I. SUMMARY AND CONCLUSIONS

World production of white maize is estimated to amount to about 65 to 70 million tons, relatively small compared to the annual output of around 500 million tons of yellow maize. However, white maize is almost exclusively grown for human consumption and is of paramount significance to nutrition and food security in a number of developing countries, especially in Africa. The volume of white maize traded internationally, estimated on average at 1.5-2.0 million tons per year, is dwarfed by shipments of yellow maize, which averaged some 60 million tons in recent years, mainly destined for use as animal feed. Market prices are usually slightly higher for white maize compared to the yellow type, although price margins can vary substantially depending on the overall supply and demand situation.

The primary policy objective for almost all white maize producing countries is to satisfy national requirements from domestic production. Exports in most cases are a result of excess production in years of favourable weather and of domestic stocks exceeding levels deemed necessary for food security purposes. In order to maintain a high degree of self-sufficiency, many potential exporting countries applied policies aimed at keeping minimum producer prices relatively high, which compromised their competitive position on the international market. In addition, white maize from southern and eastern Africa, the principal producing and consuming areas, face long distances between major production areas and ocean ports which contribute to high transport costs in many cases. As a result, when surpluses did occur, they could only be exported in years of high prices without incurring losses. This situation has resulted in several countries being competitive only in swap arrangements or triangular transactions for deliveries to neighbouring countries.

Recent efforts to deregulate national cereal sectors and to enhance market liberalization may have significant effects on the future supply and demand situation for white maize. White maize production in developing countries is expected to grow at a rate of 3.3 percent per annum between 1987-89 and 2000, but these rates of growth depend upon continued expansion of production in sub-Saharan Africa. In some countries in the region where area growth is no longer a major component of expanding production, it is unclear if yield increases will be forthcoming to sustain these relatively high predicted growth rates in production.

The international market, being primarily supplied by southern Africa and the United States, is expected to continue to be volatile in the future. Supplies will depend on the export availabilities of a few producers and most countries will continue to import only in years of inadequate domestic supplies occasioned by crop shortfalls.

In maize research for developing countries, improvement of white-grained varieties and hybrids has been greater than in developed countries, where nearly all plant breeding research has focused on yellow maize. Nonetheless, in many countries where white maize is important, adoption of improved material has been slow and limited. One of the major constraints is the development of seed systems that adequately serve small farmers. Crop management research that solves the

problems of soil fertility and unpredictable rainfall will also be crucial to continued growth in white maize production. Particularly in sub-Saharan Africa, policy changes as well as institutional and technical advances are required if white maize is to continue to meet the food needs of a rapidly growing population.

II. INTRODUCTION

For perhaps more than 400 million people world-wide, primarily in sub-Saharan Africa and Central America[1] , white maize plays a major role in the diet. Maize was domesticated in Central America some 6 000 to 10 000 years ago. It spread to the rest of the world in the 16th through 18th centuries, including sub-Saharan Africa, but white maize only became a major staple in eastern and southern Africa between the 1920s and the 1930s.

[1] For the purposes of this report, "Central America" includes Mexico.

The bulk of maize grown worldwide is yellow, and three times as much maize is used for livestock feed as for direct human consumption. In parts of the developing world, demand for maize for livestock is increasing rapidly. Nonetheless, maize remains an important part of the human diet in many developing countries and, where it is grown, white maize tends to assume much greater importance than yellow varieties.

This paper outlines and analyzes the current structure of the world white maize economy, with emphasis on production, utilization, trade and technology development. The paper also contains production projections to the year 2000 and discusses some of the major constraints to expanding white maize production to meet the potential growth in demand.

Sections III, IV, and V discuss production, utilization and international trade, respectively. Sections VI and VII analyze features of price policies that affect the production and trade of white maize. Section VIII discusses some of the major issues in technology development for increasing the productivity of resources devoted to white maize production. Section IX presents the medium-term outlook for white maize supply, demand and trade, and Section X notes some of the pressing problems that need to be solved if supply is to meet the projected growth.

The scarcity of appropriate statistics and basic information proved a major problem in the preparation of this paper, a situation which has not improved in recent years. Only a few countries publish separate data for white and yellow maize production, trade and consumption. For many countries, therefore rough estimates had to be made, of the share of white maize in total national maize production to assess world output. Even cruder estimates of area planted in major regions have been made here[2]. These area estimates are in general based upon expert opinion and not on statistical sampling procedures. In addition, little is known about imports of maize by variety or prices paid in international trade. As a result of the paucity of data, the analysis had to be confined to broad developments and issues and, thus the conclusions should be treated with some caution.

[2] These estimates are based on CIMMYT's mega-environment database and Dowswell, Paliwal and Cantrell (1996).

III. PRODUCTION

White maize is biologically and genetically very similar to yellow maize, although there is a difference in appearance due to the absence of carotin oil pigments in the kernel which otherwise cause the yellow colour of the grain. Production conditions and cultivation methods are largely identical.

