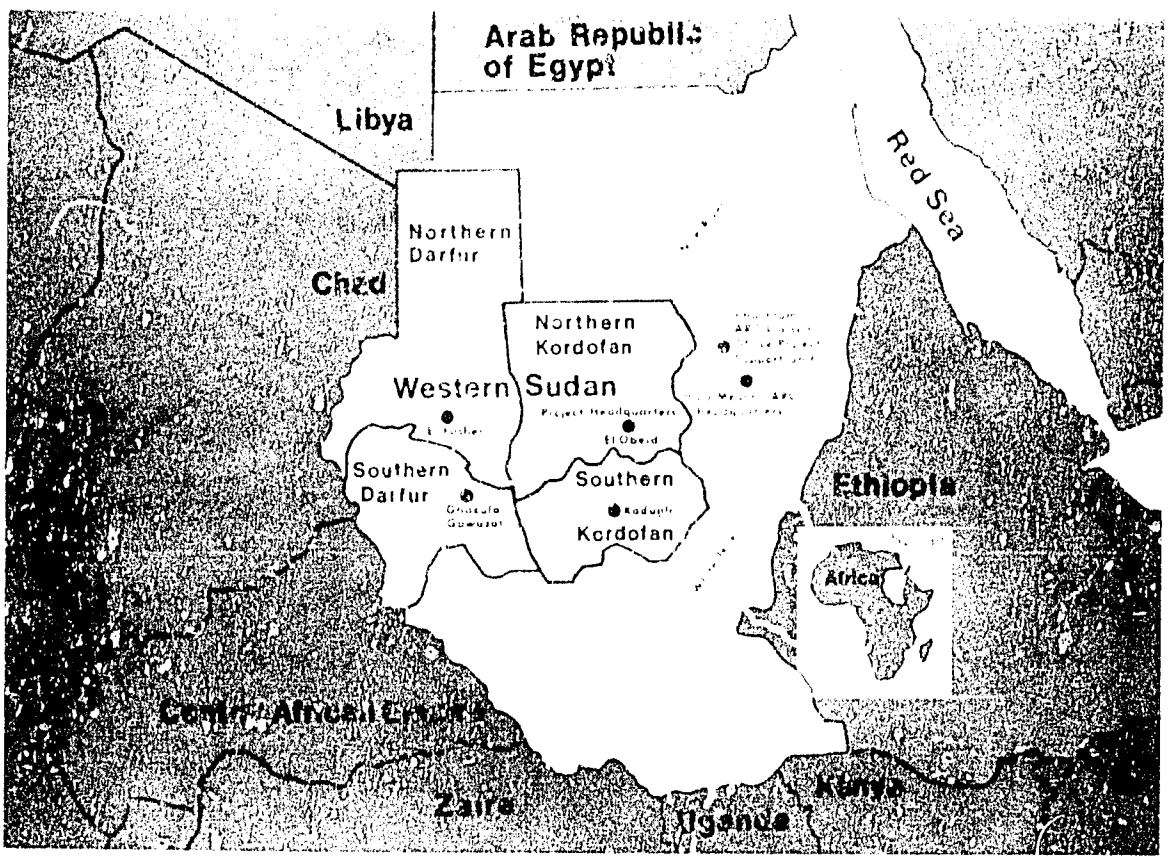
NOTES ON RAINFALL PATTERNS AND THEIR INFLUENCE ON SORGHUM/MILLET RESEARCH AND PRODUCTION IN KORDOFAN, WESTERN SUDAN



DEPARTMENT REPORT

Department of Agronomy

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NOTES ON RAINFALL PATTERNS AND THEIR INFLUENCE ON SORGHUM/MILLET RESEARCH AND PRODUCTION IN KORDOFAN, WESTERN SUDAN[1]

by

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INTRODUCTION

The rainfall pattern of the Kordofan Region, Western Sudan, has been well documented and described (6,7,8,9,11,18). That part of Sudan lies within the Sahelian zone of Africa and, therefore, is governed by the variability in climatic regimes and weather fluctuations characteristic of the Sahel. As in other parts of the Sahel, rainfall is very variable and is one of the most critical factors limiting sorghum and millet production (1,11,14). Rainfall varies both in quantity and distribution.

Plans for sound development programs and efforts to promote sustainable agriculture in this fragile and unpredictable environment require a detailed understanding of the rainfall pattern. Therefore, this paper, firstly, tries to pinpoint some of the critical aspects of rainfall variability in Kordofan and secondly, examines how the variations influence research on and production of sorghum and millet. Thirdly, some research priority recommendations are suggested.

