Potential of Quality Protein Maize for promoting nutritional security in Asia

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Abstract

After two decades of research and development, CIMMYT scientists in partnership with national program researchers developed what we today call Quality Protein Maize (QPM), combining the enhanced levels of two essential amino acids, lysine and tryptophane with high yield potential and better agronomics. During the 90s, CIMMYT released QPM inbred lines and tested several hybrid combinations. This paper discusses the results of such extensive testing of QPM white and yellow hybrids in Asia and the potential that it brings to the Asian maize farmers both in alleviating poverty and promoting better health, especially among women and children. QPM also offers tremendous advantage as animal feed especially for poultry and swine production and can reduce the cost of rations used. This is particularly important in Asia where a major portion of maize is used as animal feed. Results from four years (1999-2002) conducted over several sites in Asia are presented here. In every instance, we were able to identify high-yielding QPM hybrids that compared well with the most popular non-QPM commercial checks available in the market. Yield advantage in some cases was as high as 60% over the checks. Elite materials identified through this extensive testing have already been released by some national programs in Asia and seed production is under way.

Media summary

Three decades of research at CIMMYT has led to the development of Quality Protein Maize cultivars that possess high- yield and better quality that can lead to nutritional security among developing world poor.

Key Words

Zea mays, QPM, hybrids, opaque-2, lysine, tryptophane, stress tolerance

Introduction

Maize, is the third most important cereal in the world. Over 43 million ha of maize is grown in Asia producing 166 million tons with an average yield of 3.8 t/ha. (FAO, 2002). Asia consumes more than 62% of its maize production in the form of animal feed and the remaining for human consumption. Discovery of maize mutants in the mid-1960s containing the *opaque-2* gene (Mertz et al., 1964) which enhances levels of lysine and tryptophane in the endosperm protein, opened a new era in breeding for improvement of quality in maize. However these mutants also came with several undesirable traits such as, opaque and chalky grain texture, low grain yield, higher levels of ear rot, slow dry down and increased incidence of stored product pests. While most researchers in the developed world abandoned research on opaque-2 after a few years, CIMMYT scientists conducted two decades of work to incorporate modifier genes that remedied most drawbacks. Through an inter-disciplinary research involving breeders, biochemists and other disciplinary scientists, CIMMYT researchers slowly but steadily developed what we now call as QPM (Vasal, 1993). This special type of maize has exactly the same qualities as normal maize in grain texture, taste and colour but possess almost double the levels of lysine and tryptophane, high yield and tolerance to biotic and abiotic stresses. In 1993, 33 tropical and 22 subtropical QPM lines were released as CIMMYT Maize Lines (CMLs) and hybrids derived from these lines and next generation of lines have created excitement in the developing world (Cordova et al., 2000). CIMMYT and the national program partners working together tested these new QPM hybrids in their environments for release and adoption by farmers. The nutritive value of QPM both as human food, especially for women and children and as animal feed for pigs and poultry was widely demonstrated in many countries. Several QPM hybrids have

been released for cultivation in the developing world. From less than 4 countries that grew QPM in 1997, today more than 23 countries have released and are producing QPM in the developing world. In this paper, we will present results of testing of QPM hybrids in several countries in Asia during the period from 1999 to 2002 and discuss the future potential of QPM for promoting food and nutritional security and alleviating poverty in Asia.

Methods

Tropical QPM trials:

Two types of trials one for white and the other for yellow grain types were conducted during 1999, 2000, 2001, 2002. These trials were called CIMMYT Hybrid Trial Tropical White QPM (CHTTWQ) and CIMMYT Hybrid Trial Tropical Yellow QPM (CHTTYQ). These two trials were widely distributed around the world in countries in Asia. Latin America and Africa. However, only the results from Asia which are relevant to this paper are presented here. The number of hybrids tested in each trial varied from 16 to 25 which included two local check entries planted for comparison. The trials were planted in three replications and managed by the national program collaborators. Results from 24 sets of CHTTWQ and 22 sets of CHTTYQ conducted over the four year period (1999-2002) are summarized highlighting the performance of the best entry over the local check. The trials were conducted in India, Bangladesh, Nepal, Philippines, Indonesia, Vietnam and China.

Subtropical QPM trial

Two subtropical hybrid trials, viz. CIMMYT Hybrid Trial Subtropical White QPM (CHTSWQ) and CIMMYT Hybrid Trial Subtropical Yellow QPM (CHTSYQ) were evaluated during 1999 to 2001 and the results from three years of evaluation from 20 locations are summarized. It should be noted that although the trials were grouped as tropical and subtropical to target specific ecologies for testing, several of the hybrids included in these trials were combinations of tropical and subtropical QPM germplasm which provides potential for exploiting heterosis between these two classes of germplasm. Large scale on-farm testing of promising hybrids leading to the release of some of them was conducted.

Results

Salient findings from the tropical and subtropical QPM trials evaluated over four years in multi-location trials in Asia are presented in Table 1 and 2 respectively. Both in white and yellow QPM, there were several promising hybrids that yielded on par or better than the best commercial check hybrid, thus ensuring that the farmer does not need to pay a yield penalty by growing QPM.

