*Harvard University*

# *Harvard Institute for International Development*
# *Rural Development Studies*

*Integrated Rural Development Project*
*Abyei, South Kordofan, Sudan*

# REPORT ON THE AGRICULTURE PROGRAM IN ABYEI

4 January 1982

by

Richard Fuller

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# 1. INTRODUCTION

What follows on these pages is an attempt to report as fully as possible all of the technical information gathered by the ADP*. As is too often the case in areas as isolated from the mainstream of things as Abyei is, there were far too few actors to fill the many available roles within the Project. This was due in fact to a limited budget for a rather ambitious program.

We are convinced that the future for agricultural production among the Dinka lies with the individual farmer and that the traditional plot should be the focus for that improvement. However, this view is not held by many of the ADP staff members, prominent Dinka as well as government officials and it is unfortunate that the questions of large scale mechanization versus widespread improvement of the traditional system has not been resolved. The information in this report tends to support the traditional path, however.

Many people have contributed to the ADP Agriculture Program over the years. They include the ADP workers, too numerous to name, who worked in the fields and on our plots, who were often rather bemused at the requests made of them. Sidiq Abdallah, the ADP Director, who displayed incredible patience toward his ex-patriot staff and who had an unquenchable curiosity about all activities, was an asset which every development project should have.

Kuol Arop, the agriculture officer and eventually ADP deputy director, and the other ADP staff members were in the key role of maintaining

*Abyei Integrated Development Project

the communication link between us and the Dinka people without which much less would have been accomplished.

Mr. Charles Garman at the International Institute of Tropical Agriculture and Mr. Jim Phillips of Ciba-Geigy, Khartoum, were most helpful in getting the zero tillage program started.

To have a clear understanding of Dinka agriculture in the Abyei are the report on traditional Dinka Agriculture (Mabior) by Jay Ackroyd (1981) and the Dinka Livestock Report by Maryam Niamir (1981) should be read. Jay also did the economic analysis found in Section 7 and Maryam did the map and chart drawings found in this report.

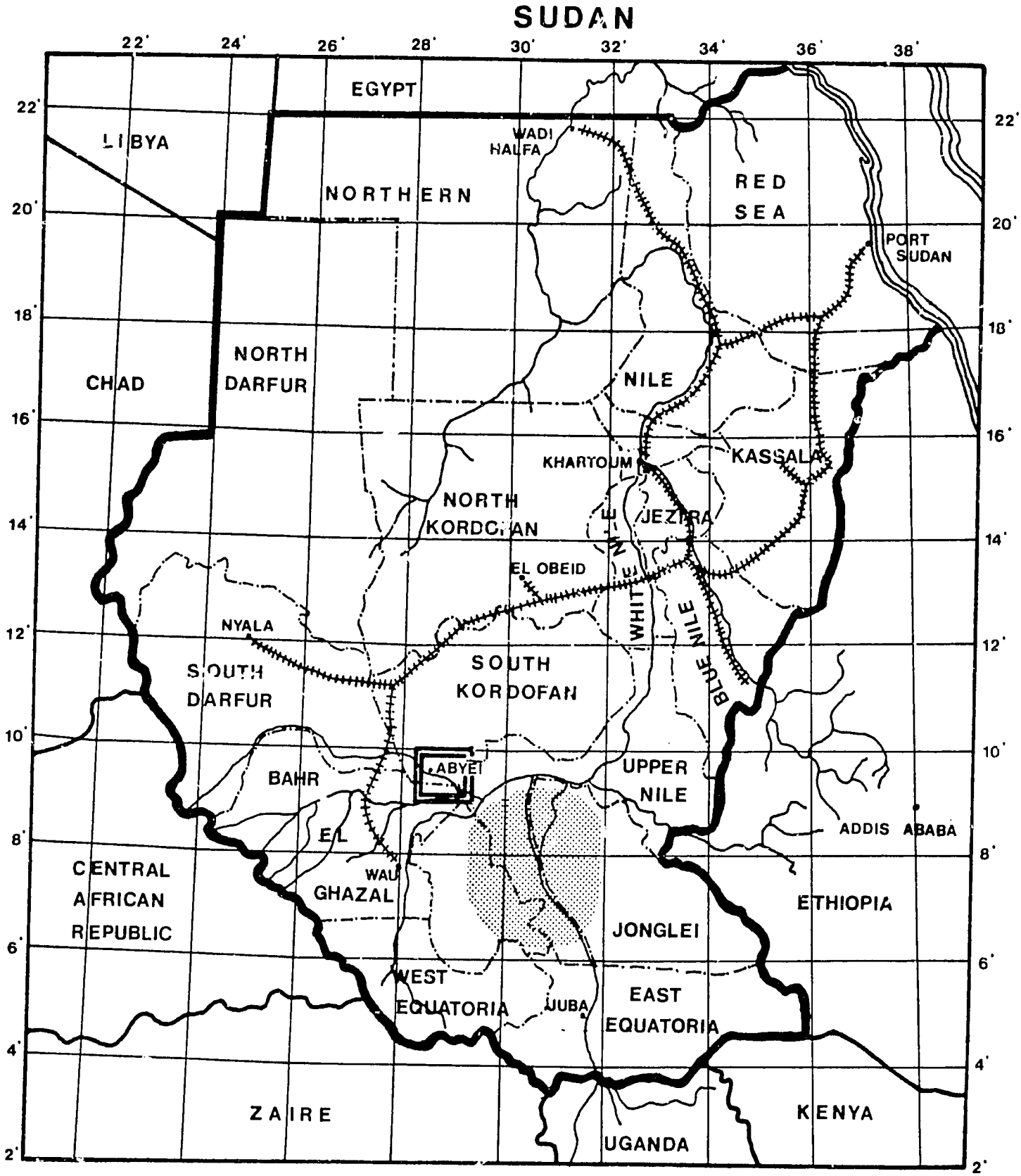
Rick Huntington helped us to back away from the technological aspects and glimpse the Dinka and their lives from a social aspect which helped to clarify many ideas. Will Donovan, Joe Sharp and Ann Byerly, by doing their work successfully, allowed many of the activities in the agriculture program to take place.

In the end, as in the beginning, it was David Cole, whose incredible optimism and unflagging enthusiasm, sustained the project through more than one crisis.

Our special thanks also to the several Dinka students with whom it is always a pleasure to work.

The information which follows in this report forms the basis for a continued well-defined agriculture program which we hope will be implemented.

R.F.




CENTRAL SWAMPLAND (APPROXIMATED)

ABYEI STUDY AREA

RIVER

0 50 100 200 500
KILOMETER

NATIONAL BORDER

PROVINCIAL BORDER

RAILROAD

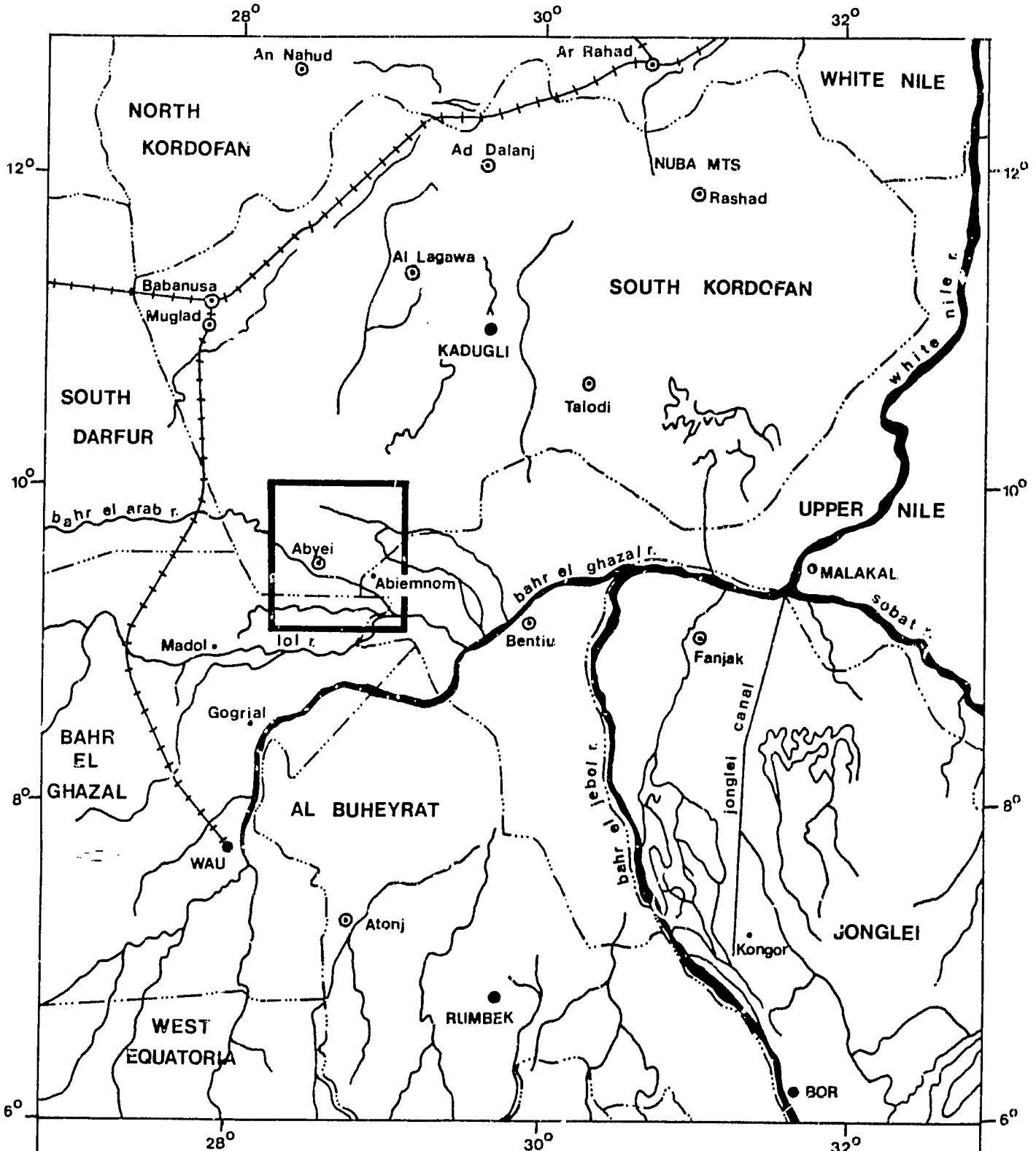



**Fig 1.1**
**REGIONAL MAP**

Detail of Sudan Survey Dep't
National Map 1978 ....
Drawn by Maryam Niamir

0 50 100 200
kilometer

Provincial boundary
Drainage systems
Railroad
Province Headquarter
Council HQ
Other Towns

# SANDY RIDGES : APPROXIMATED AREA

LEGEND:

DRAINAGE CHANNEL

DIRT ROAD

PROVINCIAL BOUNDARY

SETTLEMENT : Dinka name — Noong
: Arabic name — (Naam)

NGOK SETTLED AREA

NGOK USE AREA

SANDY RIDGE

0 1 2 3 4 5 10 20
Kilometer

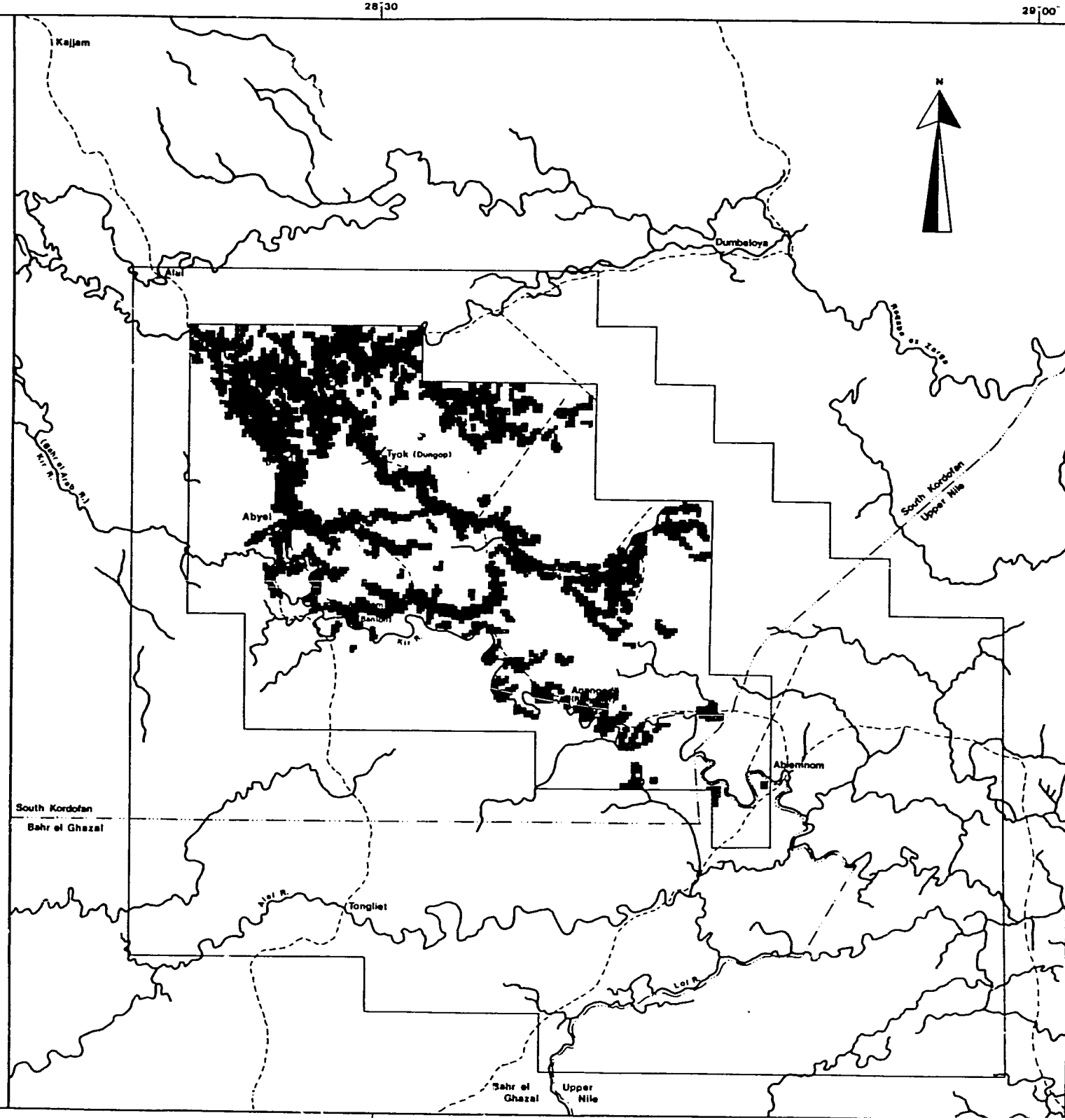
Names and boundary representations are not necessarily authoritative.

CREDITS

Topographic detail based on November 1972 LANDSAT 1 imagery and on field surveys March–May 1980 by Jane Hayes...

All other work based on field surveys April 1980 to April 1981 by Maryam Niamir...

for Harvard Institute for International Development.



## 2. FACTORS INFLUENCING AGRICULTURE

### Weather

The Sudan has a tropical climate, which is very hot and dry in the north and wet in the south. Abyei town is in the south central part of the country at $9^{o}35'$N, $28^{o}25'$E. The elevation is approximately 450 M and daylight will vary by just over one hour from 11 hours 30 minutes in December to 12 hours 45 minutes in June.*

The climate over the project area is divided into two distinct periods - the dry season, which is dominated by northerly winds, lasting from October until May and the wet season, dominated by woutherly winds. The transition period between the seasons is often marked by violent storms with high winds and spectacular, albeit, dangerous displays of lightning and thunder.

Long term meteorological data are limited. The ADP began recording rainfall, temperature, and humidity in early 1980, and annual rainfall date beginning from 1973 are available. From 1975 rainfall data are available on a monthly basis and on a daily basis from 1979.

Complete temperature and relative humidity data are available for the year 1980. These are charted below and illustrate the general pattern of monthly fluctuation which characterizes most years.

The rainfall patterns of the area vary yearly in total amount and distribution pattern. The average yearly precipitation over 8 years is 858 mm.

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*Estimated from Tothill (1948).

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In general the rains begin in May although a few showers may precede this date. The fall of agriculturally significant amounts of rain is locally variable over the area and from year to year.

A graph depicting the monthly rainfall patterns for 5 years illustrates the shifts which occur from year to year.

The total amount of precipitation related to number of rain days also varies. 1979 rainfall totaled 874 mm. and fell on 48 rainy days.* This averages 18.2 mm/rainy day. There were 21 days of less than 10 mm. and 27 days of more than 10mm. of precipitation. During 1980, 820 mm. of rain fell on 90 rainy days which will average to be 9.1 mm/rainy day. There were 62 rainy days of less than 10 mm. and 28 days of more than 10 mm. of precipitation.

When we compare the number of days that more than 10 mm. of rainfall fell we find that in 1979 88% (769 mm.) of the yearly total fell on 27 days (28.5 mm/day). In 1980 83% (683 mm.) fell on 28 rainy days (24.4 mm/day). Presented this way, the figures appear to be similar. When we consider the total number of rainy days for each year which are potentially cloudy and overcast, the difference becomes significant: 1979 = 48 and 1980 = 90. The implications of these figures are that each rainy day can mean a no-work day, especially if tractor or other mechanization is used. They also result in reduced sunlight intensity which affects plant growth.

