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9. ABSTRACT
Cereal grains produced in Tanzania include maize, rice, wheat, grain sorghum, and millet, with maize the most important. A large percentage of the grain is stored and consumed on the farm, though all wheat is marketed through the National Milling Corporation. Nearly all farm storage containers involve indigenous materials and can be classified into six categories: 1) in homes above cooking areas, in baskets or in bark containers; 2) ear maize storage on poles; 3) "baskets" woven from reeds, bamboo, or grass (may be covered with other substance); 4) dried gourds for small quantities; 5) mud pots with sealed lids; and 6) metal drums. The main causes of loss and damage are improper and inadequate post-harvest grain handling, drying, and storage methods, but the actual losses in Tanzania have not been determined. Recommendations to improve farm level grain storage in Tanzania include: 1) establishment of a "farm storage section" within the Crop Development Division, Ministry of Agriculture; 2) extension of "Kilimo" technical services to on-farm storage problems; 3) initiation of research on aspects of farm storage at the Faculty of Agriculture, University of Dar-es-Salaam, Morogoro; 4) appointment of a qualified storage person to the National Crop Research Coordinating Committee; 5) provision of a qualified grain storage specialist to "Kilimo" for two years; and 6) short-course training for four Kilimo personnel and long-term training in grain storage for six other carefully selected Tanzanians.

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REVIEW OF ON-FARM GRAIN STORAGE IN TANZANIA

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SUMMARY STATEMENT

Cereal grains produced in Tanzania include maize, rice, wheat, grain sorghum and millet, with maize the most important. A large percentage of the grain is stored and consumed on the farm, however, all wheat is marketed through the National Milling Corporation.

Nearly all farm storage containers involve indigenous materials and can be classified into six categories: (1) in homes above cooking areas, in baskets or in bark containers, (2) ear maize storage on poles, (3) "baskets" woven from reeds, bamboo or grass (may be covered with other substance), (4) dried gourds for small quantities, (5) mud pots with sealed lids, and (6) metal drums.

Main causes of loss and damage are improper and inadequate post-harvest grain handling, drying and storage methods. Actual losses in Tanzania have not been determined.

Virtually no formal programs for improved farm storage have been initiated in Tanzania. Several studies have been or are being conducted by various agencies at the cooperative and central storage level.

Recommendations to improve farm level grain storage in Tanzania include: (1) establishment of a "farm storage section" within the Crop Development Division, Ministry of Agriculture, (2) extension of "Kilimo" technical services to on-farm storage problems, (3) research be initiated on aspects of farm storage at the Faculty of Agriculture, University of Dar-es-Salaam, Morogoro, (4) appointment of a qualified storage person to the National Crop Research Coordinating Committee, (5) provision of a qualified grain storage specialist to "Kilimo" for two years, (6) short course training for four Kilimo personnel and long term training in grain storage for six other carefully selected Tanzanians.

TABLE OF CONTENTS

		Page
PREFACE		iii
I.	GRAIN PRODUCTION	1
II.	FARM STRUCTURE	2
III.	IMPORTS AND EXPORTS OF MAIN GRAINS	5
IV.	POPULATION TRENDS	6
V.	ON-FARM STORAGE OF CEREAL GRAINS	9
	Drying Methods	10
	Storage Methods	13
	Cause and Extent of On-Farm Grain Storage Problems	22
	Previous Studies and Programs for Farm Storage	24
	Other Related Projects	26
	Status of Current Government and Other Institutional Programs	27
VI.	RECOMMENDATIONS	30
	Institutional Improvement	31
	Training	33
	Research	37
	Equipment and Other Research Tools Needed	39
ACKNOWLEDGEMENT		41
REFERENCES		43
APPENDIX		45

PREFACE

Objectives of the TDY service in Tanzania were:

1. To review the current on-farm grain storage situations.
2. To examine the Government of Tanzania and other institutional capabilities to carry out the programs for improving on-farm grain storage situations in Tanzania.
3. To prepare a report on the current status of on-farm grain storage in Tanzania with recommendations for improvement in on-farm grain storage.

This report deals with a review of grain production, farm structures, imports and exports of cereal grains, on-farm grain storage situation, causes and extents of on-farm grain losses, the past and present studies and programs in on-farm storage, governmental and institutional capability, and finally, recommendations for improving on-farm storage situations in Tanzania. A review of grain marketing structures and systems in Tanzania is not included in this report; however, the persons who are interested in grain marketing aspects in Tanzania should refer to comprehensive and extensive reports prepared by Newhouse (1, 2) and Michigan State University's team through USAID/Tanzania (16). In reviewing on-farm storage situations in Tanzania, the reports by Pattinson (3) and Mphuru, et. al (4) were most helpful.

I. GRAIN PRODUCTION

Cereal grains produced in Tanzania are corn, rice, wheat, grain sorghum and millet. Among them, corn is by far the most important crop in Tanzania with respect to the total production and consumption for dietary requirements of the major portion of the population (about 15.0 million). It was estimated that over 80 percent of the population is subsistence and peasant farm families. Therefore, a significant part of total harvested grains is stored and consumed on the farms, especially corn and rice. It is assumed that 80 percent of corn production and 50 percent of rice production is stored and consumed on the farms (no scientific basis for these figures). However, the situation with wheat is quite different from corn and rice in that virtually the entire wheat crop grown is marketed through the National Milling Corporation (NMC) (2).

The table below shows annual average estimates of harvested production and annual average estimates of commercial purchases of corn, paddy rice and wheat (2).

Annual Average Production and Purchase of Corn, Paddy and Wheat

Crop	Annual Average Production (Tons)	Annual Average Purchase (Tons)
Corn	741,000[a])	106,700[a])
Paddy (rough rice)	138,700[b])	60,136[b])
Wheat	47,300[c])	37,500[d])

a) Average over 1970/71 - 72/73 seasons

b) Average over 1967/68 - 72/73 seasons

c) Average over 1968/69 - 70/71 seasons

d) Average over 1968/69 - 73/74 seasons

Major corn producing regions in Tanzania are Arusha, Dodoma, Ininga, Mbeya and Tanga which account for more than 50 percent of the total annual harvest production while Shusha, Dodoma and Ininga regions account for more than 75 percent of the average commercial purchases. For paddy Mbeya, Tabora, Morogoro, Mwanza and Shinyanga regions account for about 75 percent of the total annual harvested production and also for about 83 percent of the total annual commercial purchases. Wheat production is concentrated mainly in northern Tanzania. Arusha and Kilimanjaro regions supply more than 90 percent of total commercial purchases.

A review of Newhouse (2) indicates that there has not been any significant increase of corn production in recent years, although there may have been substantial variations between years, depending mainly on climatic differences. Total paddy production increased sharply during the period up to 1970-71 but there was a significant decline in total paddy production after 1970-71. Although total annual production of wheat is small compared to corn production, there is evidence of an increasing trend in wheat production in recent years.

II. FARM STRUCTURE

The results of the 1972 Agricultural Census show that by far the largest number of holdings fall within the category of "up to 2 hectares." The following table contains the country-wide distribution of holdings by different size classes and percentage of each size class (2).

Land Holdings by Size and Distribution

Size of Holdings (hectare)	Number	Percentage
Less than 0.5	770,720	31.45
0.5 to 1.0	653,386	26.67
1.0 to 2.0	605,291	24.70
2.0 to 3.0	218,375	8.91
3.0 to 4.0	88,696	3.62
4.0 to 5.0	49,982	2.04
5.0 to 10.0	53,252	2.17
10.0 to 20.0	9,342	0.38
20.0 to 30.0	1,181	0.05
over 30	102	0.01
TOTAL	2,450,327	100.00

The following table is a summary of a combination of the estimates made of areas under the pure and mixed stand cultivation of cereal crops by regions in Tanzania (2).

Regional Cultivation of Cereal Crops

Region	Maize	Paddy	Wheat	Millet	Sorghum
Arusha	71,100	--	33,300	12,300	11,000
Dodoma	63,700	--	--	67,700	25,700
Iringa	67,000	800	13,900	4,700	--
Coast	26,900	22,900	--	6,500	9,000
Kigoma	15,600	500	--	400	7,400
Kilimanjaro	25,500	5,000	--	3,900	--
Mara	14,700	900	--	12,500	9,600
Mbeya	46,900	23,300	100	30,500	1,300
Morogoro	50,600	55,200	900	300	26,300
Mtwara	17,800	13,200	--	8,700	33,000
Mwanza	25,500	4,600	--	20,300	--
Ruvuma	39,900	14,800	1,100	18,500	500
Shinyanga	79,900	12,900	--	23,400	42,000
Singida	25,800	200	--	27,500	34,600
Tabora	56,500	3,800	--	3,400	5,400
Tanga	57,100	3,300	--	900	--
West Lake	7,500	--	--	1,700	6,300
Total	701,900	161,400	49,300	243.200	212.100

The following table shows the total areas under cereal crops, both pure stands and mixture on unweighted basis for the country as a whole (2).

Areas Planted to Major Crops

Crop	Pure Stands	Mixtures	Total
	(1000 hectares)		
Corn	411	650	1,061
Paddy	151	26	177
Wheat	49	1	50
Sorghum	137	158	295
Millet	158	200	358

Estimates of normal cereal yields, taking the average of pure and mixed stands, are summarized in the following table (2).

Major Crop Yields

Crop	Kgs per hectare
Corn	800
Paddy	950
Wheat	950
Sorghum/Millet	500

It should be noted that there has been a significant change in the structure of agriculture in Tanzania since the Agricultural Census of 1971-72. The change in the structure of small scale agriculture dates from 1967 with the introduction of the Ujamaa system of farming. This change has accelerated since 1971-72. By March 1974 it was estimated that there were 2.6 million people living in some 4,900 villages. The recorded area under corn is 40,300 ha. equivalent to 0.016 ha/person. This compares with the 410,500 ha. under pure stand recorded in the 1971-72 census, which is equivalent to 0.033 ha/person of the estimated 12.5

million rural population at that time. Ujamaa villages, as of March 1974, tend to be concentrated in areas where corn is not grown very widely. Ujamaa villagers may also farm individual plots to supplement the proceeds of collective farming.

In addition to the introduction of the Ujamaa system, a rapid introduction of a village system took place in 1974. By October of 1974 a reported 3 million people had been relocated in such villages. Thus, up to 6 million people are now in Ujamaa or development villages i.e., nearly 45 percent of the rural population of an estimated 13.8 million. About one-half of these may be expected to be undertaking some form of collective farming mixed with individual smallholder agriculture (2).

III. IMPORTS AND EXPORTS OF MAIN GRAINS

The following table summarizes imports and exports of corn, paddy and wheat for the 6-year period from 1967-68 to 1972-73. (2)

Imports and Exports of Corn, Paddy and Wheat

Grain	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73
	Metric tons					
Corn						
imports	--	--	46,921	--	92,283	78,944
exports	252	51,837	--	53,427	--	--
Paddy						
imports (rice)	5,753	--	--	--	--	--
exports (paddy)	--	--	--	--	4,189	10,292
Wheat						
imports	13,600	36,700	35,700	11,600	45,500	8,200
exports	--	--	--	--	--	--
Total						
imports	19,353	36,700	82,621	11,600	137,783	87,144
exports	252	51,837	--	53,427	4,189	10,292

The above table indicates that net imports increased sharply after 1971-72, due partly to adverse growing conditions but also with a general decline in commercial production. There was a sharp increase in imports in 1974. This was also due to declines in commercial production and to increases in commercial consumption requirements coupled with severe crop failure in the subsistence sector. In October 1974 it was estimated that in the 18-month period up to September 1975, Tanzania would need to import 916,000 tons of grain at a total cost of 1,805 million shillings in which corn accounts for 636,000 tons (1,003 shillings). These estimates were based on the assumption that the 1974-75 harvest for all three grains would be even lower than for 1973-74.

IV. POPULATION TRENDS

A major factor in determining future grain requirements is the rate of growth of the population. Bearing in mind the wide variations in consumption patterns between regions, and the fact that commercial consumption tends to be concentrated in urban areas, it is also relevant to consider likely developments on a regional basis and to separate growth rates for the principal urban areas.

The following table gives projected population for 1970, 1975, 1980 and 1985 using higher natural growth rate (2).

Projected Population

	Estimated Population (1000)				Annual Growth Rate (%)		
	1970	1975	1980	1985	1970-75	1975-80	1980-85
Total	12,863	14,838	17,369	20,410	2.9	3.2	3.2
Urban		1,146	1,614	2,295	6.4	6.4	6.4

The projected increase in total population to over 20 million by 1985 indicates that in order to maintain average per capita consumption, it will be necessary to increase total supplies by 4 percent per annum over and above their present levels. In other words, total requirements in 1985 can be expected to be about 34 percent above the 1975 level, assuming constant per capita consumption rates. The anticipated rate of growth is even greater for requirements of urban areas which are projected to increase by about 6.4 percent per annum. This means that by 1985 commercial requirements would be more than double their 1975 level if per capita consumption remains constant.

The following table shows the consumption estimates of 1980, using the 3-year period 1970-72 as the base period of the projections (2).

