Effect of ablation and prunning on growth and yield of oil palm

Application in modelling carbon sink and source relations on architectural bases

Experimental design and schedule

Emmanuelle Lamade

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Effect of ablation and prunning on growth and yield of oil palm. Application in modelling carbon sink and sources relations on architectural bases.

1. Justifications : what about disbudding and prunning ?

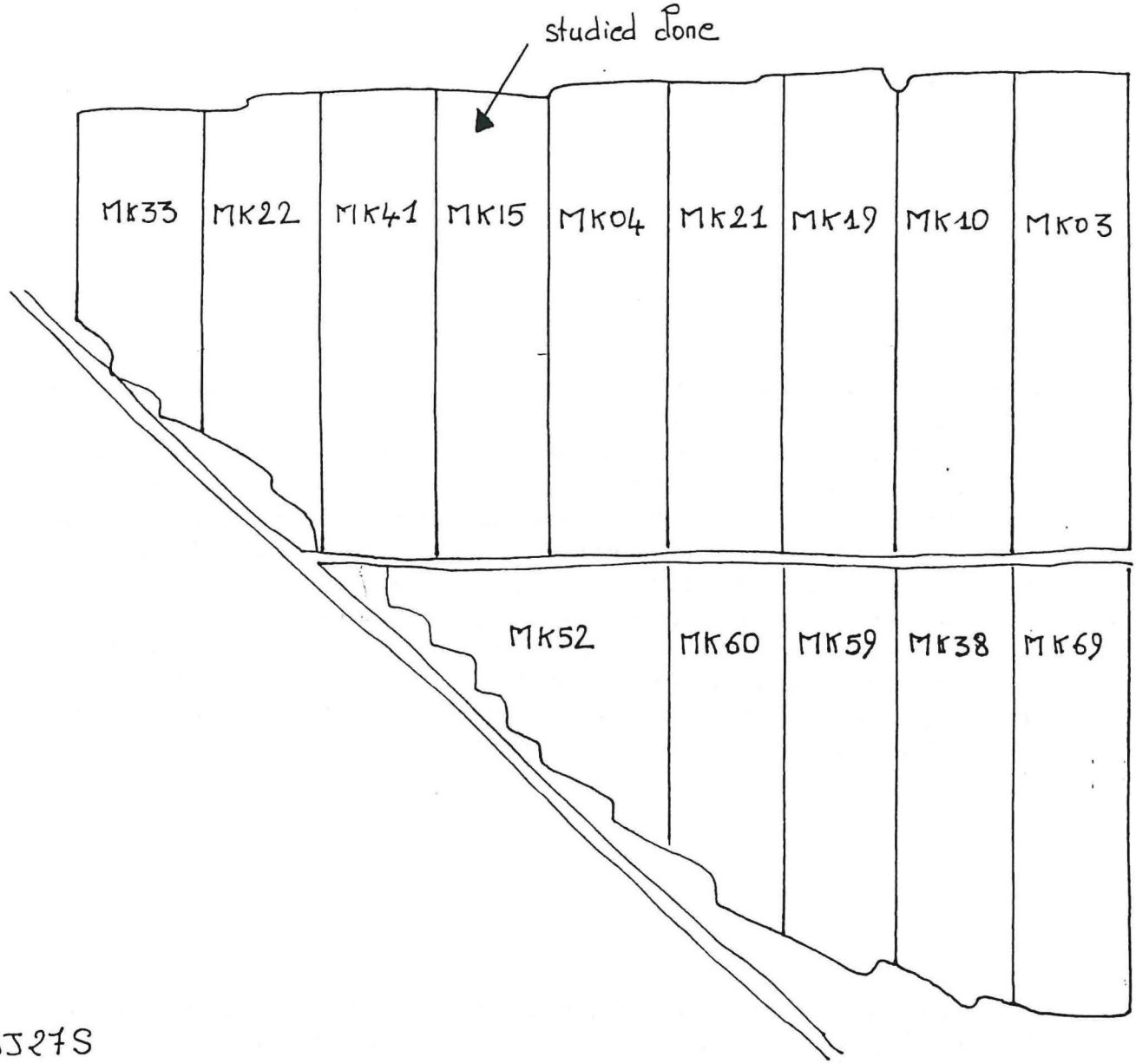
Disbudding-ablation

As it has been shown by many autors (Broekmans, 1957; Haines 1959; de Berchoux and Gascon, 1965; Corley, 1977 all quoted by Corley and Breure, 1992), the yield of oil palm is affected by the yield in previous years. A detailed understanding of such effects and the resulting yield cycles is necessary for elaborating any yield forecasting. From Corley and Breure 1992, clear results had been highlighted from an important disbudding experiment. Four treatments had been applied (1 : control; 2 : 50% disbudding; 4 : complete disbudding) from young stage to 5 year old upon a total of 280 trees (10 trees/treatment and 7 replicates). Complete evidence may be clearly bring out focused on the effect on all yield composants as the mean bunch weight (more than 60 %), the number of spikelets per bunch (increase of 14 %), on sex ratio (increase of 25 %) and also on vegetative pattern as the leaf area (increase of 7 %), on trunk diameter (increase of 15 %), on trunk height (increase of 20 %) and the leaf emission (increase of 20 %). In any case (partial and complete ablation) there is no effect on the extraction rate.

Prunning :

It is well known and generally admitted (Broekmans, 1957; Corley, 1976; Breure and Menendez, 1990 quoted by Corley & Donough, 1995) that defoliation in oil palm affect inflorescence production : it is causing a decrease in sex ratio and an increase in abortion rate. More generally, it can be noticed that significant effect occured, on oil palm, between 16 and 24 fronds retained by tree (Corley et al., 1976). More precisely a significant decrease of 26 % of the yield may be observed when 24 fronds are remaining on trees. A very effective decrease (more than 100 %) may be observed when only 16 leaves are remaining by trees.
On the experiment of Corley and Donough (1995), two treatments had been realized on a total of 77 trees per treatment. All treatment have been applied on 7 different clones. Tendency but no

Fig. 1



BJ27S

Monitoring Blok dan Klon
Augustus 1990

clear results may be highlighted from that experiment because still this effect seems to be very dependent on genetical components (Corley & Donough, 1995).

2. Main goal : Sink strenght quantification and source and sink allocation laws

Our main goal will be not so much to study directly the effect of prunning and ablation on the development of oil palm, because these effects are quite well known, but to try indirectly to get quantification on what's is the potential requirement for a bunch to growth and mature and what can be the maximum carbon gain that a single leaf may offer to the all plant system. But don't forget that we will have only a response of the tree to effective stress and pertubation : does it can be a mirror of the real funtionning of the tree ? This question is interesting to debate through experimental investigations.