The discussion on page 9, soils, points out the need for significant rainfall to wet up the soil before seeds germinate or the soil is "workable." In 1980 it was early July before sufficient precipitation fell on the ADP agricultural plots to assure germination and to support seedling growth. The area near the Thithyei group farm also experienced a late starting

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* Days = 24 hour period.

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season. Generally the season begins in June and often the last half of May.

A major difference between 1979 and 1980 was the nature of the first rains. The 1979 season got off to a wet start. 48 mm. of rain fell on May 4; 39 mm. fell on May 21, and 119 mm. fell on May 29. The first two rains totaling 87 mm. were enough to wet the soil for seeding so by May 21 many of the traditional plots had been seeded or were being sown. The rain of May 29 (119 mm.) was enough to fill the Niamora river and other low-lying places. This rain, followed by 11 smaller rains through the month of June, seriously limited the number of days that tractors could work in the field.

In contrast, the 1980 season got off to a slow start in the area around Abyei town. The total rainfall for May and June combined was 133 mm. which fell as light rain which never really soaked the soil. Some of the crops on traditional plots were seeded early but did not survive. Although the soil was just wet enough to till with tractors, it would not germinate seeds. It was early July before some crops could be sown mechanically with a reasonable expectation that they would germinate.

There are three significant characteristics in the precipitation pattern. Obviously total rainfall per season is important. The 10-year average for Abyei is 858 mm. and is adequate for good sorghum production. The rainfall pattern is the limiting factor. As we have seen, the 1979 season got off to a good start on the traditional plots but the mechanized fields were delayed by wet soil conditions. In 1980 the slow starting rainy season delayed, in some cases, the traditional agriculture as well as the crops on the mechanized plots, but it was easier to get into the fields and work with the mechanized implements. The erratic nature of the rainfall is thus a major factor affecting the use of tractors and other mechanical implements.

Soils

In the original plan the soil sampling program was to be conducted by the Soil and Water Conservation Department of the Ministry of Agriculture and Natural Resources. This was a convenient arrangement because the project director was from this organization. When nothing happened the Agricultural Research Corporation was approached through their station in Kadugli. Arrangements were made for a technician from the station to go to Abyei and do the sampling but on the day befor departure he reported in sick.*

It was hoped that a rather extensive program of soil testing would a) define the fertility level of the agricultural soils, b) measure the decline of fertility levels and other effects of crop production, c) identify other soil properties affecting crop production, d) highlight differences in soils coming off the slopes on the sandy ridges that appeared to be the key to the land utilization pattern of the area. Given the aforementioned failures of enlisting the help of outside agencies it was left for the field staff to do the sampling. An acute shortage of staff and a rapidly developing local currency shortage forced a significant reduction in the scope of work.

The new plan called for taking samples from four general locations representing agricultural land with different cropping histories and two different farming systems, i.e., land cleared for traditional agriculture and land cleared for tractor mechanization. Nine samples were taken and sent to the Agricultural Research Corporation soils laboratory at Wad Medani.

The samples were obtained using two techniques. Those at Mabior were taken by removing a slice of soil 5 cm. thick and 10 cm. wide to a depth

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* Due to the approaching rains this man was more than a little concerned about becoming marooned in Abyei as were most non-Dinka.

of 30 cm. from three randomly chosen locations at each sample site. The other samples were obtained by using a soil auger made in the workshop. It consisted of a 3 cm. wood auger welded to a metal "T" handle 100 cm. long. This handle was graduated into 10 cm. sections so that depth could be easily read. Samples were taken to a depth of 40 cm. randomly over the sample site.

Because of the limited scope of this sampling exercise the results of the analysis are not presented as definitive but as general indicators of what the Abyei soils are like relative to agriculture. From the data obtained it is clear that a more comprehensive program is needed. It seems clear from these data and on-site observations that the soil selected for agricultural purposes are fairly uniform in physical and chemical composition which would support our argument that topography, i.e., surface drainage is the predominant consideration in land selection.

Analysis of the samples taken show that the average clay content is 55% with a spread of 45-63%, silt is present at an average of 20% (16-27%) and sand 24% (16-41%). The only particles found that are over 2 mm. diameter are limestone nodules found in varying amounts.* Thus the soil would fall into the fine clay texture class. It is a deep soil and will develop cracks up to 10+ cm. wide and 150+ cm. deep during the dry season which indicates that it is a montmorillorite clay.

The high clay content of the soil results in a bulk density averaging 1.86 gms/cm$^3$ for all samples (1.70 to 1.99). They have a slow infiltration rate and are poorly drained. They have a high water holding capacity but

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* These nodules were used as aggregate in the construction program.

a fairly low amount of this water is available to plants. This is reflected by the available water capacity ratio of 2.39 (overall average) which is low on a scale of 0-6.

Soil pH (paste) hovers around neutral at 7.2 and ranges from slightly acid (6.5) to slightly alkaline (7.6). This is ideal for the crops grown in the area and would not be a significant factor in nutrient availability.

Even so, the availability of two of the macro-nutrients is low in the samples analyzed. Nitrogen (N) averaged .034% (.030 to .045%). This is, in part, due to the low organic matter content of the soil which ranged from .53% to .93% (ave = .72%). Available phosphorus (P) was deficient in all samples with a spread of 2.0 to 3.4 ppm (ave = 2.6 ppm). Soluble potassium (K) is present at fairly high levels and is not deficient.

The sodium absorption ratio and electrical conductivity indicate that sodium levels are low and not significant.

The agriculturally useful soils in the Abyei study area are, as we have indicated, deep fine greyish brown clays that develop large cracks when dry. Smaller cracks may develop also but the monoliths or chunks which are described by the larger cracks become "rock" hard. This seasonal occurance plays a large role in helping to make the soil suitable for agriculture.

The cracks form as the soil dries out and shrinks. This causes movement and a breaking up of the upper profile. These cracks facilitate aeration and also are the mechanism by which surface trash and soil particles can become mixed into the soil mass when they fall into the cracks. Soils exhibiting these characteristics belong to the Vertisol Soil order.

When wetted these soils become plastic and swell. Thus during

the rains the cracks disappear but not before they have acted as conduits to carry the water of the first rains down into the profile. This is most effective when one or more of the early rains are heavy "cloud bursts." The water also carries soil particles and surface debris as it cascades into the cracks. Without these channels to carry water to the lower profile much of it might not become wet since the expanding soil becomes very tight and water infiltration as well as root penetration are inhibited. These limitations and the low available water ratio limit the water and nutrient resources available to the plants. Frequent rains are needed to maintain an adequate water supply to the crops and present water stress damage.

These heavy soils effectively withhold a large percentage of water, which they contain, from crop plants. In addition, much of the water from the early rains is conducted deep into the soil profile <u>via</u> the cracks. This means that a substantial amount of rain must fall before the soil near the surface is wet enough to support germination of seeds. Our experience indicates that 80+ mm of rain, falling in a good downpour rather than spread over many small showers, is needed before germination is assured.

It is not possible to detect a decline in soil fertility from our limited sample data but it is reasonable to assume that it is occuring although not rapidly due to the low yields taken from the fields. The negative effect of low fertility is significantly enhanced however, by the seasonal increase of striga.

The limits set on agriculture, road and building construction are by no means unique to Abyei although a failure to understand the problems

that these soils present due to shrinking, swelling, becoming sticky and hard has resulted in some disappointments. Agriculturally the limits are rather strict. Tillage is limited to short periods when the soil is neither too wet or too dry and the need for tillage is confined to a brief period of the year when the crops are planted and weeded, i.e., significant delays in tillage limit its usefulness

The tendency of the soils to waterlog and inhibit root development reduces the range of crops which can be grown thus increasing the difficulty of developing cropping systems. This limitation on the crops which can be grown and the mechanization which can be applied must be taken into account when considering changes in the agricultural system. The traditional practices of the Dinka farmer are well adapted and it is there, on their plots, that the promise for improvement lies.

Land Availability - The Ridges

Unbroken flatness, dark grey-brown deeply cracking soils, and vegetation which is predominantly acacia species interrupted only by the vast treeless expanses of grass and the cleared fields of the Dinka characterize the Abyei area.

A key to the exploitation of this land by the Dinka is the meandering irregular ridges composed of sandy to sandy clay soils which often rise less than one meter above the surrounding landscape. The subtle variations in topography caused by these ridges* on the surrounding land facilitate surface drainage without which the lower heavy soils would become water-logged. Because these ridges create drainage, houses are built, cattle pegged,

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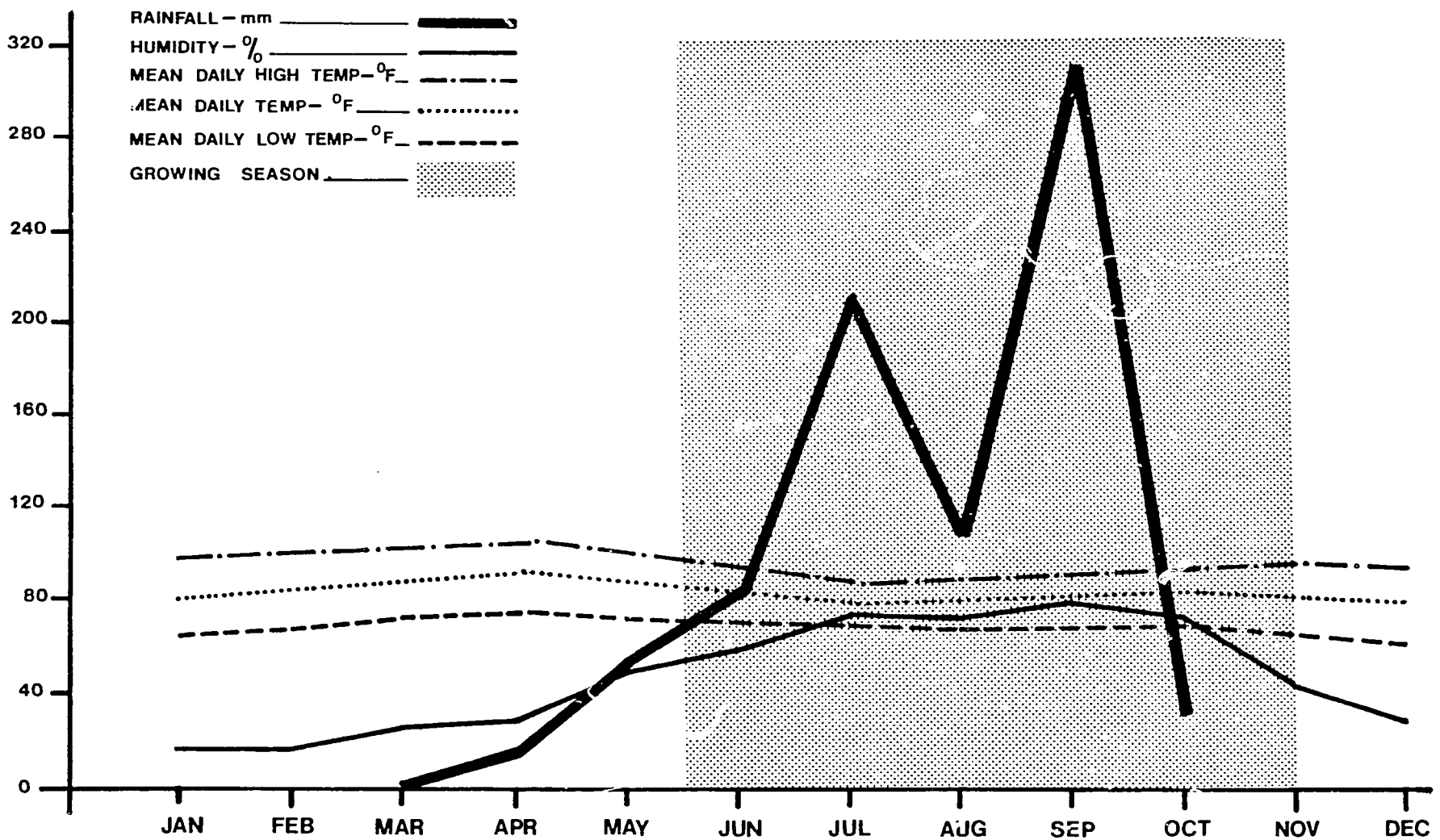
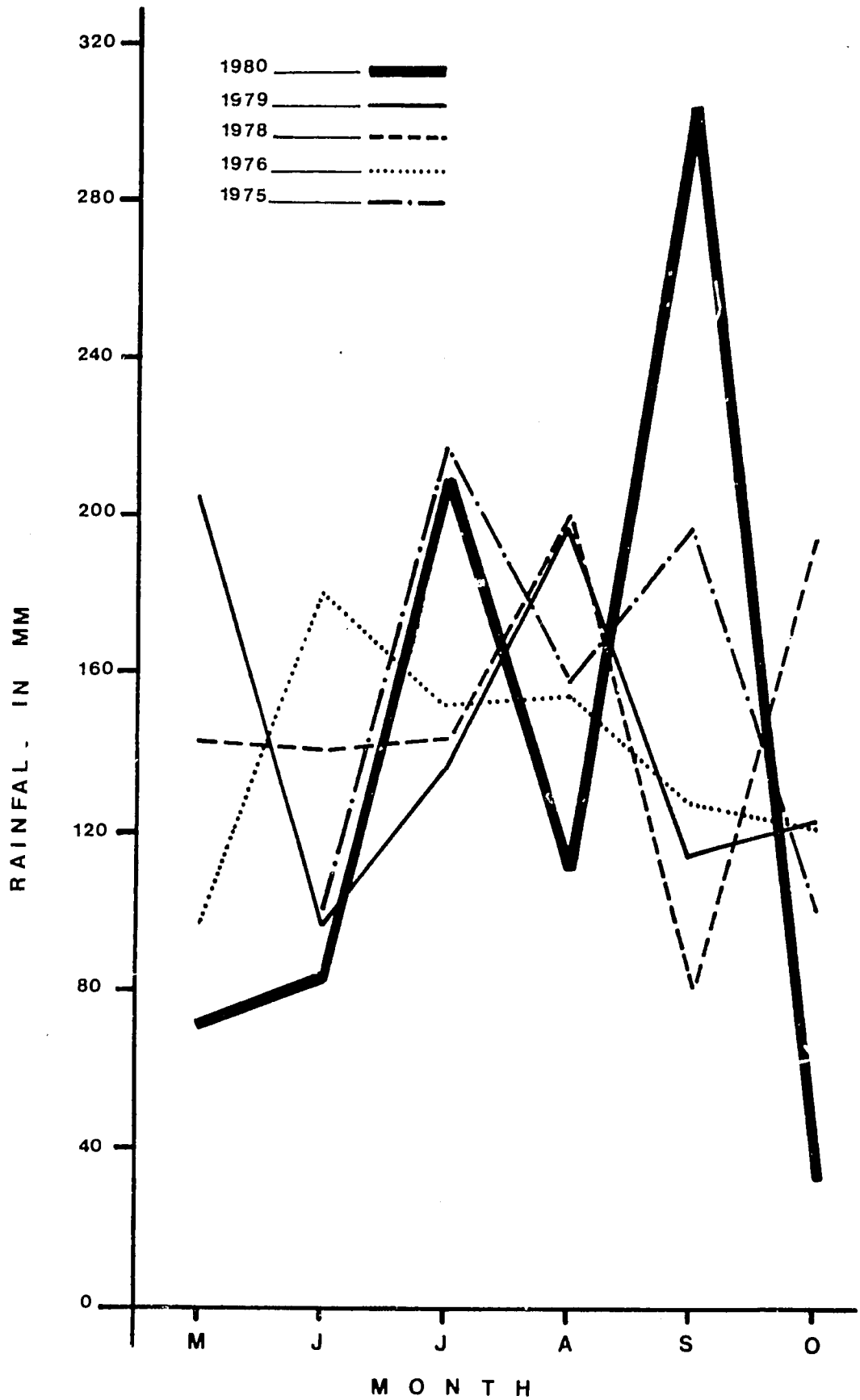
* Termite mounds have the same effect on a smaller scale.
Note: Vegetation species are reported by Niamir (1981). See Fig. 5.3

