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N ARM-631

IMPROVING RAIN PENETRATIONN AND REDUCING SOIL EROSION IN DRYLAND FARMING

(Progress Report 30/6/89)

C7-036

From January to June 1989 the following tasks were accomplished:

1. Rainfall erosivity studies

The study of different methodologies for determining various indices of rainfall erosivity in three different locations. In this study it has been analyzed the sensibility of each methodology in order to obtain information on the variability of those indices.

We have also collected and analyzed data from erosion plots located at the Vale Formoso Erosion Center. These data consist in precipitation, evaporation, overland flow and soil loss.

1.1. Indices

Rainfall data from three recording rain gages stations have been processed and digitalized into a database:

Lisboa - Portela (14 years)
Oeiras - Sassoeiros (13 years)
Mertola - Vale Formoso (20 years)

For each station the following rainfall erosivity indices have been calculated:

EI30 present by Whischmeier, but rain showers of less than 0, 5, 7.5, 10, 12.5 and 15 mm and separated from other rain periods by more than 6 hours were omitted from the erosion index computations, unless as much as 6.35 mm of rain in 15 min;

KE (Kinetic Energy Index) - summing the kinetic energy received when the rainfall intensity equals 0, 5, 10, 15, 20 and 25 mm/h or greater;

EiIj (Product energy intensity)

Ei - kinetic energy received when the rainfall intensity equals 0; 10 and 25 mm/h or greater;

Ij - maximum rainfall intensity in 15, 30 and 45 min, for each single storm.

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1.2. Results analysis

In Fig. 1 we present the indice EiIj (Vale Formoso). For each station the correlation coefficient between indices range from 0.90 to 0.99 .

In Fig. 2 it is shown the EI30 and corresponding

cc PPC/CDIE

precipitation and kinetic energy (Vale Formoso).

There is a small decrease in the EI30, precipitation and kinetic energy with the increase of the omitted storms, indicating that the erosivity storms are associated with "high rainfall events" (high precipitation and high intensity).

In Fig. 3 it is shown the KE for the three stations analized. We can see that the area of Lisboa (Portela e Sassoeiros) has the same pattern but Vale Formoso shows a different one. This could be associated with thunderstorms, quite common in this area.

The methodology proposed by Whischmeir to calculate EI30 it isn't sensitive enough if we consider storms with precipitation greater than a given value or maximum intensity in 15, 30 and 45 min.

The KE index is much more sensitive than the EI30. So according to the estimative of the KE index, the USLE can predict the soil loss. The KE index has the capability of reproducing the differences between the rainfall erosivity between the coast and the inland in Portugal.

1.3. Erosion plots

We have analized four erosion plots (1, 2, 10 and 11) from de Vale Formoso Erosion Center , subjected to the rotation "small Grain - Fallow".

	Plot 1	2	10	11
Year	63 G	F	G	F
	64 F	G	F	G
	65 G	F	G	F
	66 F	G	F	G
	81 F	G	F	G
	82 G	F	G	F

Plot	Length	Wide	Slope	Orientation
1	20.0 m	8.33 m	11 %	South
2	20.0 m	8.33 m	10 %	South
10	20.0 m	8.33 m	16 %	East
11	20.0 m	8.33 m	16 %	East

For each plot the following data were available:

- rainfall
- overland flow
- soil loss
- EI30

The soil loss computed with USLE has been compared with observed soil loss.

Plot	1	2	10	11
Soil loss (field) [t/ha]	1.04	1.92	0.65	1.23
Soil loss (USLE) [t/ha]	20.00	17.99	41.88	42.28
R (USLE) [t/ha]	98.52	98.52	98.52	98.52
K (USLE)	0.44	0.44	0.44	0.44
LS (USLE)	1.282	1.153	2.299	2.322
C (USLE)	0.6	0.6	0.6	0.6
P (USLE)	0.6	0.6	0.7	0.7

From the data analyzed we select the following figures:

Fig. 4 - observed soil loss for four erosion plots

Fig. 5 - observed soil loss versus EI30 for plot 1

Fig. 6 - observed soil loss versus EI30 for plot 2

Fig. 7 - observed versus computed soil loss for plot 2

It was verified that in plots 10 and 11 the soil loss measured is less that from plots 1 and 2, when from the USLE it should be the opposite. This could be explained by the plot orientation and wind orientation and velocity.

EI30 seems not to be a good index for the rainfall erosivity, (Fig. 6) and the USLE overestimates the soil loss (Fig. 7).

Another point is for the odd years during which the soil loss observed is much higher than in the even years. This situation could explain the differences between the soil loss observed for the plots 1-2 and 10-11, which should be the same.

The differences for the soil loss observed and computed should be due to:

- the rainfall erosion index EI30 isn't the best indicator for estimate the factor R in the USLE;
- plot orientation and wind orientation and velocity during the erosivity storms;
- greater erosivity for the odd years which leads to greater soil loss in those years.

2. Rainfall simulation studies

The three soils were studied under simulated rain with three treatments:

Control, bare soil.

Phosphogypsum, delivered over the soil surface at a rate of 5 ton/ha.

Wheat straw, mulching the soil surface at a rate of 3 ton/ha.

Each rainfall event has the duration of 30 minutes.

The main characteristics of the soils are:

	Vx	Pg	Al
Coarse sand	30.5	46.1	8.1
Fine sand	27.5	33.1	43.7
Silt	30.7	13.8	30.8
Clay	11.3	7.0	17.4
pH (H2O)	5.8	5.9	6.9
C.E.C.(meq/100g)	4.9	5.2	10.0

The effect of straw was spectacular (Fig. 8, 9, 10), but the phosphogypsum effect was not so evident:

On the Vx soil (Fig.8, 8a) the gypsum controls sediment production and infiltration during the first stage, but after that the sediment production is larger than the control plot, and the infiltration is the same.

It seems that the crust, forming a erosion pavement on the control plot, prevents the soil loss.

On the Pg soil (Fig.9) the plots with phosphogypsum have a larger soil loss than the control ones and near the end of the rainfall event the sediment production in both treatments match each other.

The infiltration (Fig.9a) at the beginning was higher on the control plot but decreased to the same level than in the gypsum plot, which maintained the same rate during all the event.

One of the reasons could be that the enhancement of the aggregation due to the calcium, resulted in a decreasing of the soil macroporosity at the surface layer, because the aggregates clogging the soil macropores and only at the end of the event the effect of the aggregation showed up. In the control treatment the clay was carried out deep into the profile.

On the Al soil (Fig. 10, 10a) the soil loss started at a lower rate and the infiltration at a higher rate on the phosphosipsum plots, but later after 20 minutes of rainfall the soil loss rate is lower than in the control and the infiltration is the same.

3. Soil column experiments

On the column experiments (Fig. 11, 12, 13) the hydraulic conductivity increased always with the concetration of the percolating solution and as it was expected and reached the highest values on the Pg and the lowest ones on the Al.

