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A POINTED COLLECTION OF ZERA-ZERA SORGHUMS IN THE GAMBELLA AREA OF ETHIOPIA

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C O N T E N T S

A POINTED COLLECTION OF ZERA-ZERA SORGHUMS IN THE GAMBELLA AREA OF ETHIOPIA

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SUMMARY

1. 'Zera-zera' sorghums belonging to the race 'caudatum' and intermediate race 'caudatum-guinea' are used extensively in several Sorghum Improvement Program These are highly prized for their yield, grain quality and resistances to diseases and drought.

2. A pointed collection was organised in the Gambella region of Ethiopia where Zera-zera sorghums are extensively grown on the bank of river 'Baro' after the receding of floods. 'Agnwak' tribe farmers are exclusively associated with the cultivation of Zera-zeras in this area.

3. The geographic distribution of 'Zera-zera' sorghums in the Ethio-Sudanese border suggests their predominance in this region. The ethnic relationship of the sorghum growing tribe 'Agnwak' their relatively close resemblance of food habits with the people on the Sudan border and their unrestricted movement supports this.

4. Sorghums belonging to the group Zera-zera, are locally named mainly as 'Ganga', 'Juwalum' and 'Utedit'. Plants are agronomically superior, with attractive heads and good grain quality. Plants are tan and practically free from diseases inspite of the high temperatures and humidity prevailing during seed setting. This suggests their possible utilization as source material in the breeding projects for yield, grain quality and resistances for grain moulds and leaf diseases.

5. Most of the samples collected are from crops grown after the receding of floods with the residual moisture under high atmosphere temperatures. It is reasonable to assume that some of the lines may be heat tolerant.

6. Since the season and cultivation of Zera-zeras somewhat correspond to the rabi (post rainy season) situation in India, some of the lines could directly enter into the 'rabi program' breeding project.

7. In general the present collection forms a good addition to the existing few Zera-zeras and provide a broad genetic base to work with in the breeding progr

8. As in the case with other Zera-zeras the only restriction for their easy flow into improvement programs may be their photoperiod sensitivity. To circumvent this, some of the Zera-zeras will soon be converted by including in the 'Introgression and Conversion Project'.

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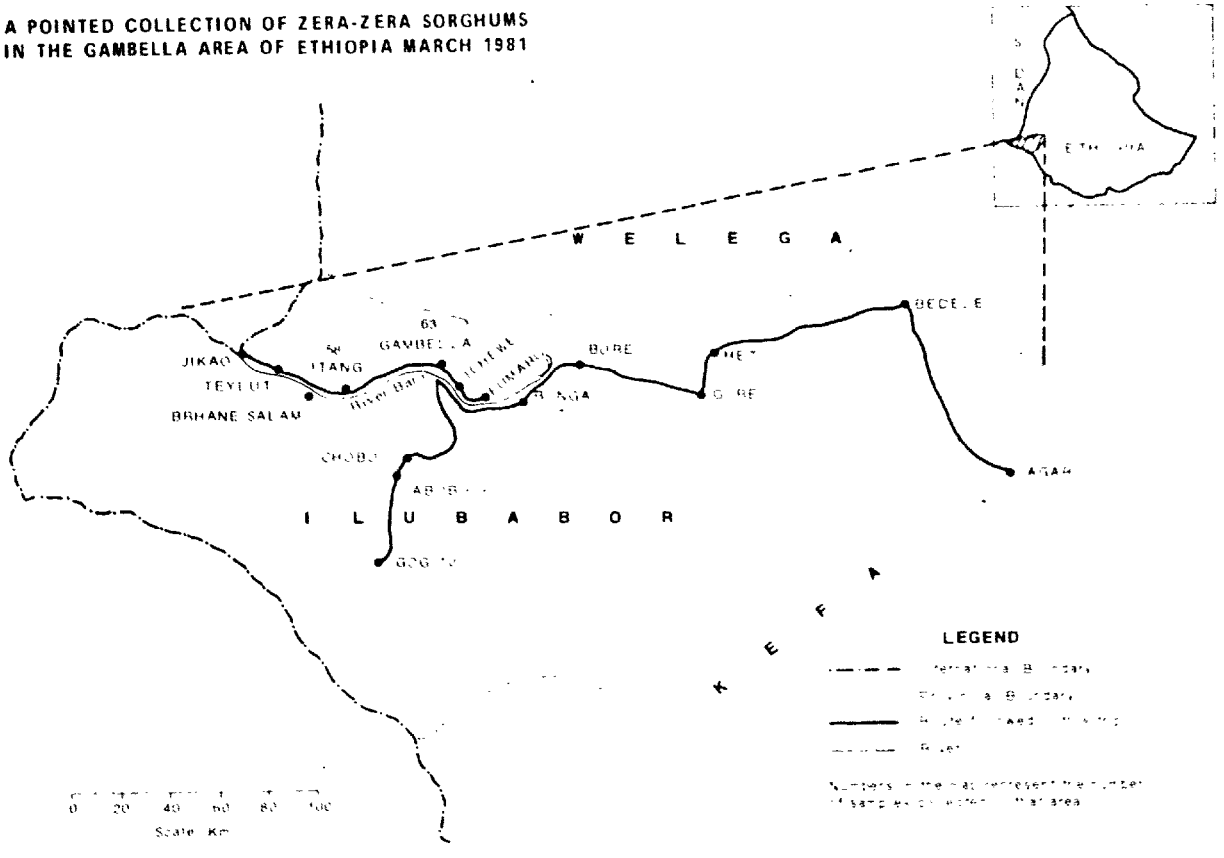


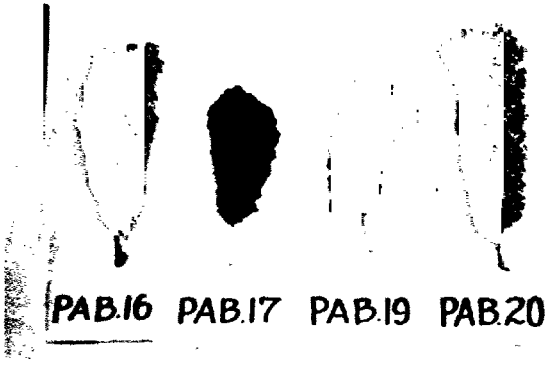


Fig. 1.

