MEASUREMENT OF THE AERIAL HERBACEOUS BIOMASS AND NET PRIMARY AERIAL PRODUCTION OF THREE GRASSLAND COMMUNITIES IN THE SAHELIAN ZONE OF SENEGAL

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INTRODUCTION :

For the ecologist, the understanding of the functionnals aspects of an ecosystem requires the knowledge of the processes of growth and productivity, which are the basic aspect of plant and communities responses to the environmentals factors.

"The net aerial primary production is the sum of biomass and litter increments and of dead material disappearance" MENAUT (1976). The determination of the net aerial primary production (NAPP) requires the measurement of the biomass and of the dead material (necromass) variations, but also of the disappearance rate of the dead material and the actual mortality.

The WIEGERT and EVANS method (1964) revised by LOMNICKI and Al. (1968) is based on the use of paired plots and allows the calculation of NAPP, but without accounting of the decomposition of dead material. BILLE (1976 A) showed that the calculation of the NAPP in the sahelian grassland communities requires the knowledge of the disappearance rate of dead material, because it is very high during the growing season. In the present work, a method based on paired plots is suggested for calculating disappearance rate, mortality and NAPP during a time interval.

This study was conducted in the live-stock Reserarch Center of DAHRA, located in the sahelian zone of Senegal. The mean annual rainfall is 492 mm. The rainy season includes only three months : July, Ausgust and September. The measurements were conducted on three representatives grassland communities.

- Community I_B characterized by *Tephrosia purpurea*
- Community II_B by *Schoenfeldia gracilis*
- Community I_C by *Zornia glochidiata*

The study of the vegetation has been published previously (CORNET and Al. 1977)

In each community measurements were made on twenty repetitions of paired plots. Each plot, a quadrat of 0,25 m2 in aera, was randomly selected in the vegetation. The measures began when the seedlings appeared and were carried on during the whole growing season, at time intervals of 7 or 14 days. The harvested material was dried at 80°C and weighed.

METHOD OF CALCULATION

In accordance with the WIECERT and EVANS method, two similar, paired, plots were studied. At time to, an equal biomass bo, and an equal weight of dead material go, are present on each plot. On the plot n°_2 all the dead material was harvested.

At the time ti the biomass bi, is equal on the two plots. These is a weight gi of dead material on the plot n° 1, and on the plot n° 2 an amount of dead material hi accumulated during the time interval ti-to.

If yi, is the value of NAPP during the time interval ti-to, and ai, is the value of the actuel mortality, the NAPP of these plots can be calculated as

$$yi = bi-bo + ai \quad (1)$$

The dead material on these plots is produced, and simultaneously, partly decomposed, in a similar manner than forest litter. The evalution of the amount of dead material is studied in accordance with the works of OLSON (1963) and BERNHARD-REVERSAT (1970).

If x, is the weight of dead material at the instant t, and a, the instantaneous mortality, and k the disappearance rate of dead material, the variation of dead material can be expressed by the differential equation :

$$\frac{dx}{dt} = a - kx \quad (2) \quad \text{or} \quad \frac{dx}{(\frac{a}{k} - x} = kdt$$

The general integral of this equation is

$$- L_N \left(\frac{a}{k} - x\right) = kt \;/\; Cste \quad (3)$$

Coming back to the experimental conditions of the paired plots method, the two plots are assumed to be identical, and k have the same values of the two plots.

On the plot n° 2, the dead material is harvested at time to. In this case $x_o = 0$, and the equation (3) gives : $- L_N \left(\frac{a}{k}\right) = C^{ste}$ and it can also be written $L_N \left(1 - \frac{k}{a} x\right) = - kt$, expression which can be expressed in the exponential form : $1 - \frac{kx}{a} = e - kt$. From this equation $a = \frac{kx}{1-e^{-kt}}$ (4) If the interval between two measurements, is taken as time unit.

$ai = \frac{ki\ xi}{1-e^{-ki}}$. As at time ti, xi = hi on the plot n° 2, it can be written

$$\boxed{ai = \frac{ki\ hi}{1-e^{-ki}}} \quad (5)$$

If the plot n° 1 is considered, at time to, xo = go, and at time ti, xi = gi, but if no material had died between to and ti, the weight of dead material at time ti would be xi = gi - hi, because hi is the amount of dead material accumulated during this interval. In this case the equation (2) becames $\frac{dx}{dt} = - kx$ or $\frac{dx}{x} = - kdt$, the integral of this equation is $L_N\ x = kt + C^{ste}$. At time to, xo = go and $C^{ste} = L_N go$, it can be written $L_N \left(\frac{x}{x0}\right) = kt$. If the interval between two measurements is taken as time unit, it can be written $ki = - L_N \left(\frac{xi}{xo}\right)$ and the disappearance rate ki is given by :