The report is based on observations of the author during on-site (Fig. 1) experience from 1982-1985. It is hoped that the information included here contributes to a better understanding of sorghum and millet research and production in the area.

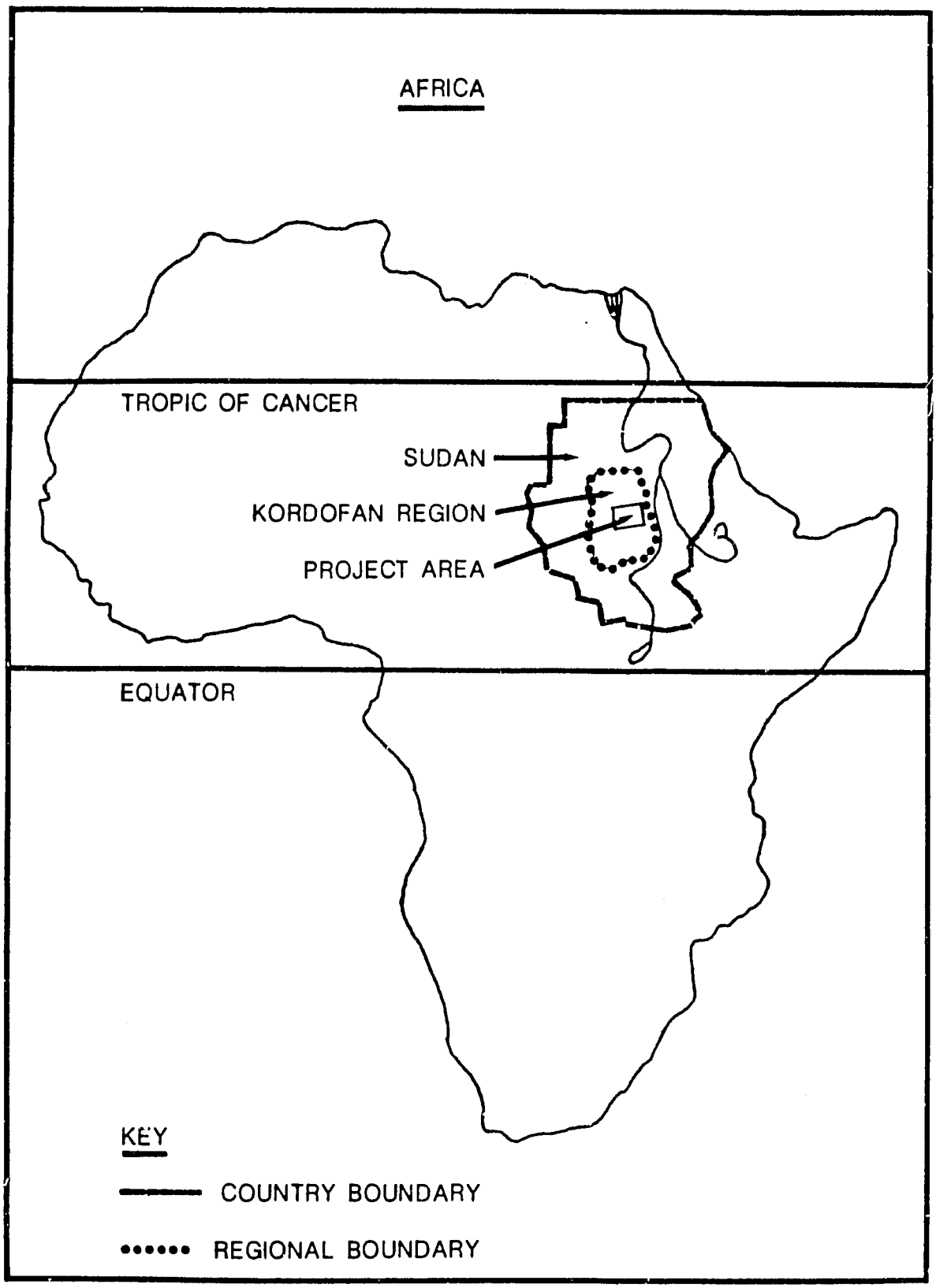

Figure 1. Continental setting of project area.

SORGHUM AND MILLET PRODUCTION TRENDS IN KORDOFAN

According to Sudan Government official crop production statistics for the Kordofan Region of Western Sudan (4,5,15) for the last two decades, there has been: 1) a two- to threefold increase in the total acreage under sorghum and millet, 2) a 40-60% reduction in yield per unit area, and 3) as a result of the two opposite factors, there has been little change in total production (Table 1).