The effect of the sodium on the Hydraulic conductivity of these soils was not so linear:

On the Pg soil it seems not to be a major factor because the lowest Hydraulic conductivity was with SAR 10 followed by the SAR 20 and SAR 0 and with a mixed behaviour of the SAR 5.

On the Vx soil the effect of the sodium is not clear. At high concentrations of the percolating solutions it seems that sodium can be an aggregation factor when in large amount and a dispersive factor in small amounts. At lower concentrations it

seems to show the same trend than in the Pg soil.

On the Al the trend is similar to the one of the Pg soil but always with a lower hydraulic conductivity.

4. Field plots

On the field plots (2x1 meter) the treatments were the same than on the rainfall simulator studies. Like in those ones the effect of the straw was evident.

On the Vx soil in Vale Formoso (Fig.14) with a slope of 9% the gypsum teatment had some effect preventing the soil loss which was 19% less than the one corresponding to the bare soil, although it was 47% higher than the soil loss on the straw treatment.

On the Pg soil in Mitra (Fig.15) with 4% slope the gypsum showed no effect, and a possible reason for this behaviour could be the one given for the rainfall experiments.

On the Al soil in Alvalade (Fig.16) with a slope of 0.5% the gypsum even had an effect of enhancing the soil loss wich was 19% higher than the one corresponding to the bare plot.

6. Conclusions

From the above it seems that the crusting effect on this soils is not related with the clay dispersion, but with the soil texture. Due to this it will be interesting to test the effect of the new soil conditioners like the polyacrylamide.

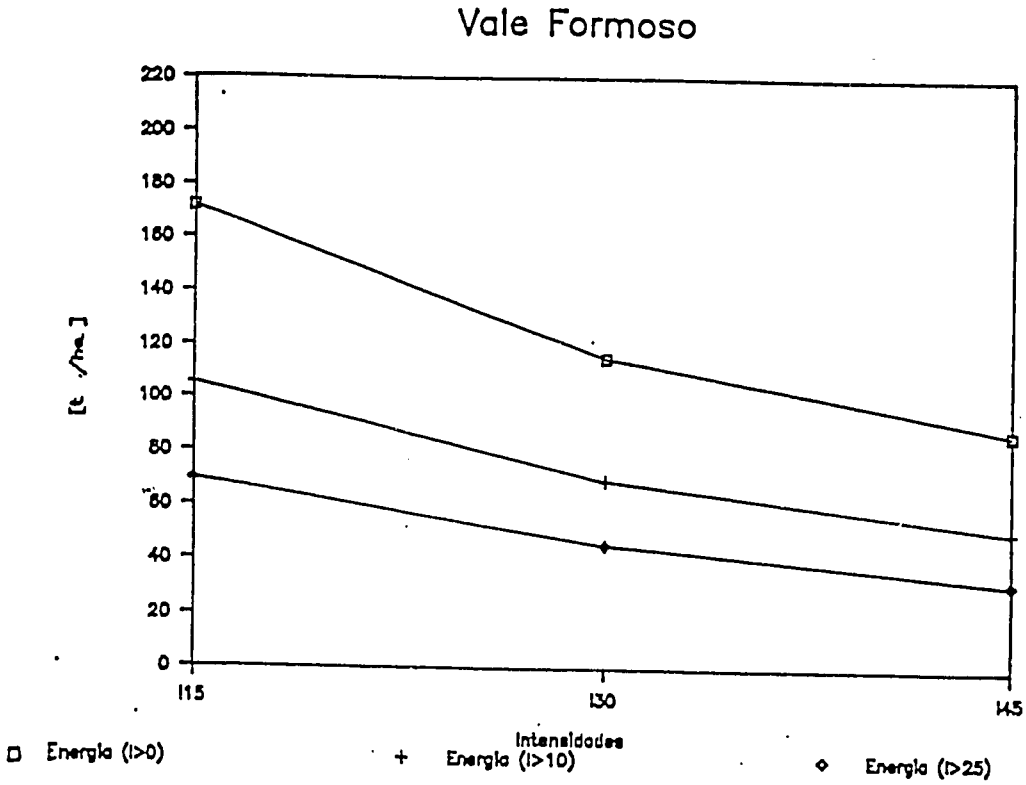


Fig. 1 - E_iI_j Produto Energia Intensidade (Vale Formoso)

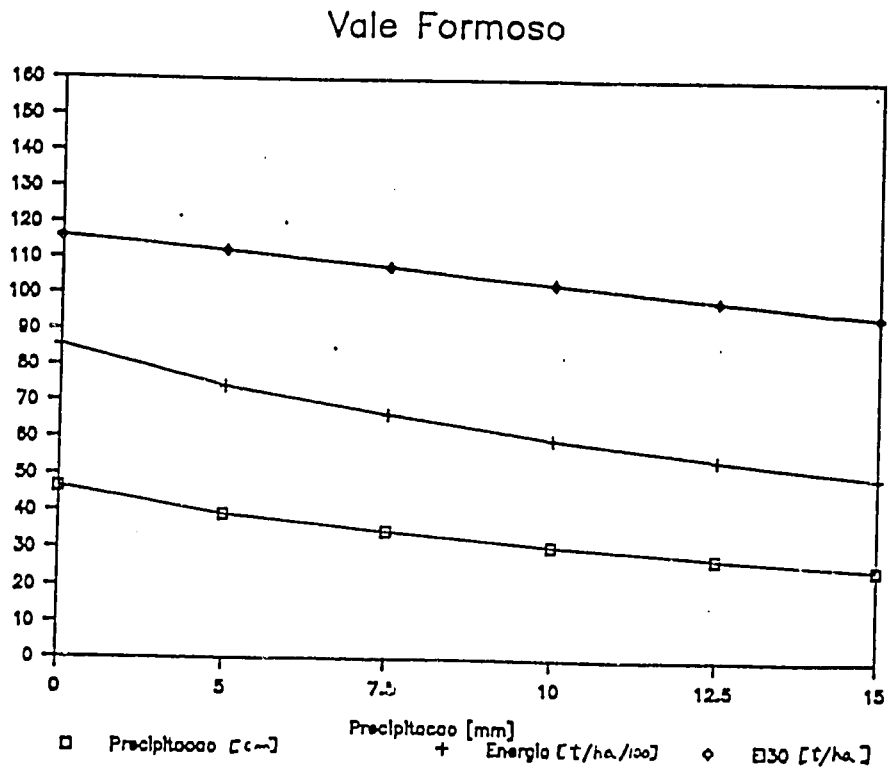


Fig. 2 - EI_{30} para várias truncaturas, Precipitação e Energia (V.Formoso)

