STUDIES ON MAIZE IN BANGLADESH

Rezaul Karim

International Food Policy Research Institute
Bangladesh Food Policy Project

September 1992

ACKNOWLEDGEMENTS

IFPRI provided generous support and freedom of work to complete this study. Harold Rice and Anthony Drexler provided encouragement and advice. Discussions with Harold Rice of IFPRI, Anthony Drexler of CIDA, Ray Morton and M.H. Khan of USAID, Ray Diamond of IFDC, and Helalul Islam, Mujibullah, Abdul Matin, Salahuddin and Fazlul Haq of BARI provided useful insight into the subject. Anthony Drexler and Steven Haggblade provided invaluable comments and editorial help.

Sincere appreciation is due to Nasreen for carefully typing my messy handwriting.

R.K.

CONTENTS

I.	INTRODUCTION	1
	Background	
	The Report	
II.	PRESENT STATUS OF MAIZE PRODUCTION	3
	Organisations	
	Area, Production and Yield	
	Regional Distribution of Area and Production	
	Comparison of Maize Yield	
	Varieties Grown	
	Economics of Maize Production	
	Constraints	
III.	CONSUMPTION AND MARKETING OF MAIZE	10
	Consumption	
	Marketing	
	Price	
IV.	POTENTIAL DEMAND FOR MAIZE	14
V.	ADVANTAGES AND PROSPECTS OF MAIZE	15
	Adaptibility	
	Flexibility	
	Potential Yield	
	Nutritional Value	
	Fodder and Fuel	
	Poultry Feed	
	Starch	
	Maize Oil	
	Other Uses	
	Targetting	
	Land Availability	
VI.	SOME MEASURES FOR MAIZE PROMOTION	22

TABLES

Table	Title
1.	Organisations Involved in Maize Activities in Bangladesh
2.	List of Maize Studies Consulted
3.	Area, Production and Yield of Maize in Bangladesh
4.	Area Under Maize by Region
5.	Production of Maize by Region
6.	Comparison of Maize Yield with the Yield of Other Cereal Crops
7.	Costs and Returns of Maize in Bangladesh
8.	Costs and Returns of Selected Crops in Bangladesh
9.	International Prices and Price Projections of Major Foodgrains
10.	Demand for Maize
11.	Possible Association of Maize with Other Crops in Bangladesh
12.	Yield of Maize in Selected Countries and Bangladesh Research Stations
13.	Comparative Nutritive Value of Maize, Wheat and Rice
14.	Comparative Amino Acid Composition of Maize, Rice, Wheat and Sorghum
15.	Comparative Trace Minerals Composition of Maize, Rice, Wheat, and Sorghum
16.	List of Products Originating from Maize
17.	Availability of Suitable Land for Maize Cultivation in Bangladesh
18.	Possible Suitable Area for Maize Cultivation in Bangladesh

FIGURES

Figure	Title
1.	Multiple Uses of Maize
2.	Simplified Flow Sheet of the Maize Wet Milling Process and the Principal Products

I. INTRODUCTION

Background

Maize has been a known crop in Bangladesh for a long time. It was probably introduced in India by the Portuguese in the mid-16th century. But efforts to develop new maize varieties or to expand or popularize the use of maize as food grain or for industrial products began in the mid 1940s when the Imperial Councial of Agricultural Research imported maize germplasm from the United States and initiated research on development of hybrid maize varieties suitable for local conditions. However the work concentrated mainly on sweet corn and popcorn varieties and was soon discontinued. In 1960 the government of East Pakistan tried to popularize maize by ordering maize to be grown on every vacant piece of land. Then in early 1960s, the short high yielding wheat and rice varieties were introduced from CIMMYT and IRRI. Agricultural research and promotional efforts focused on these crops and maize was forgotten.

Research on maize was stimulated by the establishment of the Bangladesh Agricultural Reseach Institute in 1976 initially with a Ford Foundation grant. In the early 1980s under the BARI program several studies were conducted on agronomic and socio-economic aspects of maize production. Maize promotion received further momentum when USAID signed an agreement with the government of Bangladesh in 1987 under PL 480 title II in which it has been agreed to mount a campaign to introduce a new self-targetting grain, maize, into the country's public food distribution system. The unprecedented flood of 1987 and 1988 in Bangladesh provided additional opportunity to promote maize. USAID provided 250 mt of maize seed in 1987 and UNDP provided 50 mt of maize seed in 1988 for distribution to selected maize growers in the coutry under the country's post flood agricultural rehabilitation programme. In 1985 another development took place. Bangladesh government

constituted a task force for the development of maize research and cultivation in Bangladesh. The Department of Agricultural Extention then launched a maize production program in the 1987 kharif season as a result of the task force recommendations to produce maize in 1000 acres in 20 districts and demonstrate and train farmers in maize production. In 1988 the task force on maize developed the proposal for an integrated maize development project which led to the current efforts to expand maize cultivation in Bangladesh.

Maize is one of the oldest crop in the world. It is a major food in the Central and South African countries and in parts of India, Pakistan, Nepal, Thailand, China, Philippines, Japan and Turkey. In Bangladesh it is eater mainly as a snack and rarely known as an item of main meal. Maize is generally regarded as an inferior food and therefore food for the poor and food during famine in Bangladesh. It is therefore often argued that maize can be an important means for attaining increase in food consumption by the poor. That is, if maize is introduced in large quantities in the food market, at cheaper than rice and wheat price, poor people would be more attracted to buy it and the level of consumption of food and nutrients of the poor would increase. Thus maize can be an important means to attain food self sufficiency or to reduce food gap of the poor and the country. It has high potential to produce food, feed, fuel and industrial raw material. Given appropriate support it can emerge as the third most important crop after wheat. Should the crop occupy large areas in the marginal farmers' fields it can also become a major source of income and additional nutrition for the poor.

The Report

This report summarizes the existing literature on maize in Bangladesh. Where relevant supplementary data are collected from published sources or by interviewing professionals involved in maize to update the findings. The report is arranged by broad issues discussed in the literature. The report also identifies the existing gaps particularly in the research and promotional activities of maize and highlights the prospect of maize in the country. Finally, the report suggests some measures for effective maize promotion in the country.

II. PRESENT STATUS OF MAIZE PRODUCTION

Organisations

At present 14 organisations are involved in maize activities in Bangladesh. Table 1 mentions the organisations and their brief activities. Of the organisations, 7 belong to public sector and 7 belong to NGO sector. MOA and BRAC provide administrative and research coordination services. BRAC supplies inputs, DAM conducts price monitoring and DAE provides agricultural extension. CIMMYT, WI, FF and USAID provide advisory services, staff training, and technical and financial assistance. BARI and BAU conduct agro-socio-economic research and farmer training in the public sector and AST, MCC and IFDC perform the activities in the private and NGO sectors.

From the organisations 30 reports or parts of reports having contents on maize have been collected. The materials form the basis for presentation in this report. Table 2 provides a list of the reports consulted for this study.

Area, Production and Yield

Area, production and yield of maize has been studied by Mohammad (1985), Islam and Kaul (1986), Rahman and Ahmed (1987). Table 3 presents the data and some recent data from BBS sources.

According to BBS, present area under maize is 3067 ha, production is 2588 mt and yield per hectare is 931 kg. Maize is grown in both kharif (March-June) and rabi (November-February) seasons. In the northern and western districts it is grown mainly in the kharif season and in the central and eastern districts it is grown mainly in the rabi season. In the kharif season the crop competes with Aus rice. In the rabi season it competes with boro rice, wheat, pulse, oilseed, spice, potato, sweet potato, vegetable and other rabi crops. The area under maize declined slowly from 1967-68 to 1982-83 except for some minor annual variations. The area appeared too large in 1983-84 and started declining again. The large area in 1983-84 was not due to a real increase in the area planted to the crop but was due to a shift in the data collection procedure by BBS. BBS collects the area, production and yield data of minor crops such as maize using a subjective method, that is, by personal observation of the enumerators and by interview of some local farmers by the enumerators on the percentage change in the area, yield and production of the crops relative to the last year. In 1983-84, however, a full count census of agriculture was conducted by the government and BBS used the census figures on maize as the true figures. The data after 1983-84 were again collected using the subjective method but the estimates were related to the bench mark figures of 1983-84. the data indicates that the area and production of maize were substantially under reported before 1983-84. Corresponding to the area the production also shows a declining trend though the decline is not as pronounced as in area. The present production is 12% lower than the production in 1967-68. The trend in the yield is the most difficult to discern. The yield was 816 - 935 kg/ha in

1967-68 to 1977-78, 714 - 786 kg/ha in 1978-79 to 1983-84 and 869 - 948 kg/ha in 1984-85 to 1987-88. The present yield of 931 kg/ha is one of the highest observed in the 21 year study period.

Regional Distribution of Area and Production

Tables 4 and 5 present the regional distribution of area and production of maize. Maize is grown in 12 of the 23 agricultural districts in Bangladesh. However, its cultivation is mainly concentrated in two hilly districts, namely, Rangamati and Bandarban. The geographical distribution indicates that at present maize is a high land crop in the country. The low lying flood-prone districts of Comilla, Noakhali, Sylhet, Faridpur, Jamalpur, Kishoreganj, Tangail, Barisal and Khulna do not grow maize or grow only negligible quantities. Rangamati and Bandarban districts alone had 78-80% of the total maize area and produced 79-86% of the total maize production in 1983-84 to 1987-88. Other important maize producing districts are Rajshahi and Dhaka. The districts cultivated 3-10% of the total maize area and produced 2-10% of the total maize production during the period. Dinajpur was an important maize producing district in 1983-84 but its importance declined substantially in the subsequent years. In 1987-88 it cultivated 1% of the total area and produced 1% of the total production of maize in the country.