The tremendous variation in annual, seasonal, and monthly precipitation is conservatively estimated to account for at least 20% reductions from average annual yields of sorghum and millet (12). This yield reduction is quite significant when it is considered that more than 20% of the sorghum and 80% of the millet produced in the whole of Sudan come from Western Sudan, which includes the two Kordofan and two Darfur provinces.

With increasing population pressure, there will be higher demand for sorghum and millet in Western Sudan. Therefore, it is very important that the decreasing production trend be stopped and, if possible, reversed; otherwise, food shortages will continue to occur. If any success is to be realized from research in Kordofan, researchers have to try to fit crop growth to the region's rainfall pattern.

VARIATIONS IN RAINFALL

A. Annual

The extreme variability of Sahelian rainfall is said to make the concept of "mean" and "average" meaningless. Although subnormal years clearly dominate the distribution, a few years of unusually high rainfalls can inflate the mean (1,9,14).

If annual rainfall totals of Kordofan are taken at face value, they may mislead one to believe that there is sufficient moisture for crops in 80 to

Table 1. Total area, total production and yield per unit area of sorghum and pearl millet, in Kordofan, Western Sudan, 1961/62-1983/84.[1]

Year	Area ('000 Fed.)[2]		Total Prod. ('000 MT)[3]		Yield (Kg/Fed.)	
	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
1961/62	418	302	158	121	378	401
1962/63	481	175	171	41	356	234
1963/64	529	449	184	81	348	180
1964/65	486	451	153	115	325	255
1965/66	502	453	153	93	305	205
1966/67	389	433	82	81	211	187
1967/68	468	509	145	93	310	183
1968/69	484	508	113	70	233	183
1969/70	923	666	310	128	336	192
1970/71	936	751	234	148	250	197
1971/72	968	1189	244	195	252	164
1972/73	1048	1592	200	113	191	71
1973/74	1204	1736	240	116	199	67
1974/75	978	1324	263	130	268	98
1975/76	897	1293	225	135	271	175
1976/77	1181	1323	302	194	327	158
1977/78	1249	1240	359	168	397	165
1978/79	1216	1290	381	219	298	196
1979/80	1101	843	210	100	198	158
1980/81	1078	940	269	169	298	177
1981/82	1081	1252	294	145	309	156
1982/83	1332	1145	292	65	220	121
1983/84	1457	1247	184	76	139	123

[1]Source: (4,5)

[2]FED = Feddan = approximately equal to an acre.

[3] MT = Metric ton (1,000 kgs).

90% of the time; this is not so, as indicated by the prevalence of years with low production (Table 1). One of the most critical aspects of annual rainfall is its spatial distribution. As an example, Table 2 shows some of the variation that occurred around El-Obeid and Kadugli during 1984. The data show that there was as much as 200 mm difference among locations located within a 20 km radius from Kadugli and as much as 300 mm among locations within a 50 km radius from El-Obeid.

Year-to-year variations are shown in Figs. 2 and 3. During the 1971-1985 period, annual rainfall at El-Obeid varied from 150 mm in 1984 to 467 mm in 1978. The 15-year average was 311 mm, 20% less than the 1941-1970 average (386 mm). Only three years had totals higher than the 1941-1970 average.

In Kadugli, the 1973-1985 average was 652 mm as compared with the 1941-1970 long-time average of 731 mm. Similar to El-Obeid, only four out of the 13 years had rainfall higher than the long-range mean. These facts assert that in this region (which is part of the Sahel) years with below normal rainfall are the most predominant. The facts also indicate that rainfall data of one site are quite irrelevant to the other sites of the same province because of the occurrence of rains in isolated showers.

B. Monthly

The month-to-month variability in rainfall is perhaps the most critical as far as sorghum and millet production is concerned. Variability may be in total quantity or in distribution within the month. Table 3 presents monthly rainfall for Kadugli during the 1973-1984 period. The average rainfall for June was 93 mm with a range of 25-164; for July it was 145 mm (range 54-223); for August it was 154 mm (range 82-327) and for September 129 mm (range 65-171). May and October rainfalls also

Table 2. 1984* rainfall (mm) around Kadugli and El-Obeid.

Site**		Rainfall	Site		Rainfall
ARC/WSARP Compound (Kadugli)		479	El-Obeid		155
			Abu-Haraz	(50)	347
			Um-Ramad	(33)	84
			Um-Hijly	(25)	134
Seraaf Farm	(3)	451			
			Kaba	(7)	140
Bilenya	(10)	268			
			El-Kharta	(20)	73
Kululu	(20)	363	Kazgail	(45)	103
Shaeer	(25)	313	El-Geifil	(35)	44
			Banjedid	(15)	104
			Fertenzol	(30)	50

* 1984 was a severe drought year.