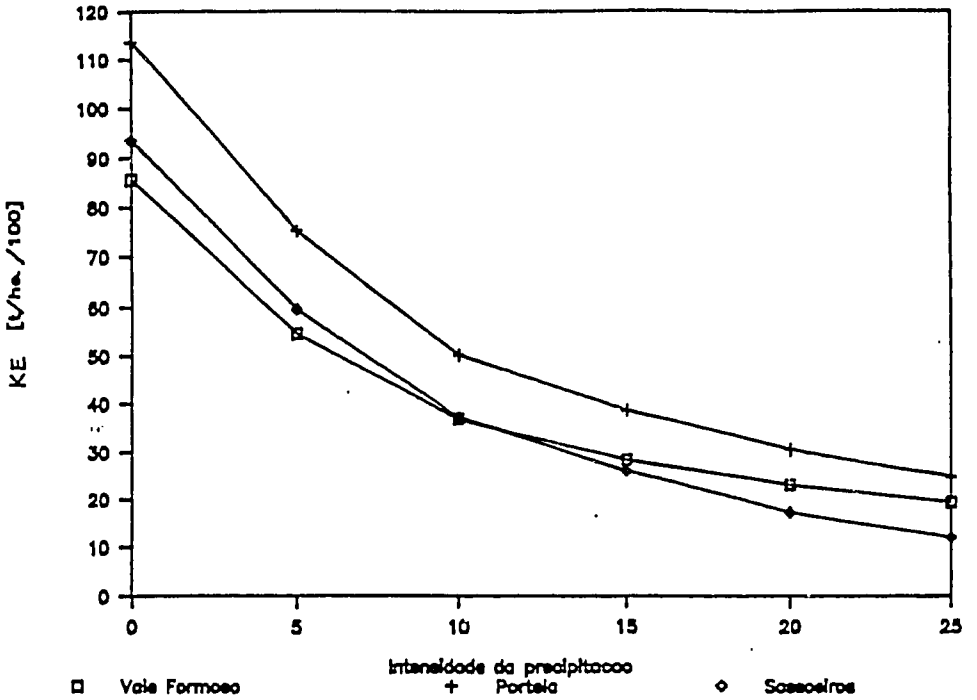


Fig. 3 - KE para várias truncaturas de intensidade (Portela, Sassoeiros e Vale Formoso)