3. Experimental design

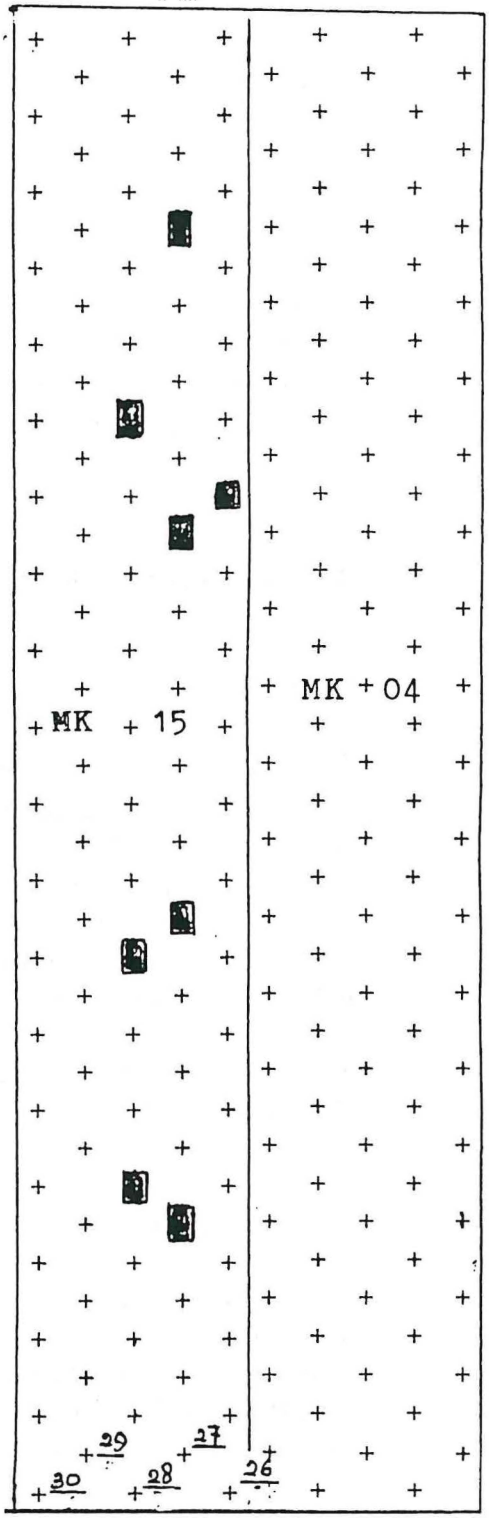
A. Material

Treatments will be undertaken on plot BJ 27 S (on PTP Bah Jambi) date of planting 1990, on clone MARK 15 (parent : DS 29 D x LM2T) (Fig. 1). This clone is very similar genetically of studied clone MK04 (same origin : DS 29 D x LM2T) on which already many physiological investigations have been done (Lamade and Setiyo, 1996; Lamade et al. 1996). Further more, MK15 is also quite similar to the control family LM2T x DA 10 D well studied by Dufrêne (1989, 1993) in Ivory Coast. Due to the lack of global available trees, this clone has been chosen in way to keep trees of the clone MK04 available for further physiological investigations and architectural studies. MK15's plot is composed by around 100 trees (fig. 2) planted with density between 130 and 135 trees/ha. Behonds trees of that clone, 8 trees had been identified as presenting "mantled" abnormality.

B.Edaphic conditions

The soil is derived from volcanic processes around Toba lake, quite sandy (60%), belonging to unsaturated ferralithic soils category. Climatic conditions in North Sumatra may be caracterised by the absence of water deficit all around the year. With a total average radiation of 16.24 MJ.m-2.s-1 (Lamade & Setiyo, 1996) and total rainfall of 2890 mm per year the crop may be considered to be in potential conditions.

Fig. 2



LEGENDA :

	J a l a n
+	Pokok Normal
	Pokok Abnormal

4. Treatments

By eliminating border effect on 3 sides (MK41 side and both road sides), and abnormal trees, the total amont of available trees wil be equal to 65. If there are 5 main treatments, this will allow a minimum of 10 trees available for each treatment.

On Fig. 3, exact position of trees and treatment are shown with reference of the color that is also indicated in the field.

Control : white
nb Tree : 28/9; 29/8; 29/16; 29/18; 28/23; 26/25; 27/22; 26/21; 9/13; 27/13; 29/17
nb Serie : N2; N4; N18; N20; N22; N31; N33; N36; N12; N47; N55.
Pheno : N2; N1; N20; N22; N33; N55

Treatment 2 : red
nb tree : 29/9; 28/18; 29/22; 27/26;6/20; 26/19; 7/16; 26/16; 26/15; 27/12;26/13
nb Serie : N5; N17; N25; N27; N37; N39; N42; N44; N46; N49; N50
Pheno : N5; N17; N27; N37; N46; N49

Treatment 3 : black
nb tree : 29/10; 29/11; 28/15; 28/16; 28/17; 26/27; 27/25; 27/21; 26/17; 27/14; 27/23
nb Serie : N7; N9; N11; N13; N15; N28; N29; N35; N43; N45; N54.
Pheno : N7; N15; N28; N29; N35; N45

Treatment 4 :blue
nb tree : 28/10; 29/12; 29/15; 29/20; 29/21; 28/25; 26/26; 26/18;26/12; 27/10; 26/11
nb Serie : N3; N10; N16; N22; N23; N26; N30; N41; N51; N52; N53
Pheno : N3; N10; N26; N30; N41; N52

Treatment 5 : yellow
nb tree : 29/6; 28/12; 28/13; 29/14; 28/20; 28/24; 26/24; 26/23; 27/18; 27/17; 26/14
nb Serie : N1; N6; N8; N14; N19; N24; N32; N34; N38; N40; N48
Pheno : N6; N8; N14; N24; N34; N38

All trees will be highlighted with a color ring, according to the treatment, on the collar at 1.3 m high.

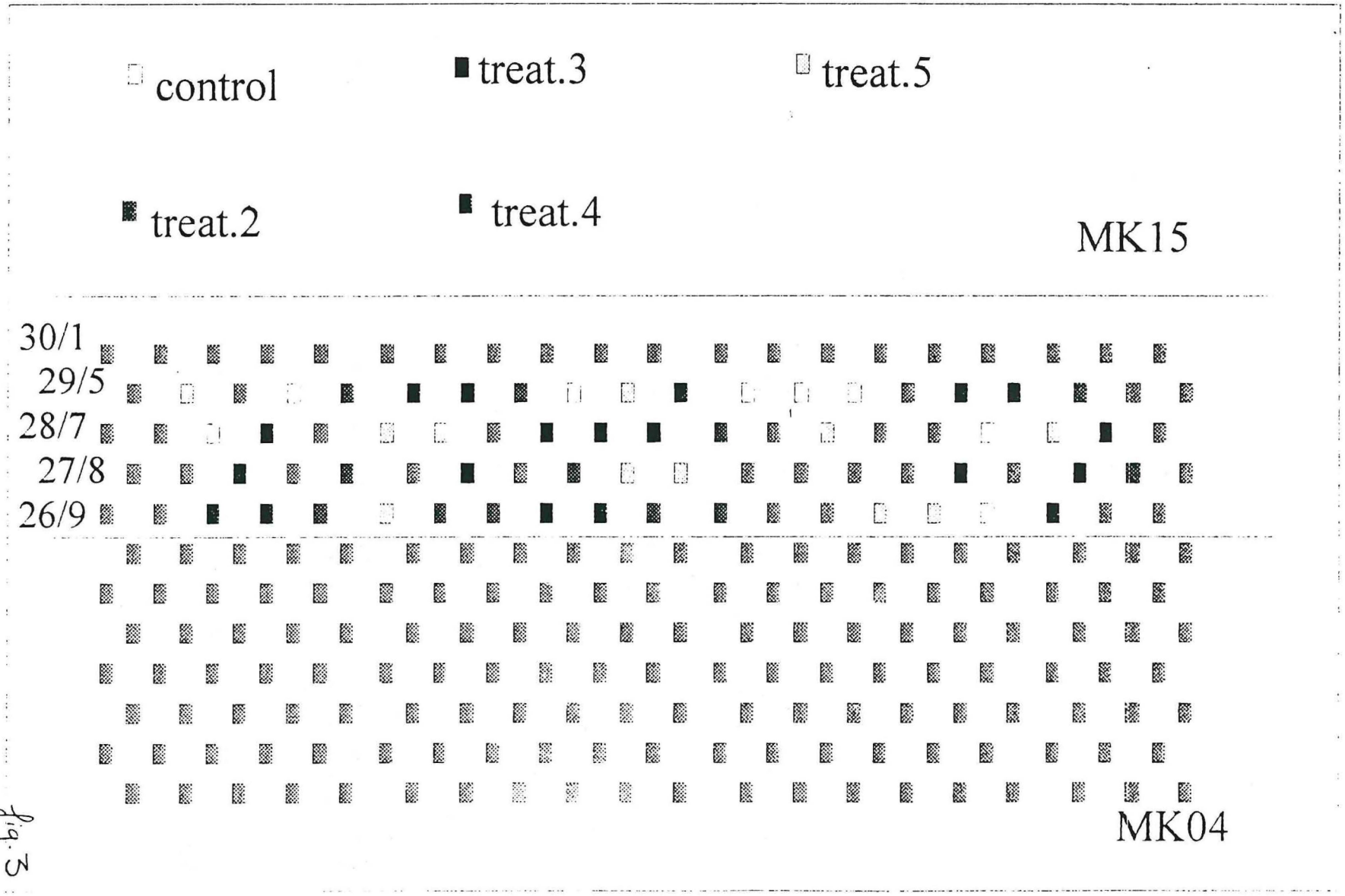

control
treat.3
treat.5
treat.2
treat.4
MK15
30/1
29/5
28/7
27/8
26/9
MK04

fig. 3

1. Control : no action.

2. Prunning : regular partial defoliation with only the first 20 fronds remaining by palms and (eventually 5 trees with only 8 fronds remaining on crowns).The trees at the begining will be check at 35 leaves trees. The other leaves will be cut at the C point (Fig. 4). Every 15 days, each tree will be checked and the new leaves cut again in way to have always the same number of leaves (20) on experimental trees.