Projected Consumption of Major Grains in 1980

	Corn	Rice	Millet Sorghum	Wheat
	----------(1000 tons)----------			
1. Gross production 1970-72	866	194 (paddy)	317	48
2. Less seed, shrinkage waste %	14	6	10	11
3. Net output, 1970-72	745	182	285	43
4. Processed output	--	11.8 (65%)	--	--
5. Net trade, 1970-72 + imports-exports	+52	+7	-8	+22
6. Estimated consumtion 1970-72	797	125	277	65
7. Consumption per capita 1970-72, kg/yr	60.2	9.4	20.9	4.8
8. Projected increase in per capita consumption 1970-72 to 1980, %	7.4	11.2	5.6	26.8
9. Projected per capita demand 1980, kg/yr	64.7	10.5	22.1	6.1
10. Total demand 1980				
high-population 17.4 mil.	1126	183 (282)	385	106
low-population 17.1 mil.	1106	180 (277)	375	104
11. Seed-waste etc, %	14	6	10	11
12. Total projected production for self-sufficiency 1980	1286-1309	295-300	420-428	117-119
Rounding	1300	(paddy) 300	430	120
Increase over 1970-72 base, %	50	55	36	150

V. ON-FARM STORAGE OF CEREAL GRAINS

As mentioned in previous sections, over 80 percent of Tanzania's population are subsistence and peasant farm families whose average land holdings are less than 2 hectares. Cereal crops in Tanzania are harvested almost completely by hand except for very few commercial and experimental farms. All crops harvested are, in most cases, dried by a natural, sun-drying method and stored on the farms at some time whether they are destined eventually for sales or for on-farm consumption. The storage period of grains intended for sales may vary from a few days to a few months but in many cases the farmer sells his crops at the time of harvest. It would appear that the main factors which influence the decision on how much to keep, how much and when to sell are:

1. the size of the total crops
2. availability of alternative for on-farm consumption
3. storage capacity
4. cash commitments (debt, supply & goods, etc.)
5. availability of time and labor at the harvest period
6. availability of transportation and weather conditions
7. prices.

It should be noted that theoretically under the present marketing system in Tanzania, the last factor--prices--should not be a governing factor. Uniform producers' prices are set by the government, regardless of regions and seasons, through a one-channel marketing system (producer-cooperative societies-cooperative unions-National Milling Corporation-consumers). However, in actual practice, price differentials exist between regions and seasons. Thus direct sales by farmers to local consumers and illegal sales by farmers, either to middlemen or outside the region, are taking place.

Subsistence food crops such as corn, millet, sorghum and, to some extent, rice, are stored on the farm under various forms of storage generally for periods up to 9 months. The different types and sizes of traditional storage units are constructed from locally available materials such as mud, sticks, tree bark, grass, banana leaves, poles and gourds. On very rare occasions the use of metal containers for grain storage, such as used oil drums or debbie tins, can be found. A detailed discussion of on-farm storage units and methods in Tanzania follows.

Drying Methods

Moisture is the most important factor influencing deteriorative changes during grain handling and storage. When grain is sufficiently low (below 13 percent) in moisture content, it can be stored safely for a long period with little deterioration providing that the original grain is in good condition and placed in an adequate storage unit. If the moisture content of the grain is high, grains deteriorate rapidly due to the biological activity of the germ, mold, bacteria, insects, and also certain enzymatic reactions.

Grain is hygroscopic; in other words, it loses or gains moisture in accordance with the surrounding atmosphere. If it is in contact with liquid water (rain), it will, of course, absorb moisture and increase its moisture content. Grain will also lose or gain moisture depending on the temperature and humidity of the surrounding atmosphere.

When grain is in contact with air, there is moisture movement between them until moisture equilibrium is reached. Equilibrium is the condition at which moisture ceases to move from the grain to the air, or from the air to the grain. Since both air and grain contain water vapor, each has a vapor pressure. Vapor moves from a higher pressure to a lower one, so

when the vapor pressure in the grain is higher than that in the surrounding air, moisture moves from the grain to the air and decreases the grain moisture. Conversely when the air vapor pressure is higher than that of the grain, the grain is wetted and its moisture increases.

In developing countries in the tropics, removal of excess moisture from crops is normally carried out by sun and wind drying. If poor climatic conditions (high relative humidity and rainfall) following harvest make this operation impossible or extend the drying period, quality deterioration may be high and rapid. Fortunately in Tanzania the bulk of corn is harvested in the dry season (June, July and August). Because of the relatively low humidity of the air and low rainfall during the harvest season in major corn producing areas (except costal areas: Tanga and Mwauza), corn may be dried to a reasonably safe storage moisture content (about 11 percent to 13 percent), by natural sun drying method (see climatological data for a few selected areas in appendix).

Since there are a number of factors (grain and air temperature, relative humidity, conditions and forms of grains, previous history of grain, conditions and types of storage, etc.) other than the moisture content of grain that would influence grain quality changes, it is almost impossible to state a definite moisture limit below which a given grain may be stored safely and above which deterioration would occur. However, in general, the limit of moisture for safe storage of grain is the moisture content of grain which is in equilibrium at 70 percent relative humidity.

Unshelled corn with sheath (husks) is usually dried on platforms of various sizes supported by a wooden framework raised some 3 or 4 feet off the ground with ears piled to various depths (maximum 3 feet). Sometimes

corn ears (with the outer sheaths of the ear intact) are tied together and suspended from a framework constructed of poles and dried by the sun. The same principle is used when ears are tied together and suspended from trees and wooden rafters outside houses. The drying methods and procedures used on the farms are fundamentally unsound because of facility design, lack of control of incoming field infestation and rodents, lack of protection from rain, non-uniform drying, etc.

Drying-air temperatures may have a significant effect on grain quality. Excessively high kernel temperatures in corn and rice (grains at the top of piles) cause increased breakage, stress cracking, kernel discoloration and lead to a decrease in milling yield and protein quality. Overdrying of grains at the top of piles or the top surface and less drying at the bottom parts may likely occur resulting in considerable moisture gradients (non-uniform drying). A wide range of moisture content of grain between different lots would also occur under the present drying methods and practices.

Proper procedures or practices before placing grains in storage units are checking moisture content of grain, grain temperature and moisture content throughout a grain lot, foreign materials, insects, and cleaning and disinfecting of storage units. Except for the first two mentioned (checking the moisture and temperature), these practices are not followed on the farms. Other practices can be easily adapted. At the present time, there are no practical and reasonably accurate ways of measuring moisture content of grain available, which can be readily adapted by subsistence level farmers.

It should be emphasized that the average moisture content of the grain mass does not determine the allowable storage time of grains. Spoilage may occur at isolated locations in the mass where grain moisture is high. Grain stored in a storage unit at a relatively low average moisture content of 13.0 percent, but with a moisture content range between 10.0 and 16.0 percent (due to improper drying) is not safe for long-time storage because of the excess moisture content (16.0 percent) of part of the grain.

It is evident from the foregoing review and discussion that studies on improved methods of grain drying and development of a simple, moisture-indicating method that can be applicable to subsistence farmers in Tanzania, are definitely needed.

Storage Methods

It was impossible to observe and evaluate all types of traditional grain storage structures in Tanzania due to only a very short stay. Thus, a review and discussion presented in this section was extracted mainly from Pattinson (3), Mphuru et. al (4), and private communication with Mr. A. N. Mphuru, Faculty of Agriculture, University of Dar es Salaam, Morogoro and Mr. A. M. Mushi, Ilonga Agricultural Research Institute.

There are over 120 tribes in Tanzania each with its traditional customs and rites. Tradition is carried down to the storage of crops, the type and shape of the container used, and the location of the food store. Nearly always, storage containers are constructed from indigenous materials such as mud, sticks, tree bark, grass, banana leaves, straw, poles, and gourds. Six types of storage will be discussed, namely: houses, poles, baskets, gourds, pots, and metal containers.

1. Houses - Because of the risk of theft or in accordance with traditional practice, harvested grain may be stored in the loft of a house usually above the living and sleeping quarters (ceiling). The grains are stored above the living room and fire to assist in drying it out. It is believed that the smoke from the fire has a repellent action on some insects. While smoke may have some repellent action, the theory of the house-fire drying of the grain in the loft is quite questionable. The considerable amount of moisture vapor produced in the house by cooking, animals, and humans rises up on heat convection currents from the living room to the grain loft. Under this condition, the rate of drying is quite slow due to a low drying potential of air (humid and low air movement) so that grain deterioration may occur during drying. Also, during the day the temperature in the loft is high but at night when the temperature falls below the dew point, moisture condensation takes place as the air is cooled and deposited on the inside of the roof and on the grain. The mustiness and moldiness of grains in roof stores bears out the unreliability of this storage method.

House storage of grain sorghum in grass rope baskets is practiced by the farmers in southern Tanzania who place the basket in the roof above the fire. A drum-like structure (Kilindo) made from bark --usually the bark of Miombo tree--is used for storing rice, sorghum, and corn in the Morogoro and Tabora regions. Some farmers cover the top with mud or cow-dung to make it airtight. This is broken only when the crop is required and the mud is replaced soon after withdrawal. The size is variable ranging from about half a bag to about 15 bags (90 kg/bag). However, most

of them have a capacity of about two to three bags. Of the traditional structures observed during the recent survey conducted by Mphuru et. al (4), they concluded that this type of container was probably the cleanest and the best for storage of shelled grains. A further critical evaluation on the effectiveness of the "Kilindo" storage container would be very useful for farm grain storage programs in Tanzania.

2. Poles - Pole storage can be considered as a combination of drying and storage of corncobs where the outer sheaths of the cobs are tied together and suspended from a framework constructed of poles. In some places corncobs are tied together and suspended from trees, wooden rafters outside houses, etc. In dry areas this method appears to be satisfactory, but changing weather conditions (rains and high humidity) lead to deterioration.

3. Baskets - A typical and common type of storage unit found is the "Kihenge". This type of storage unit is cylindrical in shape and is usually made of interwoven reeds, bamboo splits, tall grass like the *Hyparrhenia* species, or sorghum reeds. The sides and base are sometimes plastered with a thin layer of cowdung or mud. The storage unit may sometimes stand on the ground but oftentimes it is built on a platform. The storage unit may be placed outside the house, in which case it is normally provided with a grassthatched, removable roof, or inside the house in which case it is left open. Grain stored with the sheath intact suffers less from insects and rodent attack than grain which is stored shelled, but losses are still substantial and rise rapidly with the onset of the rains.

4. Gourds - Dried gourds are used for storing small quantities of seeds. If the mouth of the gourd is plastered over with mud, sound airtight

storage is assured. Oftentimes, no attempt is made to render the structure airtight.

5. Pots - According to Pattinson (3), probably one of the most advanced native storage units is the mud pot with a lid sealed to the sides of the pot with plastered mud (virtually airtight). This type is used in southern regions for storing paddy. Losses due to insects are believed to be small.

6. Metal Containers - Four-gallon debbies and second-hand fifty-five gallon oil drums are used for storing grains in some areas (Kilimanjaro). It was observed that quite a few farmers along the highway between Morogoro and Dar es Salaam own second-hand oil drums, but they are used as water tanks rather than for grain storage. Pattinson (3) concluded that this form of airtight storage is the most advanced and probably the most suitable method for farm storage of grains in Tanzania. It should be noted that the grains should be sufficiently low in moisture content (12 percent) and uniform in moisture distribution before placing in an airtight structure in order to assure safe storage.

The table on the following pages shows the summary of traditional farm storage structures used by different tribes in various regions of Tanzania including construction materials used, their capacities, life spans, and type and form of crops stored (source: Mr. A. N. Mphuru).

In summary, with few exceptions, traditional storage and drying methods are improper and inadequate for safe storage. They are conducive to the build-up of food losses due to easy access by rodents and insects; moisture transfer to grains from the air and rains; and uncleanliness inside and around premises. It is evident from the foregoing review and discussion that research,

Summary of Major types of grain storage

TYPE	MATERIALS OF CONSTRUCTION	SIZE	FORM OF STORAGE	COMMENTS
Interwoven types of Cribs	1. Thin flexible reeds of sticks 2. Bamboo splits 3. Sorghum or Maize reeds 4. Tall grass especially Hyperrhenis spp.	Mainly for large storage	1. Maize commonly stored on cob with sheath 2. Sorghum & Rice commonly stored on heads.	1. These cribs are commonly smeared with cowdung or mud depending on the amount of ventilation required for drying. 2. Most of these are separate stores outside the living house. 3. They are all circular in appearance.
Storage on the Ceiling of: 1. Raised rectangular house. 2. Living house 3. "Ngoko"	The materials used are variable depending on the availability of material.	Mainly for large storage	1. Maize commonly stored on cob with sheath 2. Sorghum & Rice commonly stored on heads.	Smoking is a common feature of most of these stores.
Storage in small containers e.g. Pots, Gourds	Post: Cowdung or mud Gourds: Vilindo: Bark of Brachystegia spp. and Julbernadia spp.	Small storage containers	1. Shelled maize 2. Shelled Beans 3. Paddy	Mainly used for storage of seeds.
Go-downs and Silos	1. Aluminium 2. Bricks etc.	Large	Shelled maize, Rice, Beans etc.	Mainly for central storage.
Dual purpose structures for drying and storage	Hanging on trees, scaffolds raised platforms etc.	Mainly for medium storage	on cob with sheath or beans or pod.	These are essentially for drying but often they act as means of storage for a long time, especially in wetter areas.

