, 203 populations and pools, and 103 trials that were shipped by ITU during (2002) to 49 countries. The countries that received more attention were India, Thailand, Mexico, Colombia, Venezuela, El Salvador, Guatemala, Ethiopia, Kenya, Bolivia, Nicaragua, Panama, Paraguay, Indonesia, Vietnam, Nepal and Bangladesh, Malawi, Peru, Vietnam (Table 57).

V. Training

The tropical lowland program staff participated very actively in training activities in Mexico and outreach locations regionally and in-country. 45 working days were spent in teaching, conferences and slide preparations. One regular training course and one advanced training course in QPM with the participation of 55 researchers from 40 different countries. 11 visiting scientists from public and private seed industry visited lowland tropical activities.

VI. Trips, Meetings and Publications

Five papers were presented at the PCCMCA meetings in Dominican Republic, April 2002.

Potencial de rendimiento de híbridos simples y aptitud combinatoria de líneas tropicales de maíz (*Zea mays* L.) de grano amarillo. H. Córdova, G. Avila, G. Alvarado y O. Cano.

Potencial de rendimiento de híbridos trilineales de maíz (*Zea mays* L.) entre cruzas simples hembra Grupo Heterótico "A" y líneas macho Grupo Heterótico "B". G. Avila, G. Alvarado, M. Sierra y H. Córdova.

Comportamiento de cruzas simples y aptitud combinatorial de líneas tropicales de maíz (*Zea mays* L.) de grano blanco. A. Ramírez, N. Vergara, M. Sierra y H. Córdova.

Rendimiento de Grano y Calidad Forrajera de Híbridos de Maíz QPM Tropicales Amarillos. N. Vergara, H. Córdova, S. Rodríguez, G.Avila, G.Alvarado y O. Cano.

Rendimiento de Grano y Calidad Forrajera de Híbridos de Maíz QPM Tropicales Blancos. N. Vergara, H. Córdova, S.Rodríguez, A. Ramírez, G. Alvarado y M. Sierra.

Continuous collaboration with PRM in Central America, make necessary the presence of Hugo Córdova in El Salvador, Guatemala, Nicaragua and Honduras, traveling with Salvador Castellanos to release hybrids, discuss issues of seed production and hybrid promotion strategies. Narciso Vergara and Hugo Córdova attended the XLVIII Annual Meeting of the PCCMCA held in Dominican Republic in April 2002. Several visits were practiced by Hugo Córdova to validate QPM hybrids, plots planted in Mexico in the subtropics and tropical lowland environments where near to 100 plots were planted.

Table 57. Seed Shipments and Trials Distributed by the Tropical Lowland Maize Subprogram during 2002.