Comparison of Maize Yield

Table 6 shows a comparison of maize yield with the yield of other cereal crops. Maize yield is lower than the yields HYV rice, local T aman, local boro and HYV wheat. It compares favourably with the yield of local aus which is the closest competitor of maize. In nine out of forteen years studied the yield of maize was higher than the yield of aus paddy. In the other years the yield was 4-16% lower. Maize yield was lower than the yield of broadcast aman paddy. In most years it was 15-33% lower. Maize yield was

3-24% higher than the yield of local variety wheat from 1974-75 to 1978-79. But afterwards the yield of local variety wheat improved markedly and the maize yield was 4-24% lower.

The present maize yield does not however reflect the potential yield of maize in the country. This is because unlike rice and wheat maize is a minor crop in the country. Farmers grow traditional varieties and hardly apply any fertilizer and take minimum care to grow the crop. The comparison only gives an idea of how maize could perform if adequate support and care were provided for the crop in comparison to rice and wheat.

Varieties Grown

Bangladseh produces mostly yellow-coloured flint-type of maize. Presently five varieties of maize are grown. About 23% of the maize farmers grow the Sadaf variety, 13% grow Savar variety, 41% grow local varieties and 23% grow other varieties. A brief description of important varieties is:

Sadaf - This is a semi-flint type variety originating from Pakistan. It takes about 105 to 130 days to mature. It is yellow in colour and grows to a height of about 135 cm. Average research station yield is 5 mt/ha. This variety is resistant to all prevalent diseases.

DMR - The variety has originated in Thailand. It takes about 108 to 132 days to mature and grows to a height of 130 cm. It is resistant to downy mildew. It has shown an average yield of nearly 5 mt/ha in research statious.

Savar - This is a flint type variety also originated in Pakistan. It takes about 106 to 132 days to mature and grows to 130 cm. It is yellow in colour. Research studies reveals an average yield of over 5 mt/ha. This variety is considered resistant to prevalent

diseases and insects.

JC-2 - This is a local Bangladeshi variety taking from 105 to 132 days to mature. It is the semi-flient type and yellow in colour. Average yield is nearly 5 mt/ha at research trials. It is regarded as disease and insect resistant.

New varieties are being tested at research stations and new entries are being researched for their yield and purity. Two improved varieties, Alajuela 7725 and La Maquina 7827 have been recommended by BARI scientists. Limited work is also underway to develop shorter duration varieties for the Aus season.

Other varieties such as sweet corn and popcorn are also notable. In recent years, popcorn is gaining popularity in Bangladesh.

Economics of Maize Production

Maize is a profitable crop. Some cost and return data on maize is shown in Table 7. According to a field survey by RI the average cost of production of maize was 4309 tk/ha and net profit was 9386 tk/ha for cob output, 8000 tk/ha for 50% cob and 50% grain output and 6614 tk/ha for grain output in 1980. An AST survey in 1984 reported similar costs but 46% higher profit for cob output, and a BARI 1984 survey reported 60% higher cost and similar profit for winter maize, and a 35% higher cost and 30% lower profit for summer maize. BARI collected summer maize data from 78 households in Jessore and Ishurdi and collected winter maize data from 120 households in Savar and Narayangonj. BARI surveys did not include rent on land and interest on capital as costs but included imputed value of family labour and other family inputs valued at their current market price as costs. The AST survey did not mention which costs were included but labour costs in the AST survey appeared too low which implies that the survey might have omitted

family labor input costs. The table also shows the Caloric yield per hectare and cost per 1000 Calories for summer and winter maize. Estimated using an average of 112 gm. of grain per cob and 3.4 Cal. per gm. of grain the average Calorie yield per hectare of summer maize is 11.15 million Calories and per hectare of winter maize is 12.55 million Calories. The average cost per 1000 Calories is Tk. 0.53 for summer maize and Tk. 0.54 for winter maize.

Table 8 shows the costs and returns per hectare for wheat, kaon, broadcast local aus paddy, transplant local aman paddy, HYV aman paddy, HYV boro paddy, potato and sweet potato. The surveys were conducted by BARI in different years, different sample sizes and different locations shown at the bottom of the table. although the results are not strictly comparable with each other, a comparison of the table with table 7 gives some idea of the relative profitibility of maize and other crops. The data indicates high profitability of maize. Net return of winter maize is 0.15-3.9 times higher than the other crops except HYV aman in which case it is 20% lower. Net return of summer maize is 0.33-2.3 times higher than wheat, local T aman, HYV boro and sweet potato and 9-45% lower than broadcast local aus, potato and HYV aman. Table 8 also shows Calorie yield per hectare of the crops and costs per 1000 Calories of the crops. Calorie yield per hectare of maize is one of the highest and cost per 1000 Calories from maize is one of the lowest among the crops. The crops are ranked by Calorie yield per hectare and cost per 1000 Calories from the crop below. The data indicates that potato produces the highest Calorie per hectare but it is one of the most expensive crop by cost per 1000 Calorie. HYV aman produces the cheapest Calorie but it produces only a moderate amount of Calorie per hectare compared to the other crops. HYV boro, wheat, broadcast local aus, transplant local aman and kaon produce moderate to low Calorie per hectare and they are also some of the expensive crops by cost per 1000 Calories. Maize and sweet potato, on the other hand, produce about the highest

Ranking of Crops by Calorie Yield and Calorie Cost

Ranking by Calorie yield/ha		Ranking by cost/1000 Calories	
Crops	yield (mCal)	Crops	Cost (Tk.)
Potato	17.39	T aman HYV	0.49
Winter maize	12.55	Sweet potato	0.51
Sweet potato	11.93	Summer maize	0.53
Summer maize	11.15	Winter maize	0.54
Boro HYV	9.76	Kaon	0.74
T aman HYV	7.93	T aman local	0.77
Wheat	5.66	Wheat	0.80
B aus local	4.83	B aus local	0.91
T aman local	4.07	Potato	1.09
Kaon	2.38	Boro HYV	1.30

Source: Tables 7 and 8

Calorie per hectare and they are also about the cheapest by Calorie cost. Thus among the crops, maize and sweet potato seems to be the crops having potential self targetting value both by yield and affordability criteria.

Constraints

Cultivation of maize has several constraints which explain the limited growth of maize in the country. Preference of farmers for growing major traditional crops, ignorence of farmers about maize and a neglect of maize in government policies and programmes are the most important constraints restricting its development. There is little or no extension support for the crop. Farmers are

unaware of improved varieties and improved cultivation practices and potential of the crop. They grow traditional varieties as a gap crop or as a catch crop during the gap between the two major crop seasons and take minimum care to grow the crop. There has been little effort to promote the crop as a major food crop and its other uses have been given even less attention.

Research supports and supply of seeds and other inputs are also seriously lacking. Scientists at BARI have conducted preliminary research in the areas of varietal adaptability, responses to fertilizer, irrigation, intercroping, plant density, disease and pest infestation, cropping pattern and socioeconomic aspects of maize cultivation but more work needs to be done. Moreover, little effort has been given to harvesting, shelling, drying, transportation and storage aspects of maize. While credit availability has increased in recent years, credit to maize growers has been virtually nil. More systematic on station and on farm research and vigorous extension supports are needed to promote the crop at the farm level.

III. CONSUMPTION AND MARKETING OF MAIZE

Consumption and marketing of maize have been studied by Mohammad (1985), Islam and Kaul (1986), Kaul, Rahman and Ahmed (1987), Hughes (1990) and Drexler (1990).

Consumption

Maize is a food of choice to about 500000 Behari population concentrated mainly in Saidpur in the north western part of the country and in Dhaka. It is also a food of choice to about 550000 tribal population living in Bandarban, Chittagong Hill Tract, Chittagong, Jamalpur, Mymensingh and Tangail. Thus there is about 1% of the Bengladeshi population to whom maize is a known food.

They eat maize in the form of flour with or without mixing with wheat flour or in boiled form. When maize flour is mixed with wheat flour in the ratio of 1:3 the difference is usually unnoticed.

Maize is however a less known food to the remaining 99% of the population. They eat maize mainly as a snack. Green cob is the most preferred form of eating maize. According to an AST survey 74% of the country's maize is eaten as roasted cob, 13% is eaten as popcorn or fried grains, 8% is eaten as flour and 5% is consumed as other products such as starch, canned corn etc. Islam and Kaul (1986) lists a large number of recipes using maize. Some common forms or recipes in which maize is eaten in the country are:

a. Roasted or boiled green cob
b. Chapati or flat bread made of maize flour with or without mixing with wheat flour
c. Pitha or pancake made from maize flour
d. Maize grits cooked with rice, pulse and spices to make Khichuri
e. Maize grains fried on oil or making popcorn
f. Making firni or sweet pudding
g. Making satu, that is, roasted corn ground to flour with or without mixing with sugar, salt and chilli

Marketing

About 80% of the maize is harvested and consumed as green cob while 70% is sold in the market. So the present market for maize is primarily a market for green cob. The market is usually located in the urban and semiurban areas and in major rural centres The market is highly seasonal. It runs for about 100 days from mid December to early March and in May and June. In each location about 25 to 30 beparis (traders) purchase green cob maize direct from farm households or from local traders, and sell the cobs by sacks or by cobs to market vendors. The vendors in turn sell the

cobs either fresh or as roasted cobs in the retail market. The beparies may have access to credit from arathdars based in wholesale markets who specialize in green cob trade. The interest rate is 6.25% per loan period of 1 to 2 days. Some fresh green cobs are also sold by vegetable traders as fresh vegetable.