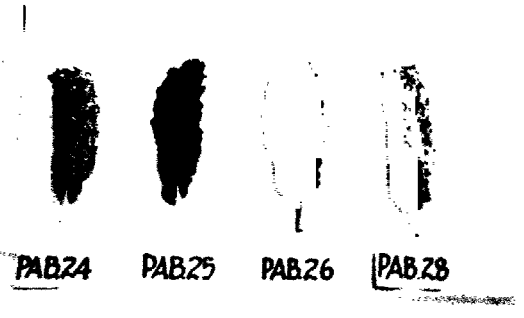


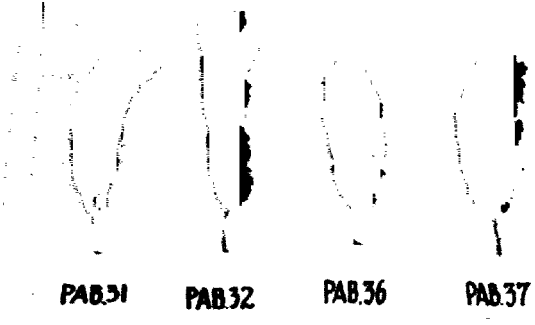
Fig. 2.

Fig. 1. PAB-16 Ganga Guinea-caudatum (Zera-zera)
PAB-17 Uluwale Guinea-caudatum
PAB-19 Utire Guinea-caudatum
PAB-20 Ganga Guinea-caudatum (Zera-zera)

Fig. 2. PAB-24 Bailo Guinea-caudatum (Zera-zera)
PAB-25 Atwol Caudatum
PAB-26 Uluwale Caudatum
PAB-28 Udogie Guinea-caudatum (Zera-zera)

Fig. 3. PAB-31 Atorkuba Guinea-caudatum
PAB-32 Atorkuba Guinea-caudatum
PAB-36 Juwalum Guinea-caudatum (Zera-zera)
PAB-37 Udok Guinea-caudatum

The dark bar in the figures represents a scale of 30 cm.



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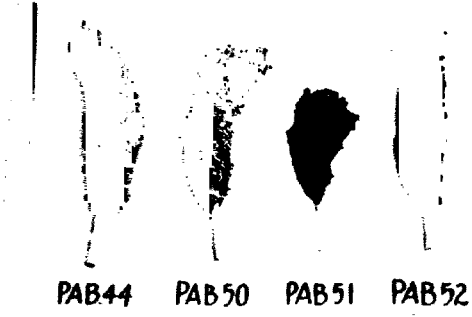

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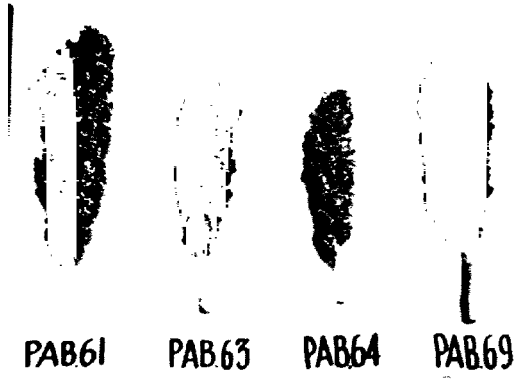


Fig. 5.

Fig. 6.

Fig. 4.	PAB-44	Ganga	Guinea-caudatum (Zera-zera)
	PAB-50	Dibao	Guinea-caudatum
	PAB-51	Agada	Caudatum-bicolor
	PAB-52	Nvaluwal	Guinea-caudatum
Fig. 5.	PAB-61	Juwalum	Guinea-caudatum (Zera-zera)
	PAB-63	Udogie	Guinea-caudatum
	PAB-64	Niddo	Guinea-caudatum (Zera-zera)
	PAB-69	Alangua	Guinea-caudatum
Fig. 6.	PAB-71	Bello	Guinea-caudatum (Zera-zera)
	PAB-72	Gudong	Guinea-caudatum
	PAB-76	Nyogega	Guinea-caudatum (Zera-zera)
	PAB-79	Ganga	Guinea-caudatum (Zera-zera)

Fig. 7.

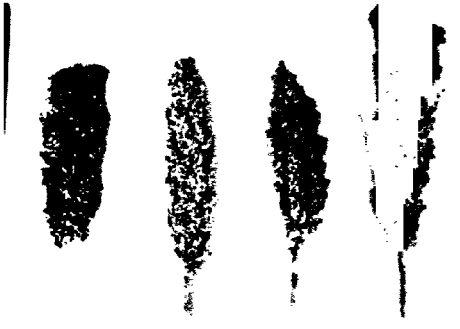


Fig. 8.

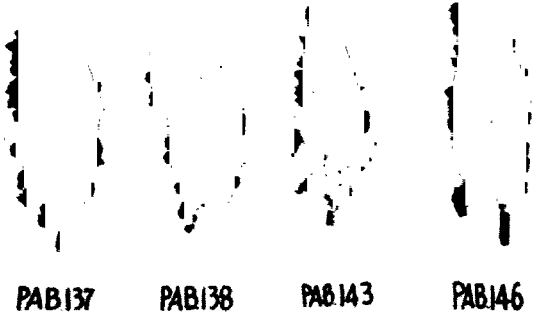


Fig. 7.	PAB- 93	Bangabong	Guinea-caudatum
	PAB- 94	Utir	Guinea-caudatum
	PAB- 96	Agira	Guinea-caudatum (Zera-zera)
	PAB- 98	Tungo	Guinea-caudatum
Fig. 8.	PAB-113	Atwal	Guinea-caudatum
	PAB-120	Wabau	Guinea-caudatum
	PAB-123	Fettie	Guinea-caudatum (Zera-zera)
	PAB-127	Nivati	Guinea-caudatum (Zera-zera)
Fig. 9.	PAB-137	Waterno	Guinea-caudatum
	PAB-138	Akuwa	Guinea-caudatum
	PAB-143	Chale	Guinea-caudatum
	PAB-146	Alongo	Guinea-caudatum

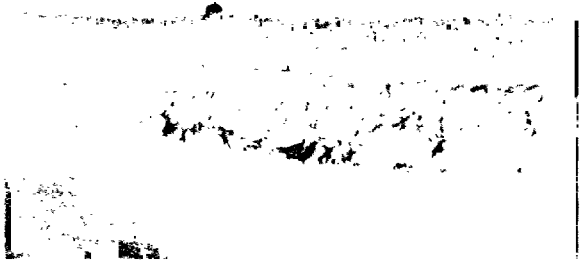


Fig. 10.

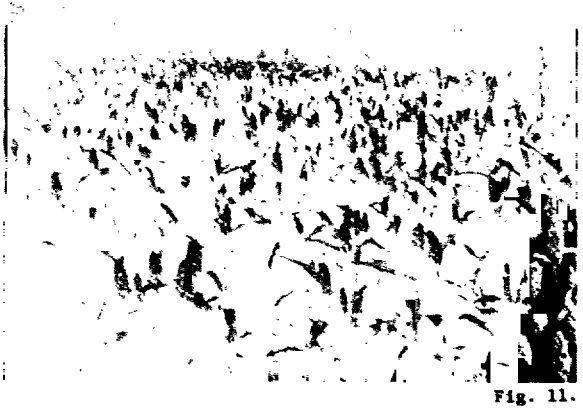


Fig. 11.