perda solo medida

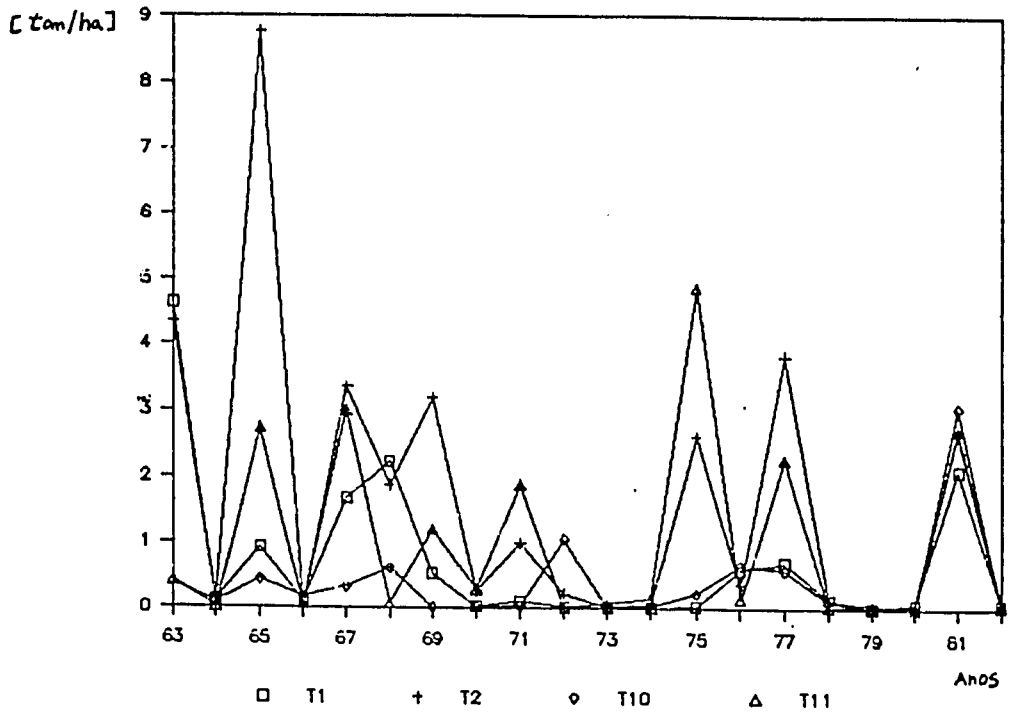


FIG. 4

talhao 1

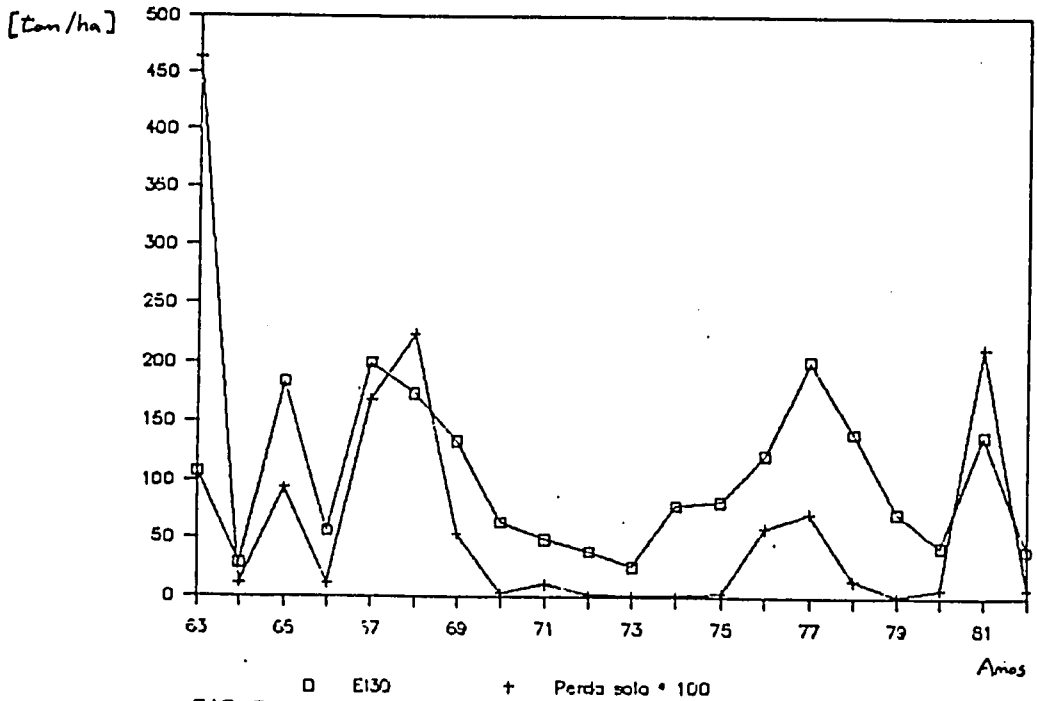


FIG. 5

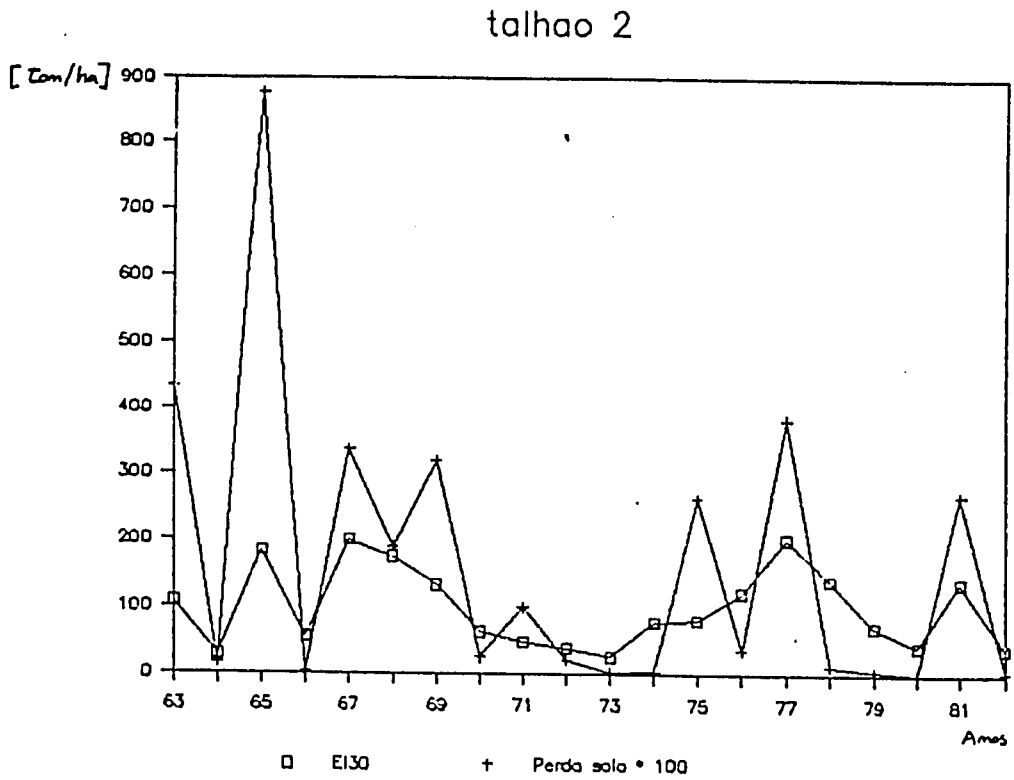

talhao 2
[ton/ha]
900
800
700
600
500
400
300
200
100
0
63
65
67
69
71
73
75
77
79
81
Anos
EI30
Perda solo * 100

FIG. 6

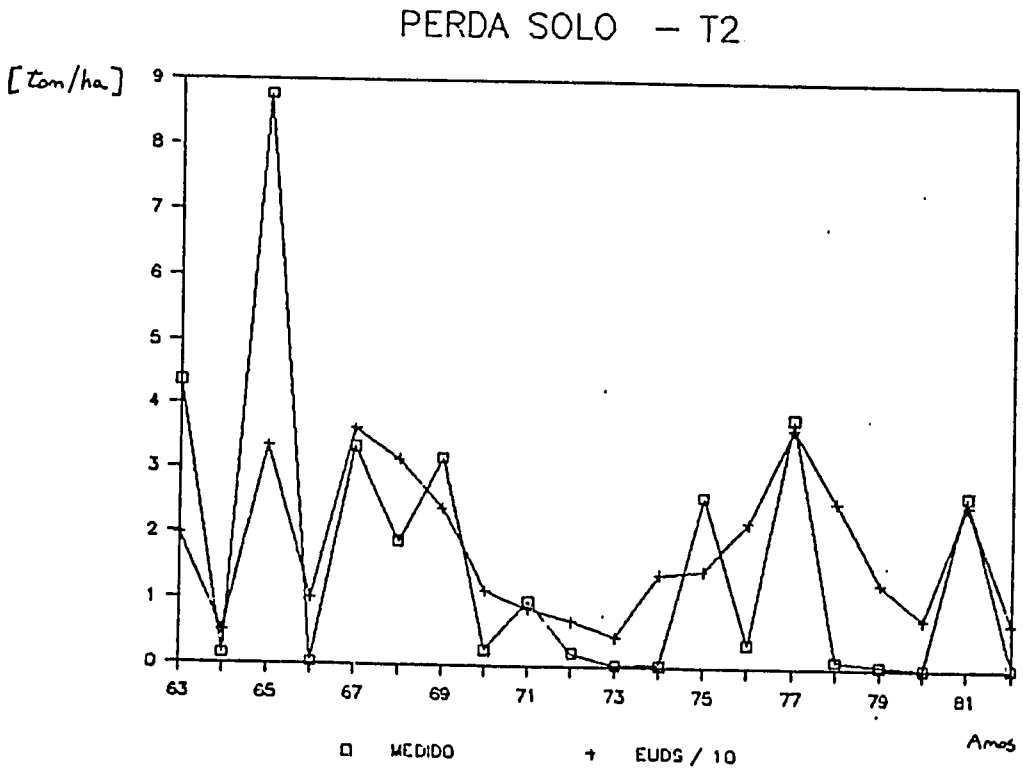
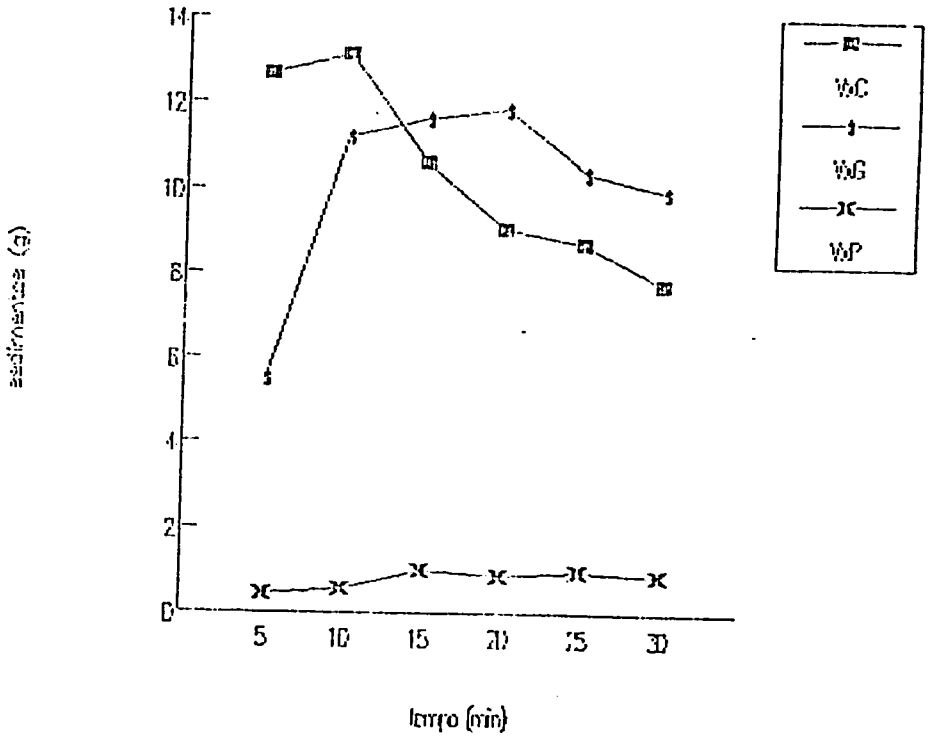