** Numbers in brackets show approximate distances (km) from Kadugli and El-Obeid.

Source: Kadugli (20)
El-Obeid (3)

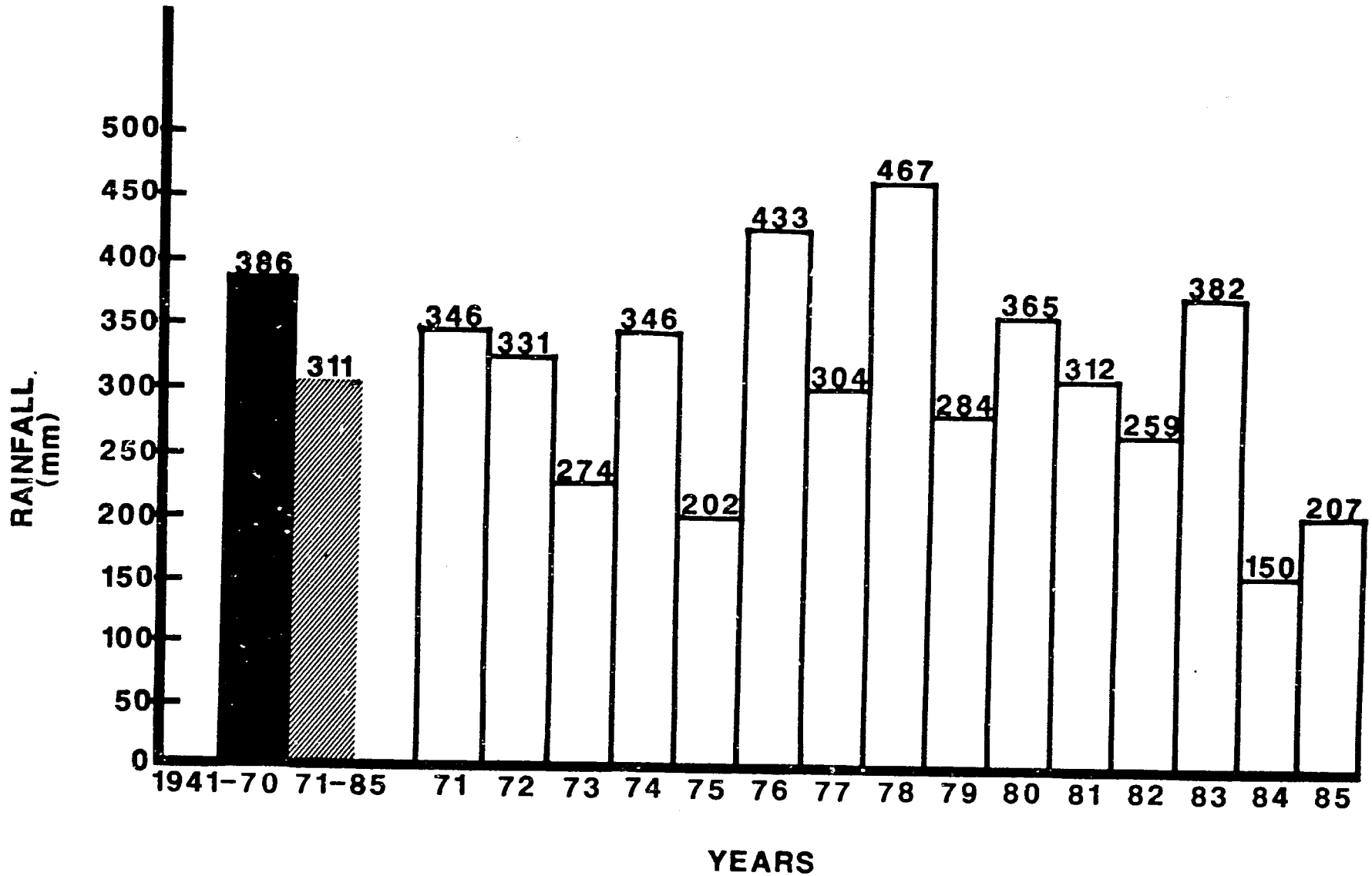

Figure 2. Yearly variation in rainfall (1971-85) for El-Obeid.

