## QPM: Maize that Means More Protein for the Poor

For twenty developing countries, maize is the single largest source of calories and a primary weaning food for babies, especially for the poor. Unfortunately, those who depend on maize as a mainstay, particularly women and children, are also prone to health problems from protein deficiencies. This is because only half the protein in maize is nutritionally useful, lacking in adequate levels of the two essential amino acids, lysine and tryptophan (Córdova 1998).

Quality protein maize (QPM) contains nearly twice the amounts of lysine and tryptophan as normal maize and represents an inexpensive, accessible protein source for the poor whose diets are based on maize. The recent interest in QPM in developing countries and among breeders and development organizations stems partly from the many experiments in which QPM hybrids developed at CIMMYT have produced yields equal or superior to those of normal maize hybrids. One subtropical QPM hybrid tested at Celaya, Guanajuato, Mexico, produced 10 Mg $ha^{-1}$ (fully 2 Mg $ha^{-1}$ more than the best normal, commercial checks). In multilocation trials, tropical QPM hybrids from CIMMYT outyielded normal maize hybrids by 10% and showed good levels of resistance to ear and stalk rots.

QPM also offers potential nutritional benefits to monogastric animals—especially pigs and poultry (Tolessa *et al.* 1999). Recent studies in El Salvador confirm results of past decades showing that swine fed QPM grow twice as quickly as those fed normal maize.

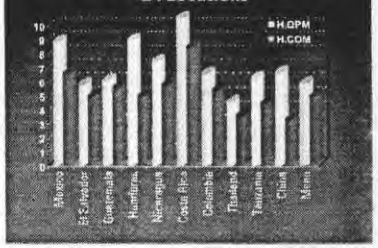
# Stability and Yield Performance of QPM Hybrids Tested at 35 Tropical Locations

H. Córdova and S. Pandey

## Materials and Methods

- 18 QPM genotypes—12 hybrids and 6 open pollinated varieties—and two normal maize commercial hybrids as checks.
- A 4 x 5 alpha lattice design was used.
- Trials were grown at 9 locations in Mexico, Central America, Colombia, and Thailand in 1997 and at 26 locations in Africa, Latin America, and Asia in 1998.
- Genotype x environment interaction and yield stability were estimated by means of the AMMI Model (Gauch 1990) for 12 genotypes common at 35 tropical locations (Table 1).

Fig. 1. White QPM Hybrids Mg $ha^{-1}$, 24 Locations




## Results and Discussion

In the 1998 trials, there were highly significant differences for yield and important agronomic traits (ear rot, root lodging, and foliar diseases) within and across locations (data not shown).

QPM single-cross hybrids CML144 x CML159 and CML142 x CML146 yielded an average 6.2 Mg $ha^{-1}$— 10% more than the best normal check—across 24 locations in Latin America, Asia, and Africa. These hybrids yielded 8.5 Mg $ha^{-1}$ in Honduras and Costa Rica (at this location the best hybrid yielded 10 Mg $ha^{-1}$). This is 90% more than the best commercial check. Finally, QPM hybrids outyielded the commercial checks at all individual location (Fig. 1).

Adoption of QPM cultivars in the past has been limited by their susceptibility to ear rot and foliar diseases. Recent CIMMYT breeding strategies for QPM hybrids have emphasized resistance to biotic and abiotic stresses. As a result, the new QPM hybrids in this study were more resistant to ear rot and rust than the commercial checks (Table 2; Fig. 2). Table 2 shows the performance of the top three, single-cross hybrids across trials, 1997-98. QPM hybrid CML144 x CML159 topped the list with an average yield of 6.0 Mg $ha^{-1}$ —600 kg per hectare more than the check—and showed more resistance to ear rot and rust and fewer uncovered tips (ears with exposed tips are more prone to damage from birds and storage pests). The three superior hybrids also had nearly twice the tryptophan (which is highly correlated with lysine) as the checks, and were as stable.

These encouraging results have revived the interest in QPM in developing countries. Releases of new QPM hybrids are taking place in 1999 in China, El Salvador, Guatemala and Mexico (photo).

Fig. 2. White QPM Hybrids Mg $ha^{-1}$ 24 Locations 1998

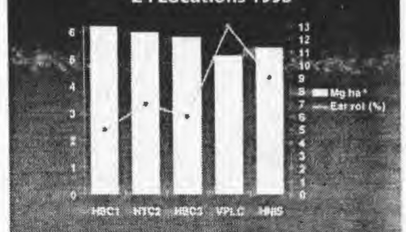



Table 1. Genotypes and trial locations in Latin America, Africa, and Asia, 1997, 1998.