PERDA SOLO – T2
[ton/ha]
9
8
7
6
5
4
3
2
1
0
63
65
67
69
71
73
75
77
79
81
Anos
MEDIDO
EUDS / 10

FIG.7

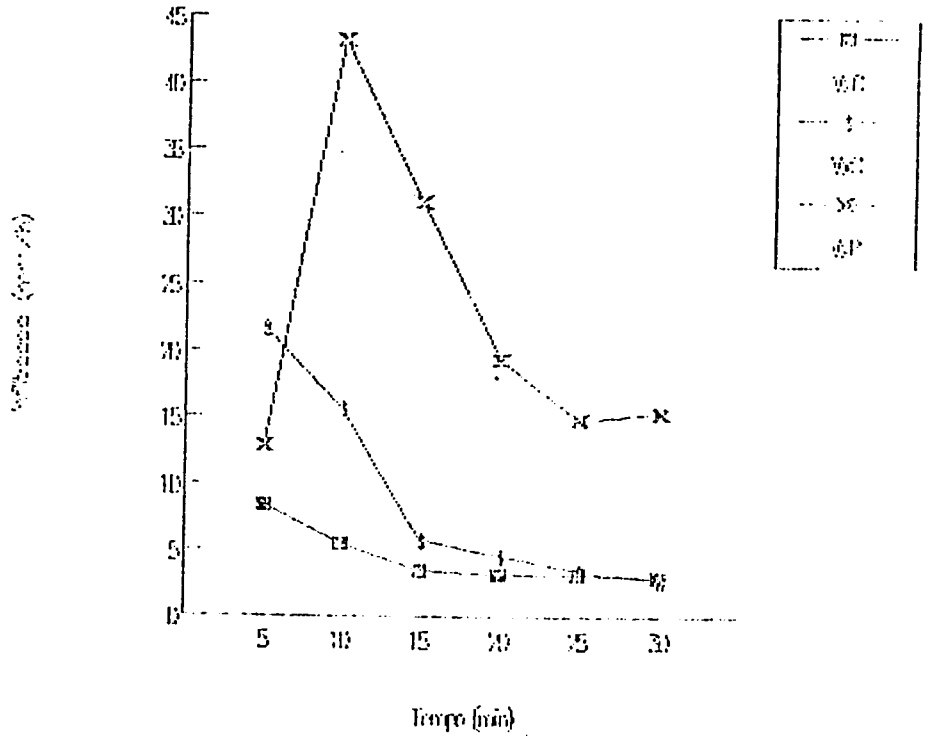
V x C - Control

V x G - Gypsum

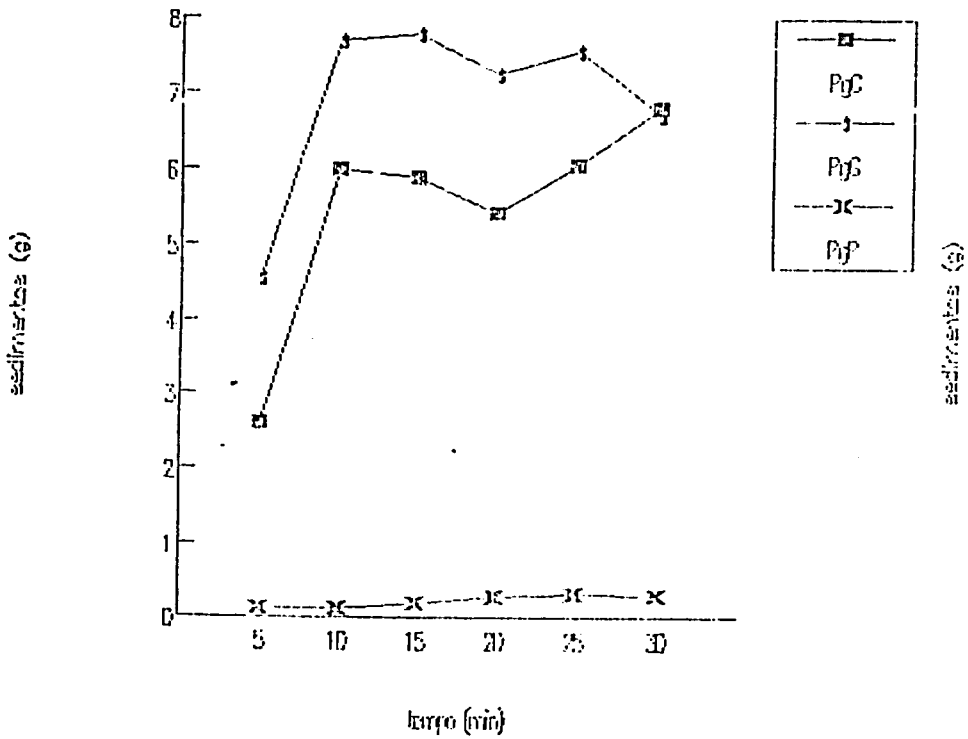
V x P - Straw



(Fig. 8)



(Fig. 8a)

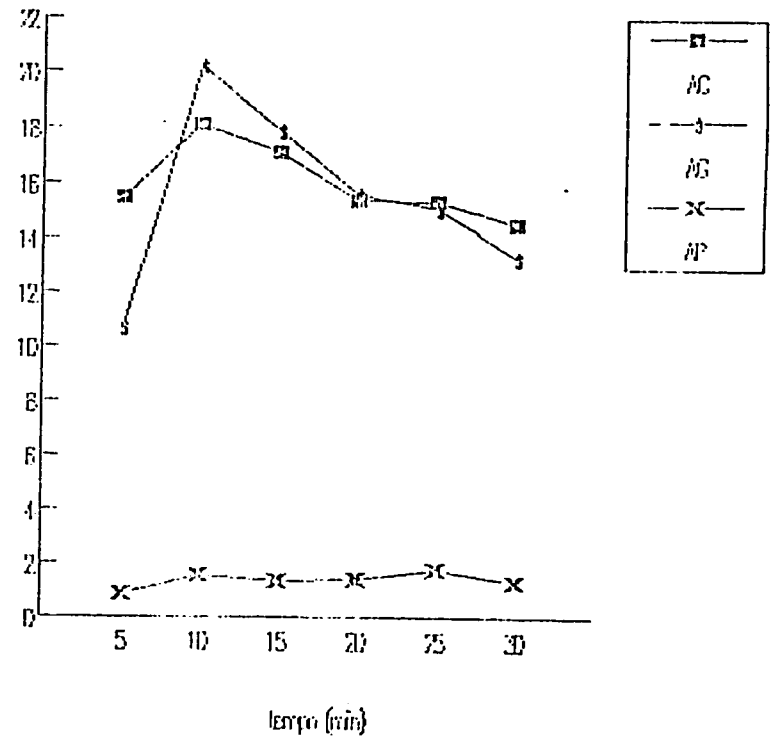


(Fig. 9)