Summary of Storage Containers in Tanzania

REGION	MAIN TRIBES	TYPE OF STORAGE	MODE OF CONSTRUCTION	CAPACITY	LIFE SPAN	TYPE OF PRODUCE STORED	FORM OF STORAGE	COMMENTS
Arusha & Kilimanjaro	Wameru & Wachagga	Kikumbi	Large interwoven baskets of thin sticks smeared in cowdung	10 - 25 bags	-	Maize Finger millet	sheathed on cob on heads	
Kilimanjaro	Wapare	Manyeko	-	-	-	Bundles of maize hung on trees	sheathed on cob	
Kilimanjaro	Wachagga	Ksike shipfuke	Interwoven dry banana leaves	2 - 6 tins	1 year	Beans		Usually admixed with herbs + ashes
Iringa & Mbeya	Wanyakyusa & Wabena & Wanyika & Wangoni	Mitenene	Tree barks	1 - 3 bags	-	Maize & Rice	sheathed on heads	
		Ndamba	Interwoven bamboo splits	5 - 10 bags	5 years	Maize Rice	sheathed on cob on heads	
		Fituba	Tree barks	1 bag		Finger millet	on heads	
		Ndeko	Pot (mud)	2 debes		Finger millet	threshed	
		Fibo	Bamboo splits	1 debe		Rice		
		Ijulu	Bamboo splits	10 - 20 bags	5 + years	Maize	sheathed on cob	
		Kibana	Bamboo splits	1 - 3 bags	5 + years	Maize	sheathed on cob	
		Chanja	Interwoven sticks	10 - 30 bags	5 + years	Maize	sheathed on cob	
	Kyela	Ngumbe	Large pot	1 - 2 debes		Maize	shelled	For seeds - Airtight structure
	Mbeya	Ingasha	Large raised rectangular building	10 - 40 bags	5 + years	Maize	sheathed on cob	
	Njombe	Kisansi (Visanzi)	Large circular crib with conical base Interwoven structure smeared with cowdung	5 - 10 bags	5 + years	Maize	sheathed on cob	

Source = Mr. A. N. Mphuru, Faculty of Agriculture, University of Dar es Salaam, Morogoro.

Storage Containers in Tanzania (page 2)

	Iringa	Kano	Rectangular house with the ceiling used for storage	5 - 30 bags	7 + years	Maize	on cob sheathed	inside living house
	Iringa	Kisandi or Litanda	Rectangular raised house for maize storage	5 - 30 bags	7 + years	Maize	on cob sheathed	outside living house
	Kyela	Kituwa	Interwoven bamboo splits smeared with cowdung.	5 - 20 bags	5 + years	Rice	Paddy	more or less airtight
		Kyanga	Kihenge - interwoven sticks smeared with cowdung & mud	5 - 20 bags	5 + years	Maize	sheathed on cob	
Dodoma & Singida		Cidonga	Interwoven sticks	5 - 20 bags	7 + years	Maize	sheathed shelled	
Lindi & Mtwara & Songea	Lindi Newala	Kese (Makese)	Bowl or dome-shaped interwoven bamboo structure or dome shaped matrix of sticks with grasses tied to the matrix	2 bags	5 + years	Maize	shelled	with mud - completely sealed with mud
	Newala	Litara	Raised rectangular hut	10 bags	5 years	Maize	sheathed	
		Ngokwe	Cylindrical crib made of sticks	5 bags		Maize	sheathed on cob	
		Pots		1 debe		Maize beans	shelled	completely sealed & primarily for seed
Morogoro Coast Tanga DSM		Ngoko	Circular hut built inside living house	10 bags	10 years	Sorghum	on heads	produce stored in ceiling of the ngoko. Smoking common
		Chanja	Rectangular hut or store	20 bags	7 years	Sorghum rice maize	on heads sheathed cobs	smoking very common
		Kilindo (vilindo)	Drum-like structure made from bark of Brachystegia	1-2 bags	6 years	Paddy	Paddy	

Storage Containers in Tanzania (page 3)

Tanga Cont.	Kanda							
Kigoma	Kibondo	Ikigega	Tall, circular granary made of reeds	20 bags	7 years	Maize	sheathed	
Sumbawanga Rukwa		Matete	Granary made from tall grass like Hyperrhamia	4 bags	4 years	Maize	sheathed on cob	
		Pit storage	Underground pot-like structure	3 bags	2 years	Finger millet		Airtight storage
		Indaha	Big drum made from animal skin such as Buffalo	1 bag	10 years	Finger millet, Rice, pulses	Paddy	
		Ikisabo	Like gourds	1 debe	2 years	Seed	-	
	Sumbawanga	Inkoma	Silo like structure made from interwoven reeds & smeared with mud	40 bags	5 years	Maize	sheathed on cob	
	Kigoma	Ulushishi						
		Kapungu						
Musoma	Wakerewe	Echtara	Elephant grass	20 bags	5 years	Maize	sheathed on cob	
Shinyanga	Musoma	Orwanja	Interwoven thin sticks	2-20 bags	5 years	Maize	sheathed on cob	
Mwanza	Tarime	Dero	Interwoven thin sticks	2-20 bags	5 years	Maize	sheathed on cob	
Tabora		Ikologoto	Millet stams	30-50 bags	7 years	Millet maize	sheathed on cob	
Mara		Iluli (Maluli)	Interwoven sticks	10-15 bags	5 years	Millet	on heads	

Storage Containers in Tanzania (page 4)

		Masagasa						
		Ifuna	Pot-like structure	1-4 debes	-	Maize, Seed	shelled	Airtight
		Malindo	Drum like structure made from Brachystegia barks	1-5 bags	5 years	Maize, Paddy	shelled paddy	
		Nshelo (Mashelo)						
		Ngunguku	Interwoven sticks smeared with cowdung	2-8 bags	5 years	Beans		
		Mabelele	Millet stalks	5-70 bags	7 years	Millet and Maize	on heads on cobs & sheathed	
		Ifuma	Grass sometimes smeared with cowdung	2-10 bags	3 years	Millet	on heads	May be airtight
	Tabora	Magesho	Interwoven structure smeared with cowdung	1-10 bags	5 years	Maize, Millet	sheathed on cob	Completely airtight
		Kunti	Pot made of cowdung only	1-2 tins		Seed		
	Kwimba	Kano	Rectangular hut	5-10 bags	7 years	Maize	on cob sheathed	Maize stored on ceiling
	Tabora	Kigagale						
West Lake		Omutwaro	Interwoven basket from dry banana leaves	1 debe	1 year	Sorghum finger millet	on heads	Usually hung below fire place
		Bitende	Interwoven basket from dry banana leaves	1 debe	1 year	Sorghum finger millet		
		Lutili						
		Kigera						
		Eitala						
		Kitukulu						
		Ekituba						
		Omushenga						

on the improvement of existing traditional storage methods and the development of a grain storage unit that can be suitable for farm or village storage levels, is urgently needed for minimizing grain quality and quantity losses during the storage at the farms. Also needed is investigation on the use of insecticides in traditional storage units.

Cause and Extent of On-Farm Grain Storage Problems

As indicated in the previous sections, main causes of grain damage and losses are improper and inadequate post-harvest grain handling, drying, and storage methods employed on the farms. An equally important aspect of safe grain storage is to employ good storage management practices during the storage period. This would include examining grains periodically for signs of heating, insects and mold activities, rodent pellets and hairs, good housekeeping and sanitation inside and around the premises, chemical pest control measures, etc. However, such practices are not followed on the farms because of not understanding grain storage fundamentals and financial exigency by farmers. It was reported that on very rare occasions, insecticides such as Malathion and Lindane are used in controlling insects on the farms (4). Pest control measures used occasionally by farmers include use of ashes, sun drying, smoking for insect control; ratguards made of tin cans, and use of cats for rodent control.

Actual extent of grain damage and losses on farms in Tanzania is very difficult to assess. No research work on grain quality and quantity losses on the farms due to insects, molds, rodents, and other causes has been carried out in Tanzania. It should be emphasized that corn quality loss is equally, if not more, important as corn quantity loss for subsistence families on the farms because their dietary requirements are mainly derived

from corn. Corn quality loss with respect to nutritional values undoubtedly attributes to poor states of health and inadequate child growth for subsistence farm families. Although general conclusions cannot be drawn from my brief observation, several cases of abnormal child growth and children in a poor state of health were witnessed on the farms. Research work on both corn quality and quantity losses on the farms due to insects, molds, rodents and others should be carried out soon in Tanzania.

In 1967 it was estimated that in Tanzania the prevention of losses under traditional storage would have provided food for more than 650,000 people for 1 year. Pattinson (3) estimated that almost 25 million shillings worth of corn was lost to insects alone annually during storage. In estimating the above figure, Pattinson (3) has used the weight loss factor of 14 percent due to insect damage which was estimated from careful field work on crib storage of corn in Kenya and producer price of 273 shillings per ton. The weight loss factor of 14 percent appears to be conservative in the Tanzanian situation.

Using the same conservative figure of 14 percent weight loss factor due to insect damage, 3 years' (1970-71 to 1972-73) average corn production of 741,000 tons and that of marketed corn of 106,700 tons, it is estimated that about 88,800 tons of farm-stored corn was lost annually in those years to <u>insects alone</u>. This amount is almost equal to the yearly corn tonnage purchased by NMC and would have fed about 1 million people in Tanzania for 1 year. In terms of monetary loss, it was estimated that 44.4 million shillings (using 1974-1975 producer price of 500 S/T) was lost by the producers. Or, the Tanzanian government could have saved almost 20 million dollars worth of foreign exchange from corn imports, based on 1974-75 corn import price of 1577 S/T if such a loss had been prevented.

In the foregoing sections, some of the technical storage problems on the farms and other problems associated with on-farm storage have been identified. Technical solutions to some problems have been worked out by many investigators in various international research institutes and in universities in developed countries. Demonstrations of the effectiveness of improved storage methods and practices developed have been made in many developing countries with some successes and failures.

It should be pointed out that the importance and seriousness of on-farm storage problems in Tanzania should not be overlooked. Tanzania can ill-afford food grain losses when she has been importing corn at an alarming rate, especially the last 5 years. Food grain losses, after harvest, indeed are not only financial losses to the farmers but also wastes of the inputs and efforts that have gone into growing the grains. Furthermore, such losses would result in a strain on Tanzania's foreign exchange reserves through food grain imports. Some losses are undoubtedly inevitable but quite a good part of these could be saved through proper storage measures. Needs for various governmental programs to improve on-farm grain storage situations in Tanzania are inevitable and urgent.

Previous Studies and Programs for Farm Storage

The studies and programs on farm storage problems in Tanzania have been very sporadic since independence in 1961. With a very few exceptions, virtually no formal programs for improving on-farm storage situations have been introduced by the Government.

It appears that the first published article on Tanzania's grain storage problems was provided in 1956 by Hall (5) who indicated the desirability of providing government legislation for control of commercial storage

procedures and suggested the expansion of food reserve storage using the underground pit method. In 1966, Gessleim (6) and Rannfelt et al. (7) made a survey on storage and handling of food grains at the central storage level in Tanzania. These studies did not cover storage under traditional farm storage.

Perhaps, the first and the most comprehensive study dealing with on-farm storage problems was reported in 1968 by Pattinson (3). In his report to the Government of Tanzania the nature and range of crop storage problems, including non-cereal crops at the farms, cooperatives and national storage centers, were identified and several recommendations were made on training, research, institutional organizations and legislation for improving crop storage problems at all levels of storage in Tanzania.

In 1968 the Freedom From Hunger Campaign FAO/UN (8) made a special effort to promote projects concerned with preventing food losses at the village level. Approximately 1,800 new petrol drums were donated by the Austrian FFH Committee under the Freedom From Hunger Campaign. Drums were distributed under the auspices of the Cooperative Department of the Ministry of Agriculture and cooperatives to three carefully chosen localities in Dodoma, Iringa, and Bukene. This pilot project action showed that good results can be achieved by simple means and at low cost.

The studies by Hall (9) and LePelley (10) gave a comprehensive list of the major pests of stored products in East Africa including Tanzania. Ringo and Mushi (11) have conducted stored products research on insecticides, screening tests, and tested the effectiveness of oil drums for grain storage. From the three insecticides tested (Malathion, Fenitrothion and Bromophos), the results indicated that Fenitrothion at 5 ppm was the most

effective insecticide in protecting the corn against Sitophilus and Tribolium attack. Closed oil drums have shown some promise as useful storage containers.

The surveys on grain losses due to insects under traditional grain storage at the farms were conducted by Mphuru et. al (4). The results showed the extent of damage to corn in traditional storage and were estimated to vary from 20 percent in the case of the grain stored for less than 3 months, to almost 100 percent, for that stored for a year or more. The report by Mphuru (4) appears to be the first of its kind in Tanzania and one of the most comprehensive studies made on traditional farm storage since Pattinson's study (3). Unfortunately, the data obtained were not sufficient enough to draw statistical inferences and could not be translated into actual weight loss or quality loss.