Fig. 12.

Fig. 10. Sorghum cultivation by 'Agnwak' tribe on the bank of river 'Baro'

Fig. 11. A field of Zera-zera sorghum

Fig. 12. Samples of 'Zera-zera' sorghums sold in the Gambella market

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 13. Agnwak farmer holding head samples of Zera-zera sorghum.

Fig. 14. Smoking the heads (left) is the usual practice of seed preservation in the Gog area.

Fig. 15. 'Abot' is a preparation made by boiling green sorghum grain with water and salt.

INTRODUCTION

'Zera-zera' is the name of a landrace of sorghum distributed in the eastern region of Sudan (Prasada Rao and Mengesha 1979). Plants belonging to this race are medium tall with tan colour which makes them look particularly clean in the field. Grain shape is of 'Caudatum' type. Glumes are short mostly ivory yellow to cream in colour. Sometimes a very light-red tinge is also seen. Grain colour is yellow, cream or dull white. Endosperm highly corneous and flinty and white to yellow in colour; subcoat not coloured; grains easily separable from glumes.

The name Zera-zera was originally given by Sudanese farmers to a few landraces cultivated in the South-Eastern part of Sudan. Later on the same name was adopted by Dr. B.R. Murty and associates to describe and classify a number of closely resembling landraces which were grouped under the name, Zera-zera (Murty et al, 1967). There are other landraces in Sudan like 'Nyithin' (IS-3541), 'Wad Bashir' (IS-6928), 'Tarana' (IS-6991) that are also classified into 'Zera-zera' group because of their close morphological resemblence. Some of the landraces distributed in the Gambella area of western Ethiopia bordering Sudan also exhibit similar morphological characteristics and are presently included into the group 'Zera-zera'. Gambella 'Zera-zeras' closely resemble the Sudan 'Zera-zeras' except for their slightly bigger grain size and lesser opening of their glumes. These could be classified as 'caudatum-guineas' (Harlan 1972).

Zera-zera sorghums were used and are being used extensively in various sorghum improvement programs for their agronomic desirability, superior grain quality and tolerance to diseases and drought. Interestingly E-35-1 (a selection from E-35, a Zera-zera from Gambella, Ethiopia) is being introduced on farmer's fields in Upper Volta after its successful performance in trials (ICRISAT Annual Report 1978-79).

The following are some of the Zera-zera sorghums or Zera-zera based lines extensively used as source material in the current sorghum improvement programs.

S.No.	Accession	Pedigree	Importance
1	CS-3541 (IS-18484)	A converted line of IS-3541 (Nyithin) from Sudan	1. Released as a variety by the AICSIP[1/] (CSV-4) 2. Good source for grain quality, grain mould resistance charcoa. rot resistance.
2	SC-108-3 (IS-18522)	A converted line of IS-12608 from Ethiopia	Good source for increasing yield grain quality, grain mould resistance and charcoal rot resistance.
3	SC-108-4 (IS-18523)	- do -	Good source for grain mould resistance, charcoal rot resistance.
4.	E-35-1 (IS-18758)	Medium photosensitive selection of E-35 from ESIP, Ethiopia	Good source for grain quality, grain mould resistance.
5	E-36-1	Medium photosensitive selection of E-36 from ESIP[2/], Ethiopia	Good source for charcoal rot and drought resistance.

1/ All India Coordinated Sorghum Improvement Project, India.

2/ Ethiopian Sorghum Improvement Project, Nazreth, Ethiopia.

S.No.	Accession	Pedigree	Importance
6	E-12-5	Selection from E-12 from ESIP, Ethiopia	Source for grain mould resistan
7	IS-956	Collection from Sudan	Source for grain mould resistan
8	IS-2327	'Thok Grey' a collection from Sudan	Source for grain mould resistan
9	IS-2328	'Malwal' a collection from Sudan	Source for grain mould resistan
10	IS-3443	'Achigo' a collection from Sudan	Source for charcoal rot resistance.
11	IS-3574 C (IS-18842)	A converted version of IS-3574 (Zera-zera) from Sudan	Source for headbug resistance
12	IS-6928	'Wad Bashir' a collection from Sudan	Released as a post-rainy season variety by the APAU[3/], under the name 'Moti'.
13	IS-12611	Collection from Ethiopia	Source for grain quality and drought resistance.

Based on the tremendous importance of the material, the IBPGR Advisory Committee on Sorghum and Millets had made a special recommendation for an intensive collection of 'Zera-zera' sorghums in the Sudano-Ethiopian border. Accordingly a collection mission was organized in Eastern Sudan by the ICRISAT in collaboration with the Ministry of Agriculture, Government of Sudan and the IBPGR in 1979 and a good number of Zera-zeras were collected (Prasada Rao and Mengesha 1979). The white Nile river side area which is also supposed to be a potential area for Zera-zera (personal communication with Prof. Ali Kambal) could not be collected last year because of acute shortage of fuel. If funds and facilities are available it is worth exploring the area near Junglea river before the new irrigation projects come and push the sorghum out of cultivation.

3/ Andhra Pradesh Agricultural University, Rajendranagar, India.

Although the Ethiopian National Sorghum Program collected about 5,000 accessions in the country, the Gambella area bordering Sudan was given little attention. This has necessitated to organise the present mission in collaboration with the ESIP and PGRC[4]/E and to make a pointed collection of landraces in the Gambella area especially the Zera-zera sorghums.

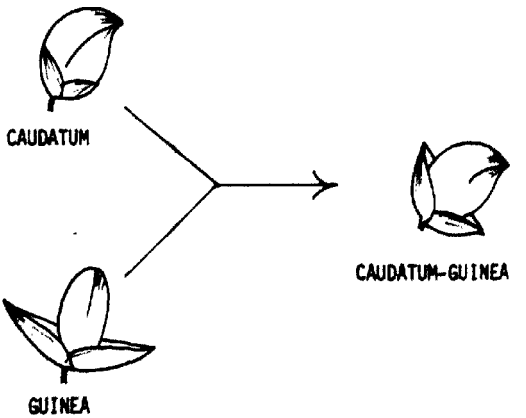
DISTRIBUTION OF ZERA-ZERA SORGHUMS
IN THE ETHIO-SUDAN BORDER

Sorghums belonging to the group Zera-zera come under the basic race Caudatum or the intermediate race Guinea-caudatum. Caudatum is an important race in Nigeria, Chad, Sudan and Uganda and it is a minor race in Ethiopia (Harlan and Stemler 1976). Caudatums are sparsely distributed in the highlands of Ethiopia A few durra-caudatums were noticed around Kobo and some nigricans types were seen in the border areas of Wollo and Shoa provinces (Prasada Rao 1976). It is only in the Gambella area (which is ecologically isolated) where a good number of caudatums and half caudatums are noticed. Caudatum growers in the Gambella area of Ethiopia mainly belong to the tribe 'Agnwak' which is predominant in this area.