SERIAL No.	COUNTRY	INSTITUTION	MATERIAL SENT	WT. (KG)
1	Angola	World Vision International	3 Hybrids, 4 Lines	7.000
2	Argentina	Rusticana S. A.	14 Lines	0.200
3	Bangladesh	CIMMYT	4 Hybrids	6.000
4	Barbados	Attorney - At - Law	2 Hybrids, 3 Varieties	3.200
5	Bolivia	AGRICOM CIAT Ctr. de Inv. Fitoecogenéticas de Pairumani IBTA, Sistema Boliviano de Tecnologia	17 Hybrids, 8 Varieties, 25 Lines	41.670
6	Brazil Brazil	Centro Curitiba, PR, Brasil Universidade Federal do Parana - UFPR	5 Hybrids, 5 Lines	0.828
7	Cambodia		7 Hybrids, 13 Lines	0.885
8	Colombia	Centro de Investigación Semillas Expro Procampo S.A. CIMMYT c/o C.I.A.T.	50 Hybrids, 49 Varieties, 86 Populations, 63 Lines, 23 Trials	185.049
9	Congo	Centre de Recherche sur le Mais (CROM)	32 Lines, 1 Population	0.607
10	China	Guizhou University Heilongjian Academy of Agricultural Sciences Henan Luoyang Agricultural Research Institute Hubei Acaademy of Agriculture & Science Institute of Cereal Crops Institute of Crop Breeding and Cultivaion Institute of Food Crops Ningxia Academy of Agricultural and Forestry Northeast Agricultural University Shandong Academy of Agricultural Sciences Unstitutr of Crop Breeding and Cultivation Yangzhou Prefectural Agriculture Yunnan Academy of Agriculture Science	516 Lines, 2 Varieties, 2 Populations	7.908
11	Ecuador	INIAP - Estación Experimental Santa Catalina	5 Hybrids, 17 Lines	5.914
12	El Salvador	C E N T A	13 Hybrids, 87 Lines, 1 Trial	13.143
13	Ethiopia	Bako National Maize Research CIMMYT Ethiopian Agricultural Research Organization Melkasa Agric. Research Center	4 Hybrids, 24 Varieties, 13 Populations, 5 Pools, 11 Lines, 2 Trials	22.245
14	France	INRA - Université Paris Sud	4 Lines	0.057
15	Georgia	CIMMYT Int.	2 Lines	0.028
16	Germany	Institute for Plant Nutrition,	1 Line	0.028
17	Ghana		2 Lines, 3 Pools	0.628
18	Guadeloupe	I N RA - U R P V	1 Line	0.142
19	Guatemala	CIMMYT Compañia Cristiani Bukard Instituto de Ciencia y Tecnolgoia Agricolas (ICTA) Prosemillas, S.A.	100 Hybrids, 8 Varieties, 1 Populations, 141 Lines, 34 Trials	104.598
20	Haiti	World Vision	4 Varieties	6.000
21	Honduras	Dirección de Ciencia y Tec. Agrop. (DICTA) PROGRAMA REGIONAL DE MAIZ Secretaria de Recursus Naturales	1 Variety, 4 Populations, 10 Lines, 2 Trials	12.764
22	India	CCS - Haryana Agric. University CIMMYT Directorate of Maize Research (ICAR) Greentech Seeds International Pvt. Ltd. Narendra Dev University of Agriculute & Tech. NARP PROAGRO, Seed Company Limited Punjab Agricultural University Rajasthan College of Agriculture	75 Hybrids, 78 Varieties, 2 Populations, 3 Pools, 1134 Lines, 21 Trials	240.082
23	Indonesia	Balai Penkajian Sulawesi Utaa INCRI Research Institute for Maize and Other Cereal	27 Varieties, 4 Populations, 40 Lines	5.447
24	Iran	Seed and Plant Improvement Institute	14 Hybrids, 4 Varieties, 16 Populations, 8 Pools, 59 Lines	6.785
25	Italy	Instituto Agrobiologico per la qualita delle colture mediterranee	45 Lines	1.285
26	Kasakhstan		1 Variety, 14 Lines	0.260

Table 57. Seed Shipments and Trials Distributed by the Tropical Lowland Maize Subprogram during 2002.

SERIAL No.	COUNTRY	INSTITUTION	MATERIAL SENT	WT. (KG)
27	Kenya	CIMMTY IGRAF House KARI, National Dryland Farming Research Centre Maseno University	12 Hybrids, 13 Varieties, 13 Populations, 154 Lines, 2 Trials	51.755
28	Malawi	Sasakawa Global 2000 Chitedze Reseasch Station	1 Hybrid, 2 Varieties, 2 Populations, 7 Lines	11.100
29	México	Agroquimicos Rivas S.A. de C.V. Agrotecnica del Centro, S.A. de C.V. Centro de Investigación Cientifica de Yucatán CIANO - INIFAP Colegio de Postgraduados Colegio de Postgraduados - Campus Córdoba INFAP - CIRNE INIFAP Instituto Tecnológico Agropecuario No. 33 ITESM Campus Sanmina-SCI Corporación Semillas Certificadas de Veracruz, S.A. de C.V. Semillas Genotec, S.A. de C.V. Universidad Autónoma Agraria "Antonio Narro" Universidad Autónoma Chapingo Universidad Autonoma de Guadalajara	25 Hybrids, 20 Varieties, 1 Population, 112 Lines, 8 Trials	109.112
		CIMMYT-Biotechnology	1 Line	0.285
		CIMMYT-Economia	4 Varieties	12.000
		CIMMYT-Entomology	6 Varieties, 2 Lines	3.685
		CIMMYT-Fisiology	23 Hybrids, 47 Lines	5.963
		CIMMYT-Gene Bank	6 Hybrids, 5 Lines	1.192
		CIMMYT-Laboratory Soils	3 Varieties	1.500
		CIMMYT-Phytopathology	47 Hybrids, 8 Varieties, 111 Lines, 1 Trial	66.331
		CIMMYT-Subtropical	3 Hybrids, 1 Line	7.057
30	Myanmar	Santa Maria Travel & Tour Co. Ltd.	4 Hybrids, 4 Varieties	1.600
31	Nepal	CIMMYT Nepal Agricultural Research Council	14 Hybrids, 5 Varieties, 24 Lines	37.047
32	Nigeria	Institute for Agricultural Research Samaru	6 Hybrids, 6 Varieties, 2 Lines	1.742
33	North Korea	Pyongyang Crop Genetic Resources Institute	32 Lines, 1 Population	0.599
34	Pakistan	National Agriculture Research Centre	12 Varieties	1.014
35	Panama	IDIAP-Azuero	1 Hybrid, 5 Lines, 3 Trials	8.718
36	Paraguay	MAG HCA , Min. de Agric. y Ganaderia	5 Hybrids, 1 Line, 2 Trials	16.886
37	Peru	Univerdidad Nacional Agraria La Molina	3 Varieties, 175 Lines	15.856
38	Philippines	University of Southern Mindanao University of the Philippines - Los Baños	88 Lines, 11 Populations	2.327
39	Rep. Dominicana	CESDA, Secretaria de Estad de Agricultura	5 Hybrids, 1 Variety, 9 Lines, 1 Trial	4.683
40	Republic of Yemen	PU	10 Lines	0.142
41	South Africa	Agricultural Research Council (SGI)	2 Hybrids, 3 Varieties, 5 Lines	0.571
42	Tanzania	Selian Agricultural Research Institute	1 Hybrid, 2 Lines	3.500
43	Thailand	Nakhon Sawan Field Crops Research Center	8 Varieties, 4 Pools, 4 Populations, 28 Lines	2.000
44	U.S.A.	Pioneer Hi-Bred University of Hawaii University of Illinois	10 Lines	0.170
45	Venezuela	Fondo Nacional de Investigación Agropecuaria Fundación para la Investigación Agricola Danac Instituto Nacional de Investigaciones Agricolas Semillas Flor de Aragua C.A	10 Hybrids, 60 Lines	21.983
46	Vietnam	National Maize Research Institute Southern Seed Joint Stock Company	13 Hybrids, 8 Varieties, 7 Pools, 6 Populations, 216 Lines	14.105
47	West Africa		3 Lines, 1 Population, 3 Pools	0.842
48	Yugoslavia	Institute of Field and Vegetable Crops	4 Lines	0.057
49	Zimbabwe	CIMMYT	159 Lines, 2 Hybrids, 3 Trials	28.897
212	**49**	**96**	**479 Hybrids, 315 Varieties, 168 Populations, 33 Pools, 3513 Lines, 103 Trials**	**1105.472**