It is apparent from the literature that very little research and very few programs have been carried out on food grain quality and quantity losses during on-farm storage. Efforts to improve the traditional structures or to develop a simple, inexpensive non-traditional storage unit or method have not been fully explored. Effective pest control measures and drying methods which can be adapted to farm use in Tanzania need to be developed.

Other Related Projects

1. Studies made on off-farm storage problems in Tanzania are: Evaluation of Grain Storage Systems for Cooperatives by the Food and Agriculture Organization/United Nations Development Programs (FAO/UNDP) (12); Generalized Prospectus for Local Manufacture of Modern Corrugated Steel Grain Bins by Ron Hawkey (13); and Low Cost Steel Silos by FAO/UNDP (14).

2. National Milling Corporation (NMC) has a four-man team of technical advisers, including Storage and Transportation Adviser, Mr. Roger Newburn, financed by USAID.

3. FAO/UNDP Agricultural Marketing Development Bureau (AMDB) with the Ministry of Agriculture is studying the grain marketing system and requirements for strategic (reserve) grain storage.

4. FAO/UNDP Rural Credit project is assisting the Tanzania Rural Development Bank, particularly in the Iringa area, in providing credit to primary cooperatives for inputs, storage, and transport facilities.

5. Swedish International Development Agency (SIDA) has a bi-lateral project to provide silos for NMC at the central level.

6. Canadian International Development Agency (CIDA) has a project (temporarily suspended) to investigate suitability of steel silos with associated handling and drying equipment for use by cooperative societies and unions.

7. In 1974, a 6-week training course on "Grain Storage Pest Control" for East African countries was organized by FAO and SIDA and held at the Faculty of Agriculture, University of Dar es Salaam, Morogoro. Nine Tanzanian Produce Inspectors from the Ministry of Agriculture and NMC were enrolled. These trainees are expected to assist in training new inspectors in courses to be held at the Faculty of Agriculture, Morogoro in June and July 1975.

It should be noted that none of above activities and projects are directed toward on-farm storage problems.

Status of Current Government and Other Institutional Programs

In reviewing various reports and activities of the Ministry of Agriculture, it appears that there is no separate governmental or other institutional organization directly responsible for planning, implementing, and administering farm grain storage programs in Tanzania.

The agricultural policy of the Government of Tanzania is to gear production more to the domestic market, while continuing with exports in processed form, in order to earn foreign exchange. Within the context of the Arush Declaration and the Iringer Declaration, agriculture will be developed at the peasant level, with emphasis on Ujamaa Villages, and priority will be given to food production for nutritional self-sufficiency (15).

Currently, considerable effort is being made by Tanzanian and foreign agricultural scientists to increase yields through improved seed, fertilizer application, pest control, etc. These efforts are being supported through external aid (CIDA, FAO/UNDP, USAID, etc.) at 9 Agricultural Research Institutes and 23 Agricultural Experiment Stations under the Ministry of Agriculture ("Kilimo"). A few foreign technical advisers are attached to the Ministry of Agriculture to provide technical assistance in the above production programs. Some programs on the improvement of on-farm post-harvest activities are currently underway. In examining the composition of the National Crop Research Coordinating Committee, which is responsible for the operations of a common national program integrating the isolated research efforts of major crop research programs throughout the country (15), it was found that no qualified grain storage scientist is included in their membership.

The Ministry of Agriculture's technical services, including extension, currently cater only to agricultural production problems. Thus, on-farm grain storage problems have had no direct or indirect technical service available to the subsistence level farms over the years. Most of Tanzania's population are the subsistence or peasant level farmers. Thus, a large

proportion of grains produced is stored for consumption on the farms under adverse storage conditions. Therefore, it is at this level that assistance is most needed to reduce food grain losses.

There are only four or five qualified grain storage personnel in the entire country; incidentally, all of them are stored products entomologists. No qualified grain storage engineer is available in the country. The following is a list of qualified storage personnel and their stations in Tanzania:

1.	Dr. D.F.P. Ringo	Ministry of Agriculture, Dar es Salaam
2.	Mr. A.N. Mphuru	Faculty of Agriculture, University of Dar es Salaam, Morogoro
3.	Mr. A.M. Mushi	Ilonga Agriculture Research Institute, Kilosa
4.	Mr. Luhusa	Katrin Agriculture Research Institute, Ifakara

Dr. Ringo and Mr. Mushi had engaged in grain storage research at Katrin Agricultural Research Institute in early 1970. Unfortunately, they are no longer engaged in the grain storage research. Mr. Mushi is now located at Ilonga Agricultural Research Institute, Kalosa and working as a field entomologist. Mr. Mushi, who is capable of carrying out grain storage research, is working with virtually no equipment and instruments for conducting scientific research. Also, very few reference materials, needed for planning and conducting research, are available to him.

As indicated in a previous section, Mr. Mphuru, Faculty of Agriculture, University of Dar es Salaam, Morogoro, has been actively engaged in studies on grain losses by insects under traditional storage methods for the last 5 years. His laboratory is adequately equipped for grain storage research but a few essential instruments and equipment are not available.

It is apparent that more trained storage entomologists and especially trained storage engineers, are urgently needed in Tanzania to carry out on-farm grain storage programs.

VI. RECOMMENDATIONS

It is a well recognized fact that a substantial proportion of food grain production in Tanzania is lost every year during the post-harvest period, especially at the farm level, due to improper and inadequate post-harvest handling, drying, and storage methods. Grain losses have been estimated to vary from 10 percent to almost complete destruction of the grains stored by the farmers, mainly depending upon the length of storage, and the types and form of grain storage methods employed. In addition to the quantity of grain loss, it is believed that considerable food grain quality loss is experienced in Tanzania. This is of vital importance to the subsistence level families because their daily nutritional requirements are extracted mainly from cereal grains.

Such a huge waste should be viewed with vital concern not only by the Government but also by the agricultural scientist and the public at large. This is particularly so when the domestic demand for food grains in Tanzania outstrips domestic production, due partly to the adverse weather conditions (drought) as in recent years. Moreover, the overall world shortage of food grains resulting in sky-high grain prices and difficulties in procurring food grain imports have further aggravated the food grain situation in Tanzania. The increased food grain imports in recent years, due to a short domestic supply in Tanzania, has put a tremendous strain on the foreign exchange reserve.

Currently, within the context of the Arush and Iringa Declarations, emphasis has been placed on increased food grain production through the use of production inputs, especially improved seeds, fertilizers, and chemical pest control measures. Practically no attention has been given to on-farm storage aspects. It is indeed ironic to spend sums of money on increasing production only to lose a substantial amount of grains produced through improper and inadequate storage methods.

Therefore, it should be immediately recognized that the improved on-farm grain storage programs are a vital necessity in Tanzania and should be an integral part of overall agriculture policy in the context of Arush and Iringa Declarations.

The following recommendations for the improvement of on-farm grain storage in Tanzania are made and based on personal observation, review of various reports, and private communications with personnel in various agencies in Tanzania. Where recommendations given cannot be met by government resources, it is suggested that further technical assistance and aid should actively be sought through USAID, FAO/UNDP, SIDA, CIDA and other international donor or lending agencies.

Institutional Improvement

1. It is recommended that a "Farm Storage Section" be established within the Crop Development Division, Ministry of Agriculture. The Farm Storage Section will be responsible for identifying, planning, formulating, implementing, and evaluating programs or projects in the areas of training, research, and technical service for the improvement of on-farm grain storage in Tanzania. It will also coordinate grain storage programs with other appropriate governmental

and inter-governmental agencies by gathering and disseminating technical information available in Tanzania and other countries.

The following is a list of some international organizations engaged in grain storage research:

a)* Tropical Stored Products Center (TPI), Slough, England

b)* FAO/African Rural Storage Center, International Institute of Tropical Agriculture, (IITA) Ibadan, Nigeria

c)* Tropical Agriculture Research Institute (IRAT), Paris, France

d)* Food and Feed Grain Institute, Kansas State University, Manhattan, Kansas, USA

e)* International Development Research Center (IDRC), Edmonton, Canada

f) International Rice Research Institute (IRRI), Los Banos, Phillipines

g) Indian Grain Storage Institute, Hapur, India

* Member of GASGA (Group for Assistance on Storage of Grains in Africa)

2. It is recommended that technical services of "Kilimo" not only cater to agricultural production problems but also to on-farm storage problems. The technical staff used for extending technical services dealing with agricultural production should also be used for extending improved storage techniques. Training materials for technical staff in on-farm and off-farm storage methods are available through members of GASGA (contact: Dr. Peter E. Wheatly, GASGA

Secretariat, Tropical Stored Products Center, Slough, England). Training aspects of extension staff will be discussed in a later section.

3. It is also recommended that research activities at the Agricultural Research Institute and Faculty of Agriculture, Morogoro, should include post-harvest grain handling, drying, and storage at the farm level. Personnel, facilities and equipment needs, location, and problem areas to be studied will be discussed later.

4. It is recommended that either Dr. D.F.P. Ringo, "Kilimo" or Mr. Mphuru, Faculty of Agriculture, University of Dar es Salaam be appointed as a member of National Crop Research Coordinating Committees for on-farm post-harvest grain handling, drying, and storage problems.

5. It is recommended that external technical assistance of a qualified grain storage specialist be made available for a period of 2 years to the Crop Development Division, "Kilimo", in an advisory capacity through USAID or FAO/UNDP. Such assistance is a vital necessity for the improvement of farm grain storage programs in Tanzania. Qualifications of such an adviser should include experience in agricultural economics, stored products entomology and agricultural engineering and familiarity with East African farm grain storage problems.

Training

As identified in the foregoing sections, only a very few qualified grain storage personnel are currently available in Tanzania. Successful training of well-selected Tanzanians, working with on-farm post-harvest problems, is

essential to "Kilimo"'s future activities in the improvement of grain storage on the farm. It is at this level that external assistance and aid is most needed.

a. Training of Dar es Salaam "Kilimo" staff

1. It is recommended that four carefully selected Tanzanians from "Kilimo" be sent to Kansas State University, Manhattan, Kansas, USA, to attend the 8-week Short Course on "Grain Storage and Marketing"held annually from mid-June to mid-August. This should be done within the next 2 years through USAID.

1976:	Two participants	1-agriculture background 1-agriculture economics background
1977:	Two participants	1-agriculture background 1-engineering background

2. It is recommended that these trainees be given the opportunity to observe and discuss grain storage research activities at TSPC, Slough, England; IDRC Farm Storage Project at Bambey, Senegal; and the FAO African Rural Storage Center at IITA, Ibadan before returning to Tanzania. A tentative prospectus, with a general outline of course content for the AID Grain Storage and Marketing Short Course annually held at Kansas State University, is included in the appendix as a reference.

b. Training of Agriculture Research Institute and Faculty of Agriculture, Morogoro researchers and instructors

1. It is recommended that post-graduate training, in post-harvest grain science, for six carefully selected Tanzanian individuals be obtained at Kansas State University through USAID within the next 4 years. Kansas State University has trained many foreign students specifically in post-harvest grain science under the USAID contract.

A summary of KSU experience in training students in post-harvest grain science is included in the Appendix as a reference.

Starting January 1976

- 1-Ph.D. candidate (possibly Mr. Mushi) for 3-year training (2 years on-campus for course work study and 1 year at the Faculty of Agriculture, University of Dar es Salaam for the field research): To be placed at Agriculture Research Institute.
- 1-M.S. candidate for training in cereal chemistry (2 years on-campus training): To be placed at ARI.
- 1-M.S. candidate for training in engineering (2 years on-campus training): To be placed at ARI.

Starting January 1977-1979

- 1-M.S. candidate for training in stored products entomology (2 years on-campus training): To be placed at Crop Development Division "Kilimo"
- 1-M.S. candidate for training in engineering (2 years on-campus training): To be placed at Faculty of Agriculture, Morogoro.
- 1-M.S. candidate for training in cereal chemistry (2 years on-campus training): To be placed at Faculty of Agriculture, Morogoro.

It is recommended that these trainees be given the opportunity to observe and discuss grain storage research activities at TSPC,

Slough, England, IDRC Farm Storage Project at Bambey, Senegal and FAO/African Rural Storage Center, IITA, Ibadan, Nigeria.

c. Training "Kilimo" extension staff

1. It is recommended that all "Kilimo" technical service staff be given every opportunity to attend an In-Country training course, such as "Grain Storage Pest Control" for East African countries. This course was organized by FAO/SIDA and held at Faculty of Agriculture, Morogoro in 1974. Two or three carefully selected "Kilimo" technical service staff should be given opportunities to attend a training course such as "African Rural Storage Seminar" held at FAO/African Rural Storage Center, IITA, Ibadan, Nigeria, February, 1975. The schedule of the above seminar is included in the Appendix as a reference.

