Precipitation at Zriba Village (NE-Tunisia) - Was Segermes a part of the 'Granary of Rome'?

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Rain is the most important single factor for agriculture in a semi-arid area like the Oued R'mel basin in north-eastern Tunisia. In this article, the distribution and variability of the precipitation at Zriba Village, close to the Roman settlement Segermes, will be analyzed as well as the frequency of drought. Zriba is located at the economic-ecological limit for commercial cereal cultivation. On the assumption that the climate in Roman times was similar to that of today, the basic agricultural conditions during the Roman era will be considered, although it is doubtful whether Segermes acted as a supplier of wheat to Rome.

Keywords: *Zriba Village, Tunisia, Segermes, Africa Proconsularis, Roman era, agriculture, precipitation, drought, Mediterranean climate.*

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The basis for the Roman colonization of North Africa was agricultural production, presumably concentrating on the rain-fed farming of cereals and olives, and raising of livestock. This would have been true of the Oued R'mel Basin, in the center of which the Roman settlement of 'Segermes' was situated. The area is located at the geographical limit for commercial cereal-growing, to the north of which wheat-growing is predominant, while to the south agriculture is based on barley, olives and grazing. In Roman times, rain was, as now, the most essential single factor for sustaining agriculture in a semi-arid area such as the region around Segermes. Presumably in the Roman era, the climate of North Africa was quite similar to that of today - cf. Slim 1960, (historical-archaeological evidence), Shaw, 1981 (climatological e.), and Rouvillois-Brigol, 1985 (floristic e.). Based on this assumption, the distribution and variability of precipitation at Zriba Village, close to the location of Segermes, are analyzed in an attempt to assess the productive conditions for agriculture in the Roman period and to consider the potential importance of the Segermes area as a part of the cereal supply system for Rome. This is not a climatological study and the recent climatic situation, including the dry years in the late 1980's, has not been dealt with.

SITE AND SITUATION

The focus of this study, Zriba Village, is just 3.5 km W of the Roman settlement of Segermes, 10 km from Zaghouan to the W and 24 km from the Gulf of Hammamet to the E. The situation is 130 m above sea-level in a broad valley, the Oued R'mel Basin, which is approximately 20 km wide and found in the northern part of the mountain chain, 'La Dorsale Tunisienne'. The valley stretches between the plain to the south of Tunis and the coastal plain along the Gulf of Hammamet. Apart from the Djebel Zaghouan, which lies 14 km W of Zriba Village and dominates the region with its 1295 m, the valley is surrounded by low mountains, generally rising to 300-400 m above sea-level. The situation of Zriba is shown in fig. 1.The climate is semi-arid, mediterranean. The natural vegetation consists of open berbian cypress forest (Tetraclinis articulata), but the main land-use is agriculture (cf. below). A general presentation of the landscape and agricultural resources in the area will be presented elsewhere (Mørch).

DATA AND METHODS

The material for this article was kindly supplied by the Direction des Ressources en Eaux, Tunis. The precipitation was measured at the D.R.E. station no. 47178, Zriba Village, 36°20' N, 10°15' E. The information consists of

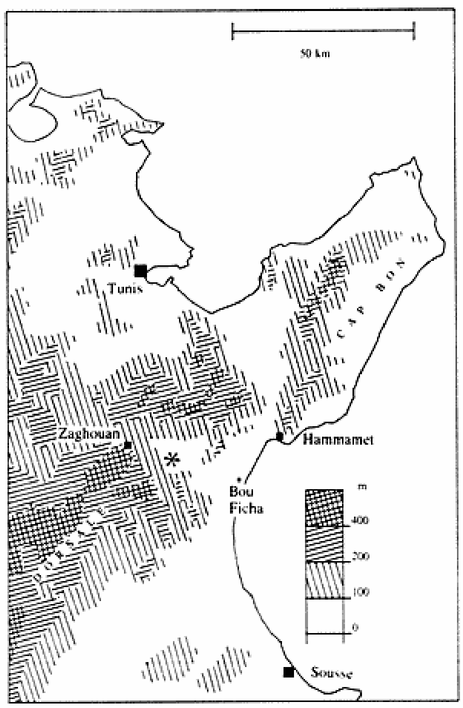

Fig. 1. Zriba Village - location. (Indicated by the asterisk between Zaghouan and Bou Ficha).

monthly precipitation records in millimeters, accurate to one decimal point, and, (for the purpose of this article), rounded to the nearest integer). The monthly data are arranged according to the agro-ecological year, beginning with September one year and ending with August the following year. The information covers the period 1920/21 to 1974/75, excluding the interval from 1959/60 to 1964/65. Unfortunately, records are lacking for single months, and to the extent records were available, the precipitation has also been calculated on the basis of seasons, growing period, and the whole year. The seasons are; autumn: September-November - winter: December-February - spring: March-May - summer: June-August. The growing period is: September-May.The description here has been kept short and uses just simple statistical parameters: mean, standard deviation, the coefficient of variation (standard deviation as percent of mean), median and quartiles. These parameters appear in table 1. The cumulative percent deviation from the mean shows the possible long-term changes explained below. Drought is defined as a negative deviation from some certain specific threshold amounts which are specified later.