3. Disbudding and ablation : at time = 0, all inflorescences will be cut at the exception of the youngest one. Every week, all new inflorescence newly emitted (and after sex determination) will be eliminated and this during 4 months and half. After that period, if one youngest is identified , this last one will remained and the other older one eliminated.
At six months : the youngest one will be kept until the emission of a new female that will remain on tree.

4. Disbudding and ablation : removal of 50% of total inflorescence.Concerning the number of bunch produced by year in North Sumatra, we have indication that for LM material, at 7 years old, this number is around 14 (Nouy, 1990). It means that we will have to "save" 14/2 +1 = 8 bunches per experimental tree. Sex ratio for LM is around 55%, it means that, as for the female inflorescence, the ratio of male remaining on trees will be 6+1 = 7.

For the disbudding, the most important is to keep safe all the leaves during that operation. For that, the inflorescence must be cut at the base without widen space between petiola (Fig. 5).

5. Roots removal : see ATP report.

5.Treatment operations

1. Control :
nb of trees involved : 11
prunning : 35 fronds
frequency control : 1/month
ablation/castration : no action

2.Treatment n° 2
nb of trees involved : 11
prunning : 20 fronds ; frequency control : 2/month

3. Treatment n°3
nb of trees involved : 11
prunning : 35 fronds ; frequency control : 1/month
ablation/castration : 1 female ; frequency control : 1/2 weeks
assisted pollinisation : 170g/cm2 ; frequency control : 3 days/year/bunch

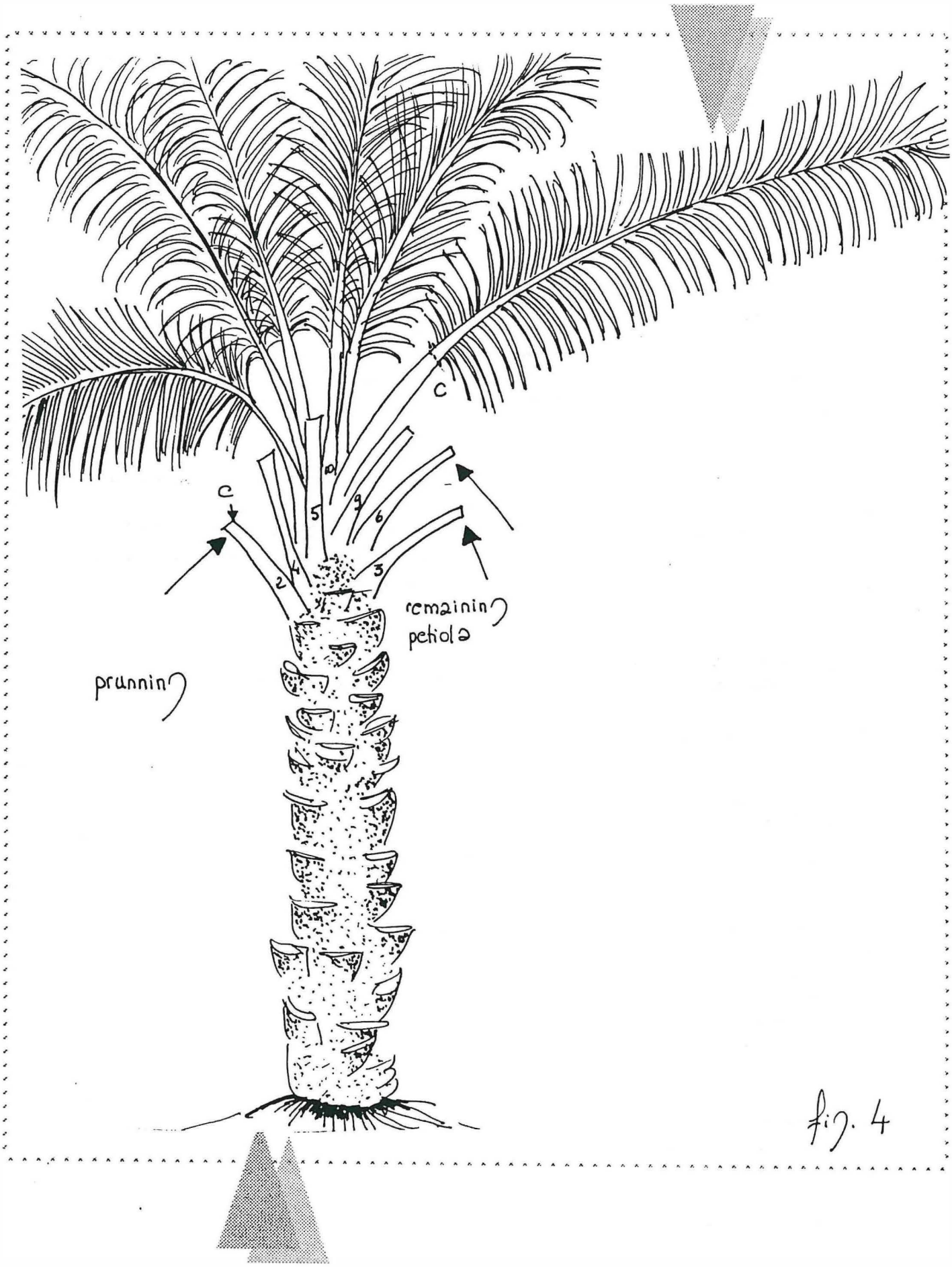


fig. 4

n° 4 Treatment n°4
nb of trees involved : 11
prunning : 35 fronds ;frequency control : 1/month
ablation/castration : 50% female and male ; frequency control : 1/ 2 weeks
assisted pollinisation : 90g/cm2 ; frequency control : 3 days/year/bunch

For the frequency control : prunning or ablation will be performed with the frequency mentioned in the table taking into account the specific growth of oil palm.

For the castration/ablation : for n° 3 the remaining female inflorescence will be observed during around 6 months from anthesis to harvest. All other inflorescence male/female and buds will be continuously removed.