'Agnwak' farmers grow sorghums on the banks of the rivers and they do not tend cattle at all because of 'Tse-tse fly' problem. On enquiry, it was revealed that 'Agnwak' tribals of this area have relations with people in Sudan side and there is movement of people across the border without much restriction. 'Agnwaks' generally stay in the lowlands. This could be one of the possible reasons for the limited movement of caudatums into the highlands of Ethiopia. In addition the altitude difference acts as a major ecological barrier.

4/ Plant Genetic Resources Center/Ethiopia.

There is some evidence suggesting that caudatum sorghums may have moved to Gambella area from Sudan side. During the course of their movement few changes could have occurred in the spikelet morphology. Zera-zeras of Sudan are more or less pure caudatums with clasping glumes whereas Zera-zeras of Gambella are mostly 'Caudatum-guineas' with slight opening of glumes and bigger grain size. These changes might have occurred as a result of introgression of guinea sorghums distributed in the Southern Sudan (Kambal's collection from Southern Sudan contained several guineas) or due to mutation followed by selection for these two characters. The open glumed characteristic seem to be advantageous in the Gambella area because of the higher rainfall (1270 mm) and humidity thereby preventing grain weathering.



PLANNING AND ORGANIZATION OF THE MISSION

In realization of the danger of germplasm erosion and in view of the immediate utility of Zera-zeras, a pointed collection expedition was organised in the Gambella area of Ethiopia in collaboration with the Ethiopian Sorghum

Improvement Project (ESIP) and the Plant Genetic Resource Center (PGRC), Ethiopia and also the IBPGR. Detailed planning was made by Dr. M.H. Mengesha, Leader, Genetic Resources Unit, ICRISAT in consultation with Dr. Brhane Gebrekidan, Leader, Ethiopian Sorghum Improvement Project, Nazreth and Dr. Melaku Worede, Director, PGRC, Addis Ababa, Ethiopia.

Before starting the expedition Mr. K.E. Prasada Rao had a detailed discussion with the officials of PGRC and ESIP on the exact areas to be covered. It was stated that one collection mission to Gambella area was infact attempted sometime back but could not be organized successfully. Since then, Gambella area was left unexplored for the collection of sorghum germplasm.

The collection team of the present mission consisted of the following persons:

1. Mr. K.E. Prasada Rao; Botanist, GRU, ICRISAT, India
2. Ato Abebe Menkir, ESIP, Nazreth, Ethiopia
3. Ato Brooke Abebe, PGRC, Addis Ababa, Ethiopia
4. Ato Mohammed Hussain, IAR, Gambella, Ethiopia
5. Ato Hailu Haile Marium, Driver, PGRC, Addis Ababa, Ethiopia

The route followed and areas collected are shown on the map. The present mission turned out to be most successful because of advance planning and excellent cooperation and support received from ESIP, Nazreth, PGRC, Addis Ababa and IAR, Gambella. The mission was launched exactly in time especially for the collection Zera-zera sorghums.

GAMBELLA AREA OF ETHIOPIA

Gambella is the largest awraja (region) in Illubabor province. Gambella town is located at a distance of 820 km from Addis Ababa. With its 24,000 km^2 land area Gambella awraja takes just over half of the total area of Illubabor. The topography is nearly uniformly flat with an altitude of around 500 meters. The land and soils are of three different types - river bank, swamp, and upland. The river bank is the seasonally flooded narrow strip of land (20-50 m wide) which is almost entirely cultivated. The swamp lands are just beyond the river bank and mostly not cultivated. Still further away from the river is the upland area. This constitutes about 80% of the land area in Gambella which is mostly forest with wooded grass lands. 'Baro' is the major river in this area. There are two other small rivers, 'Siru' and 'Aloro'. The soils of river banks are alluvial in which the plant nutrients are replenished every year by floods. Soils of upland area are sandy loams. The actual bank of 'Baro' river is covered by a lush growth of small trees and bushes.

Among the natural vegetation Capparidaceae, Acacia brevispica, Phragmites spp., Saccharum spontaneum, Beckeropsis sp. and Panicum maximum are most common. These plants are often densely covered by a variety of climbers including species of Cucurbitaceae (especially Luffa) Convolvulaceae and Leguminosae. There are two major weeds. One is a grass, Rottboellia exaltata which has irritating hairs and the other, a spiny herb Hygrophila auriculata. The latter however is economically important. The plants are collected, burnt and salt is extracted from the ashes.

Rainfall in Gambella is unimodal with a long-term mean of 1,270 mm which falls between April and November. Gambella is one of the hottest areas in Ethiopia with a maximum temperature of 44°C recorded in the months of March and April.

Rainfall, temperature and relative humidity in the Gambella area is shown below:

Month	Rainfall (mm) (long term mean)	Temperature maximum centigrade		Temperature minimum centigrade		Relative humidity (3 (long term mean)
		Mean	Highest	Mean	Lowest	
January	6	36.8	41.0	18.2	11.0	55
February	11	37.6	42.0	19.7	9.0	50
March	34	38.5	44.0	21.3	12.4	49
April	82	36.8	44.0	22.0	14.9	61
May	160	33.6	40.0	21.4	14.5	74
June	174	31.8	39.5	20.7	14.9	79
July	224	30.7	36.0	20.4	16.5	83
August	243	30.8	37.0	20.3	16.0	85
September	180	31.7	39.0	20.1	16.6	78
October	95	33.4	40.0	19.6	13.4	72
November	48	34.6	39.4	18.9	15.0	66
December	13	35.8	41.0	18.3	12.0	59

(Source: Progress Report of Institute of Agricultural Research, Gambella Experiment Station December 1975.

CULTIVATION OF CROPS IN GAMBELLA

The sedentary agriculture that is practiced by the people is primarily based on the hoeculture with sorghum, maize, cowpea, mango and banana as dominant crops. Land holdings are very small often below a hectare for each house hold. Unlike to many other parts of Ethiopia, the use of animal drawn implements is least practiced, in Gambella. In the recent past a large percentage of the people of Gambella were herders of cattle. Currently however, especially on the upper part of the river 'Baro', cattle have been virtually wiped out by 'tsetse fly'.