RESULTS

General Distribution of Precipitation

The Segermes region receives around 400 mm rain annually, less in the eastern part, more in the western and northern part, and also the surrounding mountains receive a bit more. Zaghouan has a mean, annual precipitation of 510 mm, Zriba 412 mm, and Bou Ficha 332 mm. This gradient is due to altitude and distance from the sea, and agrees with mapping of the regional distribution of precipitation in Tunisia (Henia, 1980, and others).The annual distribution of rain is mediterranean and is thus concentrated in the cool season: about one-third in autumn, one-third in winter, one-fourth in spring, and less than one-tenth in summer. At Zriba, October, with a mean of approx. 60 mm, is the month with most rain. The next five months receive 40-50 mm each, and July and August receive almost nothing. Fig. 2 shows the mean monthly precipitation.

Period	n	mean	st.dev	c.var	min	25%	med	75%	max	i.var
Sept	49	35.7	38.9	108.9	0	9.0	22.0	44.3	183	106.5
Oct	49	58.6	81.2	138.6	1	19.8	39.0	75.5	540	142.8
Nov	49	47.9	48.7	101.7	5	18.8	30.0	49.0	173	100.7
Dec	49	52.4	60.8	116.0	0	16.8	30.0	62.5	293	152.3
Jan	49	48.2	35.2	73.0	0	18.8	41.0	70.0	145	124.9
Feb	49	43.0	39.0	90.6	0	13.8	35.0	58.5	181	127.7
Mar	49	46.0	40.4	87.8	2	16.5	32.0	67.3	160	158.8
Apr	48	35.6	33.7	94.8	0	15.0	28.0	43.0	163	100.0
May	48	19.1	15.5	81.3	0	6.5	16.5	29.5	63	139.4
Jun	48	12.8	18.3	143.9	0	0.0	4.0	20.0	77	500.0
Jul	48	2.8	5.3	191.2	0	0.0	0.0	2.0	21	n.c
Aug	47	11.5	14.3	124.4	0	0.0	5.0	18.0	60	360.0
Year	47	412.3	155.5	37.7	183	307.8	372.0	485.5	790	47.8
Gr.p	48	382.9	153.1	40.0	163	274.5	644.0	447.0	740	26.8
Aut	49	140.8	110.9	78.8	12	72.0	101.0	196.5	591	123.3
Win	49	143.7	79.7	55.5	0	87.3	119.0	174.5	329	73.3
Spr	48	101.1	61.6	61.0	15	61.0	90.5	131.5	363	77.9
Sum	47	26.6	26.1	98.2	0	7.3	19.0	38.5	126	164.2
Period	n	mean	st.dev	c.var	min	25%	med	75%	max	i.var

Table 1. Statistical summary of the precipitation at Zriba Village. - Columns: number of observations, mean, standard deviation, coefficient of variation (st.dev. as percent of mean), minimum, lower quartile, median, upper quartile, maximum, index of variation (interquartile range as percent of median). - Lines: months, whole year, growth period, seasons. -n.c.: no calculations.