World production of white maize is currently estimated at around 65-70 million tons (Table 1), representing 12-13 percent of the annual world output of all maize. Over 90 percent of the white maize is produced in the developing countries, where it accounts for around one quarter of total maize output and just under two-fifths of the total maize area. However, white and yellow maize occupy approximately equal areas when maize grown in temperate zones is excluded (Table 2). In the developing world, a larger area is planted to white than to yellow maize in the tropical highland and sub-tropical/mid-altitude environments, and it occupies about 40 percent of the lowland tropical maize area.

Argentina, Brazil and China account for over 60 percent of total maize output in the developing world, China alone for 45 percent. When these countries are excluded from consideration, white maize constitutes over 60 percent of the maize area in developing countries, and just under 60 percent of total maize output in those countries.

TABLE 1 - White maize: estimated world production and share of white maize in total maize production

TABLE 2 - White maize: percentage of total maize area in the developing world, by environment and grain colour

Environment	Colour		TOTAL
	White	Yellow	
Lowland tropical	18	26	44
Sub-tropical/tropical mid-altitude	14	8	22
Tropical highland/transitional	6	1	7
Sub-total of above	38	35	73
Temperate	1	26	27
TOTAL	39	61	100

Source: CIMMYT mega-environment database; C.R. Dowswell, R.L. Paliwal and R.P. Cantrell, *Maize in the Third World,* Boulder, Colorado, Westview Press, 1996.

By contrast, white maize is a product of much lower importance for the developed world. In the United States, for example, by far the world's largest producer of maize, white maize cultivation accounts for less than one percent of the total domestic maize output, produced to a large extent under contract farming due to the relatively limited market.

Among the individual geographical regions of the developing countries, white maize production is of paramount importance in Africa. In this region, which produces about one-third of the global white maize crop, it represents about 90 percent of the total regional maize output. The main producers include Kenya, Malawi, Tanzania, Zambia and Zimbabwe, countries in which white maize represents between two-thirds and 90 percent of total cereals production. Other important producers of the region include Egypt, Ethiopia and Nigeria, where white maize constitutes from 15-35 percent of total cereals production. In these latter countries, white maize rivals in importance other cereals, such as wheat, rice, millet and sorghum.

Two other significant areas of white maize production are, firstly, Central America (excluding the Caribbean sub-region), where it represents about 90 percent of total maize output of the region, and, secondly, the northern part of South America (Colombia and Venezuela). Among the main producers in Asia (China, Indonesia and the Philippines), rice, wheat (only in the case of China) and yellow maize are considerably more important in their total cereal production than white maize. White maize tends, however, to be a main staple food in certain areas of these countries.

World production of white maize is estimated to have expanded at a rate of 2.4 percent per annum between 1979-81 and 1989-91 and global output has continued to grow further thereafter, albeit at a slower pace during the first half of the 1990s (Table 1). The rate of expansion in the production of white maize was somewhat below the expansion in production of all maize, white and yellow, in the developing world over the same period. In recent years, the patterns of output changed for white maize and have diverged somewhat in individual regions. While output increased in all developing regions, the rate of growth levelled off in Africa during the first half of the 1990s. When relating production to population growth, the picture becomes even more diverse. In many countries per caput production was already declining between 1979-81 and 1989-91 (Table 1), a development which accelerated since the end of the 1980s, especially in Africa south of the Sahara, where output did not keep pace with population growth.

As noted, lack of statistical records precludes the accurate estimation of the total area under white maize in the world and the subsequent calculation of average yields. Area figures (Table 3), therefore, which are based primarily on the opinions of maize breeders worldwide, should be treated with caution. They are noted only on a regional basis as this tends to smooth out discrepancies for some of the individual countries. Combined with the production data reported in Table 1, they allow rough estimates of regional white maize yields (Table 3). Despite their lack of precision, these data indicate wide variation in yields worldwide. In recent years, white maize yields ranged on a regional basis from 1 ton per hectare or less in Western and Central Africa through 1.2 tons per hectare in Eastern and Southern Africa, to 1.8 tons per hectare in Asia, and 2 tons per hectare or more in Central and South America. If the severe drought year of 1992 in Eastern and Southern Africa were excluded, average yields in that region over time would be about 1.3 or 1.4 tons per hectare.

Where official data on yields are available they also point to significant variations within and between countries, and between white and yellow maize in the same country. In Africa, average national yields for white maize in the main producing countries of the eastern and southern sub-regions are reported to range between 1.1 tons and 1.8 tons per hectare, although they have occasionally surpassed 2 tons per hectare in Zambia, Zimbabwe and Kenya. On the other hand, they are 0.5

tons per hectare or even lower in Angola and Mozambique. At the other extreme, the national average yield for Egypt, where all maize is irrigated, is 6 tons per hectare. In Mexico and Venezuela, average white maize yields have climbed in recent years to 2.4 tons per hectare, leaving all the other countries in Latin America behind. Among the developed countries, average yields in the United States range around 6 tons per hectare. In the Republic of South Africa, where a large portion of the maize is produced on large-scale commercial farms, average yields range from less than 2 tons to almost 3 tons per hectare, depending on weather conditions.