Hugo Córdova participated as advisor of several thesis at "Universidad de Colima and Universidad de Guadalajara, Mexico". The most important were:

1. Uso de Probadores en la Selección de Líneas para formar Híbridos de Maíz (*Zea mays* L.). (M.C. Mauro Sierra Macias) Doctor en Ciencias. Universidad de Colima. México. Graduated in May 2002.
2. Respuestas a Selección Recíproca en tres Poblaciones Tropicales de Maíz (*Zea mays* L.). (M.C. Norberto Carrizales Mejia) Doctor en Ciencias. Universidad de Guadalajara, México.
3. Aptitud Combinatoria y Heterosis de Líneas Tropicales de Maíz con Alta Calidad Protéica (QPM). (M.C. Salvador Menéndez Mungía). Doctor en Ciencias. Universidad de Guadalajara, México.
4. Selección de Líneas Tropicales de Maíz de Alta Calidad Protéica a Través de Marcadores Moleculares (M.C. Florencio Reséndiz). Doctor en Ciencias. Universidad de Guadalajara, México.

Five years of non-stop work in the tropical lowland subprogram have enabled us to build-up a tremendous array of hybrids and synthetics normal and QPM. We are very proud of the progress achieved in fixing problems in operation and selection methods and introducing new ideas and strategies in breeding techniques and field operation, that are reflected in the new normal and QPM hybrids and synthetics making them more attractive to farmers. The problems confronted always increased our ability to grow up under stressed circumstances.

VII. Summary

Outreach and headquarters activities in the tropical lowland were enhanced in 2002.

A total of 100 early tropical hybrids were tested in six trials in five locations during 2002. Advanced hybrids yellow early and white early, were tested in international trials in 60 locations in late 2001 and in 2002. Excellent results were obtained and are described below.

CHTTEY hybrid trials including 14 tropical early yellow hybrids and two local checks were conducted in India, Myanmar, Philippines, Vietnam, Bangladesh, Mexico, Ecuador and Panama. Information collected from 37 locations indicates 15 to 100% yield superiority and one week earlier to harvest compared to the local hybrid check, majority late maturing. In 16 locations CIMMYT early yellow hybrids outyielded the best seed industry checks. Locations where the opposite occurred were mainly because the hybrid checks utilized were late maturing hybrids.

40 tropical early white TWC hybrids were tested in six locations in Mexico, Guatemala and Colombia.

10 TWC early white hybrids outyielded single cross early check with 500 to 1200 kg/ha, flowering at 49 to 50 days and harvested at 90 days with 15% moisture.