Traditionally, only the alluvial soil on the river bank is cultivated where maize is mainly sown in April/May and harvested in September, before the river floods. The bank vary from a few to about 200 m in width averaging about 50 m. Sorghum is not cultivated in the rainy season probably because of higher disease incidence and heavy attack of Quelea birds. In addition, heavy rain during maturity affects the grain quality of sorghum besides causing lodging of the crop. Sorghum is grown on the residual moisture after receding of the floods. The remains from the previous crop is used as mulch. Ten to twenty seeds are dropped in each hole at a distance of 1m. Four to five plants are left after thinning. Intercultivation and manuring are not practiced. This practice prevails only between Gambella and Brhane Salaam. The areas between Brhane Salaam and Jikao are not planted with sorghum. These areas are inhabitated by 'Nuers' who are seminomads and primarily cattle herders. They plant maize instead of sorghum mainly because of shortage of man power required for bird scaring.

In the upland area of Abobo and Gog, sorghum is planted in May and harvested in September-October. The same is true with Bonga area. Traditionally, farmers keep their seed of best selected heads attached to the ceiling of the huts where they live and expose them to smoke in order to avoid weevil damage (Fig. 14).

Sorghum and maize rank first in the lives of the population in Gambella area. People consume sorghum by making porridge and also by preparing local beer. This type of consumption extends well into Southern Sudan. The farmers of the adjascent highland areas usually use sorghum for making 'Injera' which is an entirely different type of food preparation. This indicates the resemblance in food habits of the tribes residing in this area with the people of Southern Sudan. In the Abobo area a special type of preparation 'Abot' (Fig. 15) is made by boiling green sorghum grain with water and salt.

ETHNIC GROUPS

The majority of 133,000 inhabitants* of Gambella have settled along the banks of the major rivers and derive their livelihood by subsistence agriculture, 60% of them are 'Agnwaks', 25% are 'Nuers' and remaining belong to tribes 'Majengir', 'Komo', and 'Opoe'. The distribution of tribal groups and their occupation is presented below:

Tribe	Location	Occupation
1. Agnwak	Gambella to Brhane Salaam	Agriculture. Experts on Zera-sera sorghum cultivation on river banks with residual moisture.

*Source: Progress Report for the period April 1973 to March 1976 Gambella Experiment Station, Institute of Agricultural [illegible]rch Dec[illegible]er 1975.

Tribe	Location	Occupation
2. Nuer	B' Salaam to Jikao	Mainly cattle herders and also cultivate maize.
3. Majangir	Around Bonga area	Honey extracters practice shifting cultivation.
4. Komo	Around Gambella town and also Bonga town	Cultivate groundnut, cassava and small amount of sorghum and maize.
5. Opoe	Around Itanga and the border area of Gambella and Welega	Agriculture

From the table it could be seen that the cultivation of Zera-zera sorghums is totally in the hands of 'Agnwaks' who are the experts of sorghum cultivation on the river banks. The food habits, marriage systems and way of life of this tribe extends to the boarder areas of Southern Sudan.

COLLECTION OF GERMPLASM

The present collection mission was launched in a good crop season and at the correct harvest time. Head samples from standing crops were collected in the entire river side area where sorghum was planted after the receding of floods. Only in the upland areas of Gog and Bonga both head and seed samples were collected from the farmer's storages. Market samples were also collected from the Gambella market where there is a practice of selling sorghum heads (Fig. 12).

Almost all the samples collected in this mission are sorghum. Pearl millet, pigeonpea and chickpea are practically absent. Other than sorghum, one sample each of finger millet, groundnut and bambara-nut were collected from the Agricultural Research Station, Gambella.

The number of samples collected is detailed hereunder. All the collected samples were from cultivated species and none was wild.

Crop	No. of samples
Sorghum	147
Groundnut	1
Bambara-nut	1
Finger millet	1
Total:	150

VARIABILITY IN THE SORGHUM COLLECTION

Most of the samples collected in this mission are head samples either from the standing crop or drawn from the farmer's storages. This has enabled easy classification of the material. The panicle shape and spikelet morphology of the samples were observed and classification was made at the time of collection. All the samples collected are local landraces and no improved variety could be noticed in the river bank area of Gambella. The collected samples were classified into basic and intermediate races. In addition, observations of special interest on the plant aspect were also noted on the data sheets. The complete list of samples collected is shown in Appendix I.

Majority of the samples collected belong to the intermediate race caudatum-guinea, few are pure caudatums and caudatum-bicolors. The gaping involvute nature of glumes characteristic of guinea race is conspicuous in all the caudatum-guinea samples collected. Guineas are almost absent in Ethiopia except in a small part in the southwest near rifty vally (Stemler et al. 1977). The introgression of guinea germplasm into the caudatums of

Gambella is questionable because of geographic and ethnic barriers. Since caudatums, guineas, and caudatum-guineas are well distributed in Sudan, it would be reasonable to assume their movement from Sudan side. Ethnic relationship of people, similarities in their food habits supports this.

The collected samples belong to the following taxonomic races.

Caudatum-guinea (Zera-zera)	-	64
Caudatum-guinea (Others)	-	78
Caudatum	-	3
Caudatum-bicolor	-	2
		147

The variability in each race, the agronomic importance and its ecological distribution is discussed hereunder.

Caudatum-guinea (Zera-zera group)

Sorghum belonging to this group are well distributed in this area. There is a wide range of variability for plant height, head compactness and shape and glume colour. However, plant pigementation, grain colour, grain shape and glume covering remain the same. It was most pleasing to see a Zera-zera field. Plants are agronomically good relatively uniform with attractive grain quality and almost free from diseases (Fig. 11).

Grain of these sorghums is mostly utilised for porridge. The local names of this group are presented below:

Ganga	-	33	Agiru	-	1
Juwalum	-	9	Pettia	-	1
Utedit	-	6	Local names		
Bello	-	3	could not be		
Udogie	-	2	traced	-	5
Nivati	-	2			
Niddo	-	1			64
Nyogega	-	1			

Among the samples collected majority of them are named as 'Ganga' (Fig.1, PAB-16, PAB-20, Fig.6., PAB-79). These have a fairly big semi-compact heads, clean straw coloured grain, with characteristic caudatum guinea shape. 'Juwalum' (Fig.3., PAB-36, Fig.5., PAB-61) is next important local variety with short plant type and attractive panicles. Utedit, (PAB-34) collected in Itang has an excellent plant type and almost looks like a breeding accession. The other local types belonging to the 'Zera-sera' group are Bello (Fig.6., PAB-71), Udogie (Fig.2., PAB-28), Nivati (Fig.8., PAB-127), Niddo (Fig.5., PAB-64), Nyogega (Fig.6., PAB-76), Agira (Fig.7., PAB-96) and Pettie (Fig.8., PAB-123).