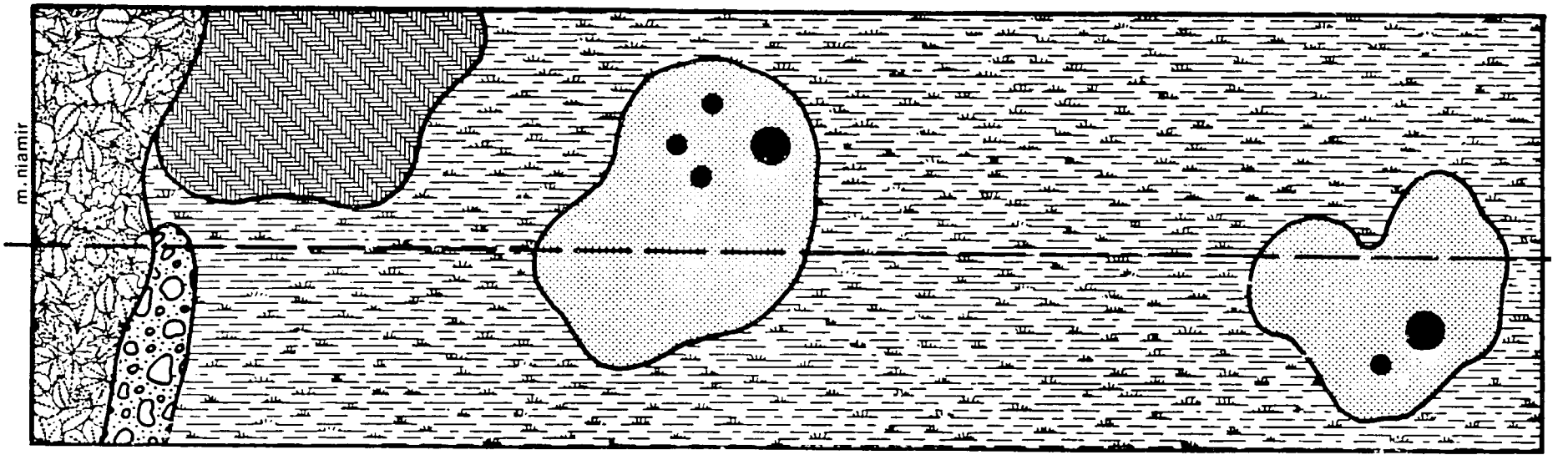
# CLIMATIC VARIATIONS PER MONTH IN 1980

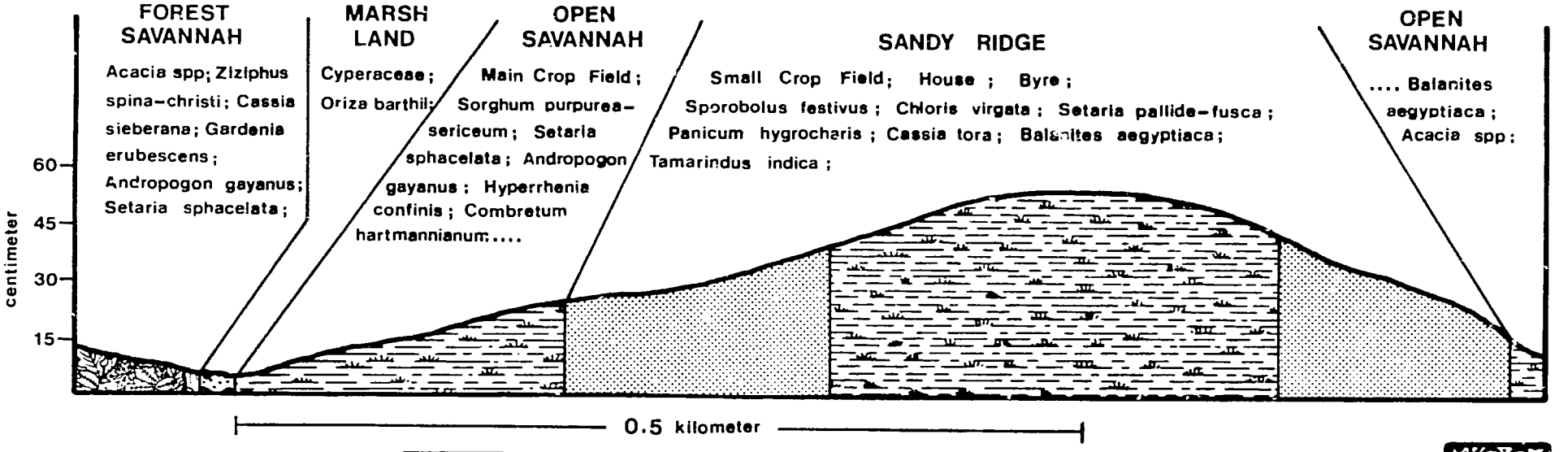


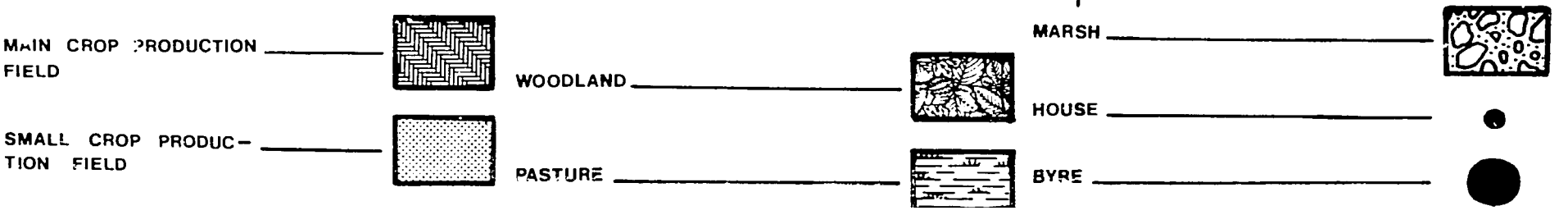
# YEARLY RAINFALL



# Fig 5.3 SKETCH OF A SANDY RIDGE



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and fields are established along them. They are also the local "highways" with foot paths and vehicle tracks following them. Hayes (1980) has put them into the "Raqaba" land category and Niamir (1981) into a sandy ridge class.

The high point or crown of the ridge is covered with short grasses and a few trees (see sandy ridge sketch). The soil is noncracking, well compacted with a variably high sand content.

Moving laterally across the ridge and down its slope, the soil texture changes to fine clay and cracking increases until either a river or low catchment is reached to which water will drain.

The crowns of the ridges are left for grazing, foot paths and vehicle tracks during the rains. Some ridges have patches of loose friable soil which are well suited to growing watermelon (Citruillus vulgaris) and ground nuts (Arachis hypogea) and are sometimes exploited by enterprising individuals.

On the side slopes of the ridges and before the acacia thickets begin, houses and cattle byres are built and the small field plots are established. Beyond these is a transition zone, often a few hundred meters long, of open savannah with a few acacias and medium tall grasses. Continuing further, the acacia and tall perennial grasses predominate in the forest savannah zone. The main production plots are located in the open savannah land, extending into the forest savannah.

The influence of the ridges on drainage diminishes with distance from the crown or top. This is reflected by the greater tendancy for the main fields to waterlog and the limitation of production to relatively tolerant sorghum and small amounts of sesame.

Although sorghum in general and the Abyei sorghums in particular are tolerant of waterlogging for limited periods, we have found that parts

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of a field can be waterlogged long enough (10 days and more) to affect it and other crops adversely. On the traditional plots, these bad spots are abandoned or are seeded with the local, water tolerant sorghum, called Diil. The problem is multiplied and not so easily remedied on large fields.

The rigor which the farmers apply in selecting land for their traditional plots is diluted in cooperative schemes by the pressure for large amounts of cleared land, for field symmetry - both of which enhance tractor efficiency - and by reduced personal interest in a group effort. Experience has shown that the amount of poor land after clearing on traditional plots will usually be less than 5% while on the group farms it has been as high as 20%. This latter figure reflects the lessening influence of the ridges since the group farms were located farther from sandy ridges than traditional plots normally are.

If rigorous selection equal to that used for traditional plots were applied to the group farms, the fields would pretty much follow the contours of the ridges, being long and narrow. Still if more rigourous land selection is practiced, it is a reasonable proposition to clear land in this pattern if it is needed for mechanized farming although the fields could form a barrier to livestock migration into the area during the growing season. The total amount of land available however, becomes a constraining factor if the traditional rotation system is adhered to.

Ackroyd reports that the Mabior people cultivate 4.75 feddans (2 ha) per household with 1.2 feddans (.5 ha) as ngai plots and 3.55 feddans (1.5 ha) as dom dit plots. A farmer will keep his land in production for 8-10 years before the combined effects of striga and declining fertility induce him to abandon it to bush fallow and move to new land. He also reports that the land is

left in bush fallow for 30-40 years. For the purposes of our discussion we will use a 9 year cropping and 35 year bush fallow rotation. Thus if a family cultivates 4.75 (Ackroyd-1981) feddans an additional 19 feddans (8 ha) of bush fallow must be available for future clearing to maintain adequate production on the 4.75 feddans under the traditional production system. About 23.7 feddans (10 ha) of suitable agricultural land is needed by each household.

The reason for the long bush fallow period is probably a response to striga, the seeds of which can remain dormant in the soil for many years, as well as to declining soil fertility and the need to let it build up again. The long fallow period tends to lend credence to the idea of there being much more land available than is exploited at present. Leaving land fallow for 30-40 years after all, is a luxury not enjoyed by many people - anywhere. Even so we suspect that the area of land that is suitable for farming is limited and that a discussion of that is worthwhile.

Hayes (1980) reports that there are 3,706 households for the Abyei area while Niamir (1981) gives a figure of 3,893. Using these figures we can estimate that between 17,603 feddans and 18,491 feddans (7,396-7,770 ha) of land is under cultivation by the Dinka in the Abyei area. Likewise 70,412 to 73,964 feddans (29,585 - 31,077 ha) of suitable land, presently in bush fallow, are required to support that area of cultivation.

Niamir reports (1981) five land classifications for the Ngok Dinka use area as:

| | | |
|---|---|---|
| Sandy Ridge | 375 $Km^2$ | 25.9% of total |
| Open Savannah | 655 $Km^2$ | 45.2% of total |
| Forest Savannah | 348 $Km^2$ | 24% of total |
| Marsh Land and Riverine | | 4.1% of total |
| Fresh and Recent Burnt land | | 9% of total |

Very little of the sandy ridge class is used for agriculture although some ngai plots are located there since they are normally adjacent to the houses. None of the marsh land and riverine class is suitable to Dinka cultivation because it is too wet. Clearly the farm land lies within the open savannah and forest savannah classes. How much of the land within these classes is unsuitable for agriculture is not known. We have observed that 5% of the land cleared for the traditional plots is found to be unsuitable as was about 20% of the land cleared so far for the group farms. By using the Niamir classification as a starting point we can make a very general estimate of potential land availability for expanding production. Assuming that all of the suitable land and main production, dom dit, plots are located within the open savannah class we can calculate:

655 $Km^2$ - 5% = 622.25 $Km^2$ x 238 fed/$Km^2$ = 148,095 feddans

3893 households x 3.6 feddans** = 14,015 x 5*** = 70.074

148,095 - 70,074 = 78,021 feddans not yet in the system.

78,021 ÷ 5*** = 15,604 feddans can be put into production under the traditional rotation system.

15,604 ÷ 3893 = 4 feddans/household

The suitable land as estimated by our formula above is, in fact, not totally available to the Dinka for farming. Water unavailability, political friction and ecological considerations cause a considerable portion of it to be unusable at this time.

During the wet season pools of water and some rivers provide water for people and livestock and the Dinka have established traditional agricultural plots as far north of Abyei as the villages of Naam and Maker.

** 3.6 feddans = ave. size of "domdit" (Akroyd 1981)
*** The traditional bush fallow system requires 5 times the land actually under cultivation be available to sustain itself.

The rivers El Zarga, Niamora, Lau and Kir are the main sources of water after the rains stop until the first three dry up in February or March. Deep bore wells at Naam, Tyok and in Abyei operate during the dry season but often the distances are too great to make it worthwhile and the people move south toward the river Kir which provides a year around water source from its confluence with the Niamora, south of Abyei town on to the southeast.

The Dinka-Messiriya conflict has at times forced Dinka families to abandon much of the area north of Abyei town. In some years this has occured well before the normal migration south in search of water. In 1980 it happened in August. During these times houses are abandoned and if early in the season, the crops are left behind. Furthermore, the land that is used to grow sorghum is not available to support livestock. During the growing season, when the Dinka cattle move in, the crops must be protected from the animals. After harvest, when the Misseriya make their dry season trek into the area, the fields can be grazed but the value of the sorghum fodder is considerably less than the natural herbs and grasses which have been cleared away. In effect the land is taken out of the livestock production system.

A consideration not yet addressed in Abyei is the deforestation of land. Traditionally, we have broadly estimated, about 14,000 feddans (5880 ha) or 59 $Km^2$ of land is now deforested (cleared) and is used for farming. Unfortunately, we do not have enough information about the total ecological system within the Abyei study area and clear guidelines for future activity i.e., clear more or less land, are not possible to set now. The experiences

of the sub-Sahelian region and the encroaching desert give ample credence to the need for this aspect to be investigated thoroughly.

Thus we can see that the large mass of land area within the ADP study area can be rather less in practical "development" terms, at least as envisioned by many at the beginning of the project and when taken in context with a generalized view of increasing sorghum production by mechanizing the system.

With the association of arable land to the sandy ridges the total amount available is finite rather than infinite and useable area is substantially modified again by water unavailability, political questions and ecological considerations. The question of water and politics could make 50% of our estimated land area (good for farming) unusable at this time.

## 3. TRADITIONAL AGRICULTURE

The Dinka agricultural system is divided into two production units which include the ngai or small plot which is usually located near the house and a large production plot called dom dit which is often located some distance from the house.

Quick maturing sorghums and maize are grown in the ngai plots. These are important to the Dinka family because they will sustain the family during the period when stored grain supplies have been exhausted before the main harvest is gathered. This period occurs in the early part of the rains usually in July-August. The families can be vulnerable during this time as the cattle have moved north, the new crop needs tending and market grain prices can be quite high.

Maize is a marginal corp as it is sensitive to poor soils, drought periods, and yield are poor. The maize is usually eaten before maturity at about the hard dough stage by roasting it. It more often constitutes a snack rather than a main meal. Some of the maize will be allowed to reach full maturity, is dried and ground with sorghum but this is not common due to low yields and availability. The maize is red and yellow and is pleasantly sweet. It is sown at the onset of the rains and reaches the edible stage in about 75 days.

The ngai sorghums are also sown with the onset of the rains They are medium in height (1-2 m.) and can also be eaten in about 60 days or at the hard dough stage. Because the grain is harvested before full maturity yield data is not available but they appear to be low yielders with small

1. Because of the higher sand content of the ngai soils the crops grown there get off to a faster start (see soils section).

loose panicles and are grown at low plant populations.

Other crops will often be intercropped with the cereals. Okra, an important non-grain part of the diet, is found everywhere. Usually it is not sown. The volunteer plants are not weeded out but allowed to grow. Sesame, cow pea, small amounts of tobacco and pumpkin are most commonly found in these "garden" plots.

The dom dit plots are the main production plots and it is on them that most of the sorghum is grown as well as some sesame and okra. Again, the okra is not sown but left where it grows. Sesame is sown on selected high places in the field often intercropped with the sorghum and frequently in small plots of pure stands.

The dom dit sorghums are referred to collectively as "rowath" by the Dinka and they show a lot of variability of type. A collection was made in the 1980 season and more than 50 types were identified from within a one hour walk of Abyei town.[1]

The Abyei sorghums have undergone considerable selection and each year the process continues. Each farmer will select the best heads of grain from his plots and keep them to sow the next crop. The characteristics of each type are well known to the farmers and they will maintain a mixture which will give the greatest assurance for an adequate harvest in competition with the environment.

The rowath types are medium maturing, about 145 days, and are tall, reaching about 3 m. in height. They tiller well and after the main harvest are encouraged to ratoon by cutting the stalks back.

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1. This collection has been given to Dr. Gebisa Ejeta, Sorghum breeder, ARC Gezira Research Station, PO Box 126, Wad Medani, Sudan.

Over two seasons (1979-1980) there was very little incidence of disease on the sorghum plants. Covered kernel smut [Sphacelotheca sorghi (Link) Clinton]and loose kernel smut [Sphacelotheca cruenta (Kuhn) Potter] appeared in the rattoon crop.

There were no serious insect pest infestations. During the 1979 season, however, some farmers reported that an attack of army worms destroyed the young sorghum crop which necessitated reseeding some plots. Some stem borer activity was observed but it was not significant.

The most serious pest of sorghum is Striga hermonthica which becomes a serious problem after 4-6 years of cropping. The farmers do not move actively to control striga in their fields such as by weeding it frequently to prevent seed formation, but instead rotate the land out of production every 8-10 years and let it return to "bush". The land is left in bush fallow for 30-40 years before again being cleared and put into production. This practice trebles or quadruples the amount of land required per farmer and makes it essential that land be cleared continuously.

Traditionally land is cleared by hand, using locally made steel bladed axes. The trees are cut about 1 m. above the ground and are burned. It is not necessary to remove the stumps since they do not interfere with the labor intensive farming operations.

Occasionally, though, and for all tractor mechanization, the stumps must be removed. Axes and the traditional farm implement - a long handled straight bladed hoe - are used, or wood from clearing is stacked around the stump and burned. The stumps are not cut back or burned more than 10-15 cm. below the soil surface but that is enough for the other implement - the tractor drawn wide level disk - to pass over safely.

After the trees and brush have been removed the perennial grasses remain. Even after burning clumps or tussocks remain and must be removed using the hoe. It may take two years of considerable effort to fully control the grasses on newly cleared land.

## 4. MODERNIZATION

1973 was the first season in which the Nuba Mountain Agricultural Production Corporation (NMAPC) operated in the Abyei area providing tractor services to local farmers. The extension of the NMAPC* into Abyei was the result of the cessation of the civil war and the desire of the government to make the area a model for reconciliation. Many believed that the tractor mechanization technology used with success, at least initially, on several large schemes in eastern Sudan and at Habila in South Kordofan, could be transferred easily and with comparable results to Abyei.