50 TWC early yellow hybrids were tested at six locations in Mexico and Guatemala. 10 three-way cross hybrids yielded around 5.7 ton/ha and flowered at 47 days, similar to the single cross check that yielded 3.7 ton/ha.

With the support of the Pathology, Entomology and Physiology Units GLET early and late were planted under inoculation with *Fusarium moniliforme*, infested with fall armyworm and SWB and under low-N respectively. Six tropical white early and two early yellow lines were identified as resistant to *F. moniliforme* ear rot. No early lines showed resistance to FAW, nevertheless 8 lines showed tolerance to produce under low-N conditions.

Population improvement continues to be a high priority in the tropical lowland subprogram. In 2002 we formed the S_2 and S_2 x tester families for C_5 in P21 and P32 C_3 in P28 and P36 and C_2 in P30 and P31. 30 new synthetics, open pollinated varieties derived from the pedigree selection breeding project.

EVT12 and EVT13 include the evaluation of 18 new synthetics, tropical yellow late and two checks. Trials were evaluated in several locations. Information from 8 locations in Mexico, Central America and Asia shows one t/ha more yield in the new synthetics.

26 hybrid trials including the evaluation of 1700 tropical late white and yellow normal and QPM hybrids were conducted in 2002 in addition, 74 advanced hybrids normal and QPM were tested internationally in 50 locations in Africa, Asia and Latin America.

50 testcrosses amongst advanced tropical late white inbred lines were tested at six locations in Mexico, Colombia, Guatemala and India. Hybrid CL-RCW063 x CML448 yielded 18.1 t/ha at Dholi, India.

50 tropical late white single cross hybrids (stage 3 of evaluation) formed with lines tolerant to different stresses were tested at seven locations in Mexico, Guatemala, Colombia and India. Two additional sites are being tested under Low N and drought. Hybrid CL-021103 x CML449 topped the trial at Zacapa, Guatemala with 11.5 ton/ha, 26% more than the check and 8.6 ton/ha across locations and showed resistance to ear rot and foliar diseases. 10 hybrids yielded from 17 to 27% more than the checks.

25 tropical late yellow single cross hybrids were tested in several locations in Mexico, El Salvador, Guatemala, Colombia and India. Single cross hybrid CML287 x CML451 topped the trial with yield of 7.0 t/ha. This hybrid outyielded Pioneer 3041 (45% more yield than P.3041) at Colombia, showing resistance to ear rot, root lodging and corn stunt, while Pioneer check showed susceptibility to ear rot.

65 tropical late white three-way cross hybrids were tested in seven locations: Cotaxtla, Veracruz, and Agua Fria, Puebla, Mexico, Las Vegas, Guatemala, Turipana, Colombia, and Comayagua, Honduras. 7 TWC hybrids yielded up to 9.0 ton/ha across locations and ranked in the best 10% at individual locations and demonstrated resistance to ear rot and standability. The check yielded 7 ton/ha, 7 hybrids performing superior to checks with 17 to 35% more yield.

Head to head analysis in the hybrid CL-04368 x CL-SPLW04 and CML442 x CML444 applied in experiments planted in 40 locations during 2000 to 2002, demonstrated the yield stability of the new hybrid under stressed and non-stressed environments with an average yield of 9.1 ton/ha while the RE check yielded 6 ton/ha or 50% less yield across 40 locations.

Head-to-head analysis between CL-04368 x CL-SPLW04 and CML442 x CML444

	Yield (t/ha)	% ER	MF	FF	PH (cm)	EH (cm)	% Mo	PA	EA	% RL	% SL	% BH
CL-04368 x CL-SPLW04	9.130	4.2	53.4	52.5	244	135	18.6	3.0	2.4	13.9	4.4	8.0
CML442 x CML444	6.062	12.4	53.1	53.5	240	134	19.3	3.3	3.3	12.1	8.4	3.1
Data points	40	38	37	39	39	39	40	33	38	36	38	34
T test prob.	0.000	0.000	0.237	0.002	0.064	0.325	0.115	0.001	0.000	0.424	0.052	0.007

40 tropical yellow late three-way cross hybrids were tested in twelve locations in Mexico, Panama, Paraguay, Colombia, India and Guatemala. 11 new yellow TWC hybrids outyielded the seed industry checks across locations (23 to 30% more yield) significant statistically to the best seed industry checks. TWC hybrid (CML451xCL-SW002)CL-RCY017 yielded up to 13.0 ton/ha at Honduras and first across locations with 7.5 ton/ha. The hybrid check showed poor roots and susceptibility to ear rot and foliar diseases. The resistance to ear rot and foliar diseases will help to increase maize productivity in developing countries in Asia and Latin America where superior hybrids will be tested.