Caudatum-guinea (Others)

Several other local varieties of sorghum collected in this region belong to the race 'guinea-caudatum' but do not come under the group 'Zera-sera' There is a wide range of variability present in these local varieties and

some of them are very close to Zera-zeras. The local names are presented below:

Nyaluwal	-	9	Dibao	-	3
Alangua	-	8	Gangabong	-	3
Uluwale	-	6	Julumo	-	2
Tungo	-	6	Udabao	-	2
Udogie	-	5	Akuwa	-	2
Atwol	-	5	Oudong	-	1
Ganga	-	5	Udaterno	-	1
Utire	-	4	Local names		
Chale	-	4	could not be		
Luwale	-	3	traced	-	3
Atorkuba	-	3			
Udok	-	3			78

The local varieties 'Nyaluwal' (Fig.4., PAB-52), 'Uluwale' (Fig.1., PAB-17) and 'Luwale' look almost alike with brown to dark brown pericarp and coloured testa (subcoat). These look agronomically good but poor in grain quality and are preferred for beer preparation. 'Alungua' types (Fig.5., PAB-69) have light red, red and brown grain colour but without subcoat. Most of the samples collected are short. Sorghums belonging to 'Atwol' (Fig.8., PAB-113) have medium plant height, good head size and white grain with subcoat. 'Utires' (Fig.1., PAB-19) are dark brown types sometimes with subcoat. 'Atorkuba' (Fig.3., PAB-31, 32) have larger head size with brown or grey coloured grain. 'Udoks' (Fig.3., PAB-37) are tall varieties with medium head size and straw coloured grain. 'Dibao' types (Fig.4., PAB-50) with straw coloured grain are considered to be good for porridge as well as beer. 'Udogies' (Fig.5., PAB-63) have straw coloured grain with poor exsertion but plants are nonsenescing. 'Tungo' sorghums (Fig.7., PAB-98) have grey grain colour with subcoat. 'Udabaos' (Fig.8., PAB-120) have cream colour grain and straw coloured glumes with medium head size. These types resemble

the popular sorghum variety 'Dabar' from Sudan. These are very close to Zera-zera but plants are pigmented. 'Chale' (Fig.9., PAB-143) the predominant local variety of 'Bonga' area is having chalky white to grey coloured grain and coloured testa. These are upland sorghums grown in the rainy season (June-Oct.).

A wide range of variability is seen in caudatum-guineas. Almost all caudatum-guineas other than Zera-zeras have either chalky white, red or brown grain colours frequently with coloured testa.

Caudatum

Pure caudatums are very few in number with such local names as 'Atwol' (Fig.2., PAB-25) and 'Uluwale' (Fig.2., PAB-26). Both are agronomically good but poor in grain quality. Farmers in Akobo village think that one collection (PAB-91) is bird resistant.

Caudatum-bicolor

This is again sparsely distributed with local name 'Agada' (Fig.4., PAB-51) with red grain colour and without subcoat. These are half broom-corn types with sweet stalks.

WILD SORGHUMS

Since Ethio-Sudanese border has been considered significant for the distribution of wild sorghums, a special search was made for wild and weedy sorghums in the Gambella region especially near the swamps. But no wild types could be noticed. This may be due to the fact that the present mission

was launched very late in the season when all the wild and weedy sorghums would have shattered their seeds. October-November seems to be the correct time for the collection of wild sorghums in this area.

PESTS AND DISEASES

Spotted stem-border (Chilo partellus) is the most important pest in this area that affects sorghum. Outbreaks of army worm also occur sometimes. Grass-hoppers also affect sorghum although of minor importance.

High incidence of diseases and heavy attack of Quelea birds are threatening sorghum cultivation in the rainy season. The post-rainy season sorghum crop (samples collected in the present mission) looked clean and practically free from diseases inspite of high temperature and humidity prevailing during seed setting. This suggests that the present collection might offer some useful source material for resistance to head moulds and leaf diseases.

UTILIZATION OF SORGHUM GERMPLASM
IN THE SORGHUM IMPROVEMENT PROGRAM

Almost all the samples collected in this mission are agronomically good. The majority of them belong to Zera-zera group which should be a good addition to the existing small number of Zera-zeras in the world collection. Because of the agronomic superiority, some of the lines from the present collection could be a good source material in the breeding programs for broader genetic base.

In general, the material collected is relatively disease free inspite of the high temperatures and humidity. As such at least some of the lines from this collection may provide useful source material for resistances for grain moulds and leaf diseases.

Most of the samples collected are from crops grown after the receding of floods with the residual moisture and under high atmosphere temperatures. It is reasonable to assume that some of the lines may provide lines capable of growing under limited residual moisture situation and may also possess heat tolerance. Some of these lines could be tried directly in rabi sorghum (post-rainy season) project.

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3. Dr. Abu Zeid - PGRC/GTZ, Addis Ababa, Ethiopia
4. Dr. Wolf Krauss - PGRC/GTZ, Addis Ababa, Ethiopia

5.	Ato Abebe Merkir	ESIP, Nazreth, Ethiopia
6.	Ato Brook Abebe	PGRC, Addis Ababa, Ethiopia
7.	Ato Mohammed Hussain	IAR, Gambella, Ethiopia
8.	Ato Hailu Hail Mariam	Driver, PGRC, Addis Ababa, Ethiopia

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Appendix-1

SORGHUM GERMPLASM SAMPLES COLLECTED IN THE GAMBELLA AREA OF ETHIOPIA

(February-March 1981)

No.	Coll. No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
1	PAB-1	Gambella	Gambella market	-	Guinea-caudatum	Zera-zera	Good head size and grain quality.
2	PAB-2	"	"	-	"	Zera-zera	Medium head size-good grain quality.
3	PAB-3	"	"	-	"	Zera-zera	"
4	PAB-4	"	"	-	"	Zera-zera	Very light brown wash on the glume.
5	PAB-5	"	"	-	"	Zera-zera	Spotting on the grain
6	PAB-6	"	"	-	"	Zera-zera	"
7	PAB-7	"	"	-	"	Zera-zera	"
8	PAB-8	"	"	-	"	-	-
9	PAB-9	"	Penkio (1 SW Gambella)	Alangua	"	-	Crop infested with stalk borer
10	PAB-10	"	"	Utedit	"	Zera-zera	Best for porridge-early
11	PAB-11	"	"	Ganga	"	-	Long panicle and late maturing.
12	PAB-12	"	"	Luwale	"	-	Medium height-early maturing.
13	PAB-13	"	"	Nyaluwal	"	-	Short & early maturing
14	PAB-14	"	"	Julumo	"	-	Best for porridge, grain sweet
15	PAB-15	"	"	Ganga	"	Zera-zera	Sturdy plants-large panicle.