$$\boxed{ki = - L_N \left(\frac{gi - hi}{go}\right)} \quad (6)$$

This rate can be calculated from the experimental datas if go ≠ 0. And the net aerial primary production can be calculated from the experimental datas with the relation :

$$\boxed{yi = bi - bo + \frac{Ki\ hi}{1-e^{-ki}}} \quad (7)$$

RESULTS

The study was realised in 1977 and 1978. In 1977 the rainfall was low, 296,7 mm, and the rainy season was late but regular. In 1978, the rainy season began early, but was interrupted by many dry periods. The figure 1 show biomass and dead material evolution, for each groupment during the growing seasons 1977 and 1978. During the dry season (from November to June) there is not living material let, because the annual species are dead. The dead material decreases in relation with the grazing.

This figure shows that the dry periods brake up the growing curves in 1978 The effect of the dry periods was variable, depending on groupment and soils.

The biomass was known with mean confidence limits of 19,3 % (probability 0,95). The confidence limits was 25,3% for the weight of dead materials.

The table 1 gives the calculated results of NAPP and the actual mortality expressed in grams of dry weight/m2 and the disappearance rate expressed in g/g/m2. The evolution of these values is shown by the figure 2.

Table 1 : The calculated values of disappearance rate (ki), mortality (ai) and the net aerial primary production (yi).

Groupement		I_B			II_B			I_C		
Date	ti - to	ki	ai	yi	ki	ai	yi	ki	ai	yi
21/07/77	9*			1,2**			1,6**			5,4**
02/08/77	12	0,046	0	0,9	0,125	0	1,4	0,291	0,231	2,63
10/08/77	8	0,040	0,61	2,91	0,078	0,52	4,52	0,054	1,04	0
21/08/77	11	0,087	1,88	9,28	0,092	0,52	14,42	0,108	4,43	3,43
02/09/77	12	0,056	1,44	20,44	0,082	1,77	18,87	0,227	1,34	23,94
09/09/77	7	0,263	1,71	24,01	0,070	2,49	32,89	0,797	3,48	41,98
22/09/66	13	0,575	12,89	55,39	0,158	15,78	91,28	0,336	3,30	79,0
05/10/77	13	0,030	24,77	34,37	0,151	16,27	30,47	0,458	29,17	0
20/10/77	13	0,029	65,5	67,55	0,047	84,03	49,63	0,004	58,1	15,4
Total 77				216,05			245,0			176,8
26/06/78	10*			9,4**			12;7**			20,8**
04/07/78	14	0,213	2,22	5,52	0,065	3,2	4,7	0,505	2,29	2,39
19/07/78	15	0,127	2,66	27,26	0,096	4,3	23,80	0,433	1,85	1,84
30/07/78	11	0,037	2,55	63,25	0,057	4,11	67,81	0,543	5,14	5,14
09/08/78	10	0,323	29,84	64,44	0,012	25,55	1,55	0,754	16,09	10,49
19/08/78	10	0,381	14,55	25,55	0,081	8,86	59,16	0,420	10,55	9,55
30/08/78	11	0,343	67,92	6,22	0,266	33,94	0	0,879	17,58	14,98
08/09/78	9	0,574	76,87	77,67	0,472	46,67	73,77	0,811	8,90	50,10
21/09/78	13	0,327	29,90	56,90	0,319	35,98	68,68	0,969	21,39	48,30
30/09/78	9	0,593	38,98	61,98	0,425	58,92	81,72	0,698	48,63	17,53
11/10/78	11	0,010	39,90	19,60	0,227	115,12	47,72	0,099	39,50	0
26/10/78	15	0,287	50,61	0	0,030	58,69	5,59			
Total 78				417,8			447,2			203,2