6. Observations

A. Phenology

First of all the complete set of leaves of each trees will be quoted with observations numbers (with the same frame done in Andarasi , see progress report I 1995) from the oldest (will have the number 1) to the yougest (if there x leaves on tree , this one will wear the number x) as in fig. 6. Each tree will be observed weekly and following dates will be recorded

1. Date of the leaf emission
2. Date of the leaf when it's rank n° 1
3. Date of flowering of the inflorescence on the same axis
4. Date of harvesting
5. Date of the cut of the leaf

and also :

- the sex of the inflorescence
- the lenght of the petiole and the rachis
- the weight of the bunch when harvesting

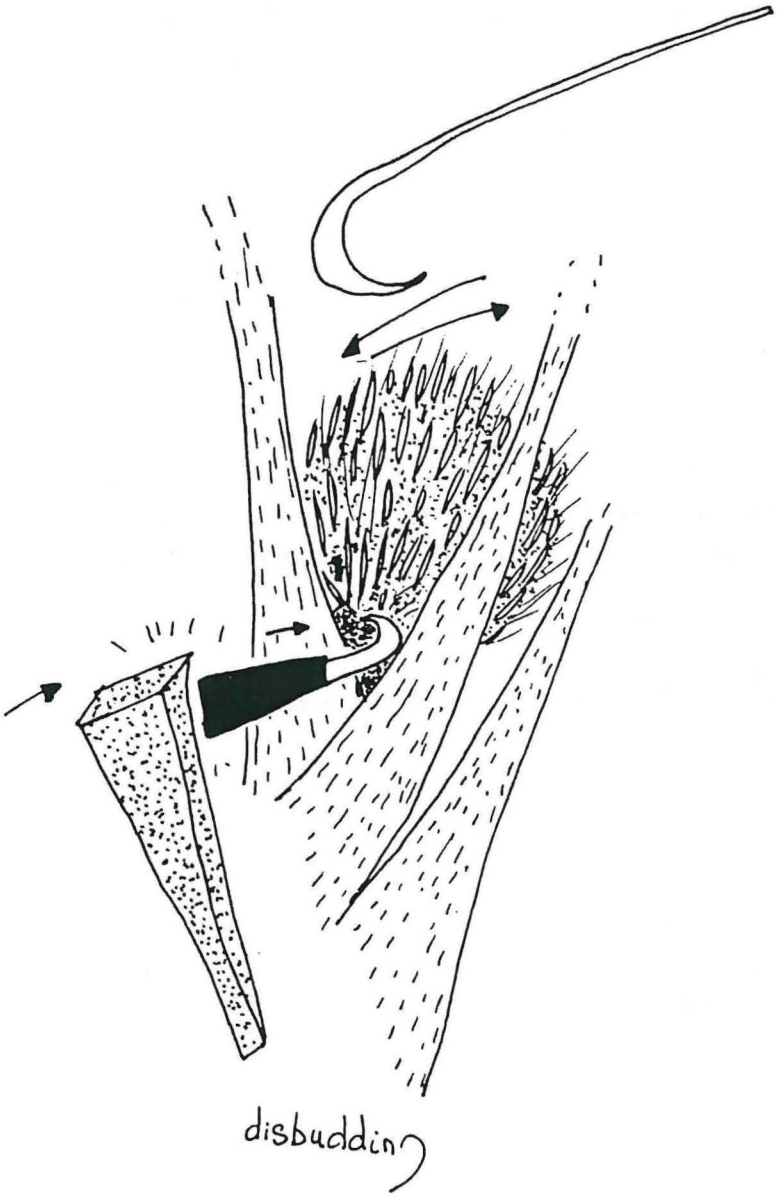
B. Growth

Trunk height

For trunk height (following Corley & Breure in the technical note "Measurements in Oil Palm Experiments"), the reference of the leaf 33 will be used. Two paint points will be done , one at the base of the trunk (and not to the ground) and one at the base of the petiole of the chosen reference leaf.

Trunk diameter :

Fig. 5



After removing sufficient old leaf base, at 1.5 m above ground, for points at opposite side will be taken into account for estimating trunk diameter. This will be done one a year.
The circumference of the total trunk will be measured at the edge of the older leaf and at the base of the collar.

Trunk density

With a special wood auger, samples will be collected for at least 5 trees per treatment to evaluate through known volume, the specific density of the trunk. To get idea, it had been measured by Dufrêne (1989) a volume density equal to 184 kg DM/m3 on L2T x D10D in Ivory Coast.

C. Vegetative biomass

- on removed leaves
On each removed leaves for all treatment, the leaf aera will be measured following the Tailliez'method (Tailliez & Koffi, 1992) - see may be if the simplest shortest method can be applied taking into account the numerous quantity of leaves-. The total biomass in dry matter of the removed leaves will be measured too. From that specific leaf weight will be followed.
Note : the leaves will cut at the C point. Two circumferences of the remaining petiola , one at the base and the second at the border of the cut will be done at the same time with the lenght.

D. Inflorescences and Bunches

On each removed inflorescences

- on male
Only the total dry matter will be weighed.

- on female
The bunch or female inflorescence will be depeced and each fruit will be separated from pedoncule and spikelet and weight fesh. A sample of 30 fruits will be collected for analysis (extraction rate). The rest of the fruit will be dried and weighed : the mean weight of fruit will be determined. The rest of the bunch (or inflorescence) will be dry and weight also.

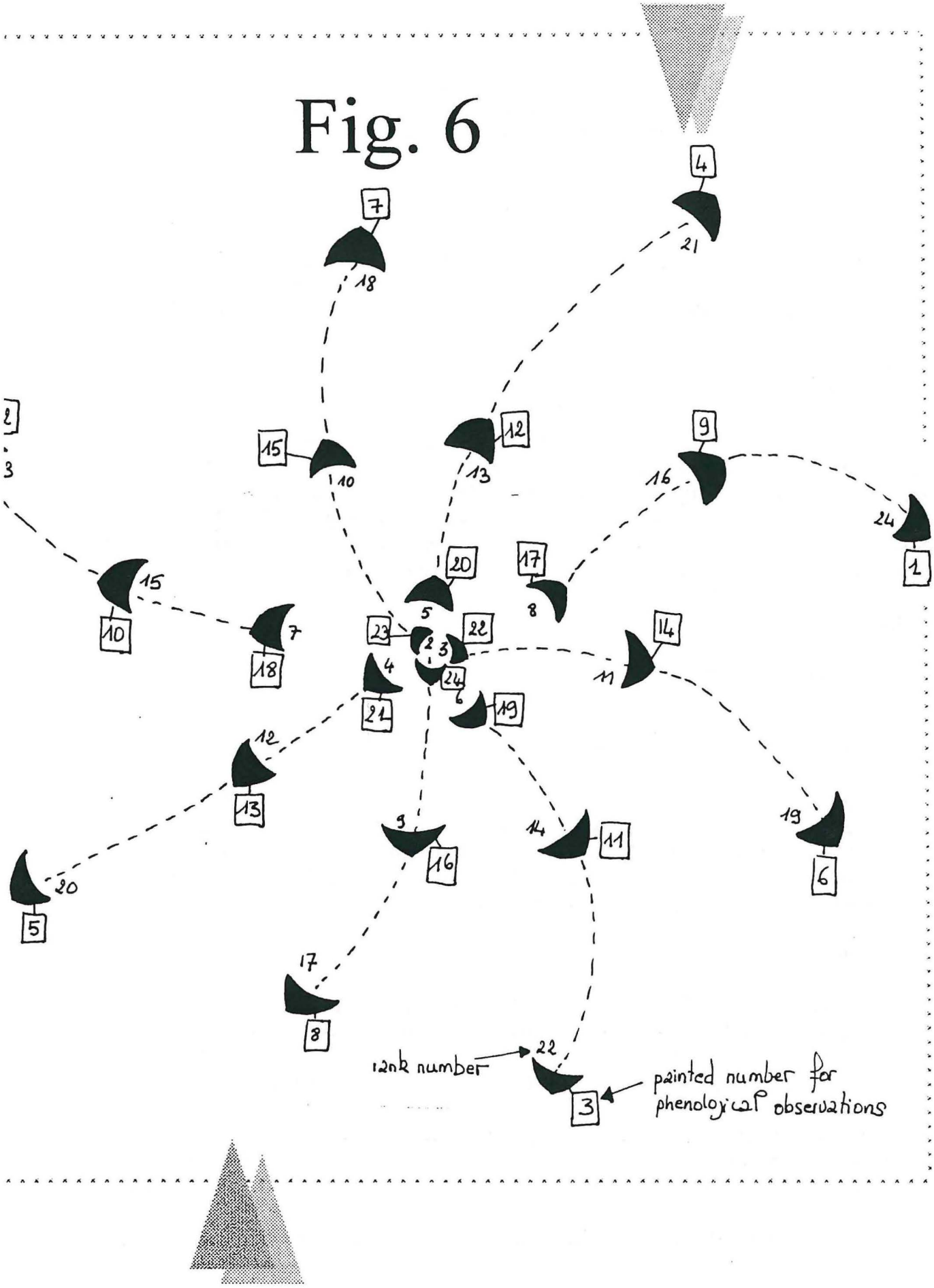
E. Physiology

It is clear that physiological investigations on this prunning/ablation experiment will deals more with the response to such a stress than to really quantify source and sink relation.