2. It is also recommended that a short refresher course be held regularly in order to permit an exchange of experience and to maintain interest in grain storage problems and new solutions at Faculty of Agriculture, Morogoro.

d. Training field extension workers

It is recommended that "Kilimo" technical service and research staffs at Agricultural Research Institutes, who have had training in post-harvest grain technology, in turn, be responsible for training field extension workers. It is suggested that such a training course for field extension workers be offered at various Agricultural Research Institutes throughout the country at a time when grain storage problems are most acute.

e. Training college students at Faculty of Agriculture

It is recommended that a formal university course in post-harvest technology (handling, drying, storage and processing) be introduced within the agriculture curriculum at Faculty of Agriculture, University of Dar es Salaam, Morogoro.

It should be stated that training manuals and materials containing on-farm post-harvest technology are available through the members of GASGA.

Research

Through the last 29 years many investigators at international research organizations and universities in developed countries have studied various aspects of post-harvest grain science in order to develop improved post-harvest grain handling, drying, and storage methods under tropical and semi-tropical conditions. In most cases technical solutions to the problem are already worked out. Still many areas in post-harvest grain science under tropical conditions have to be worked out in order to develop economically feasible methods and solutions that can be readily adapted to local conditions. In the foregoing sections research projects to be conducted in Tanzania have been identified. Before such research projects are undertaken active recruitment of qualified grain storage specialists, post-graduate training of Tanzanians in post-harvest technology and upgrading of facilities, instruments and equipment needed for conducting scientific research at the Agricultural Research Institute and to some extent, at the Faculty of Agriculture, University of Dar es Salaam, Morogoro, are urgently needed.

1. Suggested research projects to be conducted in Tanzania are:

   a. Extensive surveys on grain quality and quality losses under various

traditional grain storage methods on the farms throughout the country.

b. Investigation to improve traditional storage structures and methods.

c. Investigation to develop a simple and inexpensive, non-traditional grain storage unit or method.

d. Investigation to develop effective pest control methods.

e. Investigation on effective and efficient post-harvest handling and drying methods that will be suitable to the subsistence level farmers.

f. Investigation to develop a simple and inexpensive method to determine grain moisture content with reasonable accuracy and precision that can be readily adapted by the farmers.

g. Investigation to develop a simple grading method (quality evaluation).

h. Investigation to improve nutritional value of a staple food for the subsistence level farmers.

i. Investigation on improved corn and rice milling yields.

It is suggested that economic analysis (cost-benefit ratio) of research findings be made after the studies.

2. It is recommended that development research on on-farm post-harvest problems be conducted at two locations, Milngano ARI (instead of Ilonga or Katrin) and Faculty of Agriculture, Morogoro. The reason for recommending Milngano ARI instead of Ilonga ARI is because of the most adverse weather conditions (Tanga area) for safe grain storage among major corn-producing regions in Tanzania. Therefore

if methods developed are effective or workable in this area, it is safe to assume that these would be effective in other major corn producing areas easily accessible to transportation and communication systems. Reasons for selecting Faculty of Agriculture are: availability of qualified personnel and student help; adequate facilities reasonably well equipped with research tools; availability of reference materials (library); reasonable assurance of continuing research activities; easy accessibility to good transportation and communication systems.

Research Staff at Milngano

- 1-senior research entomologist, (research leader) e.g. Mr. Mushi transferring from Ilonga (recommended for Ph.D. study at Kansas State University, see training section).
- 1-research engineer (to be trained for M.S. degree at KSU).
- 1-research cereal chemist (to be trained for M.S. degree at KSU).

At Faculty of Agriculture, Morogoro

- 1-senior research entomologist (research leader), e.g. Mr. Mphuru (to be trained for Ph.D. at University of Reading, England).
- 1-research engineer (to be trained for M.S. degree at KSU).
- 1-research cereal chemist (to be trained for M.S. degree at KSU).

<u>Equipment and Other Research Tools Needed</u>

At Milngano-

Vehicle (1), cleaning equipment, grain testing equipment (laboratory oven, moisture tester, balances, thermometers, thermocouples and potentiometer hygro-thermograph, sample probes, sieves, sieve shaker, Boerner sampler, weight-per-volume appartus, sample pans and cans, etc.)

microscope, vitascope, germinator, refrigerators, incubator; experimental corn and rice mills; equipment and instruments for protein, lipid and carbohydrate analyses; pest control equipment, etc.

Utility: gas and distilled water

Library: reference materials

At Faculty of Agriculture, Morogoro

Cleaning equipment, thermocouples and potentiometer, sample probe, sieves and sieve shaker, Boerner sampler, weight per volume apparatus, vitascope, experimental corn and rice mills, pest control equipment.

3. It is recommended that the external technical assistance of a qualified grain storage engineer be made available to two research locations for the period of 2 years, through either USAID or FAO/UNDP.

It should be noted that recommendations made for research proposals in the report will complement or supplement the pending project proposal on "Evaluation of Grain Storage Systems for Cooperatives, prepared by FAO/UNDP (12).

ACKNOWLEDGMENT

The author acknowledges with gratitude the generous help of the many persons and agencies contacted for information on on-farm grain storage and grain marketing in Tanzania during my 2 weeks' stay in Tanzania.

The author especially thanks Mr. D. Masanja, Director; Dr. S. C. Bhargava Senior Research Officer; and Mr. F. Owenya, Research Officer, Crop Development Division, Ministry of Agriculture, Tanzania for information, transportation and other services provided me through the Ministry of Agriculture while in Tanzania.

Also my sincere appreciation is expressed to Dr. Vernon Johnson, Director; Dr. Richard Podol, Assistant Director; Dr. H. C. Wiggin; and Mr. John Cornelius, USAID/Tanzania and other USAID/Tanzania personnel for their assistance and cooperation.

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APPENDIX

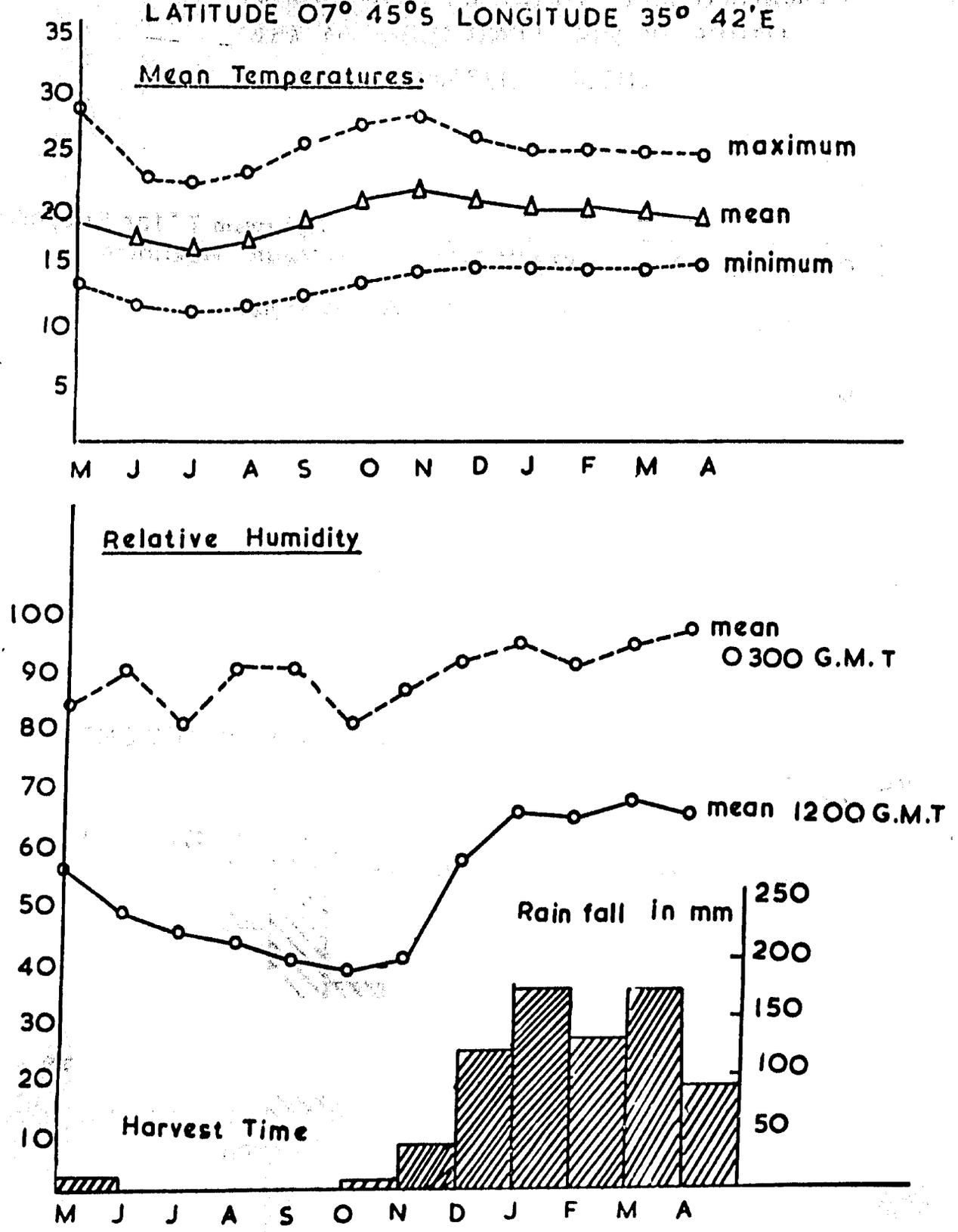
ITINERARY

April 27	Arrived in Dar es Salaam, Tanzania.
April 28	Discussed on-farm grain storage problems, TDY objectives and available information sources with Mr. D. Masanja, Director, and Dr. S. C. Bhargava, Senior Research Officer, Crop Development Division, Ministry of Agriculture, Tanzania, and Dr. Henry C. Wiggin, USAID/Tanzania. Visited with Dr. Henryk Podedwory, FAO/UNDP, FAO Country Representative in Tanzania. Obtained several reports on grain storage in Tanzania for review.
April 29	Visited with Mr. Peter M. Newhouse, Marketing Development Bureau, FAO/UNDP, Ministry of Agriculture, Tanzania. Obtained two reports on grain production and marketing systems in Tanzania for review. Reviewed available studies.
April 30	Visited with Mr. D. Masanja and Dr. S. C. Bhargava for field trip arrangement. Reviewed available studies.
May 1	May Day holiday. Reviewed available studies.
May 2	Drove to Morogoro with Mr. F. Owenya, Research Officer, Crop Development Division, Ministry of Agriculture. Visited briefly with Mr. A. N. Mphuru, Senior Lecturer (Entomologist), Faculty of Agriculture, University of Dar es Salaam, Morogoro, and Dr. John M. Liwenga, Chief Research Officer, Crop Development Division, Ministry of Agriculture, Tanzania.
May 3	Drove to Ilonga, Kilosa with Mr. F. Owenya. Visited with Mr. A. S. Hamad, Director and Mr. A. M. Mushi, Entomologist, Ilonga Agricultural Research Institute. Discussed extensively the on-farm grain storage problems in Tanzania and also observed the research activities of Mr. Mushi. Accompanied Mr. Mushi to Kilosa to observe on-farm grain storage, grain storage facilities (warehouses and metal bin) of National Milling Corporation, Tanzania, and a village corn mill. Obtained a few reference materials concerning on-farm grain storage in Tanzania from Mr. Mushi for review. Returned to Morogoro.

May 4	Sunday
May 5	Visited with staff members of Faculty of Agriculture, University of Dar es Salaam, Morogoro. Discussed extensively with Mr. Mphuru on-farm grain storage problems in Tanzania, teaching and research aspects of post-harvest grain science, with particular reference to on-farm grain storage. Obtained a few references from Mr. Mphuru for review. Returned to Dar es Salaam. Observed several farm storage conditions and inquired about farm storage problems of farmers enroute.
May 6	Discussed on-farm grain storage problems in Tanzania with Dr. Vernon Johnson, Director, and Dr. Richard Podol, Assistant Director, USAID/Tanzania; Dr. Henry C. Wiggin and Mr. John Cornelius, USAID/Tanzania. Reviewed reference materials obtained from a field trip.
May 7	Worked on report.
May 8	Accompanied Dr. S. C. Bhargava, Ministry of Agriculture, Tanzania to National Milling Corporation (NMC) Headquarters. Discussed NMC operations, KSU short course on grain storage and marketing, and possibility of technical assistance on operational and management aspects of NMC from KSU, with Mr. H. Shirelang, General Manager, NMC, Mr. Roger Newburn and Mr. Peter William, USAID/Tanzania TDY consultants for NMC. Worked on report.
May 9	Worked on report. Returned reference materials to Dr. Podedwory and Mr. Newhouse, FAO/UNDP.
May 10	Worked on report.
May 11	Sunday
May 12	Discussed the written report, with particular reference to recommendations, with Mr. D. Masanja, Dr. S. C. Bhargava, and Dr. H. C. Wiggin. Debriefing session with Dr. Richard Podol, Assistant Director, USAID/Tanzania, Dr. H. C. Wiggin, and Mr. John Cornelius, USAID/Tanzania. Left Dar es Salaam to return to U.S.