The original plan envisioned a four year program during which the NMAPC would provide tractors, implements, maintenance and drivers while the Provincial government would supply fuel, lubricants and other supplies. The Abyei rural council was expected to participate by providing housing for the staff. The goal was to bring 6,000** feddans (1 fed = 1.04A = .42 ha) under tractor mechanized production.

During the 1973 season, NMAPC officials reported 2,600 feddans were seeded to sorghum and that 15,000 sacks***of grain were harvested for a yield of about 5.7 sacks per feddan. This success lent credence to the initial optimism and encouraged land clearing for more extensive participation in the tractorization - cum modernization program. The actual performance of the program is a bit clouded by time and reports which are based on data that

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* NMAPC is a subsidiary of the Public Corporation for Agricultural Production. It was reorganized in 1967 as the NMAPC to implement a primarily tractor mechanization program to stimulate cotton production in the Nuba Mountain area of South Kordofan Province.

** Some reports give figures as high as 10,000 to 12,000 indicating the vast optimism and high hopes of some.

*** 1 sack of sorghum will average 95 Kgs.

seems to be less than precisely measured. However a trend which has been observed in other mechanization schemes (see: Thimm - Development Projects in the Sudan - The United Nations University Press, 1979 and Problems of Savannah Development: The Sudan Case - Gunnar Haaland Ed.), of declining yields on decreasing areas cultivated, seems to apply in Abyei from 1973 through 1979. During 1977 the service was not available at all, probably because of the violent incident between Dinka and Missiriya that year. In 1978 the service returned with the support of the fledgling Abyei Integrated Rural Development Project (ADP) in terms of fuel and seed. The NMAPC field director reported that 1,200 feddans* were sown and yielded about 2 sacks of sorghum per feddan that year.

The service was again not available in 1979. In discussions held with the NMAPC Director in Kadugli, he gave high cost/low return and mismanagement in the field as reasons for discontinuance.**

Depending on whom one asks the NMAPC Program in Abyei has been characterized as being everything from a total success to a failure. Indeed the scheme had problems. NMAPC people were never able to get the tractors, spare parts, fuel, lubricants, and staff in place on time. Management and technical problems caused by the soil, rainfall, topographical and vegetative characteristics of the area were never mastered. Political maneuvering especially at the Provincial and local level influenced decisions and the inter-tribal pressures bearing on the NMAPC field manager were very great.

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* Later experience in verifying land area estimates showed a high degree of optimism. The vested interest of some to have the program succeed may have biased these figures.

** It is probable that the presence of the ADP counted more in the decision. It was felt at the provincial level that the ADP could and should support the service. Also, a degree of peevishness on the part of the Provincial authorities stemmed from North -South animosities and the fact that the ADP bypassed the Provincial bureaucracy in finance, procurement and management. Criticism and ill feelings from Provincial authorities (northern Arabs) and the Arab tribes to the North plagued the project continuously. The fact that budget limitations and the Missiriya-Ngok Dinka conflict, which often erupted in violence, prevented a simultaneous development effort with both tribes did little to assuage these people.

If the person were from the area the pressures from family and clan for special consideration along with the natural temptation to use personal position to further one's own political status could take precedence in decision making. For any manager, local and Provincial politics were always tightly interwoven with decision making. It is, therefore, not surprising that the sorghum was frequently sown late or not at all and that the program was seen by some as mismanaged.

The very nature of a tractorization scheme, i.e., the need for large tracts of cleared land, biased the NMAPC service toward the more influential and affluent members of the community, thus opening the gap between the haves and the have-nots. Those that could afford to clear the land with hired labor or work parties (nafirs) could benefit from the service.

It would seem that because the service was unreliable in timeliness of field operations and year to year availability, the concept would have been rejected by the farmers. One factor, however, worked to negate the normally rational decision making processes of the farmers. A token charge of only .35 pt ($.70) per farmer, regardless of area tilled and number of operations, was levied. This, of course, did not even approach the real cost and was not intended to.*

It was with this rather unreal perception of the potential for tractor mechanization, on the part of government officials and local people, that the ADP entered upon the scene. From the very earliest beginnings of the project, the expansion of tractor mechanization was one of the five** requests coming from the area. The question of tractorization has remained an issue from then to the present.

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* A full discussion of tractor costs can be found on pages 46-50.

** 1. water, 2. health, 3. schools, 4. tractors (more sorghum), 5. all-weather road (not necessarily in any order of priority).

The most immediate effect that this had on the project was the inclusion in the design of a program to support four group farms with tractor services and, because of the dubious cost/benefit ratio, to study the effectiveness of tractors in the immediate and long term.

## 5. GROUP FARMS

The formation of cooperative farms was an attempt by the Abyei local government to increase sorghum production in the area. Although it is not entirely clear, the idea of cooperative farms no doubt had its genesis with the consumer cooperative formed in the mid 1970's and was seen as a way of spreading the activities of the NMAPC mechanized farming operations. Under the cooperative farming plan, groups of people would be organized to clear land and produce sorghum. By pooling a common resource, their own labor, the less affluent farmers would be able to participate in the modernization scheme. An ad hoc agreement was worked out with the NMAPC by which excess fuel and tractor time would be available to the cooperatives, although the NMAPC work on private fields had first priority.

When the ADP started operating in Abyei in early 1978, a shortage of equipment and the impending onset of the rains made it impossible to begin a full program with the cooperative farms as outlined in the project agreement. Instead, after considerable debate it was decided to support the NMAPC program that season with fuel and seed.* Vigorous discussions surrounding this decision were generated, because the HIID field team, the Sudanese Project Director, and the primary funding agent (USAID) did not want to become enmeshed with the provincially controlled program's questionable viability. The Provincial authorities were jealous of their control over the NMAPC scheme and did not want this to be shared

*The ADP in 1978 purchased a variety of sorghum that was recommended by the principal sorghum breeder at the Agricultural Research Corporation in Wad Medani. The variety known as Gadam Hamam was suggested on the grounds that it had grown well at research stations in Sudan with climatic and soil conditions similar to those believed to exist in Abyei. Also, it was readily available at the Habila Mechanized Farming Area in South Kordofan.

with any other institution. On the other hand, the Ngok Dinka, including the Dinka members of the field staff, were adamant in their support for extensive tractorization.

As it turned out only one cooperative received tractor services in 1978 although three had available cleared land. The NMAPC land still had priority despite inputs from the ADP.

In the beginning the ADP Group Farm program* was to include three farms of 1,000 feddans each. This was later modified to include four farms, two of which would be 500 feddans each. The original cooperative farms were taken on as group farms including:

Mabok - no land cleared

Mabior - about 20 feddans cleared

Nuenchior - about 15 feddans cleared

Thithyei - about 25 feddans cleared

This gave representation to seven of the nine Ngok subtribes.

The Mabok group farm is located near the village of Mabok which is 33 km. southeast of Abyei town. The members are from the Diil and Mareng subtribes. The area selected by the members for the field is covered with a dense growth of thorn bush and small trees with *Acacia seyel* the predominate species. The nearest year-round water supply is the river Kir (Bahr El Arab-Arabic) which is located about 3 km. to the south. The farm had an original membership of 36, had cleared no land by 1978, and managed to clear only four feddans during the next two years. During the 1980 season 95 feddans of former NMAPC land were used by the membership

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*See Memorandum of Understanding Between HIID and the Government of the Sudan, 1978; also, Proposal for Amendment of Grant Agreement, 1979.

as their farm. Due to some mismanagement and rainfall problems, the farm was seeded twice before a satisfactory stand of sorghum was established. Although the members managed to put together some cooperative workdays, much of the field was not weeded or properly thinned. A shortage of precipitation during the last quarter of the growing season (early October) severely damaged the crop. The total yield from the farm was 33 sacks or .35 sacks per feddan (79 kg/ha).

Mabok group farm is considered to be the least successful of the four. They have not been able to clear more land and failed to tend their first crop satisfactorily. Attempts to meet with the membership only rarely brought more than 4-6 of them out. The reasons for the failure of this group are not entirely clear, yet the following certainly are the most obvious factors:

a) The distance -about 3 km- of the field from a permanent source of water. Since clearing is done during the dry season, this is limiting.

b) A membership drawn from two subtribal groups made it more difficult to organize the members, deal with farm problems, and reach decisions. This was aggravated by weak leadership which, unfortunately, was tied to local lines of authority, rather than based on the competence of the individual.

c) The distance from the ADP center, near Abyei town, to the group farm limited contact between the two.*

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*The project, in any case, had difficulty developing and implementing an effective and regular group farm outreach. This was due mainly to staffing problems.

The Mabior group farm presents an interesting case in that the membership represents three villages and two subtribal groups, Aniel and Manyar. The field is located about 8 km. from Abyei town and is situated between the villages of Geller, Piok, and Mabior, being nearer to the latter. The membership totals 33 heads of family and they have managed to clear 20 feddans, although an additional 8-10 feddans were cut in 1979 but the stumps not removed. The farm has produced three crops (1978-80). The 1980 crop was the best at 4 sacks/feddan (904 kg/ha). The previous two crops produced yields of less than 1 sack/feddan.

By far the overriding characteristic of the Mabior group is the membership which represents two subtribes. During the three years, 1978-80, of ADP involvement it proved to be impossible for the members to suppress inter-tribal politics, petty differences, and anxieties enough to allow the group farm to function on a cooperative basis. The situation was further exacerbated by an inept and somewhat self-seeking president who, again, retained his position primarily on traditional rather than on merit grounds. This hopeless situation is best characterized by the failure of the group to find a way to separate into two distinct groups along the traditional subtribal lines even though the cleared land was delineated into two equal parts by the ADP.

The best tool for fostering the cooperative work spirit proved to be a good harvest, i.e., success, although not easily attainable. For Mabior it did not happen until 1980. After two rather poor crops in 1978 and 1979, of which some of the grain disappeared while in the care of the president, the season of 1980 began well. The field was tilled early and

was seeded in good time, but the failure of the seed to germinate and the July reseeding date negated the early start. This setback was partially compensated for by the resowing because it was well into the rainy season by then and most weeds had germinated. Thus when the field was reseeded these weeds were killed and the crop remained virtually weed free through the rest of the season. It is doubtful that the members would have been able to organize a weeding program had the weeds not been controlled in this way.

Although late the crop looked good all season long and promised the best harvest yet. This was apparent to the members too and with the help of some hired labor the crop was gathered and produced 4 sacks/feddan

The more obvious obstacles facing the Mabior group are similar to those of Mabok and include:

a) Lack of a nearby year-round water supply.

b) Ineffective leadership.

c) A membership drawn from two subtribes.

d) An ineffective ADP outreach.

To these we must add:

e) The failure to produce a good crop for the first two seasons.

The Nuenchoir group farm can trace its beginning back to 1974 when the local Community Development Officer and the local District Commissioner made their first effort to establish farming cooperatives in Abyei.

The 36 members are of the Abior subtribe and have cleared approximately 32 feddans which have now produced two crops and a yield in

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*This figure compares favorably with an average yield of less than 3.5 sacks/feddan (791 kg/ha) on traditional plots.

1980 of 2.5 sacks/feddan (565 Kg/ha). The members work well cooperatively but do not designate enough days for group farm work.

The farm is located, and its members live, in an area west of Abyei town and across the Niamora River. The distance of about 3 km. means that it is nearer to the services and market of Abyei than the other farms are. The river, however, is a barrier to vehicle traffic during the rainy season and means that tractor work must be completed before the water rises.

Progress in clearing more land was virtually nil during the period June 1979 through April 1981. The more obvious reasons are:

a) No year-round water supply. During the period January to June the nearest water supply is the deep bore wells near Abyei town.

b) Periodic outbreaks of violence between Missiryia and Dinka in the area north of Abyei have caused Dinka to move south and, from time to time, the Nuenchoir area is affected. During 1980, the largest migration in recent years occurred.

c) A certain wariness developed against cooperative action as the result of the apparent mismanagement of the group's first harvest in 1974 when the 150 sacks of sorghum disappeared into the Rural Council store--never to be seen again. This mismanagement, the unreliability of the tractor service, and low yields in the later years all contributed to weakening of support for the Abior Cooperative Society in Nuenchoir.

The Thithyei community (village) is located approximately 5 km north of Abyei town and the farm field is nearby. Unlike the other group farms, Thithyei is not located in an area that received NMAPC tractor services. The land that the original farm cooperative cleared was not plowed until 1979 after the members were organized into the Thithyei Group Farm. The first crop was disappointing, as is the usual case on newly cleared land, but the members persevered and cleared more land for 1980.

The poor germination experienced in 1980 required that one-half of the farm be reseeded but a yield of 3.5 sacks/feddan (791 kg/ha) was harvested.

Thithyei Group Farm is considered the most successful of the four based on its demonstrated ability to organize cooperative workdays which has allowed them to clear approximately 52 feddans of land, effectively weed and thin the crop, harvest, thresh, and dispose of the grain.

The 36 members of the group are from the Bongo subtribe and have succeeded in working together effectively and in not allowing divisive issues to interfere with their cooperative activities. Furthermore the president, Sheikh Majok, has been willing to use his position effectively for the benefit of the group rather than for personal gain, and he has had the support and cooperation of the members, and that is the most significant factor for the relative success of the group.

Sheikh Majok witnessed every farm activity. His active participation in the work fulfilled his obligation as a member but it is his ability to organize the members, anticipate coming farming activities, and to see

the group farm as an organization that could be developed to meet other social needs of its members that sets him apart. It was clear, when visiting the farm on workdays, that the current activity had been discussed and agreement reached on how to do it among the members.

The most encouraging aspects, however, were their plans to extend the scope of activities beyond sorghum production. Some of these other areas of cooperation would include:

a) water supply based on the small bore wells and hand pumps being developed by ADP;

b) a consumers' cooperative shop selling cooking oil, sugar, tea, and a few other items frequently in short supply or high priced in Abyei shops;

c) grain storage structure;

d) the continuation of the already established community health workers' program.

The question of what the group farms should be was never resolved to the satisfaction of anyone. To the Misseriya nomads north of Abyei and the northern Arab Provincial authorities in Kadugli and farms were nothing more than a political tool used by the Dinka-dominated ADP to block the migration routes of Arab cattle into the area during the dry season.

The local Dinka wanted the farms to be expanded with bulldozers and modeled on the NMAPC program which would have given them the benefits of modernization with no cost. The farms would also help the Dinka to strengthen their claim on the area north and east of Abyei town. However, some Dinka saw the farms as nothing more than research stations of HIID, which were delaying the implementation of more extensive mechanized farming.

In fact, the farms became the focus for the application and study of tractor mechanization as well as a continuing program to develop a mechanism for community self-help. Because the farms did not increase the area cultivated or sorghum production significantly in a short period as expected, and because the ADP eventually emphasized a search for alternatives to tractors, the Group Farms did not enjoy the full support of local people and staff.

If the groups were to function solely as recipients of subsidized tractor services, not much would have been required in the way of organization and contacts with the ADP. It was, in part, because the local staff viewed the groups to be just that, that a useful system of interchange was not developed. The principal avenue of contact and exchange was the Community Development Officer* and, to a lesser degree, the Agricultural Officer and Project Director.

If, as was beginning to happen, the group farms had developed into more complex entities with functions touching into more areas such as water and health, then a more active organization with more "back and forth" exchange would be needed. The program as set up originally clearly did not accomplish that.

The failure to establish adequate ADP-group farm interchange was also due to the transportation problems during the rains and the difficulty

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*The ADP Sudanese field team consisted of nine people seconded from various departments and included: Project Director, Deputy Director, Agricultural Officer, Financial Officer, Forestry Officer, Training Officer, Livestock Officer, Health Officer, Community Development Officer. In some instances not all slots were filled and in others an individual would fulfill another role, i.e., the Forestry Officer was usually the liaison person in Khartoum.

of getting the staff to go out into the field on a regular basis.*

Within the ADP staff there were two views on how to proceed with ADP involvement with the group farms. On the one hand, it was thought that the groups should be left to identify problems and to sort out solutions with only minimal ADP involvement. The other view held that the ADP should play an active role in the process by stimulation and encouragement of the identification of problems and their resolution and that this would be best accomplished by having an ADP representative or "extension agent" working full time with each group. Unfortunately, a shortage of funds, qualified staff, and the termination of HIID involvement precluded a move in this latter direction.

The basic organizational structure of the farms were similar. Each had an elected executive committee consisting of a president, vice president, secretary, and treasurer. Although elected, the president was someone already a part of the traditional leadership chain. In the case, for example, of Thithyei Mabok and Mabior, they were sheikhs.

Each of the groups adopted a set of bylaws similar to those listed on page 39. These were developed during a series of intensive meetings between the ADP staff and the separate groups and were designed to codify the terms of membership. Two of the most notable outcomes of the adoption of the bylaws were that all nonfarm members were eliminated from the membership roles thus retaining only active members and a value was put on membership by the clause which provided for reimbursement to a departing member.

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*Dinka social customs and traditions put heavy responsibilities and obligations on individual family and clan members. More often than not, and quite understandably, family and personal matters will take precedence over an individual's work responsibilities. Also, job descriptions were very general and individual accountability is almost nonexistent within the government bureaucracy.