After six months treatment some physiological measurements may be undertaken as

- The photosynthetic potential (before and after prunning, before and after ablation, on 5 trees per treatment) as the stomatal conductance related to the photosynthesis at saturation light.
-The leaf respiration (Before and after prunning, before and after ablation, on 5 trees per treatment);
-The chlorophyll content/nitrogen content in the leaf (on 5 trees per treatment)

Fig. 6


rank number
painted number for phenological observations

7. General schedule for weekly routines

The general step of observations for all trees will be equal to 15 days, that represent at least the general growth trends for organogenesis for oil palm in North Sumatra.

IOPRI-CIRAD joint programm

SCHEDULE PRUNNING/ABLATION : general routine

E.Lamade. 18 th August 1977.

Day/week	organs	treatment	field work	observations	laboratory
Monday/week 1	leaves	mera	-prunning to rank 20 -leaf area -petiole lenght/diam. -rachis lenght -collecting for dry weight	- pheno for mera on 6 trees	- put the leaves in the hooven at 105 °C/night (leaves) + 2 night for the rachis.
Tuesday/week 1	leaves/buds	hitam	- prunning to rank 35 - leaf area - petiole lenght/diam - rachis lenght - total ablation - 1 stay during 6 months	- pheno for biru on 6 trees	- put the leaves in the hooven at 105 °C/night + night for the rachis.
Wednesday/week 1	bunches	mera-putih	- diameter - fresh weight		- keep the bunches of the mera for analysis
Thursday/week 1	dry weight	mera-hitam		-pheno for putih on 6 trees	- dry weight of leaves and buds for mera and hitam

Friday/week 1	bunches	mera			- per bunches on mera : - nb of spikelets/bunches - 30 spikelets : % pollinisation, dry weight and fresh weight. - 50 fruits : diameter, fresh weight, dry weight - bunches analysis : oil extraction rate for mera.
Monday/week 2	leaves	biru	- prunning leaves to 35 - leaf area - petiole diameter/lenght - rachis lenght - ablation bud : 50 % - collecting leaves for dry weight	- pheno for hitam on 6 trees	-put the leaves in the hooven at 105°C/night and the rachis for 2 nights. And the collected buds.
Tuesday/week 2	leaves	mera-hitam-biru-putih-cunning	-painting the leaves for rank 1 if not finish.	- pheno for cunning on 6 trees	
wednesday/week 2	bunches	biru-cunning	- diameter - fresh weight		- keep the bunches of biru for analysis
Thursday/week 2	leaves+buds	biru	- finishing painting leaves		-dry weight for leaves and buds for biru

Friday/week 2	bunches	biru		- entering pheno in computer.	-- per bunches on itam : - nb of spikelets/bunches - 30 spikelets : % pollinisation, dry weight and fresh weight. - 50 fruits : diameter, fresh weight, dry weight - bunches analysis : oil extraction rate for biru

8. An example of modelling source and sink relation : development from Dufrêne 's model

Written in Qbasic by Dufrêne in 1989, this programm can be a first good basis to investigate the "sink-source" relation from the collecting data on this prunning-castration trial. It 's a french version, still in process for C++ version.