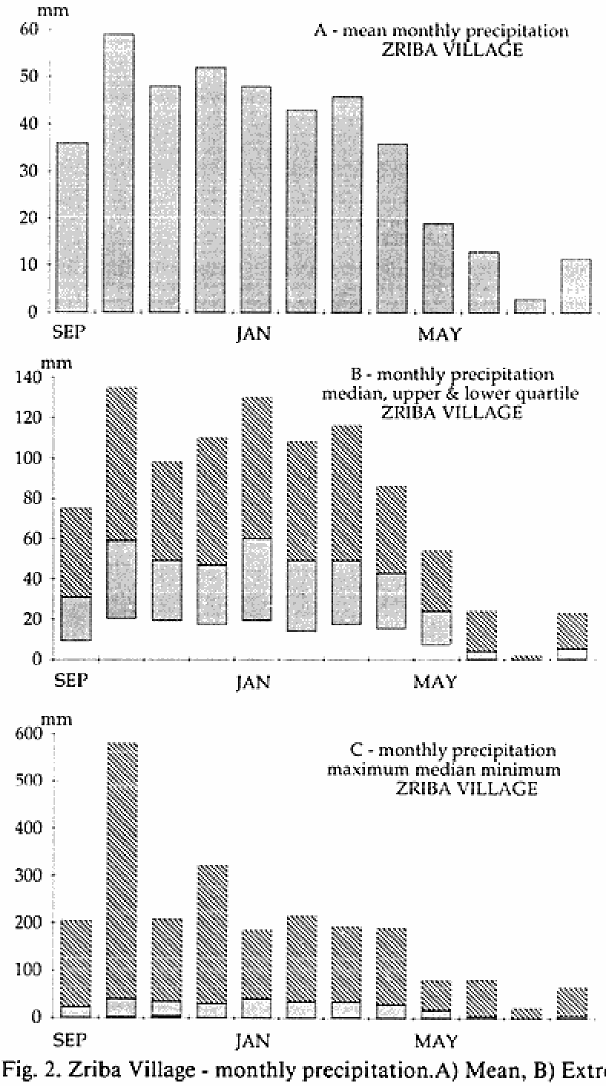

Fig. 2. Zriba Village - monthly precipitation.A) Mean, B) Extremes: the minimum, median and maximum precipitation, C) Median, upper and lower quartile. - The vertical scales are not identical.

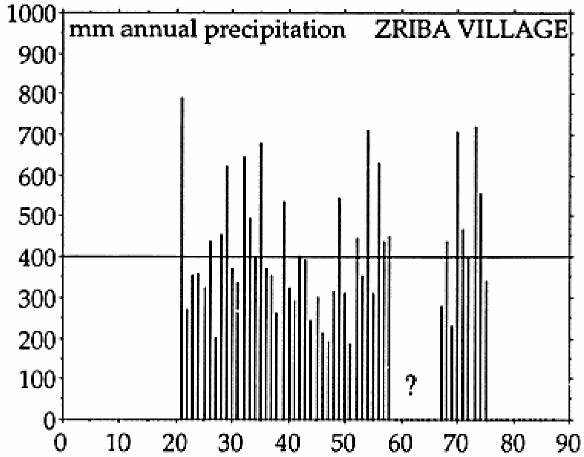

Fig. 3. Zriba Village - annual precipitation 1920-1975. The 400 mm isohyet indicates the minimum requirement for commercial cereal growing, as explained in the text. Records are lacking for part of the period, namely the interval 1959-1964 as well as for a few other years.

Variability

However, one thing is the mean figures, another the real conditions. The variability of precipitation is a feature which is just as characteristic as the seasonal distribution.

The mean annual precipitation at Zriba is 412 mm, but the observed values are very irregular and have been recorded to vary from half to almost double the amount (183 mm and 790 mm). Fig. 3 shows the annual precipitation. The coefficient of variation (standard deviation as percent of the mean) for the annual precipitation was 42 %. On a seasonal, or monthly basis, the variability is more conspicuous. The shorter the period of registration, the greater the variation. The coefficients of variation for the seasons were: Autumn, 79%, Winter, 56%, Spring, 61%, Summer, 98 %. October, with a mean precipitation of 60 mm, is recorded to have received amounts ranging from a minimum of just 1 (one) mm to a maximum of 540 mm, the latter being three-quarters of the total rainfall that year (1969/70) when a disastrous storm struck Tunisia (e.g. Kassab, 1979). Statistically, the variability is lowest during winter and highest during summer. At Zriba, the coefficients of variation, on a monthly basis, were: 73 % for January, and 191 % for July.The variability may create a peculiar effect whereby the generally humid months receive less rain than the dry ones. For instance, October, as mentioned, has a mean precipitation of 60 mm, yet a minimum of just 1 mm has been recorded, while June, with a mean of 18 mm, has a recorded maximum of 66 mm. What is more important is the fact that rainfall might well fail completely at critical stages of the vegetation cycle of the crops. Furthermore, the distribution of pre-