S.No.	Coll.No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
16	PAB-16	Gambella	Penkio (1 SW Gambella)	Ganga	Guinea-caudatum	Zera-zera	Very big head-excellent plant type.
17	PAB-17	"	Abol (21 W Gambella)	Uluwale	"	-	Goose-necked head
18	PAB-18	"	"	"	"	-	Medium head size
19	PAB-19	"	"	Utire	"	-	Half broom corn
20	PAB-20	"	"	Ganga	"	Zera-zera	Long panicle-excellent plant type-good grain
21	PAB-21	"	"	"	"	Zera-zera	Medium head size
22	PAB-22	"	"	Udogie	"	-	-
23	PAB-23	"	Pinyo (23 W Gambella)	Ballo	"	Zera-zera	Good head size
24	PAB-24	"	"	"	"	Zera-zera	"
25	PAB-25	"	Pinyo (24 W Gambella)	Atwol	Caudatum	-	Tan plant
26	PAB-26	"	Pinyo (25 W Gambella)	Uluwale	"	-	Dwarf plant-good head size
27	PAB-27	"	"	"	Guinea-caudatum	-	Medium height-tillering type-good head size.
28	PAB-28	Itang	Agnale (38 W Gambella)	Udogie	"	Zera-zera	Sturdy plants-short type
29	PAB-29	"	Itang (44 W Gambella)	Atwol	"	-	Long panicle
30	PAB-30	"	"	Atorkuba	"	-	Long panicle-good plant type.
31	PAB-31	"	"	"	"	-	Big head size-brown wash on grain.
32	PAB-32	"	"	"	"	-	Loose and long panicle
33	PAB-33	"	"	Utedit	"	Zera-zera	Good exsertion
34	PAB-34	"	Itang (1 E Itang)	Utedit	"	Zera-zera	Excellent plant type-looks like a breeding accession.
35	PAB-35	"	Abol (21 W Gambella)	Juwalur	"	Zera-zera	Tall plant

S.No.	Coll.No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
36	PAB-36	Itang	Abol (21 W Gambella)	Juwalum	Guinea-caudatum	Zera-zera	Tall-large head
37	PAB-37	"	"	Udok	"	-	Tall-open panicle
38	PAB-38	"	"	"	"	-	Tall-medium head size
39	PAB-39	"	"	"	"	-	"
40	PAB-40	"	Itang (2 W Itang)	Ganga	"	Zera-zera	Tall-good Zera-zera
41	PAB-41	"	"	"	"	Zera-zera	Good exsertion-good head size.
42	PAB-42	"	"	"	"	Zera-zera	Tall plant-long panicle
43	PAB-43	"	"	"	"	Zera-zera	Good for porridge
44	PAB-44	"	"	"	"	Zera-zera	Largest head-excellent plant type.
45	PAB-45	"	"	"	"	Zera-zera	Largest head-excellent plant type.
46	PAB-46	"	Itang (3 W Itang)	Uluwale	"	-	Good for porridge and beer-short and good plant type
47	PAB-47	"	"	Nyaluwal	"	-	Short plant type
48	PAB-48	"	"	Udogie	"	-	Poor exsertion-medium height.
49	PAB-49	"	Itang (3 W Itang)	Dibao	"	-	Tillering. Good for porridge and beer.
50	PAB-50	"	"	"	"	-	Medium height
51	PAB-51	"	Itang (7 W Itang)	Agada	Caudatum-bicolor	-	Sweet stalk
52	PAB-52	"	"	Nyaluwal	Guinea-caudatum	-	Short type-long panicle
53	PAB-53	"	"	Ganga	"	Zera-zera	Large head-excellent plant type.
54	PAB-54	"	"	"	"	Zera-zera	Tall good plant
55	PAB-55	"	"	"	"	Zara-zera	-

S.No.	Coll.No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
56	PAB-56	Itang	Itang (7 W Itang)	Ganga	Guinea-caudatum	Zera-zera	-
57	PAB-57	"	Pol (35 W Itang)	Juwalum	"	Zera-zera	Excellent plant type
58	PAB-58	"	"	"	"	Zera-zera	"
59	PAB-59	"	"	Ganga	"	-	Small heads
60	PAB-60	"	"	"	"	-	"
61	PAB-61	"	"	Juwalum	"	Zera-zera	Good plant type
62	PAB-62	"	"	"	"	Zera-zera	Short plant-small heads
63	PAB-63	"	Pol (37 W Itang)	Udogie	"	-	Tendency to recurve the peduncle short plant.
64	PAB-64	"	Pol (38 W Itang)	Niddo	"	Zera-zera	Short plant-small heads
65	PAB-65	"	"	Juwalum	"	Zera-zera	Large head-excellent short type.
66	PAB-66	"	"	"	"	Zera-zera	"
67	PAB-67	"	"	Udogie	"	Zera-zera	Good exsertion-dwarf
68	PAB-68	"	Neowan (39 W Itang)	Alwal	"	-	Short excellent plant type.
69	PAB-69	"	"	Alangua	"	-	"
70	PAB-70	"	"	"	"	-	"
71	PAB-71	"	Itang (6 W Itang)	Bello	"	Zera-zera	Short excellent type
72	PAB-72	"	"	Oudong	"	-	Tall plant
73	PAB-73	"	"	Ganga	"	Zera-zera	Tall-half broom corn type.
74	PAB-74	"	"	"	"	Zera-zera	Tall plant
75	PAB-75	"	Itang (5 W Itang)	Agada	Caudatum-bicolor	-	Sweet stalk

S.No.	Coll. No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
76	PAB-76	Itang	Itang (5 W Itang)	Nyogega	Guinea-caudatum	Zera-zera	Half broom corn Zera-zera
77	PAB-77	"	Itang (4 W Itang)	Juwalum	"	Zera-zera	Short plant type
78	PAB-78	"	"	Ganga	"	Zera-zera	Medium height-good plant type.
79	PAB-79	"	"	"	"	Zera-zera	"
80	PAB-80	"	"	Ulwale	"	-	Loose panicle-tall type.
81	PAB-81	"	"	"	"	-	Loose panicle-medium height.
82	PAB-82	"	"	Udogie	"	-	Large head-highly nonsenescing.
83	PAB-83	"	"	"	"	-	Nonsenescing type
84	PAB-84	"	"	Ganga	"	Zera-zera	Short nonsenescing
85	PAB-85	"	Itang (2 W Itang)	Debawo	"	-	-
86	PAB-86	"	"	Ganga	"	Zera-zera	Pure Zera-zera
87	PAB-87	"	"	"	"	Zera-zera	Good plant type
88	PAB-88	"	"	"	"	Zera-zera	"
89	PAB-89	"	"	"	"	Zera-zera	Tall and good plant type.
90	PAB-90	"	Itang (Itang)	Alwal	"	-	Tall plant
91	PAB-91	Akobo	Akobo	-	Caudatum	-	Bird resistant
92	PAB-93	Gambella	Itchewe (1 E Gambella)	Ganga bong	Guinea-caudatum	-	Short plant
93	PAB-94	"	"	Utir	"	-	-
94	PAB-95	"	"	"	"	-	-
95	PAB-96	"	"	Agira	"	Zera-zera	Stalk borer present