This programm is only an example of how to feel the bunches with the assimilation carbon and do not include for the moment architectural concepts.

```
10 '
20 ' ************************************************************************
30 ' *                                                                      *
40 ' * programm  : OPPROD20                                                *
50 ' *                                                                      *
60 ' * Date   : July 1990                                                   *
70 ' *                                                                      *
80 ' * Autor : Eric DUFRENE                                                 *
90 ' *                                                                      *
100 ' * THEME  : seasonnal variations                                        *
110 ' *                                                                      *
120 ' *                                                                      *
130 ' * SIMULATION DE L'ASSIMILATION PHOTOSYNTHETIQUE, DE LA RESPIRATION, *
140 ' *                                                                      *
150 ' *      DE LA REPARTITION DES ASSIMILATS, DU BILAN HYDRIQUE,        *
160 ' *                                                                      *
170 ' *        ET DE LA PRODUCTION DE L'AGROSYSTEME PALMERAIE.          *
180 ' *                                                                      *
190 ' ************************************************************************
200 '
210 '*****************************************************************************
220 '
230 DEF FNARCOS (X) = 1.570796 - ATN(X / SQR(1 - X * X))
240 '
250 DIM a(2000, 6)
260 DIM AV(60)
270 DIM SR(60)
280 DIM NBFEMPRO(60)
290 DIM NBFRUPRO(60)
300 DIM NBMALPRO(60)
310 DIM BFEMPRO(60)
320 DIM BFRUPRO(60)
330 DIM BMALPRO(60)
340 DIM T(15)
350 OPEN "I", #1, "a:\OPMETEO.PRN"
360 OPEN "O", #2, "LPT1"
370 WIDTH "LPT1:", 255
380 CLS
390 PRINT "OPPROD20 IS RUNNING"
460 '
470 '*****************************************************************************
480 '*****************************************************************************
490 '
500 '            DEFINITION DES PARAMETRES
510 '
```

```
520 'PARAMETRES DE RAYONNEMENT ET DE PHOTOSYNTHESE*****************************
530 '
540 PI = 3.141593
550 L = PI / 33:            ' latitude en radians
560 IO = 1370:              ' constante solaire  en W m-2
570 AL = .053:              ' efficience photosynthétique en µmol µmol-1
580 PM = 30.7:              ' assimilation maximale en µmol m-2 s-1
590 KEXT = .401:            ' coef. d'extinction du ray. vis. dans le couvert
600 '
610 'PARAMETRES DU BILAN HYDRIQUE**********************************************
620 '
630 KAR = .39:              ' constante de von karman
640 ZR = 2:        'm     : ' hauteur des mesures météo
650 HAU = .2:      'm     : ' hauteur du couvert ( Paspalum sp.)
660 DEP = .63 * HAU: 'm     : ' déplacement du plan zéro
670 ZO = .1 * HAU:  'm     : '
680 RU = 436:      'mm    : ' réserve utile du sol
690 RS = .74 * RU:  'mm    : ' réserve actuelle du sol initialisée au 1/1/88
700 '
850 'PARAMETRES DU BILAN CARBONE***********************************************
860 '
870 'B pour biomasse en kg ha-1
880 '
890 ' RACINES
900 '
910 BRO = 11790
920 BRI = 8330:                 ' racines primaires
930 BRII = 11360:               ' racines secondaires
940 BRABS = 11320:              ' racines absorbantes (ter+quater)
950 BRAC = BRI + BRII + BRABS:  ' racines totales
960 '
970 ' STIPE
980 '
990 GRAND = 4.44                ' hauteur stipe en m
1000 DSSTIP = 184               ' densité sèche stipe en kg m-3
1010 RAYSTIP = .23              ' rayon moyen du stipe en m
1020 DENS = 143                 ' densité de plantation en a ha-1
1030 '
1040 BS = DSSTIP * PI * RAYSTIP ^ 2 * GRAND * DENS  'masse sèche stipe en kg ha-1
1050 '
1060 ' FEUILLES
1070 '
1080 NF = 35                    ' nombre de feuilles par arbre
1090 SM = 9                     ' surface d'une feuille en m2
1100 EMIF = 21.53               ' emission foliaire en feuilles an-1
1110 MSF = 110                  ' masse surfacique foliaire en g m-2
1120 '
1130 LAI = NF * SM * DENS / 10000       ' indice foliaire
1140 BFOL = (MSF * 10) * LAI:           ' folioles
1150 BPET = 1.812 * BFOL:               ' pétioles
1160 BRCH = 1.224 * BFOL:               ' rachis
1170 BF = (BFOL + BPET + BRCH) / (NF * DENS):  ' biomasse foliaire
1180 '
1190 BV = BRAC + BS + BFOL + BPET + BRCH:      ' biomasse végétative totale
1200 '
1210 ' Regimes
1220 '
```

```
1230 PMAXREG = 6:                    ' poids sec maxi d'un regime
1240 PMINREG = 3.2:                  ' poids sec mini d'un regime
1250 PAVREG = 2:                     ' poids sec critique (avortement)
1260 '
1330 ' Coefficients de croissance pour les fleurs femelles et males en kg j-1
1340 '
1350 GFEMMAX = PMAXREG / (17 * 16):      ' femelle maximum
1360 GFEMMIN = PMINREG / (17 * 16):      ' femelle minimum
1370 GFEMAV = PAVREG / (17 * 16):        ' femelle critique
1380 GMAL = 1.5 / (17 * 6):              ' male
1390 GFEM = GFEMMAX:                     ' femelle sans huile
1400 GFRU = GFEM:                        ' femelle avec hule
1490 '
1560 ' CR pour coefficient respiratoire de croissance
1570 '
1580 CRFRU = 1.89:        ' fruits
1590 CRRAC = 1.45:        ' racines
1600 CRS = 1.45:          ' stipe
1610 CRMAL = 1.45:        ' fleurs males
1620 CRFEM = 1.45:        ' fleurs femelles
1630 CRF = 1.37:          ' feuilles
1640 '
1650 ' MR pour coefficient respiratoire de maintenance, O pour 25 °C, en kgCH2O/(kgms*24h)
1660 '
1670 MRSO = .0005:        ' stipes
1680 MRRCHO = .0018:      ' rachis
1690 MRPETO = .0022:      ' pétioles
1710 MRRIO = .0005:       ' racines primaires
1720 MRRIIO = .0005:      ' racines secondaires
1730 MRRABSO = .0035:     ' racines absorbantes
1740 MRMALO = .009:       ' inf. males
1750 MRFEMO = .009:       ' regimes avant remplissage en huile
1760 MRFRUO = .0034:      ' regimes pendant remplissage
2300 '
2350 STOCK = 200: 'gCH2Om-2: 'init. réserves stipes au 1/1/88
2360 STOCKMAX = 700
2370 '
2380 ' Bilan de carbone et sexualisation
2390 '
2400 PENTE = .0006
2410 '
2420 ' Initialisation des infloresences presentes
2430 '
2440 NBFEM = .55 * DENS * 14
2450 NBMAL = (1 - .55) * DENS * 6
2460 NBFRU = .55 * DENS * 2
2470 '
2480 FOR K = 1 TO 51
2490 NBFEMPRO(K) = .55 * DENS
2500 NBMALPRO(K) = (1 - .55) * DENS
2510 SR(K) = .55
2520 NEXT K
2530 FOR K = 36 TO 49
2540 BFEMPRO(K) = 17 * GFEMMAX * (K - 35) * .55 * DENS
2550 BFEM = BFEM + BFEMPRO(K)
2560 NEXT K
2570 FOR K = 50 TO 51
```

```
2580 BFRUPRO(K) = 17 * GFEMMAX * (K - 35) * .55 * DENS