TABLE 3 - White maize: estimated area and yields by selected developing regions, and selected sub-regions, 1992-94 average

	Area	Yields
	(..... thousand hectares .....)	(..... tons per hectare .....)
Africa	15500	1.4
North Africa	800	6.1
Western Africa	3600	1.0
Central Africa	1 900	0.9
Eastern Africa	9000	1.2
Southern Africa	200	1.2
Central America	9000	2.1
South America	1300	2.3
Asia	6900	1.8
Total	32700	1.7

Source: Table 1 and CIMMYT mega-environment data files.

Among the major factors affecting yields are the production environment, production systems, seed varieties and other production inputs and financial outlays on research. All other things equal, yield potential appears to be higher in temperate environments than in tropical environments. As an example of differences in production systems, the average white maize yield in Zimbabwe on large-scale commercial farms averages over 4 tons per hectare, compared with around 1 ton per hectare in the small-scale commercial and subsistence sectors. Much of that difference is the result of differences in moisture regime and soil quality, but part would remain even if these latter factors were controlled.

In the majority of countries, open-pollinated varieties are still the most common type of seed used. They can easily be multiplied so that their seeds are cheap and readily available, and the farmer usually retains a certain portion of his harvest for future planting. In fact, 60 percent of the total maize area in the developing world, outside of Argentina, Brazil and China, is estimated to be still planted to "unimproved," local varieties. Although national and international breeding programmes have considerably increased the yields of open-pollinated varieties over the past, they remain below those of hybrids. Yields of hybrids, in fact, can exceed those of landraces (open-pollinated varieties) by 30-100 percent, with an average of perhaps 40-50 percent. When hybrids have replaced improved open-pollinated varieties, the yield advantage of hybrids has usually been no more than 15-25 percent. Whereas almost all of the white maize produced in developed countries is from hybrid seeds, there appears to be still considerable scope in the

developing countries to expand their usage (Table 4).

In some Latin American and African countries, yields of white maize are generally higher than those of yellow varieties as national plant genetic research and breeding programmes for white maize have received preference when research resources were allocated. By contrast, in many developed countries, where most of the research efforts have gone into the production of yellow maize, preferred as animal feed, yields of the white varieties remain generally below those of yellow maize. In the United States, for example, yields of white varieties are reportedly still some 10-15 percent below yields of yellow maize, compared with 15-20 percent a decade ago[3].

[3] In some parts of the United States (e.g. east-central Illinois), white maize hybrids may be approaching yield parity with yellow hybrids. Alternatively, there are some reports that in a traditional white maize economy, such as Zimbabwe, commercial farmers are obtaining higher yields with yellow maize than with white (M. Weber and T.S. Jayne, personal communication).

White maize is grown almost exclusively under rainfed conditions. Full irrigation is practically unknown with the major exception of Egypt. However, supplementary irrigation is applied in some cases to support the early growth of the crop. As many of the important white maize producing areas are located in regions susceptible to drought, dependence on rainfall has resulted in marked annual fluctuations of output. For example, production in Zimbabwe and in the Republic of South Africa fell sharply from 1.5 million and 3.8 million tons, respectively, in 1991 to 0.3 million and 1.3 million tons in 1992, it recovered, reaching 1.7 million tons and 4.4 million tons in 1993 and advancing further to 2.2 million and 6.1 million tons in 1994[4] (Table 1).

[4] For all maize, at any given yield level, country yields are more variable for African than for Latin American or Asian countries (see Byerlee and Heisey, 1997).

Fertilizer use on maize also varies widely among countries. In maize producing developing countries (excluding Argentina, Brazil and China), on average two-thirds to three-quarters of total maize area receives some fertilizer in Central and South America and in Asia. In sub-Saharan Africa, only a little over one-third of all maize area is fertilized. In Egypt, all maize is fertilized at high application rates[5].

[5] For information on fertilizer application rates on maize, see IFA/IFDC/FAO (1992); Martinez (1990); and Heisey and Mwangi (1996).

TABLE 4 - White maize: estimated area planted to hybrids as percentage of total maize area, selected countries, 1992

Country	Percent	Country	Percent	Country	Percent
Egypt	28	Kenya	74	Zambia	65
Benin	0	Rwanda	0	Guatemala	12
Ghana	0	Mozambique	4	Honduras	12
Nigeria	3	Tanzania	6	Mexico	29
Togo	1	Uganda	5	Nicaragua	3
Cameroon	5	Lesotho	80	Venezuela	95

Ethiopia	4	Zimbabwe	100	United States	100
Malawi	24	El Salvador	34	South Africa	94

Source: 1993/94 World Maize Facts and Trends. Maize Seed Industries, Revisited: Emerging Roles of the Public and Private Sectors, Selected Maize Statistics, CIMMYT, 1994, Mexico, DP.