PgC - Control

PgG - Gypsum

PgP - Straw

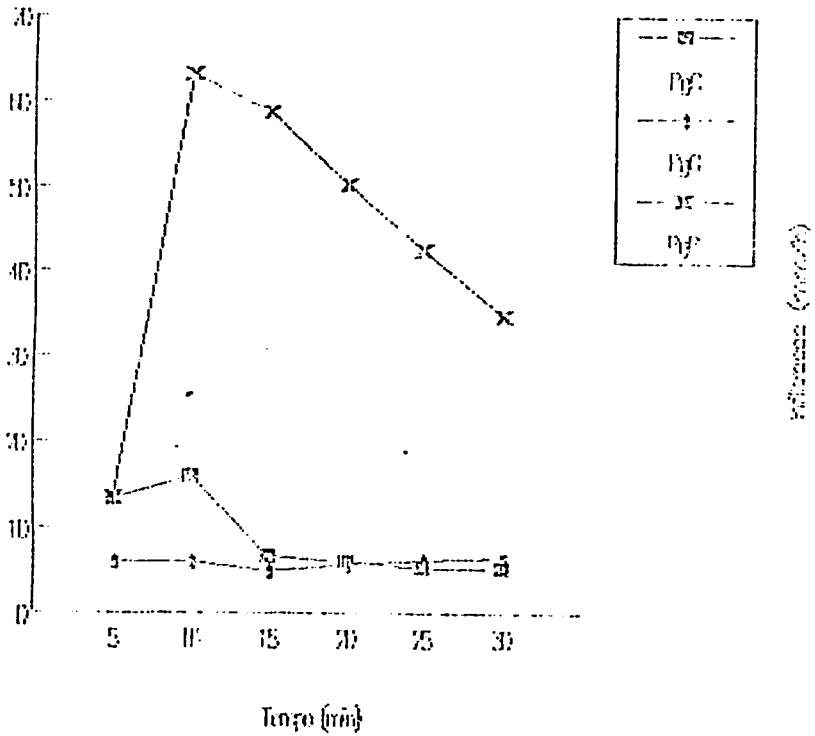


(Fig. 10)