The following form of market structure for maize has been observed.

	Marketing Link	Approximate % distribution of product
1.	Producer - Consumer	25
2.	Producer - Retailer - Consumer	30
3.	Producer - Middleman - Retailer - Consumer	20
4.	Producer - Wholesaler - Retailer - Consumer	15
5.	Producer - Middleman - Wholesaler - Retailer - Consumer	10

Thus about 55% of the maize sold involves a more or less direct deal between producers and consumers. The remaining 35% sales involve two additional intermediaries and about 10% sales entails three intermediaries.

The market for maize is highly informal and underdeveloped primarily due to limited volume of trade, lack of storage and processing facilities and seasonality of trade. To give an idea of the current market size of maize, the current maize supply is less than 0.1% of rice supply and 1% of wheat supply. The insufficient sales volume of maize is unattractive for rice and wheat traders to have an active commercial interest in maize. However the maize marketing system exists in close proximity with the grain marketing system which has significant potential for expansion to handle increased volume of maize. As maize production develops, farmers, middlemen and marchants will change their perception of maize from regarding it as a snack to a major cereal. The cereal marketing system will then take ever the marketing of maize.

Price

There is no institutional mechanism to determine maize price. Price of maize is determined by forces of demand and supply in highly localized markets. Drexler (1990) reported that the average retail price of green cob at urban centres during the harvest season (January - February) in 1990 was 1.00-1.50 taka per cob. The farm gate price was 33 - 105 taka per 100 cobs average being 60 taka per 100 cobs. The average price at rural production certres was 0.75 taka per green cob reflecting what producers usually received if they sold directly to local markets. The difference between the farmgate and the retail price, ranging from 0.20 to 0.50 taka per cob represented transportation costs and seller's margin.

A recalculation of cost and return data in tables 7 and 8 shows that the average farmgate price of green cob was 0.41 taka per cob for summer maize and 0.45 taka per cob for winter maize in 1984 which supports Drexler's findings of 0.60 taka per cob in 1990. Recalculation of the data on the basis of average grain yield per cob and green cob price gives an average farmgate price of grain maize as 3.65 tk/kg for summe maize and 4.00 tk/kg for winter maize in 1984 which is comparable to the average farmgate price of wheat (3.70 tk/kg), transplant local aman rice (3.88 tk/kg), and HYV boro rice (3.91 tk/kg) but lower than broadcast local aus rice (5.36 tk/kg) and HYV aman rice (4.42 tk/kg). Green cob being a fancy food its price is generally high. This means that our estimate of grain maize price is on the higher side and the true price of grain maize would be lower. A lower cost of production of maize also supports this contention.

Since local price of grain maize is somewhat unreliable international price of maize and other foodgrains can throw some light on the relative price of maize compared to other foodgrain prices. Table 9 presents a comparison of international FOB price

and price projections of major foodgrains. Internationally, maize price is generally comparable to sorghum price but lower than rice and wheat prices. From 1980 to 1990 maize price was 49 - 73% lower than rice price and 18 - 45% lower than wheat price. When maize production develops similar price ratios are also likely to be maintained in Bangladesh.

IV. POTENTIAL DEMAND FOR MAIZE

Potential demand for maize has been studied by Mohammad (1985), Islam and Kaul (1986), Kaul, Rahman and Ahmed (1987), Hughes (1990) and Drexler (1990), but perhaps the most elaborate study on this has been conducted by Drexler. Since the market for maize is not yet developed the authors used interview method to estimate the demand. They divided the market into several segments and interviewed the major maize users in each segment to identify their present demand and additional quantities they were willing to buy if sufficient maize was available in the market. The demand in each segment was the projected demand for all the industries in the segment and the aggregate demand was the sum total of the demands of all the segments.

There are three sources of maize demand in the country, food, feed and industrial use. Table 10 shows three estimates of maize demand. Islam and Kaul estimated a low demand as 17000 mt and a high demand as 22000 mt annually. 68-71% of the demand was for industrial use, 23-25% of the demand was for feed and 6-7% of the demand was for food. Mohammad and Kennenberg estimated the demand as 498200-1522000 mt annually. 93-97% of the demand was for food, 1% of the demand was for feed and 3-6% of the demand was for industrial use. Drexler estimated the demand as 245400 mt annually. In this case, 40% of the demand was for food, 48% of the demand was for feed and 10% of the demand was for industrial use. According to Islam and Kaul 3400-4400 ha of land would be needed to meet the potential demand, according to Mohammad and Kennenberg 99640-304400

ha of land would be needed to meet the potential demand and accoding to Drexler 49080 ha land would be needed to meet the potential demand for maize assuming an average yield rate of 5 mt/ha.

The current demand for maize includes 86000 mt of demand for green cob and poultry feed which can be realized simply by increased production. Maize is recognised and accepted in these markets and an increase in production will directly result in increased sales. Approximately 95300 mt of current demand is for starch manufacture, snack food product, and for mixture of maize with wheat flour which are recognised as superior or more efficient but require some investment in or adaptation of processing systems. A third catagory of current demand is for approximately 535000 mt of grain equivalent of maize for cattle feed and cattle fodder which will require some education, motivation, and promotion in order to realize the demand potential.

Different varieties of maize will however be needed for different market segments. The demand for fresh green cob will likely be satisfied by a sweet corn variety, the poulty feed market will need a deep yellow variety, and flour mills will like a white variety. As the volume of potential demand is recognised, new varieties of maize should be introduced to exploit specific market segments after production begins to grow.

V. ADVANTAGES AND PROSPECTS OF MAIZE

Maize has many advantages and prospects which are detailed in Islam and Kaul (1986) and Kaul, Rahman and Ahmed (1987). Some of the advantages are specific to the crop, others are related to the conditions present in Bangladesh.

Adaptibility

Maize is a highly adaptible corp. It can be cultivated in a wide range of soil and climate. It can be grown throughout the year and can fit into a wide range of cropping patterns including inter and mixed crop conditions. Unlike rice, it does not require large quantities of water and unlike wheat it does not require a cold temperate spell. It can be grown equally well on fine sandy loam to heavy clay loam soil from moderately acidic (PH 5.0) to moderately alkaline (PH 8.5) soils. Since the worst areas of Bangladesh have mainly loam soils with a PH range from 5.5 to 7.0 maize can be grown throughout the country. The crop can withstand from draughty to high moisture condition (200mm to 5000 mm rainfall). Since rainfall pattern in Bangladesh is erratic, high in summer and negligible in winter, maize can be grown throughout the year. However in the summer when rainfall is high good drainage is neccessary since water stagnation may harm maize plants. Intercultural operation for maize are easier than in rice and wheat due to its tall and stout stature. Corn ear worm, shoot borer and leaf blight are common pests and diseases in maize fields but the infestation is not very serious. Post harvest operations such as shelling is difficult in maize. At present shelling is done by fingers, by beating the dry cobs with sticks, by treading under feet or by trampting by bullocks. Karue & Co has invented a manual maize sheller with a capacity of 40 kg grain per hour. Maize can be easily dried under the sun or by natural ventilation and stored as shelled grain, whole ear and unhusked cob in earthen pots, jute sacks, bags or in containers made of bamboo. For safe storage as shelled gain, drying of maize to less than 14% moisture content is necessary. Shelf life of maize is less than that of wheat or rice due to higher oil content. There are two methods of maize milling. Dry milling is done for food and feed and wet milling is done for industrial byproduct. Burr mill is used to turn maize grain into grits for human consumption and hammer mill is used to grind maize for livestock feed.

Flexibility

Maize can be grown all the year round and it has the advantage of maturity and use flexibility. The crop can be harvested as fodder within 50 days of planting, as green cob within 60-80 days of planting and as grain within 100-130 days of planting. For early maturing varieties the periods are shorter. So if it fails as a grain crop farmers still get reasonable return in the form of fodder and fuel and total crop failure is unlikely. The flexibility of maize also allows the crop to fit in a wide range of cropping pattern without affecting the other crops. For example if the gap between the two major crop seasons is 50 days maize will fit as fodder, if the gap is 60-70 days it will fit as green cob, and if the gap is 100-130 days it will fit as grain crop. Table 11 shows the possible combination of maize with other crops in the farming system of Bangladesh. Apart from these combinations maize can be grown as inter crop or mixed crop with pulse, oilseed, wheat and vegetable.

The flexibility of maize should be seen from the point of view of cropping intensity. As the possibility of expansion of arable land in Bangladesh is very limited, growth of agricultural production should be achieved through increased cropping intensity. Increasing cropping intensity demands development of crops of shorter field duration. The average field duration of kharif maize is 100 days which is less than kharif rice or jute. The average field duration of rabi maize is 130 days which compares favourably with wheat, tobacco, gram and mustard and is much less than cotton at 180 days.