2590 BFRU = BFRU + BFRUPRO(K)
2600 NEXT K
2610 FOR K = 35 TO 40
2620 BMALPRO(K) = 17 * GMAL * (K - 34) * (1 - .55) * DENS
2630 BMAL = BMAL + BMALPRO(K)
2640 NEXT K
2650 MBMALPRO = BMALPRO(40)
2660 MBFEMPRO = BFEMPRO(49)
2670 MBFRUPRO = BFRUPRO(51)
2730 '
2740 ' TABLEAU DONNEES METEO  RG, Ta, Vent, VPD, PRI (pluie)
2750 '
2760 FOR N = 1 TO 1464
2770 FOR P = 1 TO 6
2780 INPUT #1, a(N, P)
2790 NEXT P
2800 NEXT N
2810 '
3290 '*****************************************************************************
3300 '*****************************************************************************
3340 '
3350 FOR N = 1 TO 1464:          ' N est le jour calendaire
3360 IF N < 367 THEN YEAR = 1:      ' YEAR est l'annee
3370 IF N > 366 AND N < 733 THEN YEAR = 2
3380 IF N > 732 AND N < 1099 THEN YEAR = 3
3390 IF N > 1098 AND N < 1465 THEN YEAR = 4
3400 IF N > 1464 AND N < 1831 THEN YEAR = 5
3480 '
3490 '*****************************************************************************
3500 ' RAYONNEMENT ET PHOTOSYNTHESE NETTE POTENTIELLE (HORAIRES ET JOURNALIERS)
3510 '
3520 R = 1 + (.033 * COS(2 * PI * N / (YEAR * 365)))
3530 D = PI * 23.45 / 180 * SIN(2 * PI * (284 + N) / (YEAR * 365))
3540 H = (FNARCOS(-TAN(L) * TAN(D))) * 360 / (15 * PI): 'durée du jour en heures
3550 TFIN = 12 + .5 * H
3560 ISOM = 0
3570 FOR M = 0 TO INT(H) + 1
3580 IF M <= INT(H) THEN T(M) = 12 - (.5 * H) + M ELSE T(M) = TFIN
3590 NEXT M
3600 FOR M = 0 TO INT(H)
3610 I = 3600 * R * IO * SIN(D) * SIN(L) * (T(M + 1) - T(M)) - (R * 3600 * 12 / PI * IO * COS(D) * COS(L) *
(SIN(PI * T(M + 1) / 12) - SIN(PI * T(M) / 12)))
3620 ISOM = ISOM + I
3630 NEXT M
3640 FOR J = 0 TO INT(H) + 1
3650 IF J <= INT(H) THEN T(J) = 12 - (.5 * H) + J ELSE T(J) = TFIN
3660 NEXT J
3670 I = 0
3680 RGJ = 0
3690 PNJ = 0
3700 FOR J = 0 TO INT(H)
3710 I = 3600 * R * IO * SIN(D) * SIN(L) * (T(J + 1) - T(J)) - (R * 3600 * 12 / PI * IO * COS(D) * COS(L) *
(SIN(PI * T(J + 1) / 12) - SIN(PI * T(J) / 12))): ' ray. glob. hor. au dessus de l'atmosphère
3720 RG = I * a(N, 1) / (ISOM * 3.6): ' ray. glob. horaire au dessus du couvert
3730 PAR = 4.5 * .47 * RG:          ' ray. vis. horaire au dessus du couvert
3740 RGJ = RGJ + RG * 3.6 / 1000
```

```
5450 '
5460 '
5550 ' Production journaliere d' INFORESCENCES
5560 '
5570 NBREG = NBREGPRO / 17
5580 NBMALFLO = NBMALPRO / 17
5590 SEXRATIO = SREND
5600 AVORT = AVEND
5610 YIELD = MBFRUPRO / 17
5620 YIELDMAL = MBMALPRO / 17
5630 '
5640 ' EVOLUTION DES INFLORESCENCES TOUT LES 17 JOURS ***********************************
5650 '
5660 IF N / 17 = INT(N / 17) GOTO 5770 ELSE 7200
5670 '
5770 IF INITSOM < 0 OR INITSOM > 1 THEN PRINT "INITSOM IMPOSSIBLE": END
5780 '
5790 ' Effet des avortements au rang 6 et au rang 25
5800 '
5810 IF GFEMSOM < GFEMMIN THEN AVP = (.0006 / (GFEMSOM + .001)) * NBFEMPRO(29): ' croissance
des 17 derniers jours et avortement au rang 6
5820 IF GFEMSOM < GFEMAV THEN AVT = (.0004 / (GFEMSOM + .0006)) * NBFEMPRO(49): ' croissance
des 17 derniers jours et avortement au rang 25
5830 AV(29) = AVP:                                  ' avortement au rang 6
5840 AV(49) = AVT:                                  ' avortement au rang 25
5850 SR(29) = SR(29) - AVP / DENS:                          ' sexratio au rang 6
5860 SR(49) = SR(49) - AVT / DENS:                          ' sexratio au rang 25
5910 '
5920 ' Incrementation de toutes les unites florales
5930 '
5940 FOR K = 50 TO 1 STEP -1
5950 AV(K + 1) = AV(K):            ' avortements
5960 SR(K + 1) = SR(K):            ' sexratio
5970 NBFEMPRO(K + 1) = NBFEMPRO(K):    ' nb d'inflo femelles
5980 NBMALPRO(K + 1) = NBMALPRO(K):    ' nb d'inflo males
5990 BFEMPRO(K + 1) = BFEMPRO(K):      ' poids des inflo femelles
6000 BFRUPRO(K + 1) = BFRUPRO(K):      ' poids des inflo femelle avec huile
6010 BMALPRO(K + 1) = BMALPRO(K):      ' poids des inflo males
6020 NEXT
6030 '
6040 BFRUPRO(51) = BFRUPRO(51) + DBFRUSOM * NBFEMPRO(51) / NBFRU:
6050 BFRUPRO(50) = BFEMPRO(50) + DBFRUSOM * NBFEMPRO(50) / NBFRU:
6060 NBFRU = 0
6070 FOR K = 36 TO 49
6080 BFEMPRO(K) = BFEMPRO(K) + DBFEMSOM * NBFEMPRO(K) / NBFEM: ' poids d'inflo femelle rangs 12
a 25 en kg ha-1
6090 NEXT K
6100 NBFEM = 0
6110 FOR K = 36 TO 49
6120 NBFEM = NBFEM + NBFEMPRO(K):                  ' nb d'inflo femelles ha-1
6130 NEXT K
6140 FOR K = 50 TO 51
6170 NBFRU = NBFRU + NBFEMPRO(K):                  ' nb d'inflo femelles avec huile ha-1
6180 NEXT K
6190 FOR K = 35 TO 40
6200 BMALPRO(K) = BMALPRO(K) + DBMALSOM * NBMALPRO(K) / NBMAL: ' poids d'inflo males, rangs
11 a 16 en kg ha-1
```

```
6210 NEXT K
6220 NBMAL = 0
6230 FOR K = 35 TO 40
6240 NBMAL = NBMAL + NBMALPRO(K):                    ' nb d'inflo males ha-1
6250 NEXT K
6260 FOR K = 50 TO 51
6270 BFEMPRO(K) = 0
6280 NEXT K
6290 FOR K = 41 TO 51
6300 BMALPRO(K) = 0
6310 NEXT K
6320 '
6330 SREND = SR(51)
6340 AVEND = AV(51)
6350 NBREGPRO = NBFEMPRO(51)
6360 NBMALPRO = (1 - SR(51)) * DENS - AV(51)
6370 MBMALPRO = BMALPRO(40)
6380 MBFEMPRO = BFEMPRO(49)
6390 MBFRUPRO = BFRUPRO(51)
6400 '
6410 ' Initialisation des unites forales
6420 '
6430 AV(1) = 0
6440 SR(1) = INITSOM
6450 NBFEMPRO(1) = SR(1) * DENS
6460 NBMALPRO(1) = (1 - SR(1)) * DENS
6470 BFEMPRO(1) = 0
6480 BMALPRO(1) = 0
6490 '
6520 ' Reinitialisation des compteurs sur 17 jours
6530 '
6540 DBMALSOM = 0
6550 DBFEMSOM = 0
6560 DBFRUSOM = 0
6570 INITSOM = 0
6580 AVP = 0
6590 AVT = 0
6600 GFEMSOM = 0
6610 '
7170 ' BILAN DE CARBONE JOURNALIER ******************************
7180 '
7190 ' Calcul des coefficients respiratoires d'entretien
7200 '
7210 MRS = MRSO * EXP(.069 * (a(N, 2) - 25))
7220 MRRCH = MRRCHO * EXP(.069 * (a(N, 2) - 25))
7230 MRPET = MRPETO * EXP(.069 * (a(N, 2) - 25))
7250 MRRI = MRRIO * EXP(.069 * (a(N, 2) - 25))
7260 MRRII = MRRIIO * EXP(.069 * (a(N, 2) - 25))
7270 MRRABS = MRRABSO * EXP(.069 * (a(N, 2) - 25))
7350 MRFOL = MRFOLO * EXP(.069 * (a(N, 6) - 25))
7360 MRMAL = MRMALO * EXP(.069 * (a(N, 2) - 25))
7370 MRFEM = MRFEMO * EXP(.069 * (a(N, 2) - 25))
7380 MRFRU = MRFRUO * EXP(.069 * (a(N, 2) - 25))
7390 '
7400 ' Respiration d'entretien de la partie vegetative
7410 '
7420 RVM = (MRS * BS + MRFOL * BFOL + MRRI * BRI + MRRII * BRII + MRRABS * BRABS + MRPET *
```

```
BPET + MRRCH * BRCH)
7430 RMS = MRS * BS
7440 RMFOL = MRFOL * BFOL
7450 RMRAC = MRRI * BRI + MRRII * BRII + MRRABS * BRABS
7460 RMPET = MRPET * BPET
7470 RMRCH = MRRCH * BRCH
7480 '
7490 ' Respiration d'entretien de la partie reproductive
7500 '
7510 RPM = MRMAL * BMAL + MRFEM * (BFEM + .6 * BFRU) + MRGRA * .4 * BFRU
7520 RMMAL = MRMAL * BMAL
7530 RMFEM = MRFEM * BFEM
7540 RMFRU = MRFRU * BFRU
7550 RMREG = RMFEM + RMFRU
7560 '
7570 ' Croissance des parties vegetatives en kg ha-1 j-1
7580 '
7590 DBRAC = (.15 * BRI + .31 * BRII + .1 * BRO) / 365