* Since the germination
** Is a under-estimation

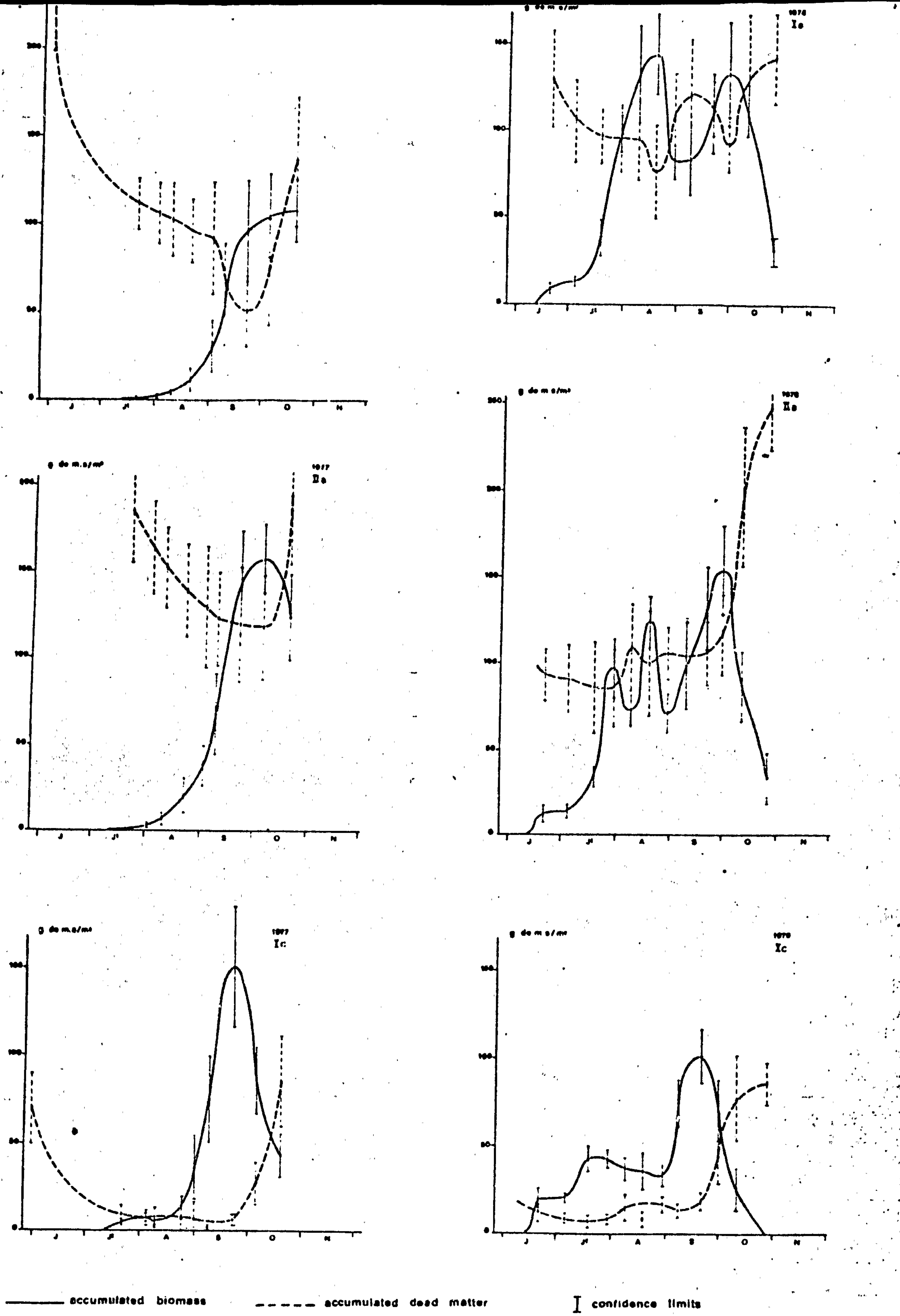

Figure 1 : Evolution of biomass and amount of dead material in three grassland communities.