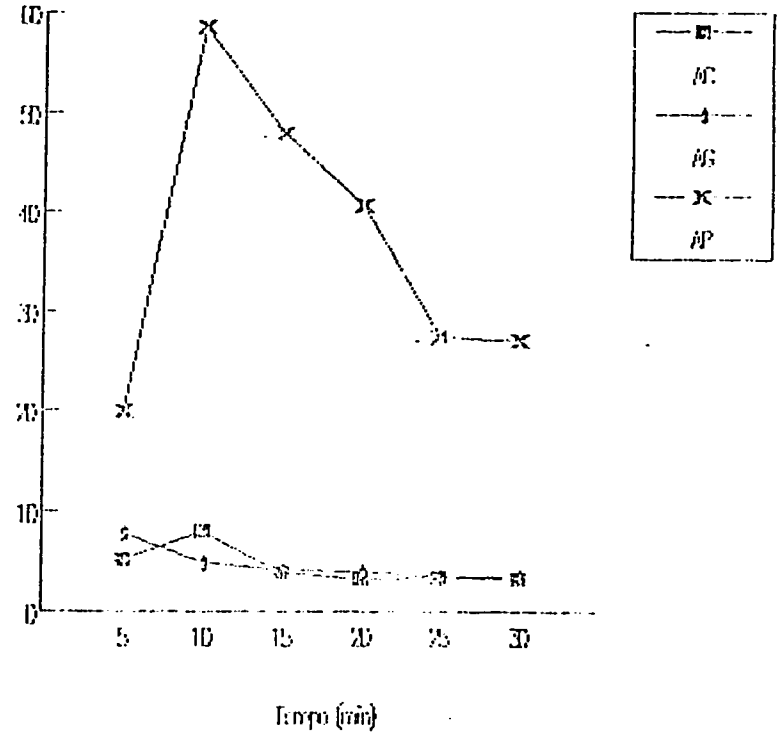
AC - Control

AG - Gypsum

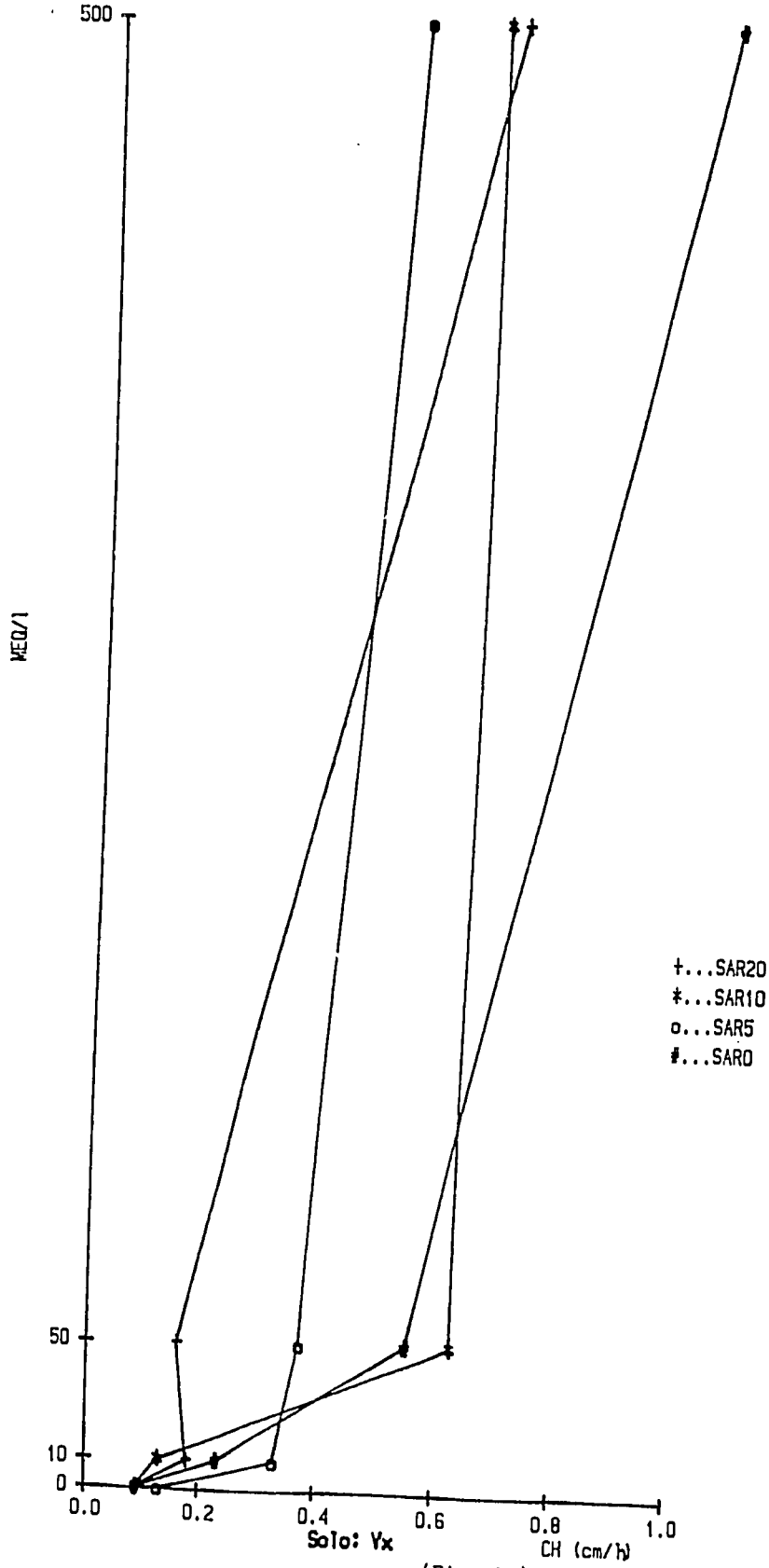
AP - Straw



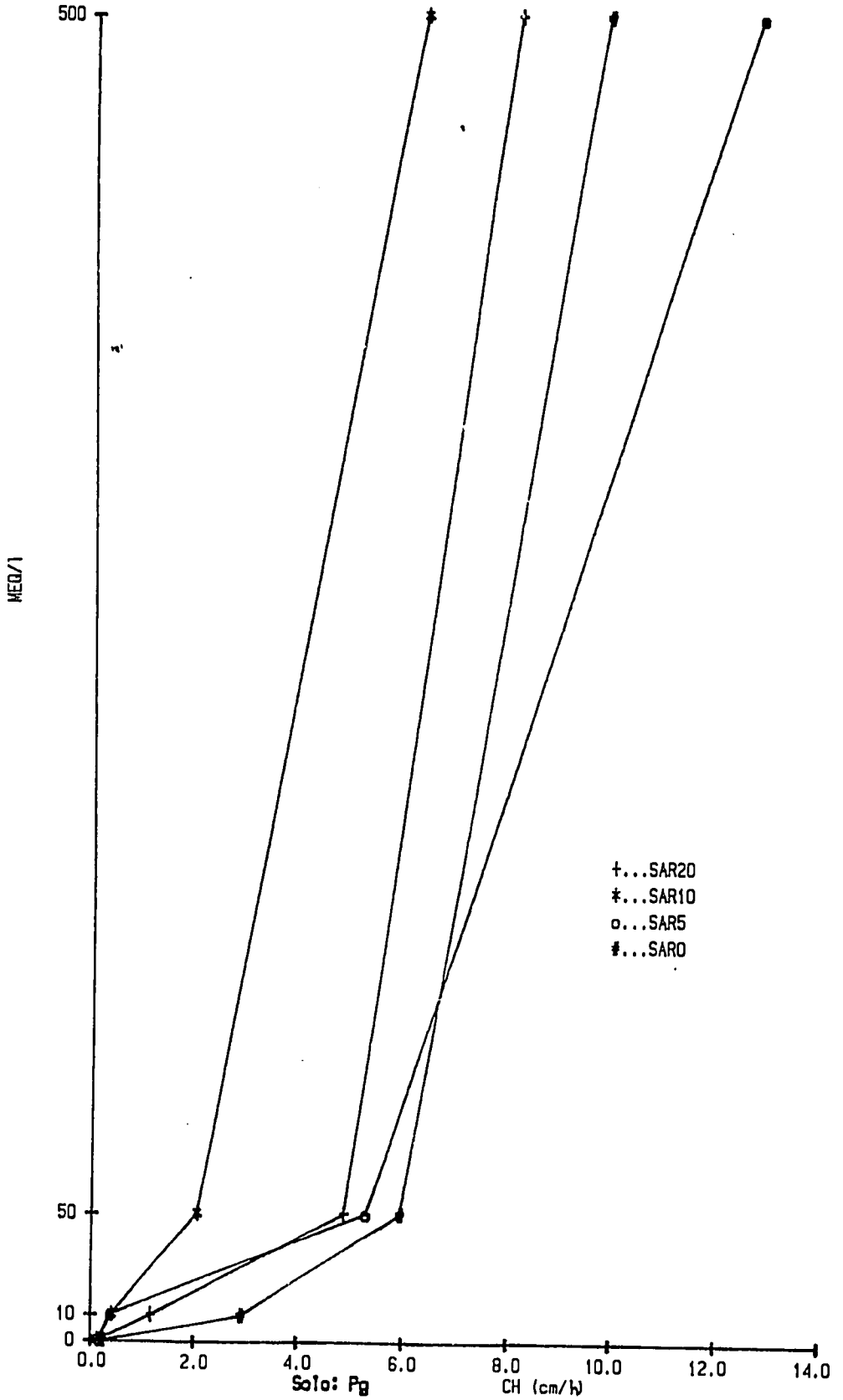
(Fig. 9a)