S.No.	Coll.No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
96	PAB-97	Gambella	Itchewe (4 E Gambella)	Ganga	Guinea-caudatum	-	Short and good plant type.
97	PAB-98	"	"	Tungo	"	-	Grey seed color
98	PAB-99	"	"	"	"	-	Loose head
99	PAB-100	"	"	Gangabong	"	-	-
100	PAB-101	"	"	Nyaluwal	"	-	-
101	PAB-102	"	"	Utir	"	-	Small head size
102	PAB-103	"	Keetchi (5 E Gambella)	Nyaluwal	"	-	Brown grain-tan plant agronomically good.
103	PAB-104	"	"	"	"	-	Agronomically good
104	PAB-105	"	"	Luwal	"	-	"
105	PAB-106	"	"	Udabau	"	-	Dabar like-good plant type.
106	PAB-107	"	"	Tungo	"	-	Long panicle
107	PAB-108	"	Fumaro (9 E Gambella)	Ganga	"	Zera-zera	Excellent plant type-tall.
108	PAB-109	"	"	Utedit	"	Zera-zera	Good plant type
109	PAB-110	"	"	"	"	Zera-zera	Medium height
110	PAB-111	"	"	"	"	Zera-zera	"
111	PAB-112	"	"	Ganga	"	Zera-zera	Long panicle
112	PAB-113	"	"	Atwol	"	-	Medium height-good head size.
113	PAB-114	"	"	"	"	-	"
114	PAB-115	"	"	Julumo	"	-	Good plant type-tall
115	PAB-116	"	"	Ganga	"	-	Small head
116	PAB-117	"	"	Gongobo	"	-	-
117	PAB-118	"	"	Ganga	"	Zera-zera	Good plant type
118	PAB-119	"	"	Juwalum	"	Zera-zera	Very large head-good plant type.
119	PAB-120	"	"	Udabau	"	-	Medium head size
120	PAB-121	"	"	Ganga	"	Zera-zera	Long panicle

S.No.	Coll.No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
121	PAB-122	Gambella	Pumaro (9 E Gambella)	Luwale	Guinea-caudatum	-	Medium height
122	PAB-123	Abobo	Chobo (53 S Gambella)	Pettie	"	Zera-zera	Medium head-good plant type.
123	PAB-124	"	"	Alangua	"	-	Short-good plant type
124	PAB-125	"	"	"	"	-	Tall-good plant type
125	PAB-126	"	"	Tungo	"	-	Clean plant-stalk borer present.
126	PAB-127	"	Abobo (57 S Gambella)	Nivati	"	Zera-zera	Agronomically good
127	PAB-128	"	"	"	"	Zera-zera	"
128	PAB-129	"	"	Ganga	"	Zera-zera	"
129	PAB-130	"	"	Nyaluwal	"	-	-
130	PAB-131	"	"	Tungo	"	-	Deep purple spots on grain.
131	PAB-132	Gog	Gog (91 S Gambella)	Nyaluwal	"	-	-
132	PAB-133	"	"	Akuwa	"	-	-
133	PAB-134	"	"	Ganga	"	Zera-zera	Very close to Zera-zera.
134	PAB-135	"	"	Utedit	"	Zera-zera	Close to Zera-zera
135	PAB-136	"	"	Ganga	"	Zera-zera	-
136	PAB-137	"	"	Udaterno	"	-	-
137	PAB-138	"	"	Akuwa	"	-	-
138	PAB-139	"	"	Tungo	"	-	Seed preservation by smoking heads.
139	PAB-140	"	"	Nyaluwal	"	-	-
140	PAB-141	"	"	Ganga	"	Zera-zera	Weevil infected

S.No.	Coll. No.	Nearest town	Village/exact location	Local name of landrace	Race	Sub-race	Remarks
141	PAB-142	Bonga	Jewie (23 E Gambella)	Chale	Guinea-caudatum	-	Seed preserved in a pot.
142	PAB-143	"	Bonga (36 E Gambella)	"	"	-	Tall-late types
143	PAB-144	"	"	"	"	-	-
144	PAB-145	"	"	Alongoua	"	-	-
145	PAB-146	"	"	"	"	-	-
146	PAB-147	"	"	"	"	-	-
147	PAB-148	"	"	Chale	"	-	-
Other Crops Collected							
148	PAB-92	Dambidello (Wollega province)	Dambidello	Daguesa-Dambidello	-	-	Eleusine coracana
149	PAB-149	Gambella	IAR	-	-	-	Groundnut
150	PAB-150	"	"	-	-	-	Bambara nut

P = Prasada Rao

A = Abebe Menkir

B = Brooke Abebe

Appendix II

ITINERARY

23-24/2/1981	-	Hyderabad-Bombay-Addis Ababa-Ethiopia	Visited ESIP, Nazreth. Discussion with - Dr. Brhane Gebrikidan
25/2/1981	-	Addis Ababa	PGRC, Addis Ababa. Discussion with Dr. Melaku and his colleagues
26/2/1981	-	Jimma	Reached Jimma
27/2/1981	-	Gambella	Reached Gambella
28/2/1981	-	Gambella	IAR - Gambella collection of samples
1/3/1981	-	Penkio, Abol, Pinyo and Itang	Collection of samples
2/3/1981	-	Brhane Salaam, Jikao	Collection of samples
3/3/1981	-	Angale, Itang, Pol Gambella	Collection of samples
4/3/1981	-	Gambella	ARI, Gambella
5/3/1981	-	Itchewe, Keetchi, Fumaro	Collection of samples
6/3/1981	-	Chobo, Abobo, Gog	Collection of samples
7/3/1981	-	Gambella	Drying of samples
8/3/1981	-	Jewie, Bonga	Collection of samples
9/3/1981	-	Gambella	Drying of samples
10/3/1981	-	Jimma	Reached Jimma
11/3/1981	-	Addis Ababa-Nazreth	Reached Nazreth
12/3/1981	-	Nazreth	ESIP, Nazreth - Processing of samples drying and threshing
13/3/1981	-	Nazreth	- do -
14/3/1981 to 17/3/1981	-	Addis Ababa	- Visist to PGRC - Discussion with PGRC staff - Gave seminar on Genetic Resources of Sorghum. - Quarantine clearance of seed samples.
18-19/3/1981		Addis Ababa-Bombay-Hyderabad	Reached Hyderabad