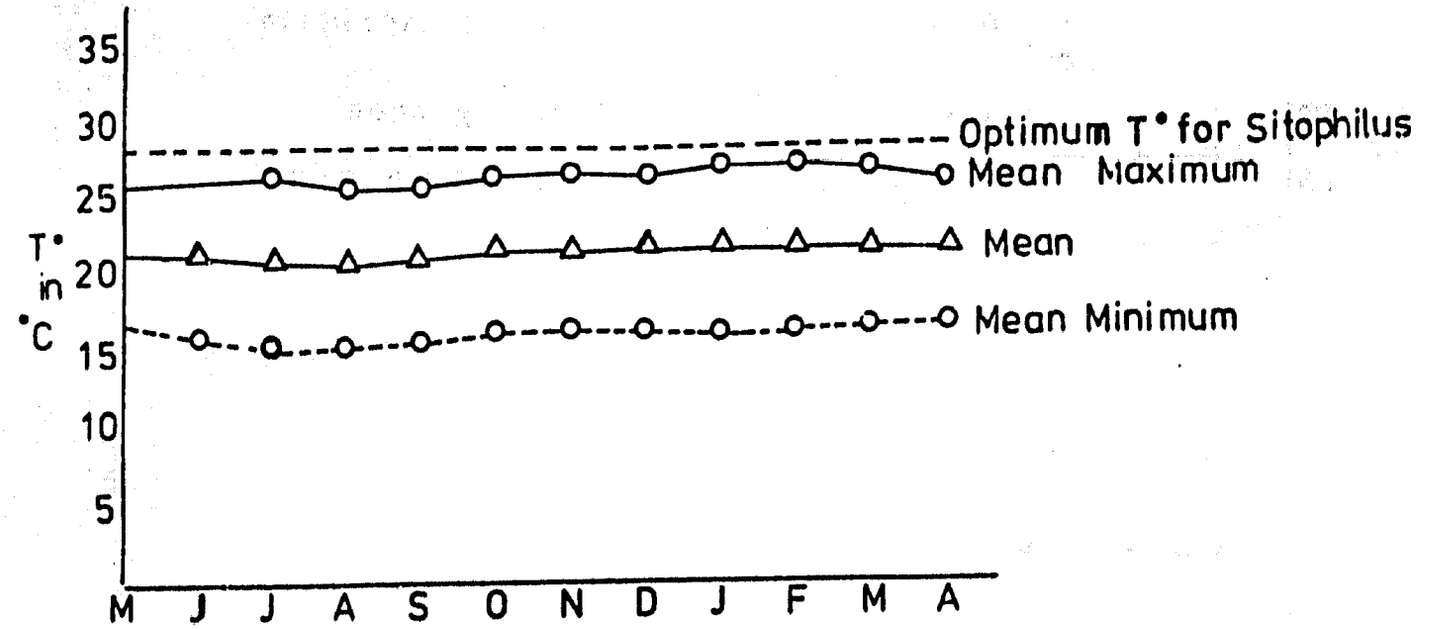
Appendix 2

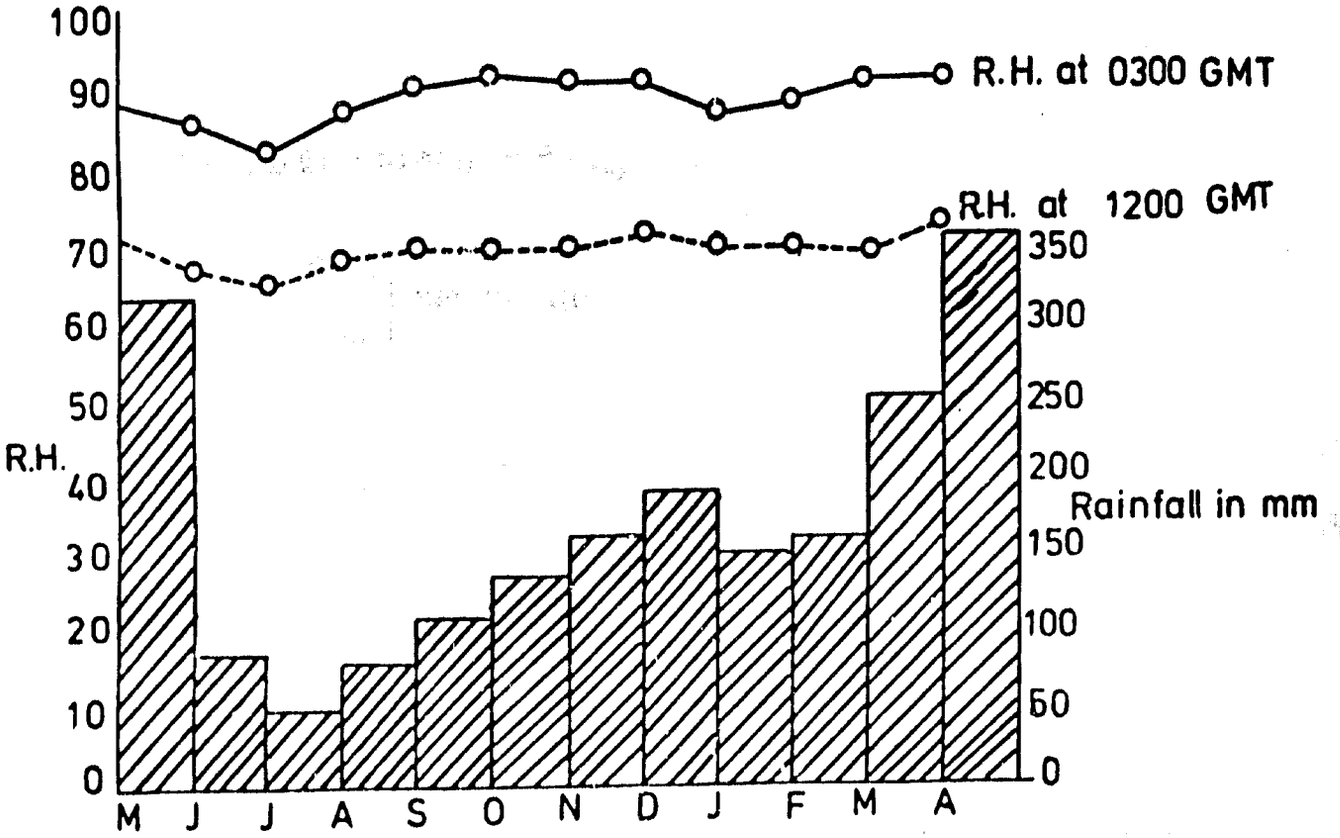
CLIMATOLOGICAL STATISTICS FOR IRINGA ALTITUDE 16.400m
LATITUDE 07° 45°S LONGITUDE 35° 42'E



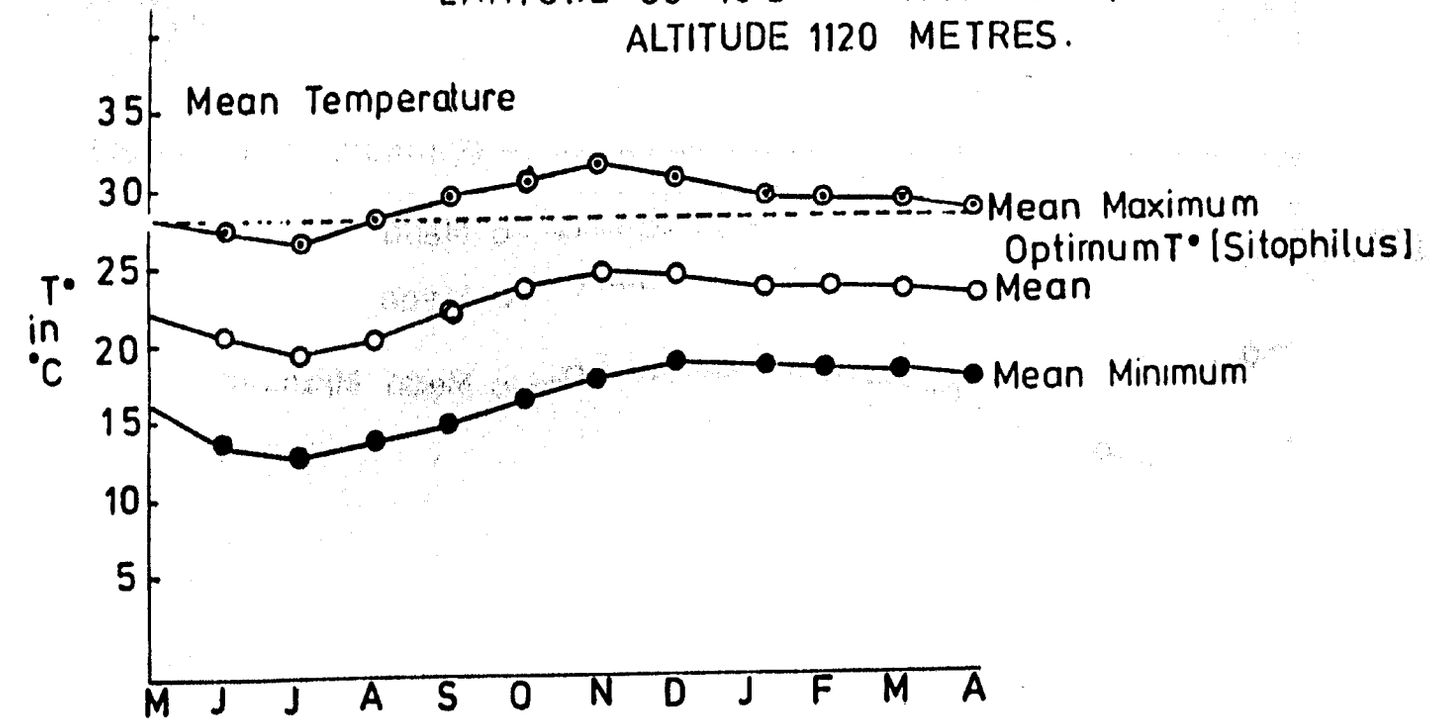
Source: Mr. Mphuru, Faculty of Agriculture, University of Dar es Salaam, Morogoro

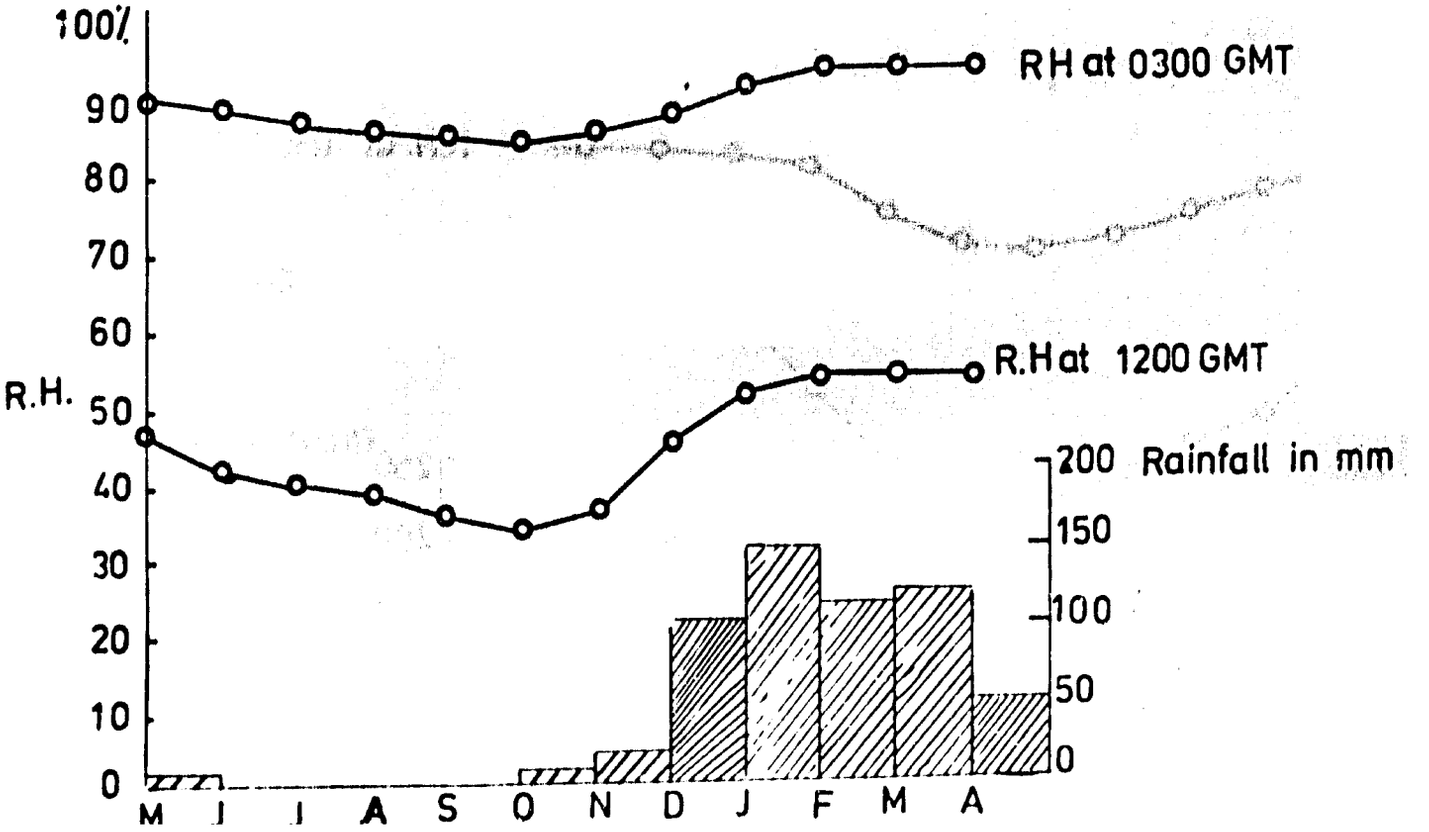
CLIMATOLOGICAL STATISTICS FOR BUKOBA
LATITUDE 01° 20'S' LONGITUDE 31° 45'E
ALTITUDE 1137 Metres