Potential Yield

An important advantage of maize lies in its high biomass potential. Being a C4 crop maize is more efficient in converting solar energy to biomass than many other crop including rice and

wheat. It responds well to fertilizer and irrigation. But since it has longer and deeper root system it can exploit soil nutrients and moisture from a deeper soil profile which means that it can provide a modest crop under low levels of fertilizer and water and a very good crop under better input supply. Table 12 provides the yield of maize in selected countries and Bangladesh research stations. Yield of maize varies from 1.4 mt/ha to 4.1 mt/ha in the neighbouring countries. Field survey data indicate that maize yield varies from 1 mt/ha to 10 mt/ha in Bangladesh. An yield of 4.5-10 mt/ha is frequently observed in research stations. Mian (1984) summerizes some varietal trial data and some recent varietal trial data are summerized in BARI annual reports. Trial in farmers field received yield up to 14.5 mt/ha. At these rates maize yield is almost double the yield of rice and wheat obtained in the country.

Nutritional value

Maize kernels provide the major human food. It has high nutritional value. Tables 13 to 15 show a comparison of the nutritional value of maize with the nutritional value of other cereals. Maize has high energy, highly digestible carbohydrates and high protein content composed of essential amino acids. It is rich in vitamin B and trace minerals. Yellow maize contains provitamin A carotene which can prevent human blindness. Maize is richer than rice in protein, fat, minerals, carotene, thiamin and riboflavin. In 1964 some high protein high lysine maize varieties were developed in Purdue, USA, protein quality of which is comparable to milk. The varieties are particularly useful in child feeding and other programmes where high lysine content is required to overcome malnutrition. High protein Opaque 2 strains can be mixed with high carotene types for the specific purpose of utilizing in the vulnerable group feeding programme.

Fodder and Fuel

Maize provides a very good fodder for livestock and fuel for cooking. Maize can be used in cattle feed both as green fodder and as grain feed. Maize is preferred as green fooder over mashkalai (black gram), kheshari (lathyrus) and other fooder material. Utilization of maize is improved by making silage which breaks down the cellulose structure and increases the bioavailability of nutrients.

The fodder and fuel potential of maize is high. Maize stalks, leaves, husks etc produce 5-7 mt/ha depending on the growth of the crop which can be used as feed and fuel. An important byproduct of green cob and grain market is stover which is used as animal feed when dried. Typically fields of green cob and grain are over planted and later thined. The removed plants are used as fodder. The average silage yield is 0.8 mt/ha in Savar government dairy farm. Dried stovers are also used as fuel. On dry weight basis stovers have 75% of the energy of coal.

Poultry Feed

Approximately 60% by weight of poultry feed needs to be cereals and maize is regarded as superior to all other cereals as poultry feed. Yellow maize contains xanthophyll II which is responsible for the golden yellow colour of the egg yolk and the desirable pigmentation of the bird's skin. Yellow maize also contains provitamin A precursor carotene which is needed for normal growth of animals. So layers require maize for the desirable colour of the egg yolk and broilers require maize for rapid growth and attractive skin colour.

In 1983 - 84 Bangladesh had 77 million chickens and ducks of which 2.9 million were commercial in municipal areas. Assuming an average annual poultry growth rate of 5% and an average daily feed

requirement of 100 g per bird, the current feed requirement of commercial and urban poultry is estimated as 164000 mt or a maize requirement for the poultry feed as over 80000 mt annually. This ignores the maize requirement for the poultry feed of over 96% of the rural birds. Drexler (1990) estimated the maize requirement for the poultry feed in the country as realistic 64000 mt annually.

Starch

Maize is recognised as the cheapest and best raw material for starch production. Furhter, production of maize starch permits the simultaneous production of valuable other products such as corn oil, alcohol and high fructose corn syrup (HFC). Starch is used in textile mills, jute industries, jute carpet backing, paper mills, handloom industry, adhesives, match industry, pastes, pharmaceutical industry and many other manufacturing units. Bangladesh imports about 10000 mt of starch annually which costs about US$ 5 million. Substitution of this import by domestic production can save this valuable foreigh exchange.

Maize Oil

The germs of maize seeds is a rich source oil which is a popular edible oil all over the world. It contains 7-12% oil depending on the variety. The oil is obtained as a by product of the starch industry. The oil is colourless and flavourless and has cholesterol free polyunsaturated fatty acids which are useful for growth, pregnancy, lactation and for maintenance of normal skin and liver and kidney functions. The cholesterol free oil is useful to prevent heart disease.

Other Uses

Maize has many other uses. Its stalk, leaves, silk, cob, all have commercial value. Table 16 shows an inexhaustive list of

products originating from maize. Figure 1 lists some of the products of maize and figure 2 outlines the process involved in producing a myriad of products from maize. In fact maize has more varied uses than any other crop. Compared to rice and wheat it offers more opportunity in experimenting in cooking and food preparations.

Targetting

Perhaps one of the most important advantages of maize in Bangladesh is the potential self-targetting nature of the crop. In Bangladesh maize is socially regarded as an inferior food and therefore food for the poor. Although the idea will change as more and more maize is introduced in the market, but until that time it has an advantage. This is, any programme to introduce maize in likely to improve the consumption and benifit the poor more than the others. A study conducted by Karim, Majid and Levinson in this subject is revealing. They introduced sorghum, an inexpensive coarse grain, into a set of urban and rural ration shops in 1978. Given the low or negative income elasticity of demand for sorghum among the middle class, offtakes in the urban areas were low. However in the rural areas, offtakes were substantial, particularly among the lower income groups, reaching almost 70% in one of the two districts studied. The programme had considerable potential in improving the nutritional condition of the poor and, to a lesser extent, the distribution of income, but the authors observed that unless the larger rationing system is reoriented, this potential has little chance of being realized. A maize programme is therefore justified on grounds of equity and social justice.

Land Availability

Table 17 shows an estimate of land that can be brought under maize cultivation without affecting existing agricultural programmes. Table 18 gives a districtwise breakup of the area from

another source. The estimates are based on following assumptions. One-quarter of about 2 m ha of land that remain idle in the char areas of flood prone districts of Dhaka, Faridpur, Barisal, Noakhali, Mymenshing and Pabna can be brought under maize cultivation with no tillage. About 5 m ha of land remain current fallow in the winter, 15-20% of which can be brought under maize cultivation. Currently about 1.5 m ha are planted to Aus rice in the north western districts where Aus performs poorly due to insufficient rain, one-half of which can be brought under maize cultivation. The country has 1 m ha of fallow khas land in the forest districts of Chittagong, Chittagong Hill Tract, Sylhet, Mymenshing, Dhaka, Dinajpur and Rangpur which can be brought under maize cultivation. Moreover, a considerable area of fallow hill slopes can be brought under maize cultivation by slash and burn cutivation method or maize can be grown as an intercrop with several other crops there. Thus altogether 2.5-5.5 m ha or about 7 m ha according to the alternate estimate can potentially be brought under maize cultivation in the country. Mohammad and kennenberg considered the estimates as ambitions. They recognised these opportunities but concluded that 0.05-1.5 m ha can realistically be brought under maize cultivation in the next five to ten years.

VI. SOME MEASURES FOR MAIZE PROMOTION

Hughes (1990) has suggested an action plan for a regional approach to production and marketing of maize, and Kaul, Rahman and Ahmed (1987) has suggested some strategies for maize introduction in Bangladesh. It is recognised that government policies can be powerful tools to encourage production and consumptian of maize in the country. Successful introduction of maize will however depend on how effectively maize can be introduced in the dietary habit of the Bahgladeshi people. Fortunately there exists a substantial scope for introduction of maize in the country through the various outlets of the country's public foodgrain distribution system. At

a lower than wheat price maize will be acceptable to the consumers of the rural rationing system. In the initial stage 500000 Beharis, 550000 tribal people and 2.5 m rural landless and disadvantaged people now being served by the country's FFW and VGD programmes may be brought under maize supply. Maize can also be supplied in jails, orphanages, destitude homes, child care centres and perhaps to police, Ansars and rural teachers. The potential recepients under the above categories will be fairly large. In the second stage maize can be introduced to the urban consumers through open market sale and urban rationing system. Other possible consumers are bakeries, manufacturers of breakfast cereals and poultry farms. The following specific geographic areas are recommended for the introduction of maize as food in the first phase.

1. Dhaka metropolitan and Mymensingh - The target population would be the Behari camps to which maize may be supplied through ration shops and open market sale. Some quantities of maize may be given to onphanages, destitude homes and relief works.

2. Saidpur - Maize flour with or without mixing with wheat flour may be sold through ration shops.

3. Chittagong Hill Tract, Modhupur, Tangail and Jamalpur - Grits and cracked or whole grain maize may be supplied through ration shops and food for work programmes aimed at tribal population.

4. Nilphamari, Rangpur, Dinajpur, Thakurgaon, Kushtia and Jessore - A few major food for work programme areas may be selected for initial pilot studies of distribution of maize as wage good to the food for work labourers. In this case, substitution of one-fourth of wage wheat by maize may be attempted. Alternatively larger quantities of whole grain maize flour may be distributed in place of wheat.

For a maize introduction program to succeed, it should be accompanied by intensive promotional campaigns aimed at nutritional values of maize and its cooking methods and recipes. Consumers should be convinced that maize is not only a livestock feed or food of last resort but it is a nutritious food which can be eaten for lunch, dinner or as items of main meal by choice.