The active season for the group farms is from May (clearing) through January (threshing and crop disposal). Understandably, the traditional plots of each member remain the most important food production source for them. Since the group farms tend to compete for the members' time, specific work days are set aside for cooperative work. Usually two days each week are designated and each member is expected to participate under the bylaws. The more successful groups were the ones that managed to get more of the members out on the work days. They also set up more work days if the work load required it, such as during weeding and harvesting time. The Thithyei group used this effectively as they would designate 3-4 days a week just before the rains to clear just a bit more land for the season as well as later on to weed, thin and harvest.

Summary

The group farms were the units which the ADP utilized to apply tractor mechanization in Abyei. The precedent for this level of technology was set by the government effort to "modernize" the area through the NMAPC tractor program. Pressure was applied for the expansion of tractor mechanization by local people, Dinka staff members, and other Dinka who held influential positions outside of Abyei. The technology proved to be difficult to apply in the area and failed to reach any of its projected goals.

The success rate of the group farms can be said to be 25% when yearly expansion of cleared area is considered. They might be judged failures if overall production is the criteria they are judged by. The subtle movement of Thithyei toward other areas of cooperation including water, health, grain storage and consumer items purchases is an encouraging indicator for the future and is a more realistic judgement of success.

Many of the problems hampering the success of all the groups are not readily apparent and are not easily resolved, such as inter-tribal competition. Water is a serious problem not only for the group farms but for much of the area and the absence of a year around supply in much of the area limits progress in social development.

A realistic consideration of tractor mechanization including cost, technical limitations and outreach indicates that it cannot be justified on these grounds.*

It seems, though, that the group farms membership and similar groups could become significant factors in improving some of the other aspects of their lives. The future for organized activity lies less with sorghum production based on tractor mechanization than with other programs which could include:

- water supply system such as the one being developed by the ADP in 1980-81
- community health; continued training and support of the community health worker at each group
- grain storage and marketing. Even more important if production were increased on the traditional plots
- the provision of basic consumer items such as cooking oil, sugar and medicines which are often not available or available only at exhorbitant prices in the Abyei market
- the point to apply any new programs which may be developed for the area.

*See the following section on Tractor Mechanization.

Thithyei Group Farm Membership Rules and Regulations

I. Conditions of Membership

A. Members should be farmers by vocation.

B. Members should live in the area of the farm.

C. Members should be responsible for a household.

D. Members should be physically able to do the work of the farm.

II. Members who are on the original membership list but do not meet the above requirements can:

A. Give their holding in the farm to any person who does meet the requirements.

B. Give up his membership and receive compensation for his effort to date.

III. Rules for work days.

-If a member comes for work late but before 10:00 am he will be fined 30 pt and will be expected to work for the rest of the day.

-If a member does not come to work by 10:00 am he will be absent and will be fined LS1.000.

-If a member is absent for 4 or more consecutive days without an acceptable reason he will be dismissed from membership and will be compensated for his work to that date.

-If a member does not participate in the work for an entire season or clearing period without an acceptable reason he will be dismissed and compensated.

-Absence for two or more seasons for any reasons will be considered and action taken by the executive committee.

-If a member misses work because he is in prison he will be fined for the work days missed. These days will not be counted in the cumulative total leading to dismissal.

The following are acceptable reasons for missing work days.

1. Illness of the member.
2. Illness of a member of the family of the farm member. In this case another member should come as a replacement for the work day.
3. Prior permission was taken from the executive committee.

If a member proves to be troublesome he will be warned, fined and then dismissed.

If a member is ill for a long period and cannot provide a family member to do his work he may lose his membership.

In the event of the death of a member any one of his family can take up the membership if he meets the qualifications set forth above. If this does not happen the membership is lost and the family will be compensated.

IV. New members.

A. New members will be accepted only when land clearing begins and not during the growing season and harvest.

B. New members will be required to pay a membership fee which will reflect the value; i.e., amount of land cleared, of the membership. The fee will be LS 30.000 for the 1980 season.

V. Health worker.

The health worker will be entitled to a share of the crop. This share will be less than a full membership share.

## 6. TRACTOR MECHANIZATION

In a previous chapter we have discussed the NMAPC modernization program and its precedent-setting use of tractor mechanization in the Abyei area. Other sections deal with land availability, soils and crops. Here we will discuss the technical and practical aspects as well as the economic implications of tractor mechanization.

Tractor mechanization of agriculture implies tillage, and soils are tilled to accomplish one or more of the following:

1. Loosen and aerate the soil.
2. Incorporate crop residues, fertilizers, and chemicals.
3. Control weeds.
4. Prepare a seed bed (pulverization).
5. Form the surface, i.e., furrows, beds, bunds, etc.

Each of the five reasons are discussed within the Abyei context below.

Aeration and the loosening of the Abyei soils occurs naturally each dry season. The soils shrink as they dry out and large cracks form. Then the rains cause the cracks to close up, as the soils swell when wet. Thus the benefits of plowing or chiseling are negated as the expanding soil becomes tighter. Even so, for tillage to have a beneficial effect, it should be done when the soil is dry as this is when the soil will shatter and break up. When wet this soil is very sticky. It tends to form "ribbons" and "slicks" if too wet and considerable damage could result to the soil mass. Ideally the soil should have just enough moisture to crumble when tilled. Unfortunately, this is a very narrow range and the continuing rains push the moisture content

beyond that point rather quickly, which very seriously limits the application of tillage practices.

The possibility of incorporating residues does not exist in Abyei since grazing animals and humans take off most of the surface trash. Consequently, at planting time little is left, usually only the sorghum root crowns.

At the present level of agricultural development the preparation of a fine seed bed is not important as mechanical planters are not used and small seeded crops are not grown on the mechanized fields. This however would change if, say, crop rotations became a part of the system.

Although soil manipulation to form ridges or bunds would be a potential method of minimizing the effects of poor drainage, the additional equipment and technical expertise to do so, as well as the cost, make it a poor alternative at this time.

Weeding is the primary reason for tilling the soil in Abyei. Usually one pass is made over the field with a wide level disker which is followed later with a second pass which usually includes sowing the seeds.

In the Sudan the standard set as the work rate of the wide level, pulled by a 65 horsepower tractor, is 1,000 feddans tilled and seeded/unit/season. This work rate and the dual capacity, tillage and seeding, make the wide level well suited to the large rainfed areas of mechanized production. Attempts to transfer this technology to Abyei and other areas where soils are heavier and rainfall is more substantial have not been totally successful

Due, in part, to the low soil moisture availability* to plants, most weed seeds have not germinated by the time of the first plowing operations if

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* See Chapter III - soils.

these are done at the onset of the rains, and weeds are therefore not destroyed. Yet the increasing difficulty of working the soil as the rains continue, the decreasing number of available working days, and the clear advantages of getting the crop seeded early, force early tillage and the second pass over the field, which usually includes seeding, will provide the only weed control.

The wide level disker is the preferred implement for rain-fed areas in the Sudan for four reasons. One machine will accomplish primary and secondary tillage operations as well as seeding. Obviously this simplifies the spare parts and service support that the vendor and user need to provide and decreases capital investment. The use of one machine can also reduce the management input requirement.

Work rates accomplished with the disker are high compared with other implements. The ADP averaged 5 feddans per hour with the disker in 1980. This compares to 1.3 feddans per hour using an offset disk harrow* under the same conditions. A disk plow with 3 disk blades worked at rates of less than 1 feddan per hour.

Often tree stumps are not removed entirely from cleared fields but are cut or burned to a level just below the surface. The wide level disker tends to jump over these obstructions without sustaining serious damage. Another advantage is that the diskers are used on the large mechanized rain-fed schemes in the Sudan and are available in Khartoum as well as being familiar to many tractor drivers and mechanics.

The implement can be used in only one direction in the field, working counter-clockwise around the edge toward the center. If not properly

* The offset used was small. A machine matched, in size, to the tractor horsepower would increase this rate about 50%.

adjusted and operated, it will form ridges and valleys which can be troublesome on soils which drain poorly. The technique of adjusting is a bit difficult to master and, in Abyei, close supervision was necessary especially after moving it from one field to another.

The wide level is unwieldy as it can be turned sharply only to the left and its width extends to the left side of the tractor. Some difficulty is encountered when it is moved on narrow tracks through the bush.

Seed germination sometimes is a problem when crops are sown with the wide level disker. The seed is metered and then delivered via tubes down to furrows made by the disk blades. As the seed drops from the delivery tubes it scatters into a broad (20-30 cm.) band. If inter-row cultivation is contemplated, this band of plants will reduce the width of the inter-row area and, therefore, the amount of the row which can be mechanically weeded by the inter-row cultivator.

The seed is covered with a loose layer of soil thrown up by the disk blades. Poor contact is made between the seed and soil and germination is delayed or prevented. The disturbance of the upper soil layer also causes it to dry out fairly rapidly which also affects germination. Usually a rain is needed to ensure that good germination takes place. We found that, for each day after being sown that it did not rain, germination declined and that after 4-5 days the prospects for a good stand of plants were slim indeed.

The wide level will cover seeds to the depth at which it is working. Since the implement is usually set to a depth for tillage purposes, it often buries the seeds too deeply. The seedlings must be vigorous to push through this soil layer. Frequently a hard driving rain will compact the deep soil layer covering the seeds inhibiting good emergence.

In the 1979 season we were able to compare the wide level disker and disk plow on newly cleared land at the Thithyei group farm by plowing 10 feddans with each.

The wide level was used a total of four times - three for tillage and one pass for tillage/seeding. The grass on this field had a chance to develop during the previous season when the trees had been cleared but it was not plowed. It required four passes with the disker to control the tufted grasses while the plow, in one pass, effectively cut or uprooted the grass tussocks but in doing so left the surface rough with chunks and clods. An attempt to sow directly into this rough surface with the wide level resulted in a very poor stand of sorghum. When the wide level was used to work down the rough surface with one pass and then used for seeding in a second pass the sorghum established well. Although the tufted grasses were controlled effectively with the disk plow subsequent weed growth required hand weeding. The differences in the amount of hand labor required for weeding the two plots was not measured and there was no difference in yield with both averaging just over one sack/feddan.

The results of this test showed that four passes of the wide level were needed to till and seed newly cleared land and that one pass of the disk plow, although very effective in controlling grasses, required two passes with the wide level to pulverize the soil and sow the seeds.

During the 1980 season it was possible to test an offset disk harrow. Its performance on newly cleared land fell between the disk plow and wide level. Because it features two gangs of disk blades working one behind the other it proved to be a bit more effective than the wide level. We found that two passes with the offset disk and one with the disker for seeding approximately

equaled the effectiveness of four passes with the disker on newly cleared land. On previously cropped land the offset tilled a bit deeper and it chopped and mixed surface plant residues into the soil more aggressively. This action is of limited value, however, since there is usually very little surface trash left on the fields. The advantages of the offset over the wide level are offset somewhat by the reduced work rate of the former and the need to use the wide level or some other machine for seeding. The wide level maintains an advantage when costs are compared. The following costs* are based on observed work rates and are adjusted to 1980 prices.

<u>Cost per feddan new cleared land.</u>

Wide level disker

4 passes X $^{LS}3.467$ = $^{LS}13.868$ (16.64)

Offset disk harrow

2 passes X $^{LS}8.669$ + seeding # $^{LS}3.467$ = $^{LS}20.805$ (24.97)

Disk plow

1 pass X $^{LS}21.672$ + seed bed prep.# + seeding # $^{LS}6.934$

= $^{LS}28.606$ (34.33)

<u>Previously farmed land</u>

Wide level disker

2 passes X $^{LS}3.467$ = $^{LS}6.934$ (8.32)

Offset disk harrow

1 pass X $^{LS}8.669$ + 1 seeding $^{LS}3.467$ = $^{LS}12.136$ (14.56)

Disk plow

$^{LS}21.672$ + 1 seeding $^{LS}3.467$ = $^{LS}25.139$ (30.17)

Note: \$1.00 = $^{LS}.800$

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* These figures were derived for comparison only in 1979 and cannot be compared with the more comprehensive figures given on page 48.

\# Was done with the wide level disker.

It is clear from these cost figures that the wide level disk has a distinct advantage which it can maintain within the low intensity agricultural framework of Abyei and other areas of the Sudan where the absence of other inputs (i.e., management, fertilizers and pest controls) limit production anyway.

While the wide level disk and tractor appear to be the most efficient form of mechanization, it is nevertheless very costly in terms of the probable returns from sorghum cultivation. To illustrate this, we have worked out two sets of cost calculations--one based on subsidized prices or prices actually paid by the project, and a second based on full opportunity cost for capital, labor and materials. These are summarized in the following table. (The basic cost factors are presented in a table at the end of this section.)

The capital cost of the tractors and equipment totaled £S23,157 in 1980, or $28,950. The equipment is assumed to last for five years and to be used on 400 feddans. In the subsidized case, a discount rate of 10 percent is used, while in the full opportunity cost case a rate of 40 percent is applied. The materials costs include fuel, lubricants and seed. In the subsidized case, fuel is charged at its official price; in the opportunity cost case it is 67% higher. Skilled and unskilled labor are shown at their actual wage rates in the first case. In the opportunity cost case, we have simply doubled the skilled labor wage. But for unskilled labor, we have used the estimated return from farm work on own plots as discussed in Section 3 (i.e., £S3.5 per worker per day. This greatly increases the cost of the mechanized fields, but it is a realistic adjustment in the sense that mechanized fields do require much labor for weeding and harvesting. The farmers need to make the choice whether to work on the mechanized field

TABLE 1

Total Costs of Mechanized Sorghum Production

(in U.S. Dollars per Feddan)

| | Actual Cost | Full Opportunity Cost |
|---|---|---|
| Capital Costs | 23.00 | 43.00 |
| Materials Costs | 2.00 | 2.80 |
| Skilled Labor | 3.43 | 7.00 |
| Unskilled Labor | 52.50 | 185.00 |
| TOTAL: | 80.93 | 237.80 |

Notes: Capital costs use 10% and 40% discount rates. Unskilled labor uses wage rate of ŁS1 per day and ŁS3.5 per day, respectively.

or their own traditional plot. In time, they will perceive any large discrepancy in the returns from the two types of work and probably either demand higher wages or concentrate their efforts on their own plots.

The total cost figures of $80.80 per feddan and $237.80 per feddan can be compared with the expected gross returns from sorghum farming. These depend upon the yields and the prices. In the past two years, 1979 and 1980, the prices of sorghum per sack in the Abyei market in the peak marketing months of April-June were ŁS10 and ŁS20 respectively. If we use an average price for the two years of ŁS15 ($18.75) then the expected return from various levels of yield is as follows:

Gross Returns per Feddan

| Yield | | Return |
|---|---|---|
| 2 sacks | @ $18.75 | $ 37.50 |
| 4 sacks | $18.75 | $ 75.00 |
| 6 sacks | $18.75 | $112.50 |

It should be noted that the average yield on farmers' own fields has been 3.5 sacks per feddan, while the tractor cultivated fields have run about 1.5 to 3 sacks. None of these yields is sufficient, at the indicated price of sorghum, to cover the actual costs of production, much less the full opportunity costs of nearly $240 per feddan. This suggests that mechanized farming would have to continue to be heavily subsidized and that it would also depend on hiring low-cost labor from neighboring areas to the south. But it would still be less efficient than simply expanding the current traditional farming areas.

TABLE 2

Data used in computing tractor costs for 1980

| | |
|---|---|
| Tractor purchase - 1980 | LS 15,450.00 |
| Wide level disk - 1980 | 7,707.500 |
| Fuel | 1.250/gal (Imp.) |
| #90 gear oil | 3.450/gal |
| engine oil | 3.200/gal |
| hydraulic oil | 3.659/gal |
| grease | 1.640/kg. |
| oil filter | 3.000 each |
| fuel filter | 2.500 each |
| tractor operator salary | 50.000/month |
| assistant operator salary | 28.000/month |
| mechanic salary | 60.000/month |
| assistant mechanic salary | 45.000/month |
| cost of 5-ton load - Khartoum to Abyei | 650.000 |

20 drums of fuel/load

Tractor life in Abyei - 5 years.

Spare parts - 25% of purchase cost over 5 years.

Tractor use = 400 hours/year.

Work rate in field averages 4.98 fed/hour.

Tractor fuel consumption averages 1.47 gal/hr.

Fuel cost consists of a purchase price of £. 750 per gallon plus transport cost of £. 50 per gallon.

Tractor engine oil is chaged each 200 hours.

Engine capacity for engine oil is 2 gallons.

Fuel and oil filters are changed every 200 hours.

Hydraulic oil is changed at least once a year.

Tractor capacity for hydraulic oil is 16.5 gallons.

One gallon of hydraulic oil and ½ gallon of engine oil will be used for topping up between changes.

The salaries of drivers and mechanics are charged in total to 400 hours of tractor use.

Average life of a wide level is 5 years and 15% of purchase cost will be required for spares.

## 7. DRAFT ANIMALS

No other activity engendered more controversy within the ADP and among the Dinka people than the "ox plowing" program. Several factors came into play that had significant influence from inception of the program through the attempts at its implementation.

HIID was not unaware of the relationship between the Dinka and their cattle. The use of cattle as draft animals in the agriculture program was considered during the initial project design phase and was not included because of that relationship.

As Dr. Francis Deng has said (Deng, F.M. The Dinka and Their Songs, Oxford of the Clarendon Press, 1973, p. 30), "It is difficult for anyone to explain fully, and even more difficult for an outsider to understand completely, what cattle mean to the Dinka", and we will not attempt to do so here. It is clear though that a mere education and training program in the use of cattle as draft animals is not going to change the very deep cultural-emotional feelings against the exploitation of their cattle.