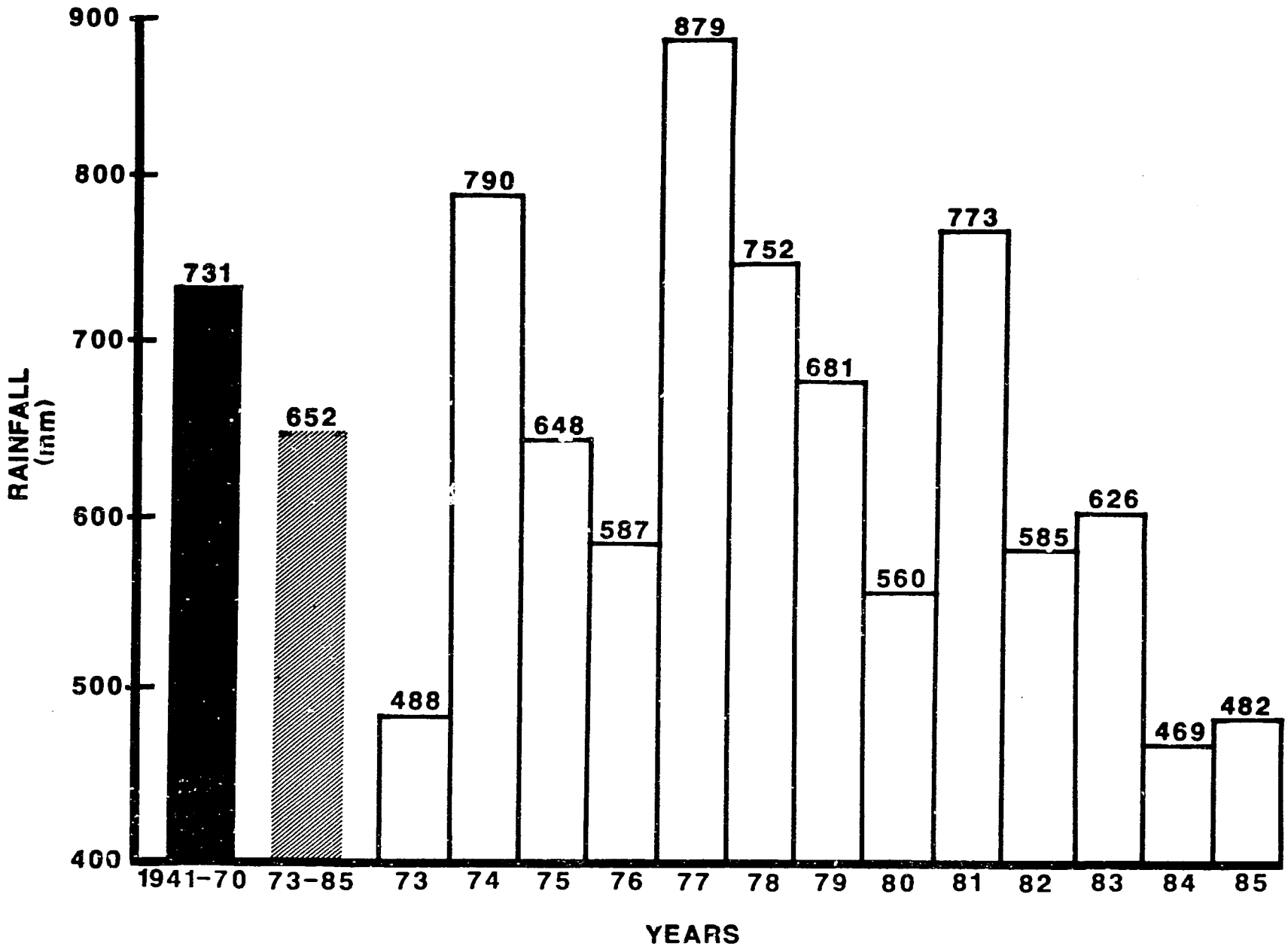

Figure 3. Yearly variation in rainfall (1973-85) for Kadugli.

Table 3. Monthly rainfall at Kadugli during 1973-1984 as compared to 1941-1970 average.