TABLES

2/ad

Table 1: Organisations Involved in Maize Activities in Bahgladesh

	Organisations	Activities
	Government	
1.	Ministry of Agriculture (MOA)	Administration
2.	Bangladesh Agricultural Research Council (BARC)	Research coordination
3.	Bangladesh Agricultural Research Institute (BARI)	Maize improvement and development
4.	Bangladesh Agricultural University (BAU)	Agronomic studies
5.	Bangladesh Agricultural Development Corporation (BADC)	Input supply
6.	Directorate of Agricultural Extension (DAE)	Agricultural extension
7.	Directorate of Agricultural Marketing (DAM)	Price monitoring
	Non-government	
1.	International Maize and Wheat Improvement Centre(CIMMYT)	Germplasm development and staff training
2.	Agricultural Sector Team of Canada (AST)	Socio-economic research
3.	Mennonite Central Committee (MCC)	Agronomic research
4.	Winrock International (WI)	Technical assistance
5.	Ford Foundation (FF)	Financial assistance
6.	US Agency for International Development (USAID)	Financial assistance
7.	International Fertilizer Development Corporation (IFDC)	Agronomic research, farmer training and marketing

Source 1. Islam and Kaul 1986.

2. Author's survey

Table 2 : List of Maize Studies Consulted

1.	Mohammad, A	Maize Development Its Prospects for Multiple Use in Bangladesh A Background Report	AST, Dhaka February 1985
2.	Kennenberg, LW	Supplementary Report to Maize Development Its Prospects for Multiple Use in Bangladesh - A Background Report	AST, Dhaka February 1985
3.	Mian, AL	Prospects and Problems of Maize Production in Bangladesh	AST, Dhaka November 1984
4.	USAID	Maize and Sorghum	USAID, Dhaka undated
5.	Drexler, AE	Maize Survey Report An Analysis of the Marketing of Maize Grown from Seed Provided as Disaster Assistance	USAID, Dhaka May 1989
6.	Drexler, AE	Progress of work on Monitoring and Evaluating the Maize Seed Distribution, Production and Marketing Programme	USAID, Dhaka January 1990
7.	Hughes, D	Action Plan for a Regional Approach to Maize Production and Marketing Promotion in Bangladesh	AST, Dhaka March 1990
8.	CIMMYT	Maize Facts and Trends	CIMMYT, Maxico 1990
9.	BARI	On-farm Research Division Annual Report 1986-87	BARI, Dhaka December 1990
10.	BARI	On-farm Research Division Annual Report 1985-86	BARI, Dhaka September 1990

11.	Hughes, D	A Regional Approach to Maize Production and Marketing Promotion in Bangladesh	AST, Dhaka February 1990
12.	BADC	Project Proforma of Integrated Maize Promotion Project under Crop Diversification Programme	BADC, Dhaka May 1990
13.	Drexler, AE	The Maize Seed Distribution, Production and Marketing Programme Monitoring and Evaluation Report	USAID, Dhaka July 1990
14.	Drexler, AE	Maize Demand Quantification Study	AST, Dhaka January 1990
15.	BARI	Annual Report 1986-87	BARI, Dhaka 1987
16.	Islam, TMT & Kaul, Ak	Prospects of Maize in Bangladesh	FAO/UNDP Dhaka 1986
17.	Kaul, AK Rahman, ML, & Ahmed, J	Bangladesh PL 480 Title III Maize Study	USAID, Dhaka September 1987
18.	Kaul, AK	CGPRT Crops Processing and Nutrition	CGPRT, Bagor 1987
19.	Kaul, AK Das, ML	Oilseeds in Bangladesh	AST, Dhaka 1986
20.	MCC	Annual Report	MCC, Dhaka 1982
21.	MCC	Annual Report	MCC, Dhaka 1985
22.	MCC	Annual Report	MCC, Dhaka 1987
23.	MCC	Annual Report	MCC, Dhaka 1987

24.	MCC	Annual Report	MCC, Dhaka 1990
25.	Hossain, M	Screening of Maize Varieties or Lines Against Leaf Blight Disease	Bangla-desh J of Agr 1987
26.	Hossain, MM & Sys, C	Climate, Soil Moisture and Temperature Regimes in Relation to Cropping Patterns of Bangladesh	ADAB News July-August, 1986
27.	ADAB News	An Wooden Hand-held Maize Sheller	ADAB News February 1979
28.	ADAB News	Maize Breeding Breakthrough Could Herald a New Green Revolution	ADAB News March-April 1990
29.	ADAB News	Plant, Soil and Water Maize	ADAB News January 1978
30.	Drexler, AE	Push-Sell and Dealer Discount Problems with Swan-II Maize	USAID, Dhaka January 1990
31.	BBS	Yearbook of Agricultural Statistics 1987-88	BBS, Dhaka July 1989

Table 3 : Area, Production and Yield of Maize in Bangladesh

Year	Area (ha)	Production (mt)	Yield (Kg/ha)
1967-68	3770	3262	865
1968-69	3367	3002	891
1969-70	3294	3080	935
1970-71	3313	3010	908
1971-72	2653	2285	861
1972-73	2720	2220	816
1973-74	2382	2724	874
1974-75	2656	2358	887
1975-76	2481	2239	902
1976-77	2398	2152	897
1977-78	2333	1961	840
1978-79	2005	1433	714
1979-80	2215	1742	786
1980-81	1925	1377	714
1981-82	1841	1343	729
1982-83	1588	1192	751
1983-84	4103	3118	760
1984-85	3772	3270	869
1985-86	3158	2920	925
1986-87	3102	2934	948
1987-88	3067	2855	931

Source : 1. Mohammad 1985

2. BBS 1985 & 1989

Table 4 : Area Under Maize by Region

Region	1983-84		1984-85		1985-86		1986-87		1987-88	
	ha	%	ha	%	ha	%	ha	%	ha	%
Bandarban HT	844	20.6	718	19.0	609	19.6	605	19.5	584	19.0
Chittagong	55	1.3	54	1.5	46	1.4	53	1.7	59	1.9
Rangamati HT	2366	57.7	2214	58.7	1901	61.2	1890	61.0	1867	61.5
Dhaka	113	2.7	226	6.0	187	6.0	186	6.0	127	4.2
Mymensingh	6	0.2	6	0.2	5	0.2	5	0.2	63	2.1
Jessore	37	0.9	17	0.5	16	0.5	17	0.5	19	0.6
Kushtia	26	0.6	12	0.3	9	0.3	2	0.1	13	0.4
Bogra	8	0.2	9	0.2	8	0.3	10	0.3	6	0.2
Dinajpur	136	3.4	81	2.1	42	1.3	44	1.4	43	1.4
Pabna	29	0.7	12	0.3	19	0.6	17	0.5	19	0.6
Rajshahi	413	10.1	365	9.7	241	7.8	255	8.2	233	7.6
Rangpur	67	1.6	54	1.5	24	0.8	18	0.6	14	0.5
Bangladesh	4104	100.0	3773	100.0	3107	100.0	3102	100.0	3067	100.0

Source : BBS 1989

Table 5 : Production of Maize by Region

Regoin	1983-84		1984-85		1985-86		1986-87		1987-88	
	mt	%	mt	%	mt	%	mt	%	mt	%
Bandarban HT	574	18.4	666	20.4	605	20.7	600	20.4	569	20.6
Chittagong	41	1.3	39	1.2	37	1.3	44	1.5	53	1.9
Rangamati HT	1905	61.1	2062	63.0	1875	64.2	1914	65.2	1870	65.5
Dhaka	54	1.7	105	3.2	100	3.4	103	3.5	73	2.6
Mymensingh	2	0.1	2	0.1	1	0.0	1	0.1	18	0.6
Jessore	21	0.7	13	0.4	19	0.7	23	0.8	38	1.4
Kushtia	7	0.2	7	0.2	5	0.2	1	0.1	12	0.4
Bogra	7	0.2	9	0.3	9	0.3	12	0.4	7	0.2
Dinajpur	114	3.8	62	1.9	35	1.2	39	1.3	40	1.4
Pabna	17	0.5	5	0.2	12	0.4	10	0.3	12	0.4
Rajshahi	322	10.3	257	7.8	206	7.1	175	6.0	134	4.7
Rangpur	54	1.7	43	1.3	16	0.5	12	0.4	9	0.3
Bangladesh	3118	100.0	3270	100.0	2920	100.0	2934	100.0	2855	100.0

Source: BBS 1989

Table 6 : Comparison of Maize Yield with the Yield of Other Cereal Crops

Year	Yield of maize kg/ha	Yield oflocal Aus kg/ha	Yield of HYV Aus kg/ha	Yield of B Aman kg/ha	Yield of Local T. Aman kg/ha	Yield of HYV aman kg/ha	Yield of Local Boro kg/ha	Yield of HYV Boro kg/ha	Yield of local wheat kg/ha	Yield of HYV wheat kg/ha
1974-75	887	747	2458	790	1098	2135	1236	2470	735	1409
1975-76	902	773	2430	979	1199	2171	1290	2542	723	1928
1976-77	897	766	2263	906	1215	2120	1120	2428	665	1936
1977-78	840	795	2298	1009	1277	2445	1409	2525	722	2030
1978-79	714	828	2274	990	1242	2360	1033	2299	694	1976
1979-80	786	751	2078	925	1175	2102	1283	2663	817	1927
1980-81	714	830	2189	952	1231	2244	1524	2665	788	1854
1981-82	729	827	2144	976	1126	1898	1548	2811	813	1816
1982-83	751	781	1950	997	1156	1995	1437	2816	933	2124
1983-84	760	826	1951	1035	1230	2045	1521	2675	944	2316
1984-85	869	777	1919	1004	1322	2196	1630	2746	955	2201
1985-86	925	807	1918	1051	1341	2198	1412	2688	1005	1960
1986-87	948	916	1785	999	1272	2125	1381	2703		1866*
1987-88	931	928	1794	914	1301	2112	1439	2655		1754*