To those development specialists concerned with the improvement of the well being of people, the logic of utilizing an abundant resource, in this case cattle, to achieve increased food production is quite clear and especially so when the gap between the digging stick and tractors is so vast. Thus it was that the idea of using cattle to till the fields was raised again and a program of implementation was initiated by the HIID field team in 1978.

The use of cattle as draft animals seems a reasonable proposition given the fact that the Dinka are cattle people with large numbers of animals available and the skills to care for them. This advantage is very quickly

offset, however, by the aforementioned cultural considerations and by most of the technical limitations imposed by soil, precipitation patterns and requisite management skills that impede successful use of tractors.

In 1978 four local people were recruited by the ADP to become "ox trainer" trainees. The first activity during those early weeks of the draft animal program was to manufacture yokes. These were head yokes and were shaped from the wood of a local tree. A pair of carts were also made using salvaged automobile wheels and axles as the running gear and local wood for the frame and body. A Unibar moldboard plow was also on hand. By the end of the rains, the two ox carts were being used to carry wood for brick firing and water to the residential compound of the ADP.

In 1979, a plan for the implementation of a draft animal farming program was designed by the HIID animal traction advisor. The program was intended to test the feasibility of using draft animal technology in Abyei conditions, to expose the Dinka to the technology and to foster a close relationship between the farmer and his land, which was considered to be a key to the successful adoption of animal traction by the Dinka. These three goals were to be achieved by establishing one "ox trainer" with a team of oxen and a set of implements at each of the group farms and to have two similar units working at the ADP research site. A traditional house was to be built at each group farm beside the field for the trainer and his family. The program was not implemented because the various implements ordered for it did not arrive in Abyei before the rains closed the road. The training of teams of oxen and drivers continued, however, with the carts and the Unibar plow being used. Late in the season a heavy duty reversable moldboard plow (Hert) was brought in by tractor and it was demonstrated at the ADP agriculture site and on a farmer's field. The plow worked

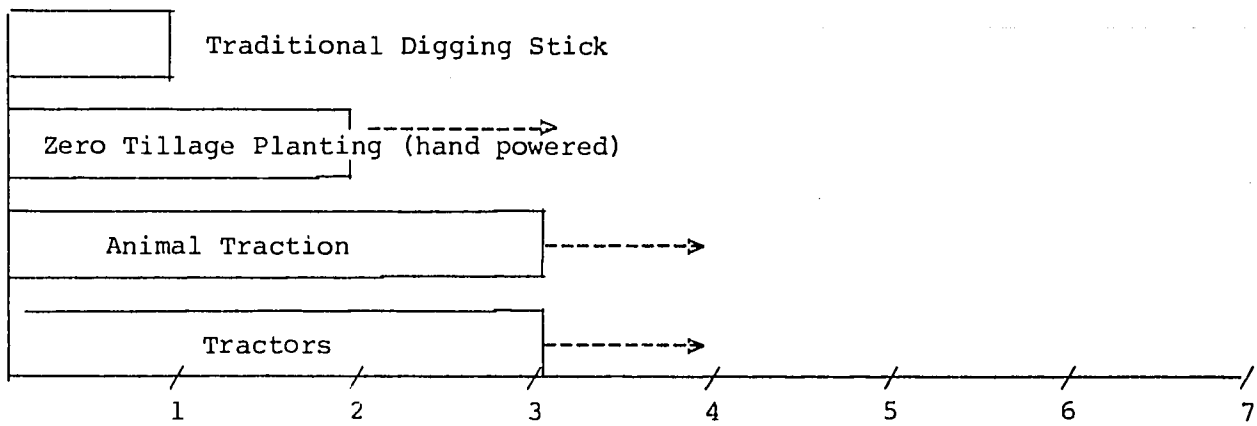
well in the Abyei soils. It penetrated the compacted soil well enough and cut and turned the grass cover over. This limited demonstration dispelled the doubts of some ADP staff members and others about the ability of tilling Abyei soils with animal power. When the road opened in late 1979 the shipment of the various draft animal implements arrived in Abyei. This gave the ADP a good selection of tillage tools to test and evaluate. Unfortunately, the HIID animal traction advisor completed his contract and departed the ADP in early 1980.

A program was designed for the 1980 season which included allowing three of the best oxen driver trainees to farm their own land or land rented for them with a team of oxen and a set of implements provided by the ADP. The main purpose was to create some more exposure to the technology and to monitor reactions as well as to test the various implements and tillage sequences and give the drivers experience.

One man was equipped with a team of oxen and a selection of implements and was assigned to his own land for the season. Three other people were assigned an area of land at the agricultural site with equipment and oxen. The program failed, however, for want of personnel for intensive supervision and guidance.

Draft animal mechanization is constrained by the same physical factors as tractor mechanization. The soils cannot be tilled when dry and are often too wet. The heavy soils increase implement draft which results in low work rates. The following diagram illustrates the relative availability of the traditional digging stick, draft animal tillage, zero tillage and tractor mechanization in primary tillage and weed control after a significant rainfall, i.e., 50+ mm early in the season and 15+ mm late in the season.

TABLE 3




Number of no rain days following significant rainfall after which each technology can be applied to a field for primary weed control and seeding.

Draft animal mechanization would also require a support system of implement procurement, education/extension program, animal health care, and supplemental animal feeds late in the dry season. The main obstacle remains the Dinka cultural relationship with their cattle and the improbability that that will change. Furthermore, it seems that the exposure of the local farmers to the NMAPC tractorization program, which was given virtually free of charge, has set the aspirations of the people in the direction of tractor mechanization. If there is to be any adoption of ox-powered modes in the near future, it will probably be by the merchants of Abyei Town for non-agricultural uses.

## 8. AGRONOMY TRIALS

An attempt was made to conduct the following agronomic trials during the 1978 season:

1. Seeding rate trial

   Two treatments - 7 lbs. and 10 lbs. per feddan.

2. Sowing date trial

   Two treatments - 15 days apart

3. Sorghum variety trial -

   Four treatments - three local and one introduced.

The area selected for these plots was poorly drained, they were flooded, and the trials destroyed.

For 1979 another area was selected for conducting agronomic tests. Emphasis was put on locating land that would be more representative of that used by the farmers, yet accessible during the rains. Suitable land which had been part of the NMAPC tractorization program was found which was close by the ADP center at Duob.

Although there were three ADP staff members involved with agriculture by 1979, only one had previous experience in conducting plot trials, and each had other responsibilities that were competing for attention. Realizing this, a request was made to the Agricultural Research Corporation (ARC) station at Kadugli by ADP for a field technical assistant to work in Abyei for the rainy season. Although the Kadugli office originally agreed with this request, no one actually arrived.

The ARC agronomist designed four trials to be conducted in Abyei. These included:

1. Cow pea (Vigna unguiculata) variety trial - 10 entries
2. Sorghum (Sorghum bicolor) variety trial - 8 entries
3. Sorghum sowing date trial - 12 treatments - 6 dates x 2 varieties
4. Sorghum time of weeding trial - 4 treatments x 2 varieties

The results of these trials were sent to the Kadugli station for analysis, but have not been returned and are presumed lost.

Three trials were designed locally. These included:

1. Sorghum population trial.
2. Draft animal mechanization trial.
3, Tractor mechanization trial.

The mechanization trials could not be implemented because the equipment had not arrived in Abyei. Some work was done with both technologies, however, and the results are found in Sections VI and VII.

Although the agronomic trial program for 1979 was a failure, the loss was not total. Observations and field notes helped to define more clearly the problems and constraints to improving traditional agriculture. The pertinent points are:

Cow peas - being sensitive to water-logged conditions are grown only on select, well drained areas of the field. It is difficult to establish a uniform and specific stand of cow pea and to protect the crop from pests on large areas. The nodulation of cow pea is low, thus reducing its N fixing capability. It is not known whether innoculation may improve this. Well established, cow peas can develop a good vegetative growth and ground cover only during good growing conditions, the frequency of which is not known.

Sorghum - the local varieties have undergone a long-term selection process of adaptation. Introduced varieties show less tolerance to frequently water-logged soils. The local farmers recognize the advantages of sowing several varieties together to minimize risk, the advantages of sowing early, and of timely weeding, but rainfall limits the former, and various pressures

come to bear on the commitment of resources to the latter.

Insects and disease pests are not significant factors to sorghum production in most years. Birds can be, however, and Striga hermonthica is a serious problem.

An important result of the 1979 season was a clearer understanding of the degree of successful adaptability of the traditional farming system. The Dinka farmers have developed a system maximizing production within the constraints of soil, climate and labor availability. We learned that we would need a more precise understanding of this complex system. We also noted the very limited range of crop species grown in the area, a limitation which has important implications for developing a cropping system.

The following points were identified in 1979 as being elements of a program to improve agriculture production.

- Sorghum production
  1. A collection of local sorghums should be assembled and a selection program for increased yield and striga tolerance initiated.
  2. Methods of increasing the productivity of traditional farmers should be identified. This includes land clearing, sowing, weeding and soil fertility maintenance/improvement.
  3. A method of reducing the incidence of striga should be identified.
- General
  1. A range of legume species should be screened for adaptation to local conditions for use in a rotation system.

2. Identification of other crops which would help to meet some local consumption needs, i.e., oil, sweetener and protein, and which would fit a cropping system based on traditional plots.

1980

The 1980 season brought an even more acute staffing problem. The HIID animal traction specialist left the project at the end of his contract in March. The Agricultural officer was appointed ADP Deputy Director and was occupied with administrative duties. These developments left just one agriculturalist, who also was the expatriate team leader, to work on the trials program. A field technician again was not available from Kadugli. The Ministry of Agriculture and National Resources and the ARC Kadugli station had again been approached and asked to fill this position in early 1980 with no positive results.

The work for the 1980 season included:

1. Cow pea variety trials - IITA (2)
2. Sweet sorghum variety and observation trial.
3. Sorghum plant spacing trial.
4. Sorghum inter-cropping trial.
5. Zero tillage observation.
6. Observation of several legume species.
7. Observation of several vegetable species.

Cow Peas -

Cow peas are grown on a very limited scale in the Abyei area. They can provide a good dietary source for protein, are a nitrogen fixing legume and can be a "trip crop" in striga control. It was decided to

continue the investigation of the suitability of the crop to the Abyei area for use in a cropping system.

Two trials were obtained from the International Institute of Tropical Agriculture. Trial #1 included 20 cultivars of a spreading type and #2 was made up of 10 brush type cultivars.

IITA Cow Pea VT #1 -

This trial was a randomized complete block design replicated 4 times. The row spacing was .75m and the plants were spaced singly at .20m within the row.

The following cultivars were entered:

| | | | |
|---|---|---|---|
| 1. | Vita - 3 | 11. | TVX 3040-01E |
| 2. | Vita - 4 | 12. | TVX 3356-04F |
| 3. | Vita - 5 | 13. | TVX 3380-042E |
| 4. | Vita - 7 | 14. | TVX 3381-02F |
| 5. | Vita - 8 | 15. | TVX 3405-014E |
| 6. | TVX 1850-01E | 16. | TVX 3401-05E |
| 7. | TVX 1948-01F | 17. | Vita - 4 LS 2-1 |
| 8. | TVX 1999-02E | 18. | Vita - 5 LS 7-1 |
| 9. | TVX 2912-011D | 19. | Vita - 5 LS 11-1 |
| 10. | TVX 2949-03J | 20. | Local check (market white) |

The plots were sown on July 2, 1980. Plant emergence was poor due to the difficulty of placing the seeds into moist soil and because the soil that was disturbed to make the seed hole would dry out very quickly.

A significant rain did not fall until July 6. The damage caused to the seeds by termites and other soil insects is not known but probably was significant. During the period July 5-August 1 plant growth was poor. This may have been due to low sunlight intensity, i.e., cloudy or overcast days. The plots appeared to remain free of disease and insect pests through most of August. In early September an infestation of a small sucking insect (Jassid or white fly) required spraying. This was done at 10-day intervals

using Actellic at 1 in./liter of water. Termites attacked some plants, cutting a trailing stem or the mainstem, then consuming it. Damage overall was about 5%. One week before the first picking, monkeys raided the plots and harvested nearly all of the pods. After that a guard was posted during the day.

The highest yielding variety was Vita 5 LS 7-1 at 228 Kg/fed 543.6 Kg/ha). The poorest was TVX 1850-01E at 88 Kg/fed (210/ha). There was a significant difference in yield between the four best and the four poorest cultivars. This suggests that the four best yielders should be

| Best Yielding | | | Poorest Yielding | | |
|---|---|---|---|---|---|
| | Kg/Fed | (Kg/ha) | | Kg/Fed | Kg/ha |
| Vita 4 | 214 | (509.7) | TVX 1850-01E | 88 | 210.4 |
| Vita 4LS2-1 | 217 | (516.9) | Vita-5LS 11-1 | 104 | 248.83 |
| Vita 7 | 227 | (541.0) | Local Check | 105 | 250.8 |
| Vita 5LS7-1 | 228 | (543.6) | TVX 3040-01E | 116 | 276.39 |

included in future tests.

IITA Cow Pea VT # II -

The design of this trial was similar to VT-I and included 10 cultivars of bush-type cow peas.

Entries

1. Vita - 6
2. 4R - 0267-1F
3. TVX 309-1G
4. TVX 1836-013J
5. TVX 2394-02F
6. TVX 2724-01F
7. TVX 3072-01E
8. TVX 3404-012E
9. TVX 3428-03E
10. Local check (market white)

The trial was sown on July 9. Poor germination and emergence resulted in poor stands overall. Initial vegetative growth was slow through July. By August the remaining plants were developing well. There was no evidence of disease or serious insect pest outbreaks until mid-August when a small sucking insect (Jassid or white fly) became a problem. This was controlled by applying Actellic, 1ml/1 liter water at 10-day intervals. Termites were a problem, destroying about 5% of the plants.

Monkeys harvested the first pick, therefore it was lost. These pods would have been ready on September 14. The second pick was on September 22. Thereafter, the pods were harvested at 1 week intervals for four weeks.

| | Yield in Kg/feddan (Kg/ha) |
|---|---|
| Vita 6 | 347 (826.8) |
| 4R-0267-1F | 211 (503.1) |
| TVX 309-1G | 265 (631.8) |
| TVX 1836-013J | 146 (346.8) |
| TVX 2394-02F | 313 (745) |
| TVX 2724-01F | 343 (815.6) |
| TVX 3072-01E | 174 (414.38) |
| TVX 3404-012E | 235 (560) |
| TVX 3428-03E | 239 (569.38) |
| Local check | 257 (612.50) |

Yields are significantly different at 35 Kg/feddan.

The production of cow pea as part of a rotation may be a marginal proposition. Intolerance to poorly drained soils and susceptibility to insect attack in the field as well as in storage result in reduced yield and potential increase in required inputs. Its usefulness as a protein source in the diet and as a component of a rotation system to maintain or improve soil fertility and to aid in controlling striga are reasons to pursue further investigation, however. A screening program, for adaptation to Abyei conditions, of cultivars obtained from the ARC, Kadugli and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), is recommended.

Sesame Observation -

Sesame (*Sesamum orientale*) is grown on a small scale by many of the Dinka farmers. Although it is sown on select areas within the traditional plots, sesame is relatively tolerant to water logging and could be grown as extensively as sorghum if the incentive were there. At present, the seeds are used as an additive to other food staples such as sorghum flour or to make an Arab-type sweet confection.

Cooking oil is imported into the area and is always expensive and often in short supply. If sesame production were adequate, a small oil extracting industry could produce oil for local consumption as well as export to the South and North. Simple animal powered technology for oil extraction is available from areas in the Northern Sudan. The resulting seed cake from an oil industry would be valuable as an animal feed supplement.

A program to select for high seed yields and oil content is a

first step to develop this industry which should be done concurrently with the identification of a suitable oil extraction process.

In 1980 a sesame variety observation assembled by the ARC, Kadugli, was conducted by the ADP. This was a non-replicated design with each plot containing 2 rows .75m apart and 4m long. The plants were spaced .25m within the rows. The plots were sown on July 2 and the following varieties were included:

| | | |
|---|---|---|
| 1. AS-70 | 11. KM-34 | 21. N-27 |
| 2. AS-73 | 12. KR-12 | 22. NA-51 |
| 3. BK-79 | 13. LK-13 | 23. T-47 |
| 4. D-35 | 14. Market white | 24. T-48 |
| 5. G-24 | 15. Market brown | 25. T-49 |
| 6. G-32 | 16. Market mixed | 26. Bladi |
| 7. HS-09 | 17. LK-14 | 27. Merabri |
| 8. KA-41 | 18. LK-15 | 28. Zira'a I |
| 9. KA-42 | 19. LK-17 | 29. Zira'a II |
| 10. KA-77 | 20. LK-18 | |

Because of the small seed size sesame must be sown at a high rate. This not only helps to ensure an acceptable number of germinating seeds, but the large number of seedlings at each station combine to push their way through the soil crust. Often though, a dry spell, insects or a heavy rain make reseeding necessary.

Not all of the plots developed an even stand and because seed supply was adequate only for initial seeding, the gaps could not be filled in as they became apparent.