7600 IF N > 274 AND N < 336 THEN DBRAC = (.15 * BRI + .31 * BRII + .1 * BRO) / 365 + (.47 * BRO) / 61
7610 IF N > 640 AND N < 702 THEN DBRAC = (.15 * BRI + .31 * BRII + .1 * BRO) / 365 + (.47 * BRO) / 61
7620 IF N > 1006 AND N < 1068 THEN DBRAC = (.15 * BRI + .31 * BRII + .1 * BRO) / 365 + (.47 * BRO) / 61
7630 IF N > 1372 AND N < 1434 THEN DBRAC = (.15 * BRI + .31 * BRII + .1 * BRO) / 365 + (.47 * BRO) / 61
7640 '
7650 DBF = EMIF * BF * DENS / 365
7660 '
7670 DGRAND = .48
7680 DBS = DSSTIP * PI * RAY ^ 2 * DENS * DGRAND / 365
7690 '
7700 ' Mortalite des parties vegetatives
7710 '
7720 MBRAC = (.15 * BRI + .31 * BRII + .57 * BRO) / 365
7730 MBF = DBF
7740 MBS = 0
7990 '
8000 ' Croissance des inflorescences en kg ha-1 j-1
8100 '
8110 IF GFEM < 0 THEN GFEM = 0
8120 DBMAL = GMAL * NBMAL:        ' males
8130 DBFEM = GFEM * NBFEM:        ' femelles sans huile
8140 DBFRU = GFEM * NBFRU:        ' femelles avec huile
8150 '
8160 ' Mortalite des inflorescences en kg ha-1 j-1
8170 '
8180 MBMAL = MBMALPRO / 17:       ' males
8190 MBFEM = MBFEMPRO / 17:       ' femelles sans huile
8200 MBFRU = MBFRUPRO / 17:       ' femelles avec huile
8210 '
8400 ' Respiration de croissance de la partie vegetative en kg ha-1 j-1
8410 '
8420 RVC = (CRF - 1) * DBF + (CRRAC - 1) * DBRAC + (CRS - 1) * DBS
8430 RCF = (CRF - 1) * DBF
8440 RCRAC = (CRRAC - 1) * DBRAC
8450 RCS = (CRS - 1) * DBS
8460 '
8470 ' Respiration de croissance de la partie reproductive en kg ha-1 j-1
8480 '
8490 RPC = (CRMAL - 1) * DBMAL + (CRFEM - 1) * (DBFEM + .6 * DBFRU) + (CRGRA - 1) * .4 * DBFRU
```

```
8500 RCMAL = (CRMAL - 1) * DBMAL
8510 RCFEM = (CRFEM - 1) * DBFEM
8520 RCFRU = (CRFRU - 1) * DBFRU
8530 RCREG = RCFEM + RCFRU
8540 '
8550 ' Bilan des respirations
8560 '
8650 RV = RVC + RVM
8660 RMAL = RCMAL + RMMAL
8670 RREG = RCREG + RMREG
8680 RP = RPC + RPM
8690 RTOT = RV + RP
8700 '
8710 ' Croissance journaliere
8720 '
8730 BILV = (DBF + DBRAC + DBS) / 10
8740 BILP = (DBMAL + DBFEM + DBFRU) / 10
8750 BIL = BILV + BILP
8760 '
8770 ' Bilan de carbone et sexualisation
8780 '
8790 IF GFEM < GFEMMAX GOTO 8830
8800 INIT = PENTE * (PNJ - BIL - RTOT / 10)
8810 INITSOM = INITSOM + INIT + .55 / 17
8820 '
8830 ' Ajustement de la croissance journaliere au bilan de carbone journalier
8840 '
8850 IF GFEM <> GFEMMAX GOTO 8930
8860 IF PNJ - BIL - RTOT / 10 > 0 AND STOCK > STOCKMAX THEN GFEM = (10 * (PNJ - BILV) - (DBMAL
+ RV + RPM + RCMAL)) / (CRFEM * NBFEM + CRFRU * NBFRU): GOTO 7570
8870 IF PNJ - BIL - RTOT / 10 = 0 GOTO 8930
8880 IF PNJ + STUTIL - BIL - RTOT / 10 < 0 THEN GFEM = (10 * (PNJ + .999 * STUTIL - BILV) - (DBMAL +
RV + RPM + RCMAL)) / (CRFEM * NBFEM + CRFRU * NBFRU): GOTO 7570
8920 '
8930 GFEMSOM = GFEMSOM + GFEM / 17:        ' croissance moyenne des inflo femelles sur 17 jours
8940 GFEMSOMB = GFEMSOMB + GFEM / 17
8950 '
8960 'PRINT #2, USING " ###.####"; N, PNJ, PNJ + .999 * STUTIL - BIL - RTOT / 10, PNJ - BIL - RTOT / 10
9000 '
9010 ' Variations de biomasse en kg ha-1 j-1
9020 '
9040 BS = BS + DBS - MBS:                  ' stipe
9050 BRAC = BRAC + DBRAC - MBRAC:          ' racines
9060 BRABS = BRABS + DBRAC - MBRAC:        ' racines fines (III+IV)
9070 BF = BF + DBF - MBF:                  ' feuilles
9170 BV = BV + DBS + DBRAC + DBF - MBS - MBRAC - MBF: ' biomasse vegetative
9180 '
9200 BMAL = BMAL + DBMAL - MBMAL:          ' inflo males
9210 BFEM = BFEM + DBFEM - MBFEM:          ' inflo femelles sans huile
9220 BFRU = BFRU + DBFRU - (MBFRU - MBFEM):  ' inflo femelles avec huile
9230 BREG = BFEM + BFRU:                   ' inflo femelles totales
9240 BP = BP + DBMAL + DBFEM + DBFRU - MBMAL - MBFRU: ' biomasse reproductive
9250 '
9260 BTOT = BV + BP:                       ' biomasse totale sur pied
9270 '
9290 ' Production et réserves journalières et cumulées
9300 '
```

```
9310 DBMALSOM = DBMALSOM + DBMAL:                    ' gCH2O m-2 j-1
9320 DBFEMSOM = DBFEMSOM + DBFEM:                    ' "      "
9330 DBFRUSOM = DBFRUSOM + DBFRU:                    ' "      "
9340 '
9350 BILANV = BILANV + (DBF + DBRAC + DBS) / 1000:    ' t ha-1
9360 BILANP = BILANP + (DBMAL + DBFEM + DBFRU) / 1000: ' "    "
9370 BILAN = BILANV + BILANP:                         ' "    "
9380 '
9390 STOCK = STOCK + PNJ - BIL - RTOT / 10:          ' réserves actuelles en gCH2O m-2
9400 IF STOCK < 0 THEN PRINT "STOCK NEGATIF": END
9410 'IF STOCK > 800 THEN STOCK = 800: PRINT "ALERTE"
9490 STUTIL = .02 * STOCK:                           ' reserves utilisables chaque jour
9500 '
9510 'PRINT #2, USING " ####.##"; N, PNJ, BILV, BILP, RV / 10, RP / 10, RMAL / 10, RREG / 10, STOCK
9520 'PRINT #2, USING " ####.###"; N, PNJ, PNJ + STUTIL - BIL - RTOT / 10, 10 * (PNJ + STUTIL - BILV) -
(DBMAL + RV + RPM + RCMAL), INITSOM, STOCK, YIELD, GFEM
9530 'PRINT #2, USING " #####.##"; N, NBREGPRO, NBMALFLO, SREND, AVEND
9540 'PRINT #2, USING " #####.##"; N, PRI, 100 * RS / RU, SY, 100 * ETR / ETP
9550 IF N / 17 = INT(N / 17) THEN LPRINT USING "#####.##"; YEAR, N, BILV, BILP, RV / 10, RP / 10, RMAL
/ 10, RREG / 10, GFEMSOMB * 1000, STOCK, SR(1), AV(30), AV(50), NBMALFLO, NBREG, AVEND,
SEXRATIO, YIELD * 30.5 / (.4 * 1000), YIELD / (.4 * NBREG)
9560 IF N / 17 = INT(N / 17) THEN LPRINT : GFEMSOMB = 0
9570 '
9580 GFEM = GFEMMAX
9590 IF N = 1464 THEN GOTO 9610
9600 NEXT N
9610 '
9620 '*****************************************************************************
9630 '*****************************************************************************
9640 '
9650 'CALCUL DE LA PRODUCTION en t ha-1  POIDS FRAIS DE REGIMES
9660 '
9670 'PFREG = 1.0325 * (STOCK - 429) / 100
9680 'PSINFTOT = (STOCK - 429) / 2.214
9690 'RINFTOT = (1 - .452) * (STOCK - 429)
9700 'PSREG = .413 * (STOCK - 429)
9710 'MSTOT = BILAN + PSINFTOT / 100
9720 '
9730 'PRINT #2, USING " ######.#"; N, RMFOLSOM, RMRCHSOM, RMPETSOM, RMSSOM, RMRSOM,
RMASOM, RCFSOM, RCSSOM, RCRACSOM, RCRSOM, RVEGSOM
9740 'PRINT #2, USING " ######.#"; PNJSOM, PNRSOM, RMASOM / 100, RCRSOM / 100, RVEGSOM / 100,
BILAN, PSINFTOT / 100, RINFTOT / 100
9750 '
9760 'PRINT #2, USING " ######.#"; N, PFREG, MSTOT, PNJSOM 'PSREG / 100, PSINFTOT / 100, BILAN,
BILRAC, BILS, MSTOT
9770 'LPRINT USING " ######.#"; N, PFREG, MSTOT, PNJSOM 'PSREG / 100, PSINFTOT / 100, BILAN,
BILRAC, BILS, MSTOT
9780 CLOSE
9790 END
9800 '
9810 '*****************************************************************************
9820 '
9830 'Conditions sur la pluie pour le calcul de l'ETR
9840 '
9850 'IF A(N - 4, 5) >= 20 THEN ETR = .81 * ETP
9860 IF a(N - 3, 5) >= 15 THEN ETR = .81 * ETP
9870 IF a(N - 2, 5) >= 10 THEN ETR = .81 * ETP
```

```
9880 IF a(N - 1, 5) >= 5 THEN ETR = .81 * ETP
9890 GOTO 4500
9900 '*****************************************************************************
```

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