Source: BBS 1985 & 1989

* Includes local variety wheat

Table 7 : Costs and Returns of Maize in Bangladesh

Items	BARI 1980 Tk/ha	AST 1984 Tk/ha	Units of Quantity	BARI 1984 Summer maize		BARI 1984 Winter maize	
				Quantity (per ha)	Value (Tk/ha)	Quantity (per ha)	Value (Tk/ha)
Labour	2687	944	Man days	167	2503	150	3865
Animal	670	499	Pair days	45	1409	32	963
Seed	74	153	kg	23	278	33	465
Manure	878*	1218*	mt	10	1038	-	-
Urea			kg	63	324	217	1085
TSP			kg	42	247	56	333
MP			kg	3	13	-	-
Others		1909	Tk		48		120
Total cash costs			Tk		1473		4008
Total all costs	4309	4723	Tk		5860		6831
Cob yield			no	29208	11979	32848	14782
Grain yield			mt	3.28		3.69	
By procuct yield			mt	5.30	424	13.30	1729
Edible Calorie yield			Mill. Cal	11.15		12.55	
Gross return			Tk				
Cob only	13695	20060	Tk		12403		16511
50% cob 50% grain	12309		Tk				
Grain only	10923		Tk				
Net return			Tk				
Cob only	9386	15337	Tk		6543		9680
50% cob 50% grain	8000		Tk				
Grain only	6614		Tk				
Cost per kg			Tk		1.79		1.85
Cost per 1000 Cal			Tk		0.53		0.54
Data year	1980	1984		1984		1984	
Sample size				78		120	
Survey location				Jessore Ishurdi		Savar Naryanganj	

* Includes fertilizer

Source: 1. Islam and Kaul 1986

2. Karim, MR and Elias, SM ed, "Economic Profitability of Major Crops in Bangladesh", Bangladesh Agricultural Research Institute, Joydebpur, 1986.

Assumptions: 1. Average grain yield per cob - 112 g
2. Edible portion of grain - 100 %
3. Calorie content of maize per 100 g edible portion - 3.4 Calories

Table 8: Costs and Returns of Selected Crops in Bangladesh

Items	Units	Wheat (per ha)	Kaon (per ha)	B Aus (TL) (per ha)	T Aman (TL) (per ha)	T Aman HYV (per ha)	Boro HYV (per ha)	Potato (per ha)	Sweet potato (per ha)
Labour	Tk	1462	1303	1856	2248	2225	5564	4086	2811
Animal	Tk	718	337	909	505	571	973	1518	605
Seed	Tk	704	24	911	275	377	291	6550	1316
Manure	Tk	270	55	355	-	74	253	1361	194
Urea	Tk	464	126	119	87	332	1006	1747	-
TSP	Tk	376	-	-	-	165	545	1419	-
MP	Tk	61	-	-	-	30	171	659	-
Irrigation	Tk	307	-	-	-	-	2285	575	-
Others	Tk	144	-	-	-	135	1106	1324	150
All cost	Tk	4526	1756	4381	3116	3913	12696	18969	6076
Dry yield*	mt	1.64	1.00	2.00	1.69	3.39	4.84	20.35	11.04
Edible yield**	mt	1.64	0.70	1.40	1.18	2.30	2.83	18.31	9.94
Edible Calorie yield	Mill Cal	5.66	2.38	4.82	4.07	7.93	9.76	17.39	11.93
Gross return									
Main product	Tk	6053	2037	10763	6546	14564	15781	27383	9359
By product	Tk	454	0	800	742	1352	1844	0	0
Total	Tk	6507	2037	11563	7288	15916	17625	27383	9359
Net return	Tk	1981	281	7182	4172	12003	4929	8414	3283
Price per kg dry yield	Tk	3.69	2.04	5.38	3.87	4.13	3.91	1.35	0.85
Cost per kg	Tk	2.76	1.76	2.19	1.84	1.19	3.14	0.93	0.55
Cost per 1000 Cal	Tk	0.80	0.74	0.91	0.77	0.49	1.30	1.09	0.51
Data year		1980-83	1982-83	1983-84	1983-84	1983-84	1984-85	1981-84	1981-83
Sample size		400	50	-	-	-	74	305	100
Survey location		Shailkupa Daudkandi Madhupur Thakurgaon	Lalmanirhat Thakurgaon				Jamalpur Joydebpur Chittagong	Dhaka Comilla	Jamalpur Kishorganj Barisal

* For rice it is unhusked grain yield
** For rice it is polished grain yield

Source: Karim, MR and Elias, SM ed, "Economic Profitability of Major Crops in Bangladesh", Bangladesh Agricultural Research Institute, Joydebpur,1986.

Assumptions: 1. Production of polished rice and kaon from unhusked grains - 70%
2. Edible portion of wheat, polished rice and polished kaon - 100%
3. Edible portion of potato and sweet potato - 90%
4. Calorie content per 100 g of edible portion:
Rice and wheat - 3.45 Cal
Kaon - 3.40 Cal
Potato - 0.95 Cal
Sweet potato - 1.20 Cal

Table 9 : International Prices and Price Projections of Major Foodgrains

Year	Rice (US $/mt)	Wheat (US $/mt)	Maize (US $/mt)	Sorghum (US $/mt)	Maize prices as % of	
					Rice price	Wheat price
1970	144	63	58	52	40.3	92.1
1980	434	191	125	129	28.8	65.4
1981	483	136	131	126	27.1	96.3
1982	293	167	109	109	37.2	65.3
1983	277	170	135	129	48.1	80.0
1984	252	165	135	119	54.0	82.4
1985	216	173	112	103	51.9	64.7
1986	211	161	89	93	41.7	54.7
1987	230	134	76	73	33.0	56.7
1988	301	180	107	99	35.5	59.4
1989	290	203	113	104	39.0	55.7
1990	252	178	98	94	38.9	55.1
1995	331	209	134	122	40.5	64.1
2000	406	277	179	166	44.1	64.6

Source: World Bank, "Price Prospects for Major Primary Commodities 1988 - 2000 Update", Washington D. C. 1990.

Table 10 : Demand for Maize

Sources of demand	Mohammad and Kennenberg 1985		Islam and Kaul 1986		Drexler 1990
	Minimum mt	Maximum mt	Minimum mt	Maximum mt	mt
Green Cob			800	1000	22000
Popcorn/Snack			100	200	6400
Flour & Grit			100	300	60000
Relief and Rehabilitation					14200
All Foods	464000	1472000	1000	1500	102600
Poultry			3000	4000	64000
Livestock			1000	1500	53500
All Feed	4200	10000	4000	5500	117500
Starch and Industrial Use	30000	40000	12000	15000	25300
All Maize	498200	1522000	17000	22000	245400
Land Needed (ha)	99640	304400	3400	4400	49080

Sources : 1. Mohammad 1985

2. LW Kennenberg 1985

3. Islam and Kaul 1986

4. Drexler 1990

Table 11 : Possible Association of Maize with Other Crops in Bangladesh

Target area	Crop combination
Flood-prone districts	1. Maize (grain) - Deepwater Aman
	2. Maize (Fodder/Green cob) - HYV Boro
	3. Maize (Fodder/Green Cob) - Spices
	4. Maize (Fodder) - Wheat
Winter fallow (medium high land)	1. Maize (Fodder) - Potato - T Aman
	2. Maize - Summer vegetables - T Aman
	3. Oilseeds - Maize - T Aman
	4. Maize - Jute
	5. Maize - HYV Boro
	6. Wheat - Maize
Winter fallow (medium low land)	1. Maize - Aus/Broadcast Aman
	2. Maize (Fodder/Green cob) - Boro
	3. Maize (green cob) & Pulses (intercrop) - Boro
	4. Maize (Fodder/Green cob) - Sweet Potato - Peanut
Substitute of Local Aus land	1. Pulses/Oilseeds - Maize - T Aman
	2. Maize - Sorghum/Millet - T Aman
Government khasland	1. Maize (Winter) - Maize (Summer)
	2. Maize - T Aman
	3. Pulses/Oilseeds - Maize - T Aman
	4. Wheat - Maize
	5. Potato - Maize
	6. Winter vegetables - Maize - T Aman
Hilly districts	1. Maize - Summer rice/Seseame
	2. Maize - Summer vegetables
	3. Winter vegetables - Maize

Source : Various published and unpublished reports

Table 12 : Yield of Maize in Selected Countries and Bangladesh Research Stations

Country/Research Station	Yield in kg/ha 1990
Bangladesh	833
Thailand	2145
Pakistan	1492
China	4142
India	1610
Indonesia	2127
Asia	3090
North America	6023
USA	7437
World	3682
BRRI	5000

Source : 1.FAO, "Production Yearbook 1990", Rome, Italy

2.BARI 1987

Table 13 : Comparative Nutritive Value of Maize, Wheat and Rice Food Composition per 100g of Edible Portion