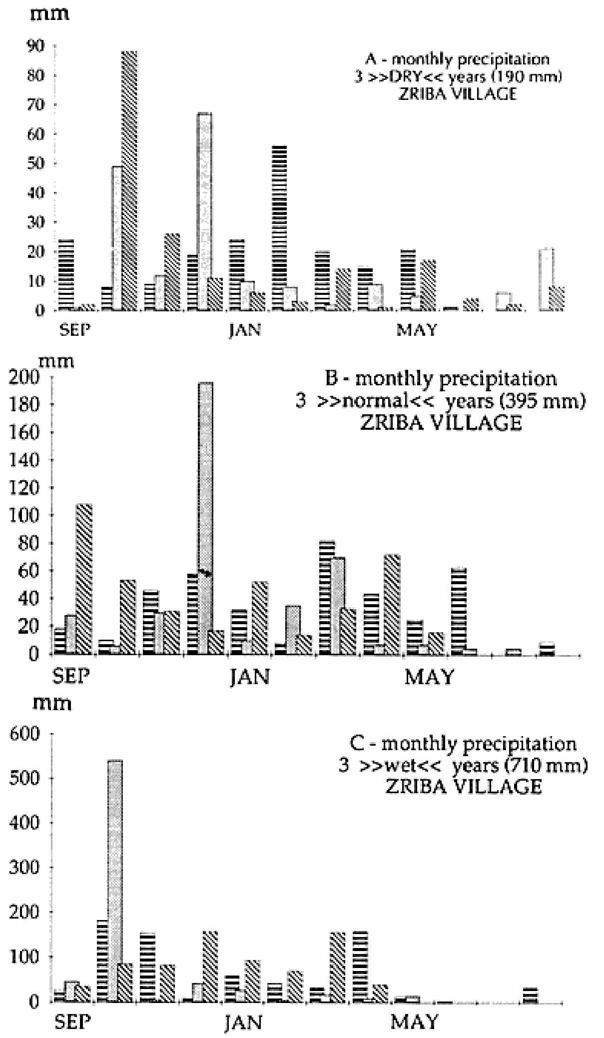

Fig. 4. Zriba Village - monthly precipitation. - The vertical scales are not identical. A. 3 'dry' years with approx. 190 mm. B. 3 'normal' years with approx. 395 mm. C. 3 'wet' years with approx. 715 mm.

cipitation throughout the year may be quite different from one year to another, despite the same total amount. To illustrate this fact, fig. 4 is a comparison between three types of years based on the amount of precipitation; 'dry', 'normal,' and 'wet' years. Each type is represented by annual totals for 3 years for which the precipitation amounts are similar:

A) 3 'dry' years 1926/7, 1946/7, & 1950/1 with 197 mm, 190 mm and 183 mm, respectively.
B) 3 'normal' years, with amounts close to the mean, 1933/4, 1942/3, & 1971/2 with 395 mm, 394 mm, and 396 mm, respectively.

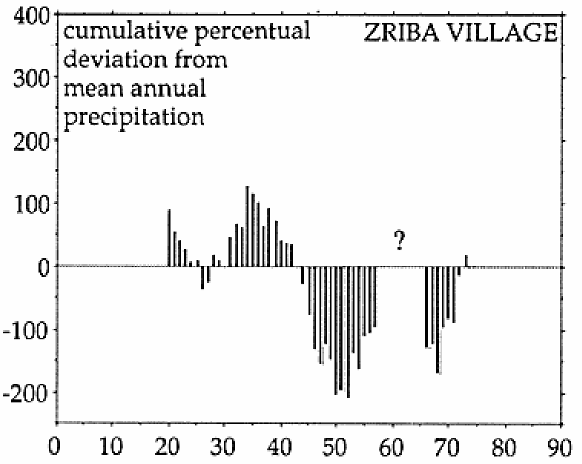

Fig. 5. Zriba Village. The long term changes in annual precipitation. The cumulative percent deviation from the mean for the period 1920-1975. Records are lacking for part of the period, namely the interval 1959-1964 as well as for a few other years.

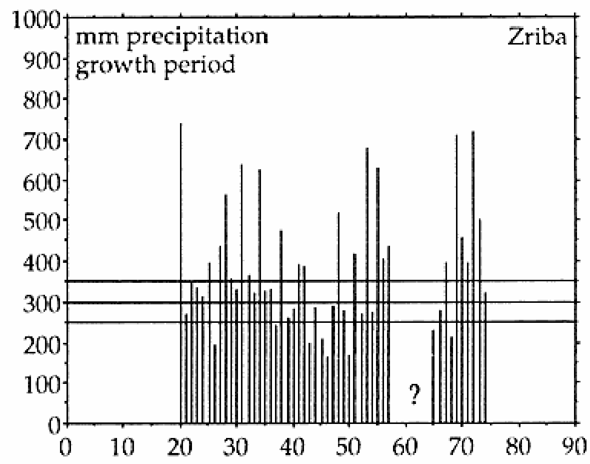

Fig. 6. Zriba Village - precipitation in the growth period for the period 1920-1975. The horizontal lines for 250, 300, and 350 mm represent threshold amounts explained in the text. Records are lacking for part of the period, namely the interval 1959-1964 as well as for a few other years.

C) 3 'wet' years 1953/4, 1969/70, & 1970/1 with 711 mm, 707 mm, and 720 mm, respectively.

The strongly individual character of each year is apparent. It could be said that 'normal' years do not exist at all, in the sense of normal years with a monthly precipitation close to the average distribution. The difference between the years is the result of different meteorological events, which will not be considered here, (but see e.g. Bousina, 1986 and Henia, 1986).

Long-term Changes

The long-term changes could be of general climatological interest, but might also be relevant seen in an agricultural context like the one studied here. These changes can be shown by the cumulative percent deviation from the mean which, despite its long and difficult name, is actually a simple method. The name indicates the procedure. On the basis of these calculations, a curve indicates whether the years are generally stable, becoming drier or, conversely, becoming more humid. The direction of the curve indicates the change. If the curve goes up, the years are more humid than the average, and the opposite is the fact if the curve goes down. The inclination of the curve is an indication of the speed of change. The accurate position on the curve is irrelevant for interpretation purposes.