Year	MONTH												Yearly Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
1973	0.0	0.0	0.0	Tr	31.7	58.9	73.6	136.4	158.9	28.7	0.0	0.0	488
1974	"	"	Tr	46.8	24.5	164.1	168.7	139.0	171.6	69.7	5.2	"	790
1975	"	"	0.0	0.0	55.1	94.0	162.9	126.2	169.0	40.9	0.0	"	648
1976	"	"	0.1	15.8	66.2	25.3	136.3	154.6	95.0	94.1	"	"	587
1977	"	"	"	0.0	22.9	102.4	317.1	327.0	151.0	48.2	"	"	879
1978	"	"	16.6	29.1	114.6	83.5	133.3	82.3	151.1	141.0	"	"	752
1979	"	"	0.0	20.6	59.8	84.3	164.6	241.3	77.4	32.8	0.3	"	681
1980	"	"	"	9.1	24.7	84.6	127.4	132.7	141.6	40.3	0.0	"	560
1981	"	"	19.2	10.2	58.7	71.6	223.1	174.5	101.8	114.5	Tr	"	773
1982	"	"	0.0	28.0	55.1	117.6	99.5	103.2	130.6	50.5	0.0	"	585
1983	"	"	"	0.0	62.4	141.4	53.3	182.0	138.2	49.0	"	"	626
1984	"	"	"	"	52.0	93.1	86.7	143.4	64.9	28.8	"	"	469
Monthly Mean 1941-70	0	0	3	13	52	93	145	154	129	62	1	0	652
Mean	Tr	Tr	2	14	81	104	139	172	139	78	2	Tr	731

were highly variable. Except for July, monthly means for the 1973-84 period were lower than those for the 1941-70 period.

Monthly rainfall totals for El-Obeid during 1973-84 are shown in Fig. 4. June rainfall varied from 0 mm in 1982 and 1984 to 40 mm in 1980 and 1983. The 1941-70 long-time average was 27 mm. The rainfall ranges for the other months were 50-176 mm for July, 59-210 mm for August, 8-90 mm for September, and trace-36 mm for October (not included in figure).

This high variability from month-to-month is the cause for the "Invisible Drought" described by Ibrahim (12). The drought occurrs mainly because of poor temporal distribution of rain. It is shown in Table 4 that a duration of 7 to 35 days may occur between two effective rains (rains in the amount of 10 mm or more) during the early weeks of the crop season. Unless the first rain was heavy and/or the gap between the first and second heavy rains short, most seedlings die, thus, causing crop failure or making a delayed second planting necessary.

C. Frequency and Intensity

Mean frequency of monthly rainfall for Kadugli during 1973-1984 is shown in Table 5. Light rains (less than 10 mm) were the most frequent, followed by those in the 10-20 mm range. Heavy rains (greater than 20 mm) constituted only one-fifth (10 days) of the 54 total rainy days. However, when intensity of rainfall is considered (Table 6), 360 mm (55%) of the total annual precipitation fell in 11 days. The heavy showers fell in no definite pattern. May and October averaged only one heavy rain each, June and September averaged two each, and July and August three each.

More than 76% of the rain showers came in amounts of less than 10 mm. Half of those were in the trace-1 mm range and for all practical purposes can be considered significant.