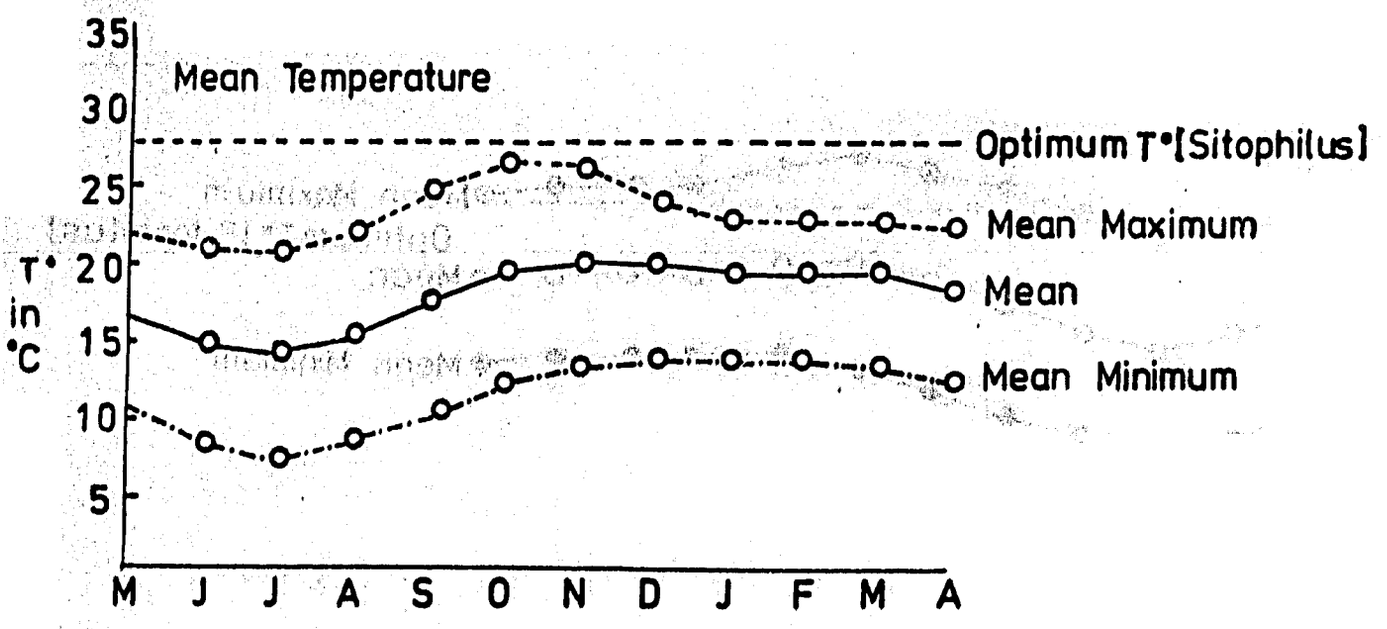


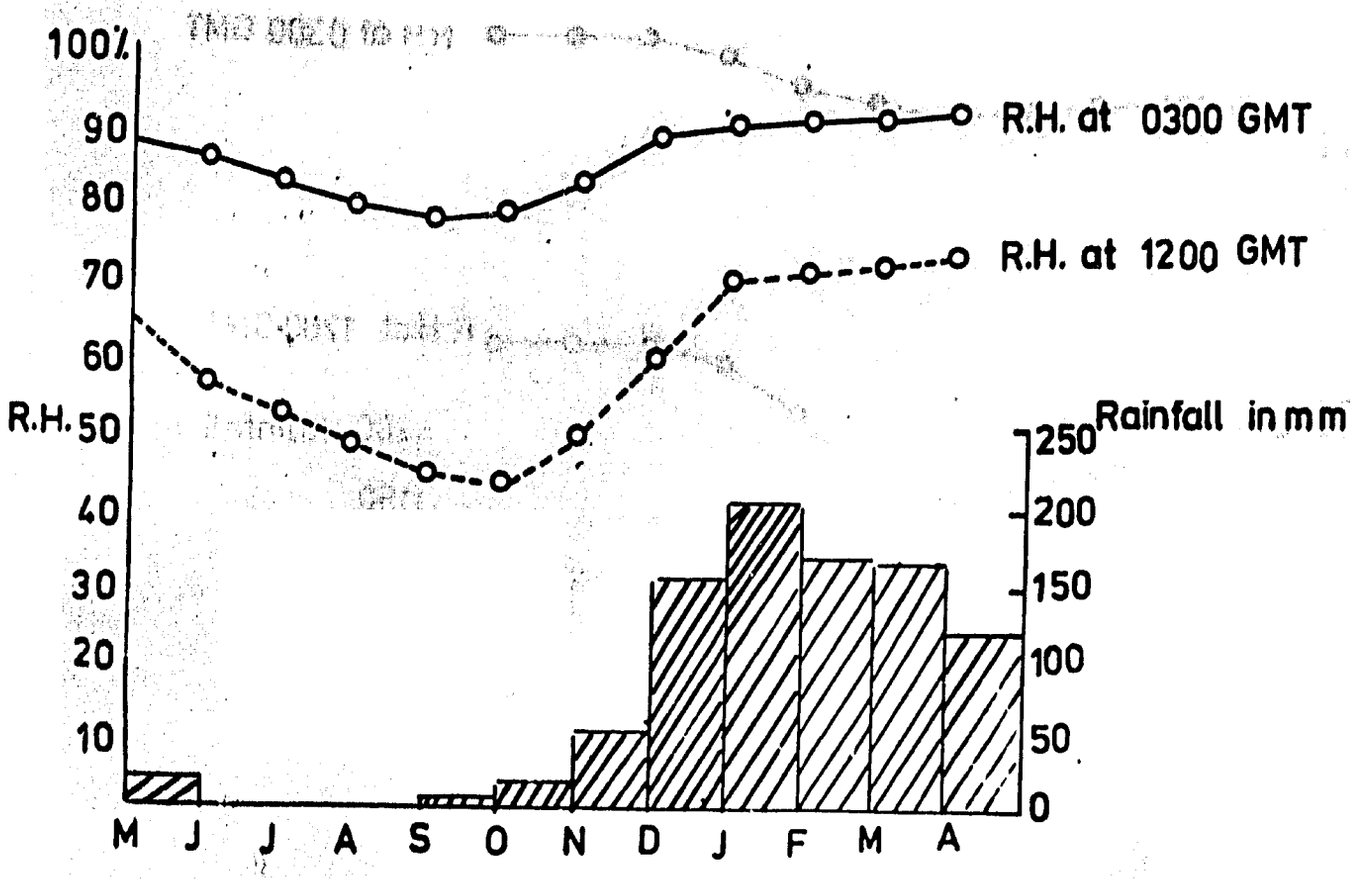
CLIMATOLOGICAL STATISTICS FOR DODOMA
LATITUDE 06° 10'S LONGITUDE 35° 46'E
ALTITUDE 1120 METRES.



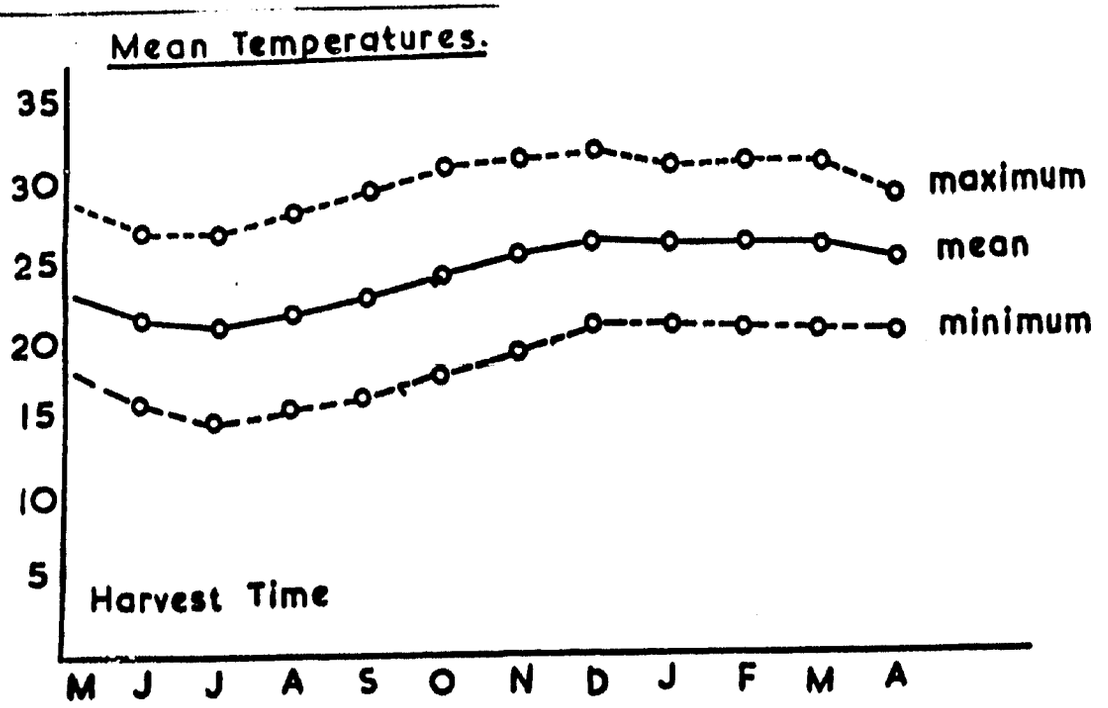


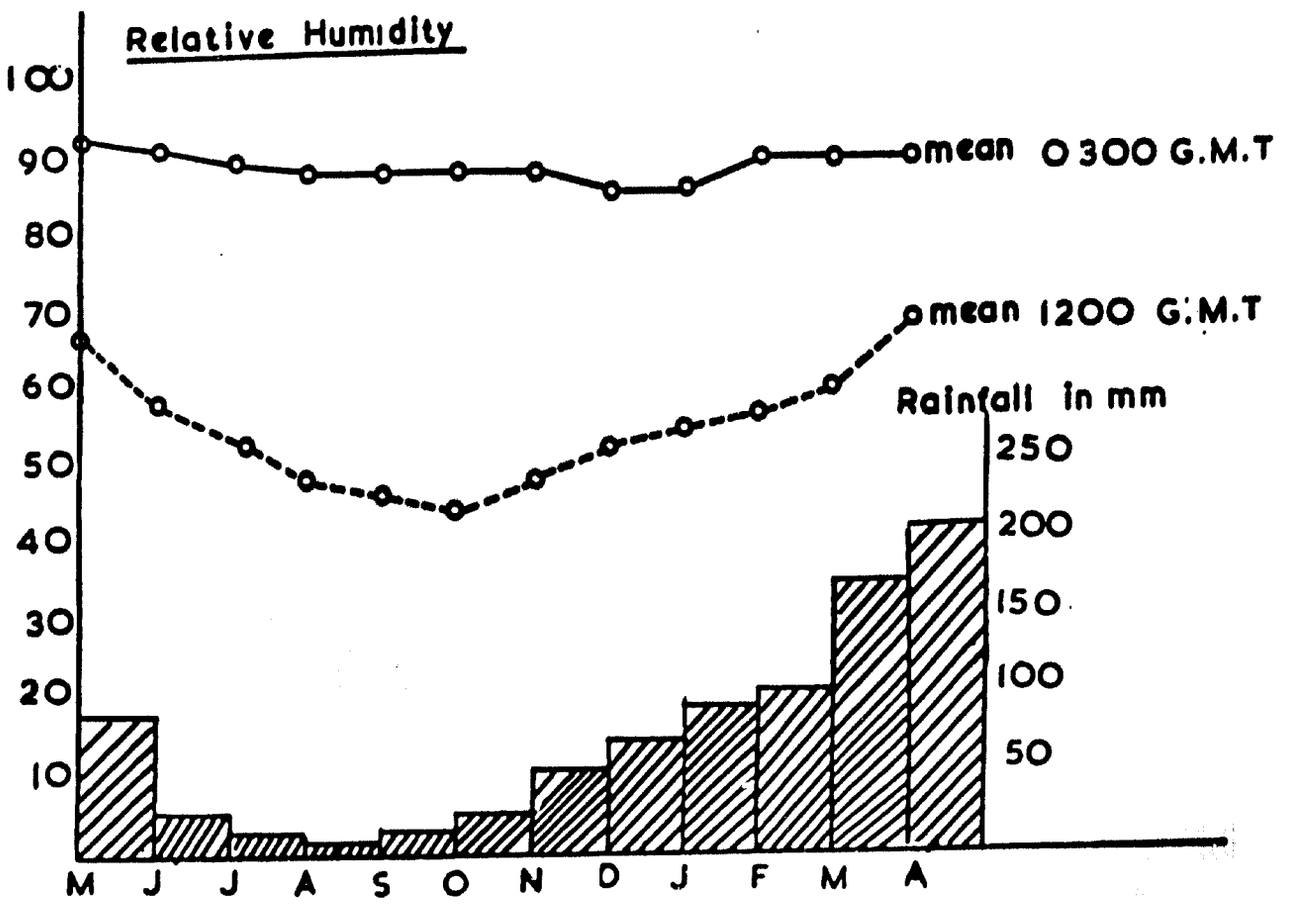
CLIMATOLOGICAL STATISTICS FOR MBEYA
LATITUDE 08° 56'S LONGITUDE 33° 28'E
ALTITUDE 1736 Metres





CLIMATOLOGICAL STATISTICS FOR MOROGORO ALTITUDE 570m
LATITUDE 06° 51'S LONGITUDE 37°E





TENTATIVE PROSPECTUS

USAID GRAIN STORAGE AND MARKETING SHORT COURSE - 1975

The Food and Feed Grain Institute, Kansas State University, is offering a Grain Storage and Marketing Short Course for AID participants and other interested individuals from developing countries under contract AID/csd-1588 technical assistance in food grain drying, storage, handling, transportation, processing and marketing.