For Zriba, the records of the annual precipitation cover a period from 1920 until the mid-1970's, with the exception of the period from 1959/60 until 1964/65. It is not possible to detect a simple trend from the cummulative deviation, neither upwards nor downwards. Progressive aridity started at the beginning of the 1920's, and was especially pronounced from 1933 until the beginning of the 1950's when the climate became more humid again. The long-term change is shown in fig. 5. These trends demonstrate that agricultural conditions might shift positively or negatively. A 20-year period above or below average might be of great importance for agricultural production, and even decisive for the economy of the individual farmer. These shifts might occur even if there is no long-term change. Regional differences may vary even within short distances. For instance, the pattern of long-term change for Zriba is quite different from that of Tunis 50 km to the NW (Frankenberg & Klaus, 1987).

Drought

Meteorologically, a significant negative deviation from the mean quantity could be interpreted as drought, measured in absolute or relative terms. For agricultural production, however, it is more suitable to define drought as a deficit of moisture which has a substantially negative effect on yield (Agnew, 1990).

In Tunisia, an annual precipitation of 400 mm is regarded empirically as the minimum requirement for commercial cereal cultivation to meet its production costs (e.g. Depois, 1961; Fakhfakh, 1977). Jaschke (1980) mentions 380 mm as 'tolerable' for semi-arid Australia). Below this minimum, there is a gradual decline in yield until it is even too low to sustain subsistence crops to feed the household, working force and draught animals, and too low to supply seed grain and act as an adequate storage supply for security. In bad years, the cereal crop might be

A - Years receiving less than 4 threshold amounts of precipitation				
< 200 mm	< 250 mm	< 300 mm	< 350 mm	total *)
4	8	17	24	48
				*) incl. years with > 349 mm
B - Probability of one year receiving less than				
< 200 mm	< 250 mm	< 300 mm	< 350 mm	
0.083	0.167	0.354	0.500	
C - Probability of two years receiving less than				
< 200 mm	< 250 mm	< 300 mm	< 350 mm	
0.007	0.028	0.125	0.250	

Table 2. Probability of drought at Zriba Village. The calculations are based on precipitation records from DRE, Tunis.

used for grazing to get at least some return, or ploughed in as green manure. Concerning yield security, it is necessary to distinguish between barley and wheat, as barley is better adapted to drought and variability in rainfall. For the Mediterranean region, 200-250 mm for barley and 300 mm for wheat (Arnon, 1972) have been empirically found to be the minimum requirements for the growing season (Sept.-May). These threshold amounts were applied to the data for the Segermes area, with 350 mm included somewhat arbitrarily as being just acceptable for securing a reasonable harvest. Fig. 6 shows the precipitation for the growing period.

The statistical probability of yield security is shown in table 2, where 0.354 (35.4 %) implies 35 years out of 100, or 3-4 out of every 10 years, receiving less than 300 mm, which is too little for wheat.

If these threshold amounts are accepted, and Zriba is accepted as being representative of the Roman Segermes territory, the barley harvest will fail every 6th year and the wheat harvest every 3rd year. A single crop failure may not be disastrous, but if the harvest fails in two or more successive years, the consequences might be serious for the supply of each farm household as well as the local supply. It would appear from table 2 that the risk of two successive years with crop failure is small, just 3 % for barley, yet 13 % for wheat.

DISCUSSION

The Relationship between Rainfall and Production

Being close to an agro-ecological limit, which is the case for the village of Zriba, a drop of just 50 mm in the annual rainfall might prove decisive. Therefore, even quite small fluctuations in precipitation might have a significant effect, on the actual conditions, either positively or negatively, which was probably the case in Roman times, although it is not possible to judge whether such small differences occurred.

The seasonal distribution of rainfall in relation to the vegetation cycle of a specific crop variety is important, and just a 10-day delay may be severe for cereal growing. In this context, monthly data are rather inadequate. As the rain commonly falls in concentrated showers, theoretically and in practice, there might be almost 8-week intervals without rain, even if the rainfall has been recorded as normal on a monthly basis. The 400 mm and other threshold amounts, applied above, are empirical 'rules of thumb' and not applicable to any single year. One year with just 300 mm might give a reasonable harvest if optimally distributed, especially if the autumn and the spring are comparatively humid. Another year with 500 mm might give a very bad one if the autumn, or spring, has been dry, or if the rain has been concentrated in vigorous rainstorms (Despois, 1961 and also Aschenbach, 1964).