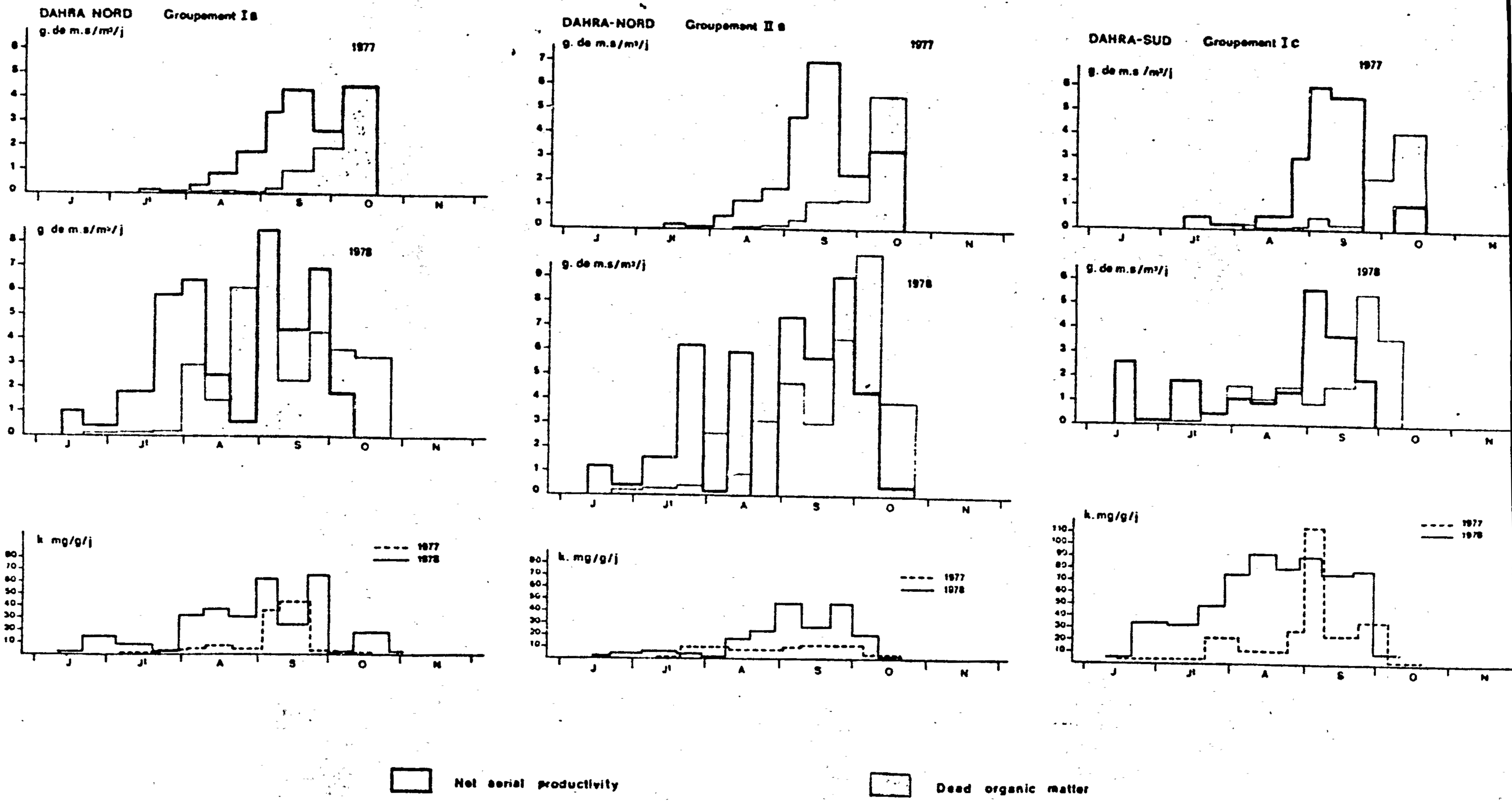

Figure 2 : Evolution of : the net aerial productivity calculated, the actual mortality and the desappearance rate of dead material.

DISSCUSSION AND CONCLUSION

From this results it is pointed out that, the net production is low in the begining of the rainy season and their increases proportionally with the accumulation of biomass, because of the increasing photosynthetic surface. The net daily productivity raised to a maximum in September, at this period the leaf aera index is the highest and the water budget is good. The highest calculated values are : 9,1 g/m2/day for the II_B groupment in 1978,

8,5 g/m2/day for the I_B groupment in 1978 and

6,0 g/m2/day for the I_c groupment in 1977.

The net productivity is in relationship with the available water. During the growing season, the drought reduces or stops the production.

The amount of dead material stored depends on the mortality and on the disappearance rate. It decreases during the active growing period, and can be reduced to zero (BILLE 1976B) during the rainy years. The mortality is low at the begining of the rainy season and then increases with the aging of plants, but occasional droughts lead to sharp increases in mortality.

The disappearance rate of dead material is the sum of the consumption by insects and other animals of the microfauna and of the microbial decomposition. The rate is low during the dry season because, the insects populations are small and the microbial activity is reduced to zero, by the dessiccation. This rate increases during the growing season. During the rainy season of 1978, for the three comunities, this rate is much higher than in the 1977 season. It is supposed that the plant material dead during the dry periods of the 1978 rainy season is easily decomposable, because consisting of young tissues.

An other experiment was realised in an other grassland-community of the sahelian zone (BERNHARD-REVERSAT personnal communication) it consisted in the weight losses measurement of samples of dry grass and disappearance rates wich are comparable with those obtained in the present work.

In conclusion, in the grassland

Communities of the sahelian zone, the measurement based on the paired plots method can be used to calculate the net aerial primary production, if mortality and disappearance rate of dead material are calculated by the relation described here (5) (6) (7). The knowledge of the production composents allows to understand the functionnement of the vegetation considered as the primary producer, in relation with the environnmental factors.

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