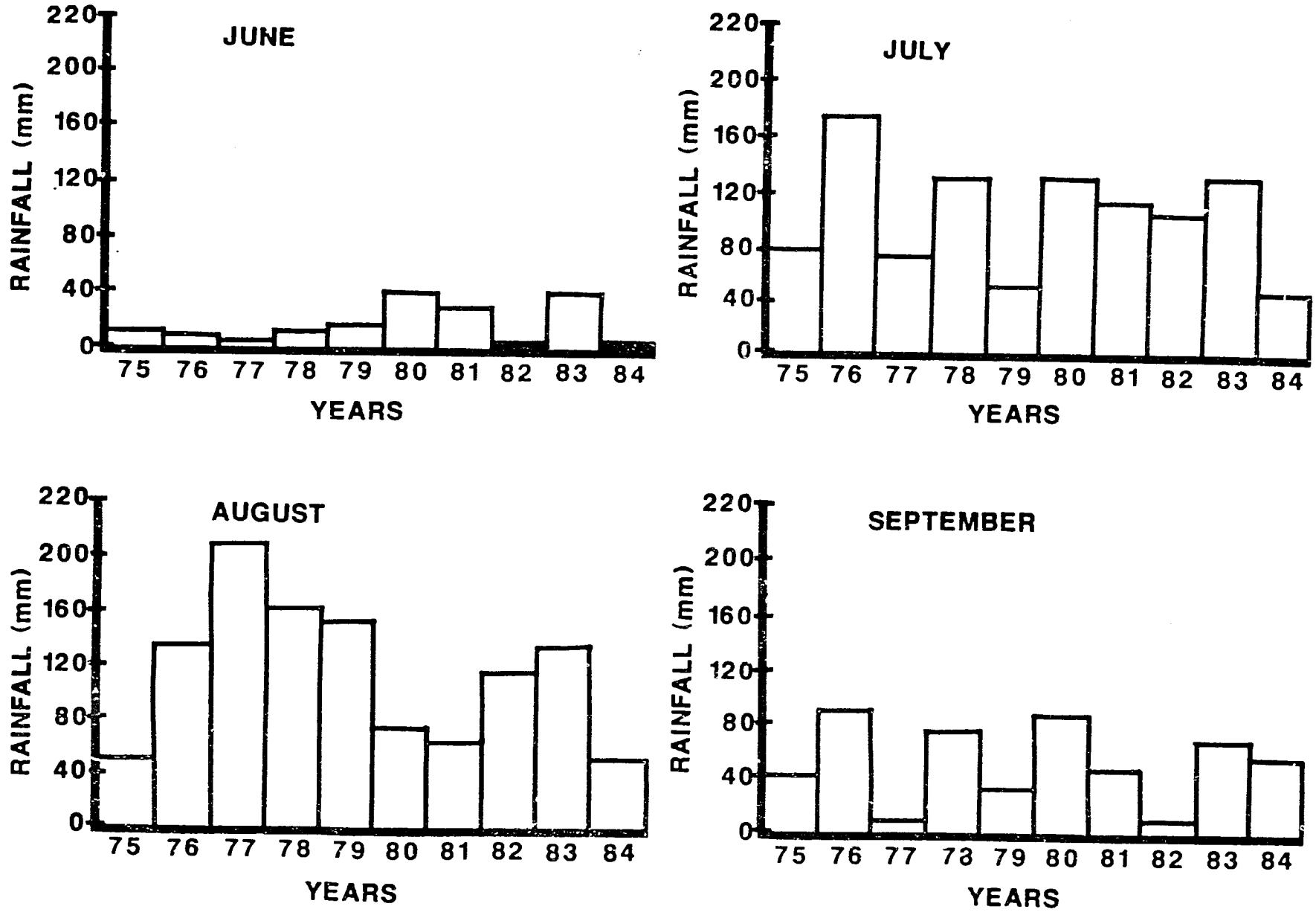

Figure 4. Variation in monthly rainfall at El-Obeid during 1975-84 period.

Table 4. Dates with rainfall above 10 mm occurring with a gap of 7 days or more after June during the planting seasons of 1973-1984.

Year	Dates with at least 10 mm rain				
	1st	Gap (Days)	2nd	Gap (Days)	3rd
1973	June 30 (15)*	17	July 16 (17)	13	July 29 (13)
1974	June 15 (13)	10	June 25 (23)	13	July 8 (13)
1975	June 7 (23)	31	July 8 (25)	14	July 22 (19)
1976	July 7 (36)	22	July 29 (25)	16	Aug 14 (42)
1977	June 21 (19)	10	July 1 (16)	8	July 9 (17)
1978	June 20 (27)	7	June 27 (32)	13	July 10 (11)
1979	June 9 (2.7)	35	July 14 (2.7)	8	July 22 (40)
1980	June 5 (23)	10	June 15 (33)	13	June 28 (13)
1981	June 3 (26)	18	June 21 (13)	11	July 2 (16)
1982	June 16 (15)	8	June 24 (19)	10	July 4 (15)
1983	June 10 (12)	12	June 22 (16)	7	June 29 (28)
1984	June 3 (49)	22	June 25 (20)	12	July 7 (32)

* Numbers in bracket indicate amount of rainfall, mm.

Table 5. Mean frequency of monthly rainfall for Kadugli over a 12-year period (1973-1984).[1]

Amount of rainfall (mm)	Mean frequency of occurrence (days)						
	May	June	July	Aug	Sept	Oct	Total
Trace-1.0	4.7	5.4	4.4	7.4	6.6	4.6	33.1
1.1-10	3.3	6.2	8.3	6.8	5.4	3.1	33.1
11-20	1.0	1.4	2.6	2.3	2.0	0.7	10.0
21-30	0.6	0.8	0.9	1.2	0.8	0.6	4.9
31-40	0.2	0.3	0.8	0.6	0.4	0.2	2.5
41-50	0.0	0.2	0.3	0.3	0.5	0.3	1.6
51-60	0.1	0.0	0.2	0.3	0.1	0.1	0.8
61-70	0.0	0.0	0.0	0.0	0.2	0.0	0.2
71-80	0.0	0.1	0.1	0.0	0.0	0.0	0.2
81-90	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-110	0.0	0.0	0.0	0.0	0.0	0.0	0.0
111-120	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121-130	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Total no. of rainy days[2]	5.5	8.9	13.2	11.6	9.4	4.8	53.4

[1] Source: Produced from Kadugli Meteorology Department Records.

[2] Not considering the trace - 1.0 mm.