2002 marked the initiation of the second phase of the QPM project funded by Nippon Foundation and six years of continuous progress in QPM germplasm development, variety testing and promotion in the developing world. CIMMYT's international maize testing unit shipped 80 QPM trials—including 25 white and yellow hybrids—that were grown at tropical, midaltitude, and subtropical sites in Latin America, Asia and Africa. Preliminary, special selection trials were grown at 18 locations in the tropics; 700 new hybrids were tested in the tropics. The evaluation of 736 new QPM cultivars in the developing world will provide excellent information for promoting new cultivars in countries where QPM hybrids have been released. The impact of this project is remarkable because in the past five years 18 countries have released QPM hybrids.

The "quality protein maize" (QPM)—has recently captured attention in the developing world for its potential to improve the nutrition and livelihoods of the poor who grow and consume maize, and for the outstanding yields of newer QPM hybrids.

Cross elite QPM lines or elite QPM with elite normal lines that complement each other for different traits, selecting donors carefully. The pedigree breeding is the main method used for development of new QPM lines currently in lowland tropical subprogram. More than 8,000 rows with QPM material were grown in year 2002.

Lowland tropics is well known as very stressful environment, with many biotic and abiotic constrains. Knowing those stresses and incorporation of resistance for the most important constrains could greatly improved yield and dependability of QPM materials for certain areas. In tropical lowland program we started incorporation of stress resistance materials into QPM germplasm. Opposite heterotic group synthetics were formed in 2002 and in 2003 we will start development of inbred lines from these synthetics.

In 2002 we continued conversion of seven elite normal lines. Once converted lines will be used as parents for hybrid formation, in synthetic formation, and for the special study to see differences between QPM hybrids and analogues normal hybrids.

Several new synthetics were formed in 2002. Also, we increased seed once, which had good yield in previous evaluations. Special study has been started with idea to compare synthetics developed using the new way (intermating the best hybrids) with the currently used method for synthetic formation (intermating the best lines).

More than 700 new hybrids and synthetics had been tested in QPM yield trials in 2002. Results are described in this report. Generally, we can say that very good results were obtained. The new QPM hybrids with outstanding yield and good other agronomic characteristics were identified. The new synthetics outyielded reference entries and had better agronomic characteristics. These hybrids and synthetics will be sent to the CIMMYT international trials and will be available to the NARS. Also, the protein quality of new developed inbred lines was very good going up to 0.140 % of tryptophan on the dry matter basis in whole kernel.

The elite hybrids grown in international trials performed better than the best local checks and should be utilized in national program as such or as donors of favorable alleles for local breeding programs.

In 2002 tropical lowland program developed database, the new method for estimation of inbred line breeding value, applied the new conversion breeding scheme, and proposed new QPM pedigree breeding scheme.

All these achievements suggest that 2002-year was very good for lowland tropical QPM breeding subprogram, besides some financial problems that we faced at the second part of the year.

Coordination activities

Central America: Salvador Castellanos and GP2 Coordinator traveled 2 weeks in El Salvador, Honduras, Guatemala, Nicaragua to support NARS activities and strategies in on-farm research and seed production technologies. A network of 200 strip test trials including 20 synthetics and OPV's resistant to different biotic and abiotic stresses and QPM was planted in hillsides where farmers do not use hybrids. All trials were prepared by the TLL subprogram. At this stage community base seed production systems will be applied to benefit small farmers that do not use improved varieties.

Mexico: INIFAP activities in QPM slowed down in 2002. 16 demonstration plots were conducted in the Bajío Subtropical Program by Ernesto Preciado and Arturo Terron. Demo plots were conducted in TLL Veracruz and Yucatan by Flavio Rodriguez, Mauro Sierra and Octavio Cano. Plots at both regions were conducted effectively. HC participated in field days providing support to INIFAP researchers.

Colombia: Carlos De Leon, Luis Narro and Hugo Cordova attended the release of QPM hybrid CORPOICA H-112 (CML161xCML165) with the presence of the President of Colombia in June 12, 2002.

Staff in the Tropical Lowland Subprogram

Hugo Cordova	Principal Scientist, Coordinator LLTM
Slobodan Trifunovic	Post Doc
Narciso Vergara	Post Doc
Antonio Ramírez	Maize Breeder, Ingeniero Agrónomo
GilbertoAvila	Maize Breeder, Ingeniero Agrónomo
Octavio Cano	Ingeniero Agrónomo, Cotaxtla
Esperanza Calderon	Secretary