Composition	Maize		Wheat flour whole	Rice milled
	Dry	Tender		
Energy (kcl)	342.0	125.0	341.0	346.0
Protein (g)	11.0	4.7	12.1	6.4
Fat (g)	3.6	0.9	1.7	0.4
Minerals (g)	1.5	0.8	2.7	0.7
Fibre (g)	2.7	1.9	1.9	0.2
Carbohydrates (g)	66.2	24.6	69.4	79.0
Calcium (mg)	10.0	9.0	48.0	9.0
Phosphorus (mg)	348.0	121.0	355.0	143.0
Iron (mg)	2.0	1.1	11.5	4.0
Carotine (mg)	90.0	32.0	29.0	-
Thiamine (mg)	0.4	0.1	0.5	0.2
Riboflavin (mg)	0.1	0.2	0.2	0.1
Niacin (mg)	1.8	0.6	4.3	3.8
Vitamin C (mg)	0.0	6.0	0.0	0.0
Moisture (g)	14.9	67.1	12.2	13.3

Source : Islam and Kaul 1986

Table 14 : Comparative Amino Acid Composition of Maize, Rice, Wheat and Sorghum

Amino acids*	Maize dry	Rice milled	Wheat whole	Sorghum
Total N	1.78	1.02	1.89	1.78
Arginine	0.29	0.64	0.29	0.29
Histidine	0.16	0.19	0.13	0.16
Lysine	0.20	0.22	0.17	0.20
Tryptophan	0.04	0.07	0.07	0.04
Phenylalanine	0.29	0.35	0.28	0.29
Tyrosine	0.24	0.30	0.18	0.24
Methionine	0.12	0.22	0.09	0.12
Cystine	0.10	0.10	0.14	0.10
Threonine	0.28	0.29	0.18	0.28
Leucine	0.72	0.56	0.41	0.72
Isoleucine	0.24	0.31	0.22	0.24
Valine	0.30	0.46	0.28	0.30

Source : Islam and Kaul 1986
*Only total N expressed as g/100g and the rest as g g^{-1} N

Table 15: Comparative Trace Minerals Composition of Maize, Rice, Wheat and Sorghum

Trace minerals (mg/100g)	Maize		Rice milled	Wheat whole	Sorghum
	Dry	Tender			
Magnesium	144.0	40.0	38.0	138.0	140.0
Sodium	15.9	51.7	10.0	17.1	7.3
Potassium	286.0	151.0	117.0	284.0	131.0
Copper	0.2	-	0.3	0.5	1.8
Sulphur	114.0	61.0	79.0	128.0	54.0
Chlorine	33.0	34.0	13.0	47.0	44.0

Source : Islam and Kaul 1986

Table 16: List of Products Originating from Maize

Paper and paper products parchment	Dyes	Plastics
Adhesives	Explosives: dynamites, fireworks, nitrated starch	Resins
Bakery products	Fish food	Core binders
Bakery ingredients	Food thickening agents; (Cream soup, Gravies, Chopsaucy, Chilli corn)	Moulded toys etc
Salad dressing	Insulating materials (wall boards etc.)	Additive to table salt
Dry batteries	Acids: Levulinic, Oxilic, Acetic, Latic, Citric, Glyconic, Amino.	Sausage filler
Canned food	Mustard preparation	Soaps & cleaners
Binder compounds	Oil well drilling	Stabilizing agents
Boiler compounds	Oil cloth	Textiles (warp sizing, finishing & printing)
Briquettes	Paints (cleaning compounds, cold water pastes, posters and siziling)	Acetaldehyde
Chewing gum	Paste for wall paper etc	Alcohol
Colour carrier in paper printing	Pharmaceutical: Binder, Extender in tablets, Nutrient medium for penicellin and for antitoxics for gas and gangrene etc	Protective colloides (emulsions)
Cones for ice cream		Rubber goods
Confectionery		Ring backing
Cosmetics: telcum & face powder, toothpaste & tooth powder		Floatation agents
Clarifying agents		Hair tonic
Coating on wood, metals and paper (ethyl starch)		Insecticides
Containers		Lacquers & moulded products
Dressing		Artificial leather
Surgical		Liniments & drugs
		Nitrocellulose

Denatured alcohol	viscocity reducer, blending agents)	Beverages
Antiseptics	Oil cutting	Candy glazes
Antifreeze	Pectin	Catsup & tomato sauce
Biological preparation	Photograaphic films	Cheese spreads
Brake fluid	Polish for shoes & floors	Citrus juice
Butadeine	Rayon	Chemical raw materials
Compasses	Rubbing compounds	Butyl acetate
Thermometers Spirit levels etc	Synthetic Rubber	B. Acetyle recinoleate
Chemicals	Laboratory use	B. ether, B. lactate, B. Stearate dibutyl Plithalate, di-B sebacale di-B Tartuate, tri-B citrate Tri-B phosphate, B. borate, B. Olitate, B. Ricinoleate, ditutoxymethane, di-B oxalate etc.
Dentifrices	Shellac solution	
Deodorants (body & nonbody)	Selvents (food & medicinal)	
Disinfectant	Serbitol	
Embalming fluids	Torpedo (Powder fuel for prepulsion)	
Ether		
Ethelene gas	Toilet preparation, scalp preparations, perfume materials, toilet soaps, shaving creams, etc	Esters and Satls
Gasohol (for motors)		Condensed milk
Vitamin preparation	Rust removers	Chemicals:
Aeroplane dopes	Solvents	Calcium lactate
Chemical agents (Solvents, detergents dehydrating agents, defrosters, penetrants	Insect sprays	Sodium lactate
	Synthetic flavours	Distriller Products
		Flavouring extracts

Dlectroplaing & galvanizing compounds	Plasticizing materials & standerdizing agents	purification, dewaxing, precipitant, dehydrating etc
Florists preparations	Emergency rations	Chemical raw materials, (diacetone, mesityle oxide, iodoform, chloroform amytacetate, denaturant for ethyl alcohol formulas 23-A & 23-H)
Foam stabilizer in fire fighting equipment	Sauces	
Finishes, synthetics	Soap dehydraulic	
Hydraulic break fluid	Vinegar	
Penetrating oils	Hot patches for lior repair	Enzymes
One floatation agents Leather tanning	Jam, jellies, marmaleds, pickles,	Vitamin C (via ascorbitor sorbose etc)
Paper coating and stencils	Licoroice	Syrup, cough syrup, medicinal, sodafountain, malt, fruits etc
Reagents	Lotions	
Frozen food, food products, cream, eggs, juice, etc.	Marshmallow	Binding agents for vegetable drying compounds
Fruits candies	Meat products	Corn flakes
Ice creams sherbets	Mayonnaise	Desserts
Infant & invalid feeding	Porridge	Doll heads
Intraveneous injection	Plywood manufacturing	Felts
Leather tanning	Pudding & custard	Food thickening agent
Meat curing	Beverages	Extraction of essential oils
Mincement Preparation	Carpet & rug sizing	Nail polish remover
Pectins	Cigarette sealing	Paint remover
	Crayons (chalk)	
	Ceramics	
	Antioxidants	
	Chemical Agents: for refining,	

Pyroxylin cements & plastics	Oil cloth	Sulphurized methyl esters of fatty acids & adjuncts to motor oil
Solvent: acetylene	Oil well drilling	
Aeroplane dopes	Paints (cloaning compounds, cold water pastes)	Canned maize
Ammunition		Ear corn
Carrying agent for vitamins	Plywoods	Pop corn
Cooking oils: Margerine & Oleomargerin	Soap & cleaners	Cork (granulated) substitute
Fritters	Straws	Cob-meal, for cleaniong furs, burnishing metal, removing oil from tins and metals, sweeping compound, removing carbon engines, light weight ceramics tile, etc
Hominy (boiled)	Tubes, spirals & convolute	
Fire works	Twine	
Flatation agents (Molybdenum)	Window shades	
Gums	Asbestos	
Glues	Esters & salt	Decolourizing solvent
Linoleum: cement & paste	Food preparation (cheese, jam, fruit essence, etc)	Filler for plastics
Matches (on head & box)	Fruit pectins	Furfural
Mucilages	Medicines	Pipe Bowls (smoking)
Caramel colour	Rust preventive (surface coating)	Corks
Fodder	Shortening	Doll making
	Tamale	Paints (sizing)

Source: MOA 1990

Table 17 : Availability of Suitable Land for Maize Cultivation in Bangladesh

Type	Available area (million hectares)	
	Minimum	Maximum
Flood-prone districts (October to January)	0.5	2.0
Cultivable fallow land in the winter	0.7	1.0
Substitute a half of local Aus rice area in northern Bangladesh	0.5	1.0
Government Khas land	0.5	1.0
Others (as inter or mixed crop and catch or gap crop)	0.1	0.5
TOTAL	2.3	5.5

Source : Islam and Kaul 1986

Table 18 : Possible Suitable Area for Maize Cultivation in Rabi and Kharif Seasons by Districts