Table 6. Frequency of occurrence of heavy rains (≥20 mms) in Kagugli during the 1973-1984 record.[1]

Year	Total no. of rains[2]	No. of heavy rains	Total heavy rains (mms)	Total in heavy rains as % of annual
1973	56	5	184.7	38
1974	61	14	532.3	61
1975	57	10	309.1	48
1976	66	8	246.3	42
1977	62	13	507.1	58
1978	64	15	455.7	61
1979	52	11	389.2	57
1980	49	9	289.2	52
1981	52	13	466.1	59
1982	49	10	304.2	52
1983	47	10	321.9	51
1984	39	9	312.0	67
Mean	55	10	360	54

[1]Source: Produced from Kadugli Meteorology Station Records.

[2]Does not include those rains less than 1 mm

RAINFALL VERSUS RESEARCH

Inadequate rainfall or poorly distributed rainfall affects research results negatively, for example:

1. No meaningful data were collected from the new WSARP site at El-Obeid during the 1984 and 1985 crop seasons. 1984 was a dry year, but the problem in 1985 was spatial rainfall distribution (3).
2. Although Kordofan soils are known to be low in soil fertility, results from fertilizer studies are usually inconsistent. This is attributed to poor rainfall at the beginning of the season (3,10,20).
3. Results from date of planting studies conducted at Kadugli Research Station showed that the optimum date of planting for sorghum (var. Gadam El Hamam) was different every year. The optimum date varied from the second week of June to the first week of August. The optimum planting dates matched with the incidence of a heavy rain(s) immediately prior to or after planting.
4. Results from the same experiments conducted in one year but at different sites show large differences (3,20).
5. Preliminary trials in soil moisture conservation studies by mulching showed very positive results (16).

The preceding brief discussions point out the fact that there is a need for research directed towards conserving and making the most efficient use of available moisture in the region.

SUMMARY AND RECOMMENDATIONS

Rainfall is the most critical climatic factor influencing sorghum and pearl millet production in Kordofan Region, Western Sudan. In the last decade, rainfall has declined both in quantity and dependability of distribution. As a result, sorghum and millet yields declined by 40 to 60%;

total area under these crops almost tripled, whereas annual total harvest remained practically the same.

In the Kordofan Region of Western Sudan, the critical variation seems to be in the distribution within each month, the intensity of each rain, and the spatial distribution of each rain. Following are some facts about Kordofan rainfall:

1. Kordofan rainfall shows high variability among years, among months, and within months. The variability is both in quantity and distribution.
2. Rainfall records show that Kadugli had 11% less rain for the 1973-1985 period and El-Obeid 20% less for the 1971-1985 period, as compared with a 1941-1970 long-time average.
3. Mean monthly rainfall for the months of May, June, August, September, and October were 10-30 mm less during the 1971-1985 period, as compared with the 1941-1970 period.
4. The annual average number of rainy days is 55 for Kadugli and less than 40 for El-Obeid. The low number of rainy days indicates that some rains fall in high intensities and that rainfall distribution is poor.
5. In Kadugli over 55% of the total annual rainfall occurs in 10-11 days of heavy showers (>20 mm), which have no distinct pattern.
6. Three-fourths of the rains come in very low amounts (less than 10 mm), 12% come in 10-20 mm amounts, 6% in 20-30 mm amounts, and only 4% in amounts of over 30 mm.
7. Gaps between heavy rains are longer in the June to mid-July period, as compared with the mid-July to August period.
8. Low rainfall coupled with poor distribution of rainfall within each season is one of the main causes for poor sorghum and millet yields in Kordofan.

In view of the above facts, research should concentrate on:

1. developing detailed agroclimatic data determining the influence of climate or sorghum and millet culture,
2. adapting water conserving technologies such as water harvesting, mulching, etc.,
3. evaluating the physical characteristics of the soils, such as their water-holding capacity, crusting, compacting, etc.,
4. breeding and selecting for early and drought tolerant varieties (2,3,13),
5. improving seed quality - larger and heavier sorghum and millet seeds produce more vigorous seedlings and establish better, resulting in higher yields (3,4,17,19), and,
6. encouraging use of alternative crops, such as sesame and kerkede, which have deeper root systems.

Finally, it is recommended that planting date studies be eliminated. The high variability of rainfall at the beginning of the season causes results to vary from year to year or even from site to site in the same year.

ACKNOWLEDGEMENT

The author expresses deep gratitude to Drs. Richard E. Vanderlip and Edward T. Kanemasu, Department of Agronomy, Kansas State University, for their critical review of the paper and useful comments.

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