Many factors influence drought. Rain has to infiltrate the soil in order to be usable for crop growth. Small isolated showers of just 10-15 mm are generally without any effect, even if the sum of the rain from these showers should be sufficient, because the water from each shower evaporates from the surface within a couple of days. Consequently, some concentrated prolonged periods of rain are preferable although violent showers lead to surface run-off and lower infiltration. Heavy soils have a low infiltration rate and a high risk of surface run-off, but the moisture capacity is high in contrast to that of light soils. Temperature and evaporation are important factors and so are; the vegetation cover, crop variety, sowing time, rotational system, agricultural techniques etc.

Yield is not simply dependent on seasonal precipitation. Many factors influence yield and great differences may be experienced, even between neighbouring areas, depending on the topography and soil. The factor relationships creating agricultural yields are indeed very complex, and drought, also agricultural drought, defies a simple definition.

Because of the general modernization of the agricultural sector, Tunisian yields have been increasing during the last 20-30 years. However, in the Segermes area they are still low, averaging 1.5 t/ha, and differing as much as +/- 100 % (Commisariat d'Agriculture, personal communication). The 1.5 t/ha is a 15-20 fold return. For the harvests prior to Tunisian independence (1956) and in the years just after, yields appear to have been almost half as high.

It is difficult to say anything specific about the yields in the Roman period. Yields and surpluses at that time, as now, depended on several factors such as; the varieties sown, agricultural techniques, rotational systems, and the size of labour force. A difficult question, too, is how much the soil fertility has changed in an area which has been

more or less continuously cultivated for more than 2,000 years, and which, without doubt, has been seriously eroded and consequently deteriorated. It is likely that yields in Roman times were not higher than in the colonial period (White, 1963). It is not an object taken in consideration here.

Nonetheless, rainfall is the most important single factor for guaranteeing crop yields in such a semi-arid area. Based on 300 locations 1896-1941, Cornish (1950) reports that more than 70% of the variability in wheat yield was due to inter-annual variation in rainfall in a climatic zone quite similar to semi-arid Tunisia. Hence, although for the time being just simple precipitation records and little evidence of the agricultural yields are available for the Segermes area, it should be possible even on this basis to venture an estimate of the prospects for agriculture. The precipitation is sparse and unreliable, and the present climatic conditions favour an agricultural preference for barley, grazing, and olives, instead of wheat. In fact, this is true of the present land-use situation. Of the total surface area, rotational land-use practices occupy 53 %. (wheat 6 %, barley 18 %, fodder crops 16 % and fallow 13 %). Olive groves occupy 19 %, and the remaining 28 % is mainly waste-land consisting of wild pasture, maquis and forest (Mørch). Thus the wheat area is very small, being surpassed threefold by barley. Irrigation obviously offers the good possibility of improving agricultural output, but currently just 1-2 % of the area is irrigated, and as yet there is very little, if any, evidence of irrigation in the area in Roman times.

CONCLUSION

In the Zriba area, the climate is semi-arid mediterranean. The precipitation is sparse and unstable. If the present climatic conditions are assumed to have prevailed in Roman times, barley, olives and livestock might have been the basis for the external economy of the Roman Segermes. The risk of food shortage might have been comparatively high, while that of real hunger low, as conveyed by an aphorism by Garnsey (1988 & 1990): 'Food crises were frequent - famine was rare'. Wheat may have met the domestic or local demand, and served occasionally, when a surplus appeared, as an export commodity. Wheat might have acted as a part of an economic gamble. If so, this poses some questions regarding the economics of Segermes and its connection with Rome. One question is, to what degree was barley a long distance commodity in Roman trade? Another question is, was wheat ever of any economic importance to Segermes?

ACKNOWLEDGEMENTS

This paper has been prepared in connection with the 'Mission Tuneso-Danois archaeologique dans le région de Segermes', which is a joint venture by the Institut National d'Archaeologique et d'Art de Tunisie, the University of Copenhagen and the Danish National Museum. The project has been sponsored by the Carlsberg Foundation and the National Danish Humanistic Research Foundation. Directeur, M. Trabelsi, Direction des Ressources en Eaux, Tunis, has supplied the basic data. Mrs. K. Winther and Mr. R. Barnes, Geographical Institute, Copenhagen, have improved the English manuscript. To these institutions and persons, the author wishes to extend his best thanks.