Names of Districts	Possible suitable area in hectares		
	Rabi *	Kharif **	Total
Chittagong Division			
1. Bandarban	15726	18621	34347
2. Chittagong	0	0	0
3. Cox's bazar	0	0	0
4. Khagrachari	5802	7914	13716
5. Rangamati	4167	9186	13353
6. Brahmanbaria	187391	7410	194801
7. Chandpur	151258	6175	157433
8. Comilla	329278	6175	335453
9. Feni	62200	0	62200
10. Laksmipur	69192	11115	80307
11. Noakhali	61844	0	61844
12. Habiganj	40088	0	40088
13. Maulavibazar	0	0	0
14. Sunamganj	0	0	0
15. Sylhet	0	0	0
Sub-total (15)	926946	66596	993542
Dhaka Division			
16. Dhaka	31784	11115	42899
17. Gazipur	14170	29640	43810
18. Manikganj	36492	0	36492
19. Munshiganj	30354	0	30354
20. Narayanganj	36739	6768	43507
21. Narsingdi	53584	15334	68918
22. Faridpur	62061	0	62061
23. Rajbari	39048	0	39048

Names of Districts	Possible suitable area in hectares		
	Rabi *	Kharif **	Total
24. Gopalganj	40039	0	40039
25. Madaripur	28632	0	28632
26. Sariatpur	38144	0	38144
27. Jamalpur	237686	14119	251805
28. Sherpur	107769	15867	123636
29. Kishoreganj	80245	823	81068
30. Mymensingh	151117	222300	373417
31. Netrokona	46362	44707	91069
32. Tangail	253864	85541	339405
Sub-total (17)	1288090	446214	1734304
Khulna Division			
33. Barisal	18372	0	18372
34. Bhola	0	0	0
35. Jhalakati	27	0	27
36. Pirojpur	479	0	479
37. Jessore	67043	22230	89273
38. Jhenaidah	61073	29640	90713
39. Magura	22356	7030	29386
40. Narail	5728	2263	7991
41. Bagerhat	6838	0	16838
42. Khulna	24502	0	14502
43. Satkhira	53826	0	53826
44. Chuadanga	35763	21521	57284
45. Kushtia	18644	16534	35178
46. Meherpur	37581	11347	48928
47. Barguna	0	0	0
48. Patuakhali	0	0	0
Sub-total (16)	362232	110565	472797

Rajshahi Division			
Names of Districts	Possible suitable area in hectares		
	Rabi *	Kharif **	Total
49. Bogra	198632	15324	213956
50. Joypurhat	55941	8946	64887
51. Dinajpur	480311	74100	554411
52. Thakurgaon	363917	63232	427149
53. Panchagarh	291203	32463	323666
54. Pabna	85403	9880	95283
55. Serajganj	96718	7410	104128
56. Naogaon	189017	20886	209903
57. Natore	1759	2512	4271
58. Nawabganj	78714	19760	98474
59. Rajshahi	112968	26945	139913
60. Gaibandha	291764	7410	299174
61. Kurigram	224805	0	224805
62. Lalmonirhat	222503	19760	242263
63. Nilphamari	322046	26105	348151
64. Rangpur	353521	24700	378221
Sub-total (16)	3369222	359433	3728655
Grand-Total (64)	5946490	982808	6929298

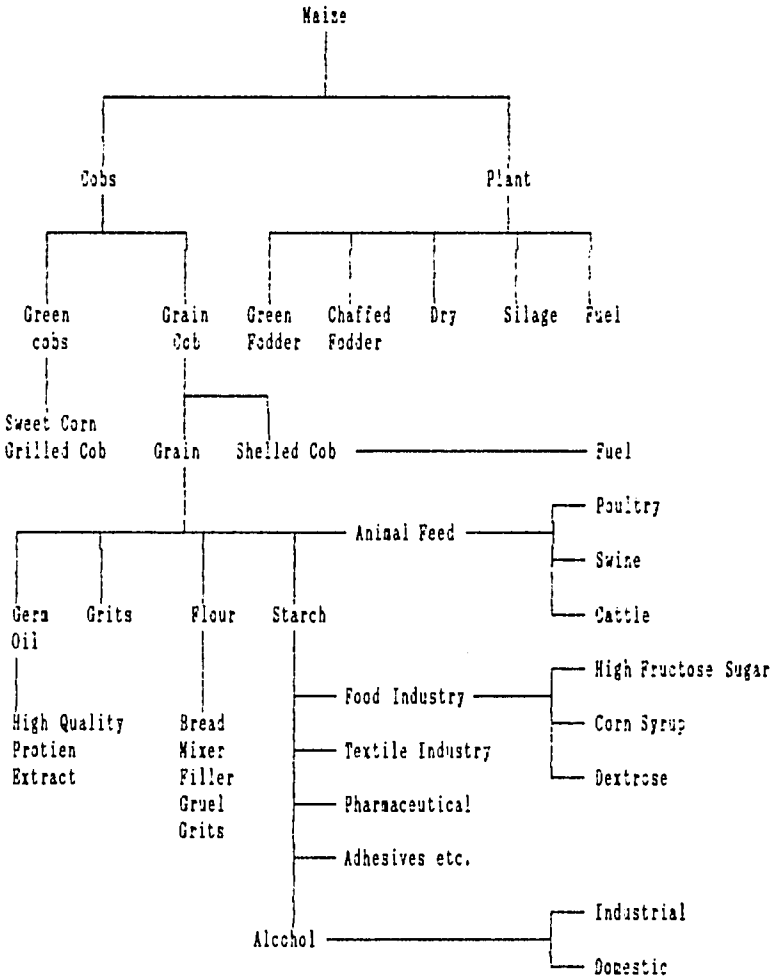
* The Rabi season potential area has been calculated on the basis of agroecological appraisal report data. The parameters considered for this projection are; inundation depth, permiability, moisture holding property, soil nutrient supply capacity, effective soil depth, salinity, soil reaction, agroclimatic data, land slope, flood hazards etc.

** The Kharif season potential area has been calculated on the basis of land phase, soil texture, internal profile drainage condition and rainfall distribution.

Source : Bangladesh Agricultural Research Council (BARC)

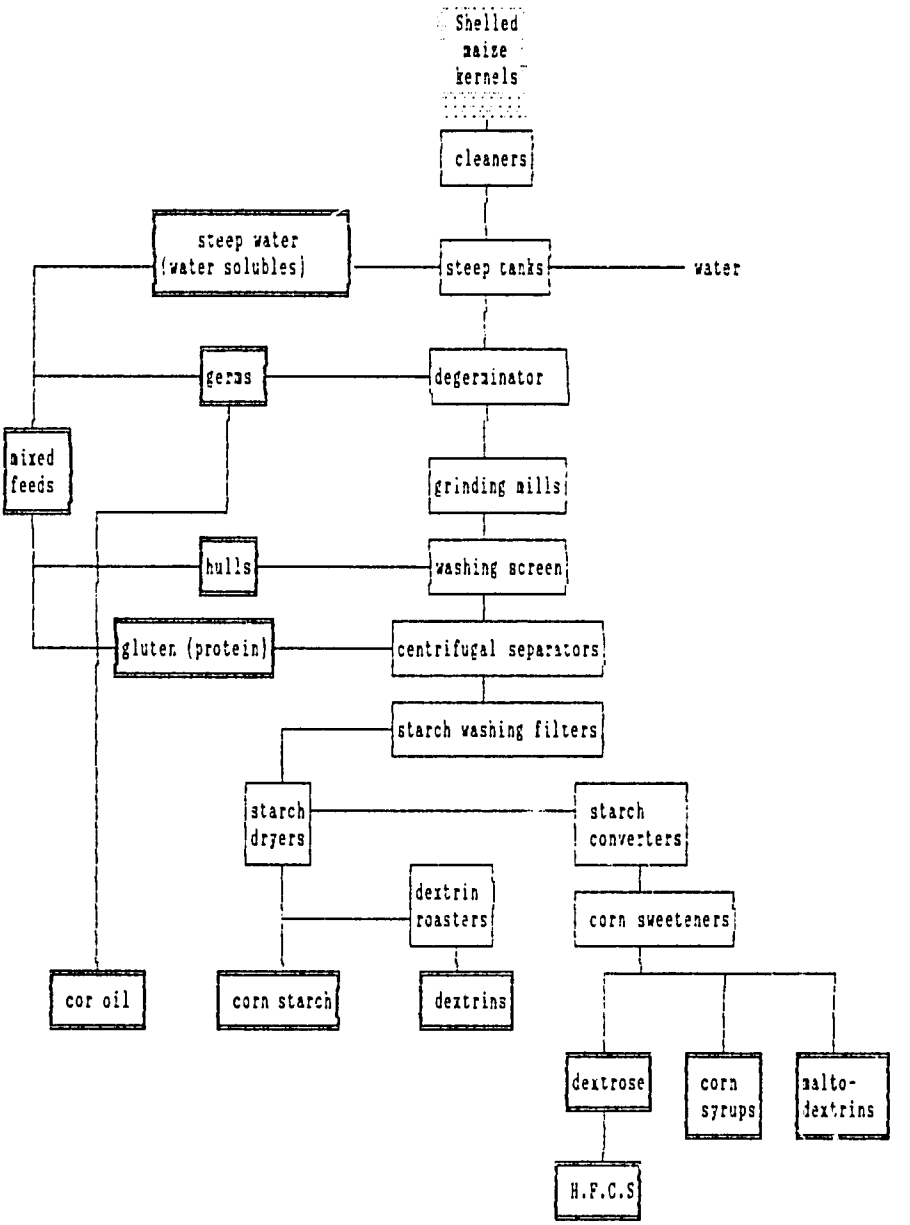
FIGURES

Figure 1: Multiple Uses of Maize



Source: Islam and Kaul 1986

Figure 2 : Simplified Flow Sheet of the Maize Wet Milling Process and the Principal Products



Source: Islam and Kaul 1986

52