The plots remained disease-free throughout the season. By August 31 an insect outbreak was observed on the pods. This was probably the sesame gall midge (Asphondylia sesami-Felt). Control was effected by spraying with Actellic at 1 ml EC/liter of water every 2 weeks. Early sowing may reduce the damage of the midge.

The samples from four of the plots were lost and the plant population in some of the others was very low. A comparison of the yield performance is, therefore, not possible. The yields of the ten highest yielding plots for which data are available are listed below, however.

10 Highest Yielding Plots Kg./feddan (Kg./ha.)

| Variety | | Variety | |
|---|---|---|---|
| G-24 | 284 (675) | AS-73 | 245 (583) |
| KM-34 | 281 (669) | N-27 | 228 (543) |
| LK-18 | 262 (623) | D-35 | 226 (538) |
| NA-51 | 250 (596) | KR-12 | 215 (512) |
| G-32 | 246 (586) | BK-79 | 204 (486) |

It is recommended that all of the varieties of this observation be assembled into a replicated trial and screened for seed yield, oil content and time to maturity. A traditional oil press should be obtained and a pilot program initiated to study its use. It could be powered with donkeys or a horse to prevent any controversy over the use of oxen.

Sorghum intercropping trial -

Often sesame and okra (*Hibiscus esculentus*) will be found growing within plots of sorghum. The merits of sesame and cow pea in a rotation have been discussed previously and sorghum, of course, is the staple food in the area. Sesame is planted each season while the okra "volunteers" or reseeds itself from year to year. Cow pea is grown on a smaller scale. An attempt was made to study the yields of sorghum, sesame and cow pea when grown in various combinations.

A randomized complete block design with four replications was used with the following treatments:

1. Sorghum
2. Cow pea
3. Sesame
4. Sorghum & cow pea
5. Sorghum & sesame
6. Sorghum & cow pea & sesame

The local variety sorghum,Rawath,was used, as were local market sesame (mixed color) and a market "white" cow pea. The trial was sown on August 9, 1980.

The cow pea failed to establish in all plots and the germination/emergence of the sesame and sorghum was poor. This was due mainly to poor placement of the seeds into the soil and poor quality seeds.

Because the data for the treatments which included cow pea is not complete,only the results of the sorghum, sesame and sorghum/sesame plots is given.

| Average Yield of Treatments | Kg/Feddan | (Kg./ha.) |
|---|---|---|
| Sorghum only - | 335 | (798) |
| Sesame only - | 173 | (412) |
| Sorghum and Sesame | | |
| Sorghum - | 369 | (879) |
| Sesame - | 68 | (162) |

All intercropped yields were lower than monocropped yields, but there was no significant difference in sorghum yields from monocropped plots and those intercropped with sesame. Sesame yields, however, were significantly lower on the intercropped plots reflecting the shading effect of the sorghum.

Sorghum Population Trial -

Although the spacing used and plant populations attained on traditional plots seem well adapted to the needs and resources of the traditional system, the duplication of those is not necessarily optimum nor practical when using machines. The possible use of planters, whether hand-powered or otherwise, warrants a study to determine optimum plant populations and spacings to maximize productive return to the user.

Observations made over two seasons indicate that the farmers will make a hole and deposit seeds at about .9m along their direction of travel and that the "rows" are approximately 1m apart. This will result in about 28,000 plants/feddan (66,640/ha.) when the seedlings are thinned down to 6 per station. It was decided to use this as the midpoint for the population trial and use two other treatments, one above at 56,000 plants/feddan (133,280/ha.) and one below of 14,000 plants/feddan (33,320 plants/ha.) to establish a bracket. The row spacing was standard at .75m and the within-row plant spacing was .10m, .20m and .40m with one plant/station.

Each plot was split and the local variety, Rawath, and an introduced variety, Gaddam El Hamam, were used.* The trial was sown on July 2, 1980. The Hamam seed did not germinate well and those plots were discounted. The Rawath plots showed better emergence, but subsequent attempts to fill in the gaps by transplanting failed. Plant growth for the first 2-3 weeks was poor due to water logging; however, plant growth picked up in August. Some leaf damage was observed characterized by chlorosis between

*These are not necessarily locally grown types. They may have been imported by a local merchant having been grown in the north.

the leaf veins and with later development of necrosis in those areas. The symptoms would begin at the tip of the lower leaves and move towards the base and may have been caused by water logging. There was no observed serious insect pest damage, although aphids were occasionally observed and several insect species were found in the heads.

The results are not significant for yield.

| | Yield Kg/Feddan (Kg/ha) | |
|---|---|---|
| 56,000 (.10X.75m) | 554 | (1318) |
| 28,000 (.20X.75m) | 617 | (1468) |
| 14,000 (.40X.75m) | 553 | (1316) |

Continued population and spacing work should be done in conjunction with continued development of the r.i.p. planter focusing on row spacing and number of plants/station.

Sweet Sorghums -

Usually during the rainy season there is a shortage of sugar in Abyei. The supplies that are available are at least in part found on the black market at high prices. Often sugar is just not available. The local varieties of sorghum include some sweet types. These are grown mixed with the grain sorghums and the stems are chewed to get the sweet juice. The production of a sweetener from sorghum to help meet local consumption demand during the periods of sugar shortage may be possible. Unfortunately, the ADP was not able to collect local sweet sorghum seeds. The supply is small since the stalks are cut before the seeds are mature and each farmer keeps only enough for his own use.

A selection of varieties from Purdue University and from the United States Department of Agriculture Sugar Crops Field Station at Meridian, Mississippi, were put out on test during the 1980 season. The USDA trial included 10 cultivars.

1. Brawley
2. Brandies
3. Dale
4. Keller
5. Rio
6. Theis
7. Sart
8. Wray
9. Sugar Drip
10. MN-1500

The plots contained 3 rows each spaced at .75m with the plants spaced at .25m and were replicated 4 times. The trial was sown on July 3, 1980. Germination and emergence was fair. Plant growth was poor through July and seemed to improve during early August. Termite damage was observed beginning mid-August. Normally these insects will attack only the dried lower leaves of sorghum, but in these plots the stalks would be cut near ground level and the fallen plant consumed. About 6% of the plants were destroyed. By mid-August the vegetative growth was again poor with the plants developing thin and spindly stalks. The lower leaves turned black and dried up. The probable cause was water-logged soil. The plants showed little tolerance to poorly drained soil conditions and responded slowly as that condition improved between rains. Other than termites no serious insect pests were observed. Monkeys managed to destroy some plants at about the flowering stage, chewing the stalks for the sweet juice.

Cane Yields Kg/feddan (Kg/ha.)

| | | | | | |
|---|---|---|---|---|---|
| Brawley | 1439 | (3425) | Theis | 3889 | (9256) |
| Brandies | 3383 | (8051) | Sart | 2644 | (6293) |
| Dale | 1828 | (4351) | Wray | 3383 | (8051) |
| Keller | 3072 | (7311) | Sugar drip | 2956 | (7035) |
| Rio | 2606 | (6202) | MN-1500 | 5678 | (13,514) |

Yields are significantly different at 460 Kg/fed (.005 level).

The Purdue sorghum observation included the following cultivars:

MN 960, MN 1048, MN 1054, MN 1056 & MN 1060

and was replicated two times.

These performed much the same as the USDA varieties:

Yields Kg/feddan (Kg/ha.)

| | | | | | |
|---|---|---|---|---|---|
| MN 960 | 1634 | (3889) | MN 1056 | 2800 | (6664) |
| MN 1048 | 3578 | (8516) | MN 1060 | 3423 | (8147) |
| MN 1054 | 3655 | (8699) | | | |

There is no significant difference in yields.

In general, it seems that these introduced varieties from both sources are susceptible to local conditions and will not perform as well as the local types although a direct test was not made.

A collection of local types should be made and selection made from them. A system of reducing the juice to a sweetener should be identified also.

Pigeon pea (Cajanus cajan) -

Pigeon pea seeds, variety unknown, were sown on a drained area of the vegetable garden. The plant grew well, reaching a height of 1.5m. Insect and disease pests were not a problem. Seed production was moderate to light. Flowering began in mid-October, as the rains ended, and continued into December.

Pigeon pea is variable in adaptation and can be used as a food, forage, shade crop, fuel and building material, and more work in selecting a variety suitable to Abyei conditions is warranted. A source for cultivars would be ICRISAT.

Chick pea (Cicer arietinum) -

This legume did not do well in Abyei. The hot weather and poorly drained soils are the main reasons.

Hyacinth bean (Lablab purpureus) (L.) Sweet -

This legume was seeded on a sandy ridge plot with good drainage. The plants developed well vegetatively, reaching a height of .40m and completely covering the ground. However, they failed to flower.

This plant is a good potential forage crop for cattle and the beans can be used as food, either fresh or dried, and several cultivars have been developed. A program to screen a range of cultivars is recommended. Sources would be ICRISAT and CSIRO, Queensland, Australia.

Field beans (Phaseolus vulgaris) -

Several attempts to grow beans were disappointing. Poor growth and flower drop were probably caused by the high humidity. Beans are not tolerant of water logging and probably do not have a future in Abyei.

Leucaena leucocephala (Lam.) de Wit. -

Seeds of this small tree did not germinate in Abyei, possibly because the hard seed coat was not scarified before being planted. Leucaena does not tolerate water logging, however, which may also affect its germination. Because of this, its value to Abyei is doubtful.

Sunflower (*Helianthus* spp.) -

Sunflower was seeded into typical agricultural land. Poor germination and the resulting poor stand made it difficult to judge the adaptation of this crop to Abyei conditions. The plants that did emerge developed well, reaching heights of ± 2.5m. Flower size ranged from .15m to .45m. Termites were a problem, often invading the stem below ground level and working upwards. Infested plants would fall over and the entire plant would then be attacked. If termite damage were not prohibitive, sunflower might be a potential oil crop. Future work should include sunflowers in a screening test for adaptation and yield.

Vegetables -

Various vegetables were tried over three seasons in a rain-fed garden. No attempt was made to measure production; rather, this program was to provide edibles for the ADP staff and to be a screen test for a wide range of potential garden crops. A list of those tried and the results are listed:

Cabbage - Poor germination and did not grow.

Carrot - Did not germinate.

Cucumber - Did well although susceptible to mildew infection.

Eggplant - Did well two out of three years.

Melon, Water - Did well. Is grown by some local farmers.

Melon, Cantaloupe - Poor, did not tolerate humidity.

Okra - Grows wild in the area. Imported variety did well initially, was destroyed by insect eventually.

Pea, sweet - Did not grow.

Radish - Does well periodically.

Squash - Zucchini type did well but is susceptible to mildew.

Turnip - Did not grow well. Susceptible to termites.

Tomato - Very poor in 1980. Did fair in 1979.

Lettuce - Leaf lettuce will grow but bolts early and often is bitter. Shade may help.

Red beet - Grew fairly well in 1980. Must harvest early.

Some vegetables do well in the area, including watermelon, eggplant, cucumber, okra and squash, and would probably give better results with more care, such as shading, drainage, irrigation, insect control and the use of beds or ridges. Future work should include identification of adapted varieties and a program of exposure to production and use directed at the local population.

Two irrigated gardens are in operation in the Abyei area. One is operated by the Government and the other by a merchant. Both are located near a year-round water source. Poor management has caused poor results for both.

Limes (citrus aurantifolia), banana (musa sapientum), papaya (Carico papaya) were friut crops that did fairly well. Other citrus did not do well. Some guava (Psidium guajava) trees were planted in the merchants garden but were not producing yet. This fruit may do well. Mangifera indica or mango does not do well although a few trees are found in house compounds.

Vegetable crops including "girgir" or rocket cress (Eruca sativa), "rigla" or purslane (Portulaca oleracea) and "figl" or Egyptian radish (Raphanus sativus) will grow well under irrigation. The merchant managed to grow an enviable crop of onions in his garden.

## 9. ZERO TILLAGE TRIALS

The vast chasm which separates traditional Dinka agriculture and a successful tractor technology was very apparent from the experience at Abyei. Animal traction, considered by some as the next logical step, foundered on Dinka tradition and culture. Tractors proved to be expensive, unreliable and limited in their contribution to the production process.

The suitability of these or any technology to a time, place or people is influenced by many factors which include the availability of inputs, costs and the increased requirement for skills in managment or technical know-how, all of which tend to act together in limiting the participants. Often the few who may have the financial and/or political "horsepower" are the principal beneficiaries of technological inputs such as the tractorization schemes, and the majority are not able to participate. To accomplish the dual goal of increasing sorghum production and spreading that task, with both its liabilities and benefits, over the greatest number of participants, it is necessary to look to the traditional farmer and his agriculture system. Invariably these systems are a complex adaptation of available inputs to local conditions whether social or physical, which, if upset, can have serious implication.

The traditional Dinka agricultural system is a reasonably efficient use of the available agro-environment within Abyei. Recognition of the strengths and the limitations of the prevailing farming system, based on a careful field investigation, led to a search for the elements of an improved system that would address the perceived limitations, or constraints, of the existing system. The most interesting possibility that was turned up in this research was the zero tillage system developed at the International Institute

for Tropical Agriculture (IITA), Ibadan, Nigeria.

The IITA system is based on chemical weed control and surface mulch maintenance principles used in other areas of the world. The difference is that the IITA system is scaled down so that it is "hand powered" except for the torch batteries required for the controlled droplet application (CDA) sprayers. Usually zero or minimum tillage systems are adopted to reduce soil erosion and to maximize moisture retention. In Abyei our reasons for trying the system were different in that it was seen as a labor-saving device which could be applied to the traditional farms as an alternative to animal traction and tractor mechanization. We anticipated that the IITA-designed rolling injection (RI) planter would enable a farmer to complete his sowing operation more quickly and improve his row and seed spacing, i.e. uniformity. The CDA-applied herbicides would help to alleviate weeding pressures and ensure timely weeding of the crop. Both the planter and the sprayer would allow modest expansion of each farmer's plot. Traditional land selection and clearing practice would not need to be changed and cropping patterns could remain the same, barring other agronomic considerations.

During the 1980 season, the system was tried on six controlled plots and observed on a field of about 6 feddans (2.5 ha). The Ciba-Geigy agrochemicals manager in Khartoum provided the herbicides for the program.* Given the limited supply of herbicides and the absence of

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*HIID and the ADP are grateful to Mr. G.J. Phillips and Ciba-Geigy for their cooperation in making these herbicides available free of charge, and for the considerable advice offered.

a field staff, the program for 1980 was limited to a set of observations to: a) test the feasibility of using the CDA sprayer and RI planter and, b) test the efficacy of herbicides in general and to select those that showed more potential under Abyei conditions.

Six plots were set up, each 15m wide x 100m long, and the following treatments were applied:

1. No herbicide - check
2. Terbuthylazine + Terbutryn (Sorgoprim) at 750 gms a.i./feddan
3. Atrazine (Gesaprim) at 250 gms a.i./feddan
4. Atrazine + Metolachlor (Primextra) at 1500 gms a.i./feddan
5. Metolachlor (Dual) at 720 gms a.i./feddan
6. Terbutryn (Igran) at 450 gms a.i./feddan

The plots were planted with the RI planter fitted with a row marker set at.75m and calibrated to drop 5-7 sorghum seeds per hole. The herbicides were applied with a "Herbi" controlled droplet sprayer.

IITA Rolling Injector Planter -

The IITA planter is based on a principle similar to the jab planters used years ago in the U.S.A. for planting corn. It consists of six opener points arranged around the periphery of a wheel. These points are not unlike the long beak of a bird. As the planter is pushed forward, these opener points rotate around and penetrate the soil one by one. Upon entering the soil, the points open much the same way a bird's beak does and a measured amount of seed is released, whereupon the point lifts free of the soil and continues around the wheel. A press wheel follows the jab wheel and is designed to help compact the soil

over the seed. Two models of the planter were used, including a machine built at IITA to the latest specifications of engineers there and a model manufactured by Groom, Ltd., England, which is in commercial production. A basic difference between the is the size and shape of the openers. The former machine has opener points which are narrow and tapered to a point. This resulted in better soil penetration and a smaller seed hole was made. The Groom design featured opener points shaped somewhat like a duck's bill, being rather broad along its length and ending with a broader, blunt tip. These differences proved to be significant in Abyei soils, which are a bit difficult to penetrate and, due to their plastic nature, tend to retain the seed holes which do not collapse and cover the seed. This problem was reduced somewhat when the IITA machine was used, since the narrowly tapered points created a smaller hole. The Groom machine did not penetrate the soil as deeply, left a larger hole and tended to flip the seeds out of the hole at faster operating speeds. The press wheels of both machines had minimal effect in firming the soil around the seed since the soil did not cover the seeds well, although it did serve as a convenient transporter wheel. The best results were obtained with both machines when a rain shower fell shortly after planting which tended to wash soil over the seeds. Late in the season the machines were used to sow sorghum in moist soil that was covered with a 1-2cm crust of crumbly, dry soil. This crumbly soil would fall into the seed hole, covering the seeds.

The seed metering devices on both machines were identical. The seed rate was adjusted by changing the wooden seed metering rolls located

on the main wheel shaft after the proper holes were drilled into the wooden roller to give the desired seed rate. The Groom machine tended to spill seed on the soil surface until a small shield was fitted, similar to the shield on the IITA model, to prevent premature discharge or spillage of the seed from the seed roll. As with most mechanical planters, variations in seed size will affect the seed rate and thinning usually is necessary. The rolling planter requires some effort to push and the ADP workers who used it on the plots had difficulty in maintaining uniform row spacings even with a marker device fitted. Those who tried got much better with practice. The machine is a bit unwieldy at the row ends when turning, but use of the press wheel and laying out long rows can minimize the problem. The planter is maneuverable enough to dodge around tree stumps often left in the traditional plots.