| Genotypes (G) | Locations (S) | | |
|---|---|---|---|
| CML146 x CML150 | 1. Cuyuta, Guatemala | 13. Palmira 97, Colombia | 25. P.Rica 98(2)Mex. |
| CML156 x CML145 | 2. LMAQ, Guatemala | 14. Cali 97 Colombia | 26. Cotaxtla, Mex. |
| CML145 x CML146 | 3. Jut., Guatemala | 15. P. Rica 97 Mex. | 27. Tlal. (2) Mexico |
| CML145 x CML144 | 4. Vegas, Guatemala | 16. P. Rica 98 | 28. S. Farm 98, Thailand |
| CML158 x CML144 | 5. Zacapa, Guatemala | 17. Cali 99 | 29. Palmira 98, Colombia |
| CML159 x CML144 | 6. Sn Miguel, El Salvador | 18. Com. Honduras | 30. Cuyuta 98, Guatemala |
| P. Rica 8763 | 7. San Ray. El Salvador | 19. Mag. Costa Rica | 31. La Maquina 98, Guat. |
| Across 8763 | 8. Guaymayo, El Salvador | 20. INTA, Nicaragua | 32. Obregon, Mexico |
| S89TLWQ | 9. Sn Vicente, El Salvador | 21. Sn Andres, El Salvador | 33. Guanxi, China |
| Nyanpala 89763 | 10. Chalate, El Salvador | 22. S. Farm 97, Thailand | 34. Cholima, Tanzania |
| Across 8762 | 11. Hacienda, El Salvador | 23. Tlal. Mexico | 35. Yun., China |
| N. Check | 12. Lombardia, El Salvador | 24. Chiclayo, Peru | |

## AMMI Analysis

AMMI BI plots showed main (additive) and interaction (multiplicative) effects for genotypes (G) and environment (S)(Fig.3). PCA1 represent 33% and PCA2 18% of the total variation, explaining the 51% of the total variation for yield caused by the interaction captured in both PCAs.

Yield stability and information on specific and broad adaptation is important for the identification of superior cultivars (Gauch and Zobel, 1997). Divergence from the mean was larger for environments (locations), whereas Genotype tended to cluster more with the mean yield across locations. AMMI analysis helped identify stable genotypes and match QPM hybrids with suitable environments.

CML159 x CML144 (G6) and CML145 x CML144 (G4) expressed yield stability and ranked between first and fourth in Central America and Mexico in 1997 and 1998 (S1, S2, S3, S6, S13, S15, S16, S18, S19, S20, S21, S23, S25, S29, S30), Colombia (S13 and S29), Tanzania (S34) and China (S35) (F1 C3).

Table 2. Performance of superior white QPM hybrids across 35 locations. Latin America, Asia and Africa, 1997 – 1998

| Hybrid | Mg $ha^{-1}$ | E rot % | D silk | Rust (1–5) | Bh % | Tri % | HE 1–5 |
|---|---|---|---|---|---|---|---|
| CML159xCML144 | 6.02 | 5.3 | 58 | 1.3 | 4.2 | 0.10 | 2.2 |
| CML145xCML144 | 5.84 | 5.4 | 56 | 1.3 | 4.7 | 0.10 | 2.6 |
| CML158xCML144 | 5.65 | 6.8 | 56 | 1.4 | 3.7 | 0.11 | 2.0 |
| Check* | 5.54 | 7.9 | 56 | 2.6 | 9.8 | 0.05 | 2.3 |
| LSD 0.05 | 0.20 | 1.7 | 0.4 | 0.4 | 3.2 | ---- | ---- |
| CV (%) | 10.82 | 1.1 | 2.0 | 22.8 | 3.7 | ---- | ---- |

*The best normal hybrid check at each location.
Tri: Triptophan % in the whole kernel.
HE: Hard endosperm. Bh: Bad husk.

## Conclusions

- The new QPM hybrids have demonstrated yield potential and resistance to ear rots and foliar diseases superior to that of commercial, tropical hybrids of normal maize.
- QPM's high lysine and tryptophan contents can help remedy nutritional deficiencies from diets heavy in maize, especially among women and children. QPM hybrids can be also used effectively in the swine and poultry industry, reducing costs of feeding meals.
- QPM breeding materials lines and hybrids available at CIMMYT can help speed the development and promotion of this product in the private and public seed industry.

# CIMMYT

INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER

Lisboa 27, Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico.


## References


Córdova, H.S. 1998. The improvement and promotion of quality protein maize in selected development countries. Progress Report 1998. CIMMYT.

Gauch, H.G. 1990. MATMODEL Version 2.0: AMMI and related for two-way data matrices. Microcomputer Power, III Clover Lane, Ithaca, N.Y. 14850.

Gauch, H.G. and R.W.Zobel. 1997. Identifying mega-environments and targeting genotypes. Crop Sci. 37:311-325.

Tolessa, B., H.S. Córdova, S. Castellanos and G. Srinivasan. 1999. Combining ability and stability analysis of quality protein maize inbred lines and hybrids presented for publication in Maydica.


## Acknowledgments

The authors offer special thanks to Narciso Vergara, Antonio Ramirez, Gilberto Avila, Mexico, and Gregorio Alvarado, Colombia. We are grateful as well for valuable contributions from scientists of CIMMYT; INIFAP, Mexico; CAAS, China; the PRM, Central America; and the national maize research programs of Thailand, Tanzania, and Peru.

**Contact: h.cordova@cgiar.org.**

Figure 3. Additive and multiplicative effects for genotype and environment among QPM genotypes tested at 35 tropical locations