CML 161 x CML 165, a yellow QPM hybrid for example ahs been released in Vietnam as HQ 2000 and is now in large scale production of over 20000 ha. The same hybrid was tested in Bangladesh and India and was found to do very well and these countries are planning their release. It should be noted that this hybrid combination shows broad adaptation and has been released in several countries in Latin America as well.

Table 1. Grain yield (t/ha) of promising tropical QPM hybrids in trials conducted in Asia during 1999-2001.

Hybrid code	Pedigree	Year of testing	Grain yield (t/ha)	% over local check
Tropical white QPM hybrids				

CMSQ 983011	CML146 x CML142	1999	5.3	115
CMSQ 983013	CML141 x CML144	1999	5.3	115
CMSQ 983037	CML142 x CML144	2000	7.0	122
CMSQ 993021	CML176 x CLQ6310	2000	6.9	122
CMSQ 993001	CML144 x CML176	2000	6.8	120
CMSQ 993029	CML141 x CML142	2001	6.1	104
CMSQ 003031	CLQ6203 x CML147	2002	5.8	143
CMSQ 003027	CLQ6203 x CLQ-RCWQ50	2002	5.6	140

Tropical yellow QPM hybrids

CMSQ 993002	CLQ-G2508 x CML161	2000	6.9	111
CMSQ 983018	CML161 x CML165	2000	6.9	111
CMSQ 983022	CML161 x CML164	2000	6.6	107
CMSQ 993004	CML163 x CML161	2001	6.2	109
CMSQ 993016	(CML172 x CLQ6601) x CML161	2001	6.0	106

CMSQ 993002	CML161 x CML172	2002	7.7	116
CMSQ 003004	CML161 x CLQ6603	2002	7.7	116
CMSQ 993014	CML161 x CLQ-RCYQ11	2002	7.1	108

Table 2. Grain yield (t/ha) of promising subtropical QPM hybrids in trials conducted in Asia during 1999-2001.

Pedigree	Year of testing	Grain yield (t/ha)	% over local check
Subtropical white QPM hybrids			
CML176 x CML142	1999	5.2	168
(CML186 x CML142) x CML176	1999	4.4	142
CML175 x CML176	1999	4.4	142
(CML142 x CML150) x CML176	1999	4.1	132
CML176 x RCWQ-A8363S5	2000	7.2	181
P68HC179-S8 c CML176	2000	6.4	161
(CML142 x CML150) x CML176	2001	7.0	112
(CMl176 x CML186) x CML142	2002	5.1	128
Subtropical yellow QPM hybrids			
CML193 x P69C6HC13-S7	2000	6.4	111
(G25Q/Mo17 o2/o2)-S6 x CML193	2000	6.2	107
(CML161 x CML170) x (G25Q/Mo17 o2/o2_-S6	2000	6.6	107

(G25Q/Mo17 o2/o2)-S8 x CML193	2001	5.8	118
(G34Qc25MH103-S6 x G34Qc22MH135-S8) x CML161	2001	5.4	110

In the case of white QPM, China has aggressively used some of the promising germplasm identified form these trials to cross with locally adapted QPM germplasm to release new QPM hybrids. In 2001, India released tow QPM white hybrids Shaktiman-1 (CML142 x CML150) x CML186 and Shaktiman-2 (CML176 x CML186) using tropical and subtropical combinations. Directorate of Maize Research scientists in Karnal, India released two new yellow QPM hybrids HQ-1 and HQ-2 in 2003 using CML 161 and CML 193. In 2004, Bangladesh and Nepal are expected to release a few QPM hybrids. Vietnam has identified a new hybrid combination HQ 2004 involving CML 193 which has shown yield superiority to HQ 2000. CIMMYT is aggressively intensifying its efforts in generating new sources of germplasm of QPM and elite lines through pedigree breeding and line conversion program.

Encouraged by the performance of QPM hybrids in Asia in the last four years, the national programs have accelerated their efforts to release, and promote QPM both for animal feed and for human consumption. CIMMYT is teaming up with private sector to advance seed production of the promising hybrids. Marker assisted selection has been initiated in Vietnam, China, Indonesia and India to convert some of their locally adapted germplasm to QPM. Feeding trials with poultry conducted in Vietnam show encouraging results.

Figure 1. Yellow QPM hybrid HQ 2000 (CML161 x CML165) in Vietnam

Figure 2. One of the promising subtropical white QPM hybrids in Asia.

Conclusion

CIMMYT working together with public and private sector partners in Asia conducted extensive testing of QPM hybrids in tropical and subtropical ecologies for both white and yellow grain types. Compared to normal commercial check hybrids these new QPM hybrids have done well in yield and other attributes and at the same time bringing in the added benefit of enhanced nutritive value because of higher lysine and tryptophane content. National programs in Asia have released promising new QPM hybrids for cultivation by farmers after extensive on-farm testing. The challenge is to produce quality seeds of the QPM hybrids in enough quantity to meet the growing demand. CIMMYT and national programs are working together with private sector towards this goal. It is evident that QPM has tremendous potential to provide food and nutritional security to resource-poor farmers in Asia and thereby help in reducing poverty.

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