The ADP experience with the IITA planter showed that measured amounts of seed could be sown at regularly spaced intervals. The row spacing was dependent on the skill of the operator and with practice could be very uniform. The seed placement mechanism was much better on the IITA model due to opener shape. In general the planters worked much better when soil conditions were just right; that is, when a surface layer of dry, loose soil was present to facilitate covering the seed. In any case, the results were good, especially if a rain fell shortly after planting. The ability of the RIP to plant through thick mulch or into rough soil without the need for careful seed bed preparations makes it well adapted to most traditional farms. There were no maintenance

problems, but seed rate adjustment requires some skill. However, more work needs to be done on the seed covering problem in dry soils.

The ADP workers were able to plant 1 feddan in 3.5 - 4 hours depending on the operator and row spacing. Most of our work was done at .75m and .80m row spacings.

One meter row spacings should be tried. This would more closely match the traditional system and would facilitate hand weeding if it were needed, as well as speed up the planting rate. At the wider row spacings, at least two plants would be desireable in each station to ensure that at least three seeds should be dropped into each hole.

CDA Sprayer -

Controlled droplet spraying has evolved from ultra-low volume spraying. The Herbi sprayer, produced by Micron Sprayers, Ltd., U.K., produces droplets of herbicide mixture at about 250 microns in size. This allows the application of herbicides at low volumes and with minimal drift.

The principal advantage of using the CDA sprayer is that large volumes of water are not needed to apply the herbicide; only 4-8 liters per feddan are required. It is also a comparatively light and maneuverable machine requiring no special support equipment.

The CDA sprayer works on the spinning disk principal and is powered with 8 "D" size torch flashlight batteries. The chemical mixture is carried in a 2.5 liter plastic bottle fitted to one end and the spinning disk at the other. The liquid mix flows by gravity thr[illegible] tube to the metering nozzle and onto the disk. Spraying is sta[illegible] and stopped

by lowering or raising the disk end below or above the bottle end. The sprayer was susceptible to flow problems when the herbicide mixture contained lumps. Care in mixing and straining the liquid into the bottle is needed. The small electric motors are prone to damage by water. This problem can be reduced somewhat by proper care but extra motors should be readily available for extensive spray programs.

During the 1980 season approximately 12 feddans (5 ha) of land were sprayed and 50-60 liters of herbicide mixture were applied. The CDA must be calibrated correctly and proper spacing of swath and travel speed must be maintained just as with any other sprayer. It was found that a walking rate of approximately one meter per second and a flow rate of 1 ml per second, as recommended by the manufacturer, were easy to approximate. The former is achieved with practice, and since it is a slow walking pace, not difficult to maintain. The flow rate is adjustable by using different feed nozzles, each with a different sized opening to be matched with the viscosity of spray mix.

At medium to high application rates of active ingredient (a.i.) for each herbicide, the overall effect of the application pattern was adequate. At low levels of a.i. per feddan, strips were left if the recommended 1.2m swath width was maintained. This indicates that the spray pattern is lighter left and right of the line of travel. This also has been reported from IITA (IITA Annual Report - 1976).

Most of the herbicides applied in 1980 were in a powder form (FW) and had to be mixed with water at the correct ratio. This posed no problems except when the measured powder was put into a wet sprayer bottle before the water was added, i.e., the bottle had

been rinsed. Then small lumps would form which clogged the sprayer screen. This was eliminated by pouring the powder into a partially filled bottle and mixing by shaking immediately. It is also a good practice to pour the mix through a common tea strainer after mixing.

The spray rate achieved with the CDA was 2 hours per feddan which included setting the row markers at each end of the plot and changing bottles. Longer rows and the use of swath markers such as old crop rows would increase the rate. Battery life in one static test was 18+ hours, which would allow about 9 feddans per set of batteries to be sprayed.

The potential environment and health dangers which may be posed with the use of herbicides cannot be ignored. The use of the CDA sprayer which allows the application of small amounts of the active chemical ingredient contributes significantly to the reduction of that threat. Considerable effort was made to impress upon the people using the sprayers the need for care when handling the herbicide. The use of soap and water was provided for clean-up of the sprayers and the workers, so that the river, used as a domestic water source, was not contaminated.

The workers who operated the CDA sprayer wore rubber boots to keep the herbicide off their skin and clothes. This could be prevented by using a version of the sprayer, available from Ciba-Geigy, which applies the chemical behind the operator.

Herbicides -

The chart below gives the yield results of the six plots:

| Plot | Herbicide | a.i. gms/feddan | Kg./fed. | Kg/ha. |
|---|---|---|---|---|
| 1 | None | -- | 367 | 873 |
| 2 | Terbuthylazine + Terbutryn (Sorgoprim) | 750 | 431 | 1026 |
| 3 | Atrazine (Gesaprim) | 250 | 367 | 873 |
| 4 | Atrazine + Metolachlor (Primextra) | 1500 | 241 | 573 |
| 5 | Metolachlor (Dual) | 720 | 132 | 314 |
| 6 | Terbutryn (Igran) | 450 | 249 | 592 |

Variability in plant populations between plots due to various factors, i.e., water logging and striga, combined to make the yield results of little value.

We did find, however, that four of the herbicides gave good weed control and that they can provide almost total control of the most prevalent weeds found on local fields. The four are Sorgoprim, Gesaprim, Primextra and Igran.

Weeds Found on the Trial Plots

Aristolochia bracteolata (Ait.) Ait.F.
Caperomia serrata Presl.
Chrysanthellum americanum
Desmodium rependum
Hibiscus spp.
Ipomoea aquatica
Merremia emarginatus
Mukin maderaspataria (L.)M.J. Roem.
Rottboelia exaltata L.F.
Solanum dubium
Sorghum sudanense
Spermacoce sphaerostigma (A.Rice.) Vatke.
Striga gesnerioides (Willd.) Vatke.
Striga hermonthica

Of these, Merremia emarginatus, Rottboelia exaltata, Sorghum sudandense, and Striga hermonthica became the most troublesome from the second year after clearing, but all of these species, and no doubt others, are weed pests. Ipomoea aquatica is the only species that did not succumb to any of the herbicide treatments.

Plots 1 and 2 were planted on July 3 and the herbicides were to be applied immediately using the planter rows as guides, but a period of rain beginning that afternoon caused work to stop for three days. Thus, when the herbicides were applied to plots 2 and 3 the sorghum had emerged and some phytotoxicicty was observed. The rest of the plots were sprayed before sowing.

Terbuthylazine + terbutryn (Sorgoprim) applied at the rate of 750 gms. a.i./fed (1785 gms/ha) gave excellent control on monocot and dicot weeds. The only hand labor required on this plot during the growing season was for thinning. In another field Sorgoprim was applied at the rate of 600 gms. a.i./fed (1428 gms/ha). This resulted in strips of weeds left unscathed. Of the 1.2m spray swath covered by the CDA sprayer, approximately .80m obtained good weed control. This suggests that the application rate should be above 600 gms. a.i./fed. and will probably fall between 650 and 750. In the plots where the Sorgoprim was applied preemergent, as recommended by the manufacturer, no phytotoxicity symptoms were observed.

Atrazine (Gesaprim) applied at the rate of 250 gms/fed (595gms/ha.) also gave good control of weeds and this plot required no hand weeding. Seedling emergence on this plot was poor and it is not known if it can be attributed to the herbicide. At an application rate of 90 gms. a.i./fed (214 gms/ha.) in another field, good weed control resulted. All weeds were not controlled here which may indicate the application was too late.

Atrazine + metolachlor (Primextra) applied at the rate of about 1500 gms/fed. gave good weed control but poor seedling emergence indicates that it was toxic to the sorghum plants. This is not surprising since metolachlor is a grass killer.

Metolachlor (Dual), when applied at 725 gms a.i./fed. (1725/ha.) effectively controlled the grass weeds and sorghum. The successful use of this herbicide on sorghum was doubted, but since it has been used with success in Mali it was included in the test. Testing in the future should be at lower rates, but because it does not control broadleaf weeds, its usefulness is limited in Abyei sorghum production.

Terbutryn (Igran) was applied at the rate of 725 gms a.i./fed. (1725 gms/ha.) which was excessive and more than the 450 gms. intended. The higher rate controlled the weeds very well but seems to have damaged the sorghum. However, the sorghum was reseeded, and some did manage to grow. Igran was applied at the rate of 600 gms. a.i./fed. (1428/ha.) on another field. Here, good weed control was obtained and phytotoxicity was not apparent.

The CDA sprayer may be the weakest link in the system. Uneven application of herbicides at low rates/feddan are readily apparent. This coupled with a certain amount of carelessness on the part of new users could certainly reduce benefits relative to cost.

Zero Tillage Costs

| | Application rate | | Cost per feddan - Sudanese Pounds | | | |
|---|---|---|---|---|---|---|
| | gms a.i./ fed. | (Kg/ha) | Herbicide | CDA | Rip | Total |
| Sorgoprim | 650 | (1.5) | LS 4.800 | LS 1.200 | LS 1.100 | LS 7.100 |
| Gesaprim | 250 | (.6) | LS 1.150 | LS 1.200 | LS 1.100 | LS 3.45 |
| Primextra | 1200 | (2.8) | LS 12.384 | LS 1.200 | LS 1.100 | LS 14.684 |

The IITA zero tillage system is seen as a method of improving the productivity of the individual traditional farmer, by (a) increasing slightly the intensity of his agriculture with more uniform plant populations, better weed control and greater timeliness of these operations, and bO increasing the area which each can farm with hand-powered mechanization.

The IITA zero tillage system components, i.e., the CDA sprayer and RI planter, offer some promise of increasing the productive capacity of the traditional farmer. The sprayer and the proper herbicide could eliminate labor problems at weeding time and result in better and more timely weed control. The RI planter likewise may improve timeliness by allowing the farmer to get his crop planted as soon as conditions are right and allow a more uniform sowing rate as well as increasing his daily work rate. The preliminary work done in 1980 tends to reinforce these ideas.

The CDA sprayer allowed small rates of herbicide active ingredient to be applied, i.e., 90 to 800 gms. a.i./fed., with a low spray mix volume of about 6-7 liters per feddan. The operation of the sprayer was readily learned by the workers using it and the work rate of about two hours per feddan would allow most farms to be sprayed in a day, giving good weed control all season. The work rate,when weeding is done by hand, is .18 - .25 feddans/man day and is often done late, thus allowing weeds to compete with the sorghum during the critical early weeks of growth.

It would be unwise to recommend the large scale application of herbicide weed control at this time, as several questions should be

resolved first. More work is needed to identify the best herbicide, taking into account efficacy, cost, residual effects, application rates and safety for humans and livestock. Certainly at this stage the herbicides Sorgoprim (Terbuthylazine + Terbutryn) and Gesaprim (Atrazine) show the most promise for sorghum production.

A technical support structure would be needed to supply the sprayers, planters and herbicides as well as an extension program for disseminating the technology and training the farmers.

The acceptance of such a system by the farmers is not known, as are the full implications unknown. Future work should include a research program to:

a. identify the best herbicide;

b. establish application rates and methods;

c. study residual effects;

d. begin the training of people who could become the core of an extension program;

e. initiate a program to expose local farmers to the system and monitor reactions.

The RI planter is a hand-powered technology for planting metered amounts of seed at uniform spacings. Even if surface mulch is not a factor, the planter is a good tool for traditional agriculture. It does not require a fine, smooth seed bed and is simple and robust.

The most serious problem with the machine was covering the

seed after it had been deposited into the soil. This was due to the plastic nature of the soil, and should not be a factor in looser, more friable soils. It is necessary that this problem be resolved, however, possibly by fitting a drag behind the seeding wheel, and establishing the optimum row spacing and sowing rate.

Conclusions.

It is clear that the various limiting factors which affect agricultural production have resulted in the evolution of a well-adapted system of traditional farming. Initial ADP perceptions of a simple system which would respond to the application of technology, whether it be tractors, draft animal tillage or "improved seeds", were off the mark. The most practical and equitable approach is to work with the traditional system to understand it and improve it. In view of this, several things stand out as avenues of approach.

ADP research data indicate that soil fertility is moderate to begin with, declines under cropping and is seriously exacerbated by the yearly increase of striga. A very practical approach to this problem is to develop a cropping system which would include crops to build soil fertility, a legume, and other crops and cultural practices which would help to reduce the incidence of striga, using cow pea as a trip crop, for instance. Such a system would also have the additional benefits of generating cash for the farmer and improving the diet of his family. It could also be a key to making more land available if the bush fallow

practice could be eliminated.

Along with the above, various methods and tools to increase the work capacity of each farmer would enable him to farm his land more intensively. It would also allow each to farm a larger area. Chemical weed control and a hand planter could be the answers here.

To do these things, a research program is needed and should follow these guidelines:

1. A comprehensive soils study to establish a clear picture of soil fertility and physical characteristics as well as soil classification and mapping.
2. A program of collection and identification of local plant species and an analysis of their potential usefulness in a cropping system.
3. A screening program of a broad selection of legume species which would have value as fertility builders, forages, food and/or cash crops.
4. A screening program of oil, fibre and food crops, other than legumes, to identify those that could be of use in a cropping system.
5. A program to identify and develop machines, tools and techniques that would be applicable to the Dinka farming system to help increase productivity. This work should include methods of land clearing, seeding, weed control and harvesting/threshing. Work with the IITA zero tillage system should be continued.

The complex nature of the Abyei agricultural production system requires more than the application of bulldozers and tractors. The basic outline of research given above would begin to define some of the many potential answers to increased production. To be successful, adequate expertise and technical know-how will be needed, as well as dedication and motivation.

## 10. CONCLUSIONS

Abyei is a transition zone for culture, religion, politics and climate. The Abyei area is one of the interaction points between the Northern Arab Muslim and the Southern Nilotes. The nomadic Missiriya of the north and the semi sedentary Dinka of the South overlap there as each tries to meet the demands of survival.

The Abyei area is also a zone of change from the arid and semi-arid northern climate to the wet southern climate. The average rainfall of 850 mm. is adequate for most agricultural needs and it falls during six months of the year giving the area two distinct, wet and dry seasons.

Two physical characteristics effectively limit agricultural production however. The topography which is flat to gently undulating results in very little surface drainage which is very important on the heavy impermeable clay soils which predominate. The overall effect is that periods of waterlogging are common through the wet season and many crops will not tolerate that condition. As it is, the main production crop is sorghum which is naturally tolerant to some waterlogging. The sorghums grown in Abyei exhibit an even higher degree of tolerance indicating a selection process has taken place over the years. The range of crops that can be grown successfully in the area is limited to those which can tolerate these poorly drained conditions. This of course has implications for the development of a farming system, including mechanization and crop rotations, much different than the one already developed by the Dinka, i.e., bush fallow and the digging stick.

It is quite clear that the traditional farming system developed by the Dinka is a response to the physical conditions found in the Abyei area as well as an attempt to meet some agronomic requisites. The use, for example, of mixed sorghum types to minimize losses to pest, the wide spacing of plants in bunches to minimize effort at seeding, weeding, and harvest time and the rotation cycle of 8-10 years in sorghum production and 30-40 years in bush fallow to build up soil fertility and to counter the yearly build up of striga in the fields are all responses to problems of production. A better understanding of the traditional system has helped to identify the major constraints to production and given clues to minimizing the effects of these constraints.

Some attempts to transfer technologies from other areas, where they have worked, to Abyei have failed. The NMAPC tractorization program was hindered by the sticky soils, poor management and inadequate technical support. The ADP draft animal program faced cultural as well as physical problems. The zero tillage system which underwent initial testing during 1980 must undergo much more testing and will require substantial technical support apparatus before its full potential is known.

The traditional system developed by the Dinka farmers has been more successful than the tractors, the oxen, the new sorghum and crop varieties brought in by the government and by the ADP. The most practical and promising approach seems to be through the Dinka farmer and his plot of land. The total area under cultivation could be increased by 50% if each farming household could be given the means to cultivate 2.4 additional feddans (1 ha). By approaching production increases through the traditional

plot many of the responses already developed to counter adversities to production could be retained and paramount among these would be land selection. By being broadly participatory the risks as well as the benefits of increased production would be spread over most of the Dinka households.

The ADP experience in Abyei agriculture has not resulted in action programs which can or should be initiated. Rather, a clearer picture of what is needed has been developed and the approach of an agricultural program defined.

It appears that a more intensive rather than extensive approach is needed and, applied through the Dinka traditional farms should be directed to:

1) Develop a system to allow the crop husbandry practices of seeding and weeding to be done on a timely basis;
2) Select, from local varieties, higher yielding sorghums;
3) Develop a farming system which will;
   a. maintain and/or improve soil fertility,
   b. control striga infestation;
4) Identify crops which can be grown and will;
   a. enhance the family diet
   b. provide extra income
   c. help to resolve #3 above;
5) Develop more integration of the livestock and cropping systems. This would involve, among other things, the identification and then integration of forage crops into the cropping system. The primary goal would be to increase the supply of milk to the family.

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