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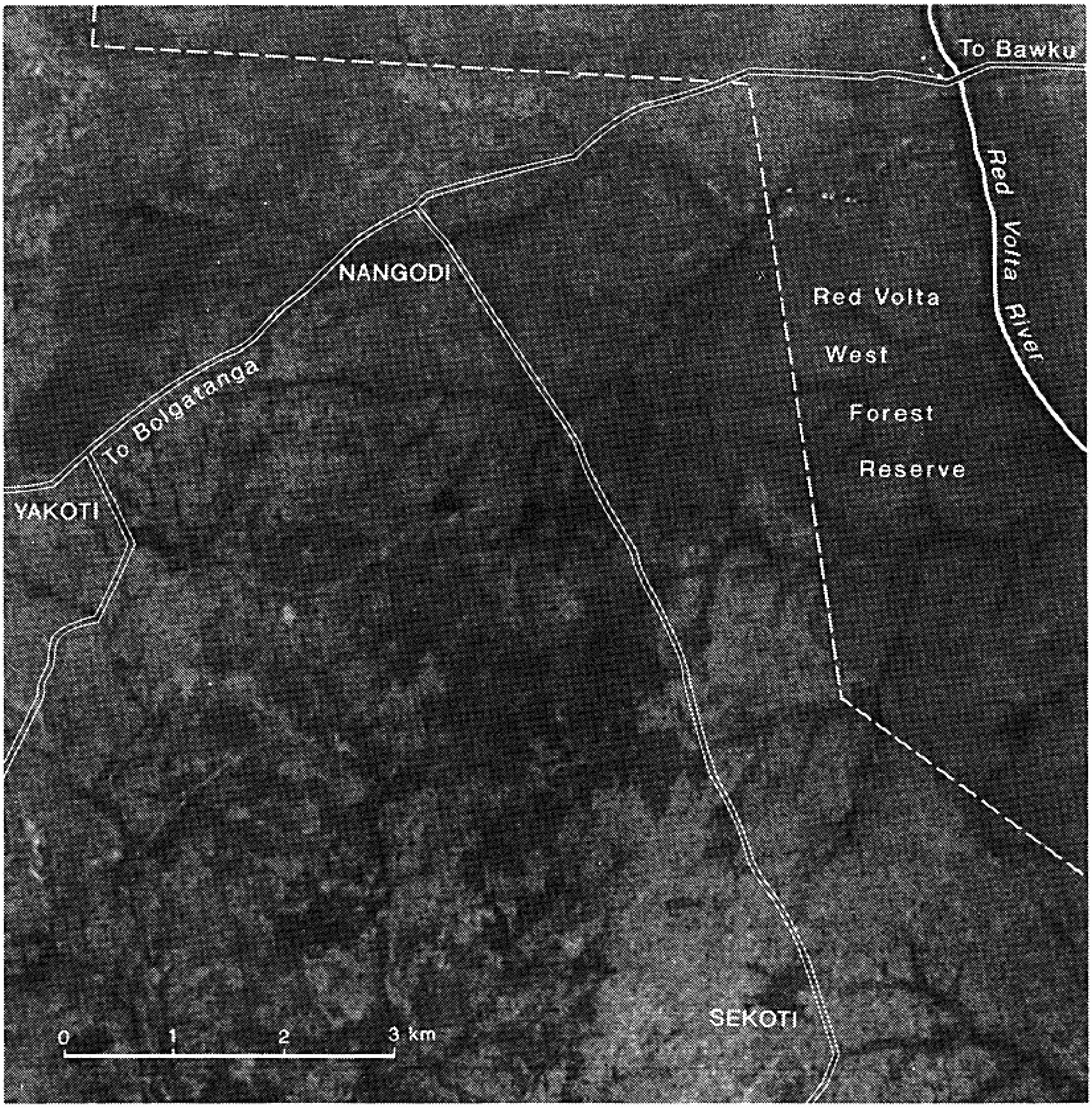

Fig. 1. The Study area. Based on topographic maps, scale 1:50,000, Published by Survey of Ghana. Superimposed sub-images of approx. 10 x 10 km of SPOT-satellite images, November 1989, band 2 (visual spectrum).