The Short Course is tentatively scheduled to be held June 17 through August 10, 1975. This provides for a week of orientation in Washington, D.C., five (5) weeks intensive training on the KSU campus from June 24 to July 27, 1975, and a 2-week field trip to rice-producing areas and port facilities. The eight (8) week long course will have a limited enrollment of twenty-five (25) participants. Instruction will be in English with simultaneous Spanish translation, if justified. Participants will be accepted on a preregistration basis only.

Instruction will be directed at the warehouse and elevator manager or operator level rather than the administrator and will consist of lectures, discussions, laboratory work sessions, and field trips. Areas covered in the Short Course are shown on the attached outline (approximately 250 class hours).

Outlines, laboratory worksheets, manuals, and other materials and equipment needed for the Short Course will be provided; however, participants will be required to bring with them data and information on climate, topography, modes of transportation, crops, production, storage, and

marketing as it exists at present in their specific countries. The information is requested so that the participants can present a brief description of existing grain storage and marketing in their country to the group and provide for an exchange of ideas in group discussion. Participant Country Information Summary Manuals will be distributed prior to the Short Course. AID Missions should help the participants in assembling the required information.

Participants are required to provide transportation to and from Manhattan, Kansas, via Washington, D.C. Housing will be made available for participants in University dormitories. Meals will be provided and served cafeteria style. The charge for dormitory and three (3) meals per day (except Sundays, no evening meals) is $8.00 (2 men/room) or $9.75 (one man/room).* Linen and soap are provided. Participants are responsible for their own toilet articles. Appropriate per diem should be provided participants for approximately five (5) days' orientation in Washington, D.C., the five (5) week short course in Manhattan, two (2) weeks travel in rice areas and travel to and from the U.S. and any additional time the participant may be authorized spent in the U.S.

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* Prices may be subject to change.

GENERAL OUTLINE

Grain Storage and Marketing Short Course

I. Introduction to Course.

- A. Importance of Grain Storage and Marketing
- B. Purpose and scope of course
  1. Provide basic fundamentals of Grain Storage and Marketing
  2. Provide practical knowledge and techniques needed in Grain Storage and Marketing.

II. Review of Grain Production, Storage, Marketing and Utilization in Participants' Countries.

III. Fundamentals of Grain Storage.

- A. Grain kernel structure
- B. Moisture and its measurement
- C. Mold: moisture relationships
- D. Chemical, physical, and nutritive changes during storage

IV. Grain Inspection - Standards, Sampling, and Grading.

V. Grain Handling.

- A. Movement of grain
- B. Methods and facilities for conditioning grain
- C. Aeration - cooling of grain
- D. Grain drying - principles, types of drying, types of driers, and drier operation
- E. Equipment maintenance

VI. Storage.

- A. Storage methods and procedures
- B. Types of structures - farm, warehouse, and elevator storage
- C. Structural maintenance

VII. Sanitation Program.

- A. Inspection - methods and equipment
- B. Housekeeping - storage sites, structures and equipment
- C. Insect control - Biology and identification; physical, mechanical, and chemical methods; pesticide safety
- D. Rodent and bird control - biology, identification, and methods of control
- E. Microbial control - molds, mycotoxins, and control methods

VIII. Economics of Marketing Management and Operations.

A. Principles of management
B. Principles of operation
C. Organization of the grain business - business, financial, operational structure, and facilities planning
D. Facilitating grain operations - public warehousing, financing and rise, crop forecasting, price warehousing, financing and rise, crop forecasting, price reporting, standardization, and price differentials
E. Bookkeeping, accounting and inventory control
F. Government and marketing

IX. Field Trips to Demonstrate Classroom Instruction.

X. Laboratory Work Sessions to Complement Lectures.

A. Grain inspection
B. Moisture determination
C. Effects of grain drying and aeration
D. Insect identification
E. Demonstration of pest control methods
F. Business procedures and marketing analysis methods
G. Record keeping for warehouses and elevators
H. Assessment of grain storage and marketing economy

KANSAS STATE UNIVERSITY EXPERIENCE

Kansas State University is internationally recognized as a center for training in the various aspects of post-harvest storage, handling, protection, transportation, marketing, and processing of grains. The KSU Departments of Agricultural Economics, Agricultural Engineering, Entomology, Grain Science and Industry, and Plant Pathology have attracted students from many countries for study in the areas of post-harvest grain science. Members of their faculties have varied international experience and a broad understanding of grain storage and marketing problems world-wide.

In addition to the departments mentioned above, the Food and Feed Grain Institute at Kansas State University, at present, has a contract with the U.S. Agency for International Development to provide technical assistance in grain storage, processing and marketing and agribusiness development to developing countries throughout the world. Recently the Food and Feed Grain Institute, KSU became a member of GASGA in order to promote and coordinate its activities in Africa with other agencies. KSU also works cooperatively in the areas of post-harvest grain science with the recently established United States Department of Agriculture Grain Marketing Research Center located near the University campus.

a) Degree Programs

In addition to many foreign students who have been granted post-graduate degrees from various departments mentioned above, those trained specifically in post-harvest grain science under the USAID contract include:

> 4 Colombian students for elevator operation and maintenance under the Master's Degree program which included on-campus research and on-the-job training.

1 Grain Storage Technology Colombian (on-campus research for M.S.)

1 Brazilian (on-campus research for M.S. and on-the-job training)

1 Costa Rican (on-campus research for Ph.D.)

1 Philippino (in-country research for Ph.D. and on-the-job training)

1 Indian (on-campus research for M.S. and on-the-job training)

1 Taiwanese (on-campus research for M.S.)

1 Korean (on-campus research for M.S.) for grain storage technology

1 Ethiopian (on-campus research for M.S.)

1 Korean (on-campus research for M.S. and Ph.D.) and

1 Venezuelan (on-campus research for M.S. and Ph.D.) for grain marketing.

b) Non-Degree Programs

Under this category, many students from Korea, Japan, Taiwan and other parts of the world have been trained in the areas of post-harvest grain science with combinations of course work, research and on-the-job training. Currently, 16 special students from Iran, Iraq and Saudi Arabia are being trained in flour mill operation and maintenance with a combination of course work and on-the-job training.

c) Short Course

i) Intensive short course training at KSU under a USAID contract in grain storage, marketing and processing has been provided for about 140 participants from 22 countries (Africa--Ethiopia, Liberia, Nigeria; Asia--India, Indonesia, Japan, Korea, Nepal, Philippines, South Vietnam, Sri Lanka, Taiwan; Latin America--Argentina, Brazil, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Paraguay, Peru, Uruguay, Venezuela).

ii) USAID/USDA touring group short courses were provided at KSU for about 100 participants from 20 countries (Africa--Liberia, Morocco, Niger, Nigeria, Upper Volta, Zambia; Asia--Bangladesh, India, Indonesia, Korea, Malaysia, Philippines, Turkey, Pakistan; Latin America--Brazil, British Honduras, Colombia, Dominican Republic, Honduras, Nicaragua).

iii) In addition, project personnel under USAID contract have discussed various aspects of grain storage, marketing and processing with 14 AID-sponsored visitors from 10 countries and over 130 non-AID sponsored visitors from 20 countries.

iv) KSU staffs were involved in in-country training. These include: 1) one week Grain Sanitation Workshop for 24 Indian participants in India; 2) Grain Storage and Marketing Seminars in India (100 participants), Bolivia (40 participants), and Colombia (70 participants).

The need for trained persons to conduct research on the various aspects of grain storage and marketing in tropical and semi-tropical areas of the world cannot be over emphasized. There is the opportunity for individuals to obtain the training necessary to effectively conduct this research in a variety of locations and in a variety of forms throughout the world. The best solutions to the grain storage and marketing problems in tropical and semi-tropical countries will come from within the various countries themselves. It is hoped that organization such as represented by GASGA can supply a meaningful contribution to the training of individuals from the African countries.

FAO/AFRICAN RURAL STORAGE CENTER

First training/study tour

Revised Timetable (14/2/75)

Monday 24 February:	7:30	Registration of participants. Administrative matters/Evaluation techniques.
	9:00	Official Opening.
	9:30	Introductory Lecture - The nature, causes and extent of grain losses in the humid tropics.
	10:30-12:00	Insect and mould characteristics and identification.
	13:00-16:00	Sampling and Storage loss assessment techniques.
Tuesday 25 February:	7:30	Influence of moisture content Principles of crop drying Scope for natural drying Principles of artificial drying.
	10:00-12:00	Demonstrations - shelling and moisture determination - crib drying - sun drying - artificial drying.
	13:00	Insecticides and fumigants.
	15:00-16:30	Demonstrations - insecticide application - fumigation - rodent control
Wednesday 26 February:		
	7:30-10:00	Storage - crib, in-sack, air tight, concrete, metal silos and mud silos
	10:00-12:00	Demonstration of above

Wednesday 26 February:

13:00-16:30 — Group Practicals

Group A - Sampling, shelling, moisture determination (field).

Group B - Loss assessment.

Group C - Artificial drying.

Thursday 27 February:

7:30-11:00 — Group Practicals

Group C - Sampling, shelling

Group A - Loss assessment

Group B - Artificial drying.

13:00-16:30 — Group Practicals

Group B - Sampling, shelling

Group C - Loss assessment

Group A - Artificial drying.

Friday 28 February: Group Practicals

	Fumigation	Crib Construction Loading & insecticides	Storage System
a.m.	Group A	Group B	Group C
p.m.	Discussion - course progress, evaluation, etc.		

Monday 3 March: Group Practicals

	Fumigation	Crib Construction Loading & insecticides	Storage System
a.m.	Group C	Group A	Group B
p.m.	Group B	Group C	Croup A

Tuesday 4 March: Excursion

a.m. Ilaro Farm Settlement - storage

p.m. Badeku and Oshun

Wednesday 5 March: **Special sessions and discussions**

e.g. Rice processing (Sierra Leone participants)

Artificial drying

Stored Products insects and control

Moulds

Concrete silo construction and management (Please submit your requirements by Friday 28/2/75)

Thursday 6 March:

8:00-10:00	Group A - Mr. Rockwood (Extension-French)
	Group B - Dr. Jellema (Economics - English) & C
10:30-12:00	Prepare notes on farm storage patterns by country.
13:00-16:30	Discussion of country submissions
	Group A - French
	Group B - English. & C

Friday 7 March:

8:00-10:00	Group A - Dr. Jellema (Economics - French)
	Group B - Mr. Rockwood (Extension - English) & C
10:30-12:00	Joint session on country submissions.
13:00	Courses evaluation and conclusions.

LIST OF ABBREVIATIONS

ARI	-	Ilonga Agriculture Research Institute, Tanzania
CIDA	-	Canadian International Development Agency
FAO	-	Food and Agriculture Organization, Rome
GASGA	-	Group for Assistance on Storage of Grains in Africa
IDRC	-	International Development Research Center, Canada
IITA	-	International Institute of Tropical Agriculture, Ibadan, Nigeria
IRAT	-	Institut Recherches Agronomique Tropicale, Paris
IRRI	-	International Rice Research Institute, Philippines
NMC	-	National Milling Corporation, Tanzania
SIDA	-	Swedish International Development Agency
TPI	-	Tropical Products Institute, London
TSPC	-	Tropical Stored Products Center, Slough
UN	-	United Nations
UNDP	-	United Nations Development Programs