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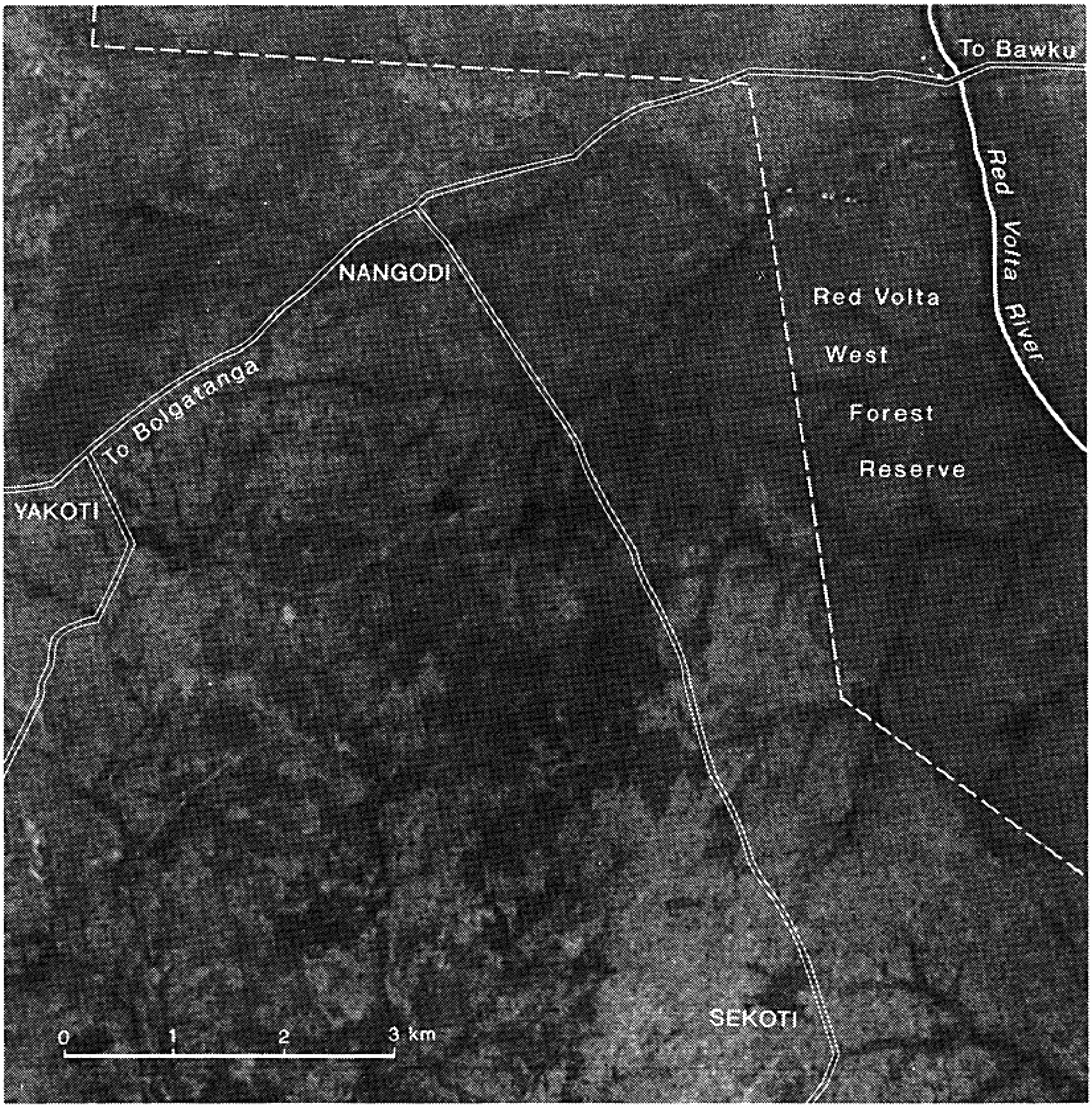

Fig. 1. The Study area. Based on topographic maps, scale 1:50,000, Published by Survey of Ghana. Superimposed sub-images of approx. 10 x 10 km of SPOT-satellite images, November 1989, band 2 (visual spectrum).

more or less continuously cultivated for more than 2,000 years, and which, without doubt, has been seriously eroded and consequently deteriorated. It is likely that yields in Roman times were not higher than in the colonial period (White, 1963). It is not an object taken in consideration here.

Nonetheless, rainfall is the most important single factor for guaranteeing crop yields in such a semi-arid area. Based on 300 locations 1896-1941, Cornish (1950) reports that more than 70% of the variability in wheat yield was due to inter-annual variation in rainfall in a climatic zone quite similar to semi-arid Tunisia. Hence, although for the time being just simple precipitation records and little evidence of the agricultural yields are available for the Segermes area, it should be possible even on this basis to venture an estimate of the prospects for agriculture. The precipitation is sparse and unreliable, and the present climatic conditions favour an agricultural preference for barley, grazing, and olives, instead of wheat. In fact, this is true of the present land-use situation. Of the total surface area, rotational land-use practices occupy 53 %. (wheat 6 %, barley 18 %, fodder crops 16 % and fallow 13 %). Olive groves occupy 19 %, and the remaining 28 % is mainly waste-land consisting of wild pasture, maquis and forest (Mørch). Thus the wheat area is very small, being surpassed threefold by barley. Irrigation obviously offers the good possibility of improving agricultural output, but currently just 1-2 % of the area is irrigated, and as yet there is very little, if any, evidence of irrigation in the area in Roman times.

CONCLUSION

In the Zriba area, the climate is semi-arid mediterranean. The precipitation is sparse and unstable. If the present climatic conditions are assumed to have prevailed in Roman times, barley, olives and livestock might have been the basis for the external economy of the Roman Segermes. The risk of food shortage might have been comparatively high, while that of real hunger low, as conveyed by an aphorism by Garnsey (1988 & 1990): 'Food crises were frequent - famine was rare'. Wheat may have met the domestic or local demand, and served occasionally, when a surplus appeared, as an export commodity. Wheat might have acted as a part of an economic gamble. If so, this poses some questions regarding the economics of Segermes and its connection with Rome. One question is, to what degree was barley a long distance commodity in Roman trade? Another question is, was wheat ever of any economic importance to Segermes?

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