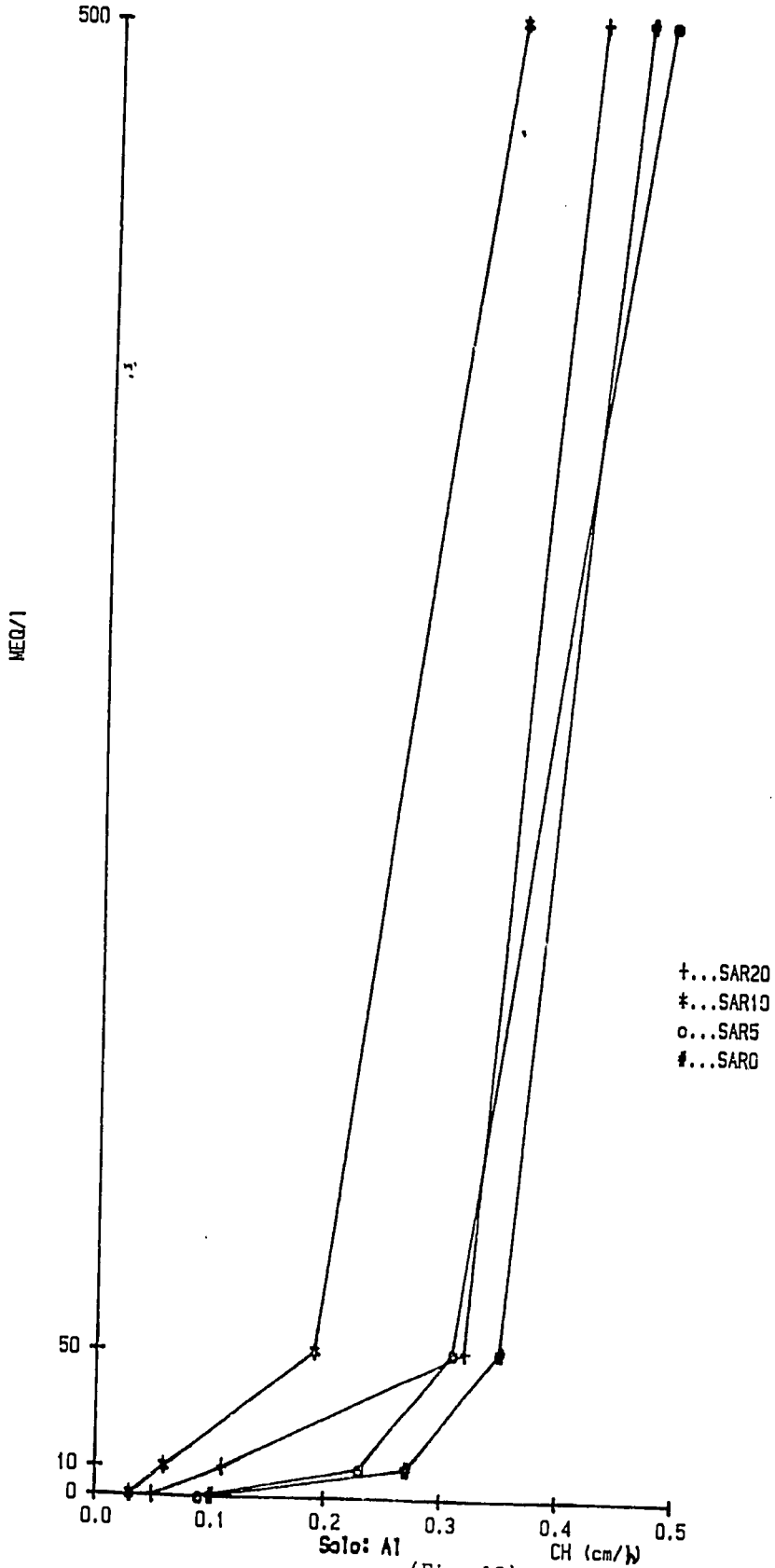
(Fig. 10a)


500
50
10
0
MEQ/l
0.0
0.2
0.4
0.6
0.8
1.0
Solo: Vx
CH (cm/h)
+...SAR20
*...SAR10
o...SAR5
#...SAR0

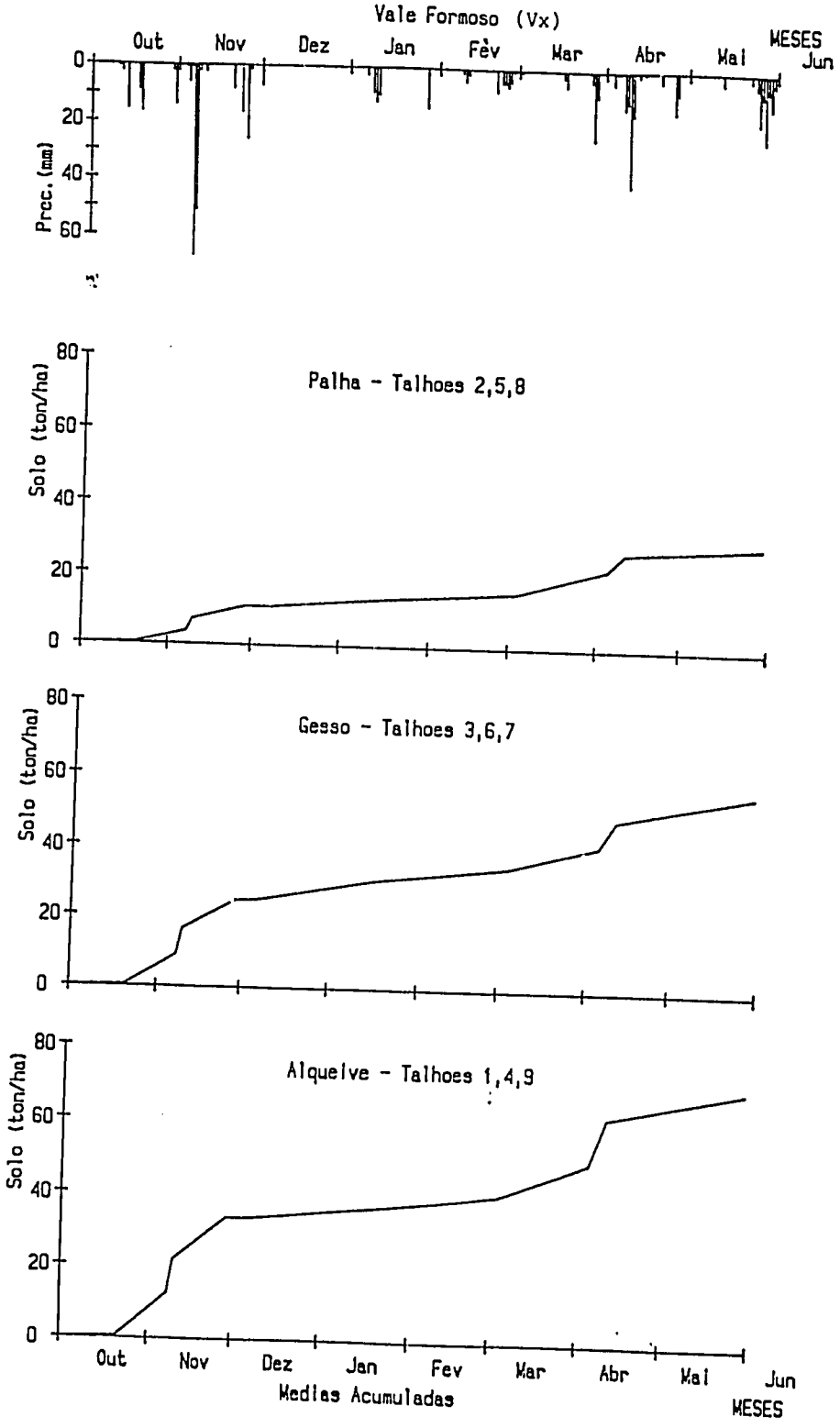
(Fig. 11)


500
50
10
0
MEQ/l
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Solo: Pg
CH (cm/h)
+...SAR20
*...SAR10
o...SAR5
#...SAR0

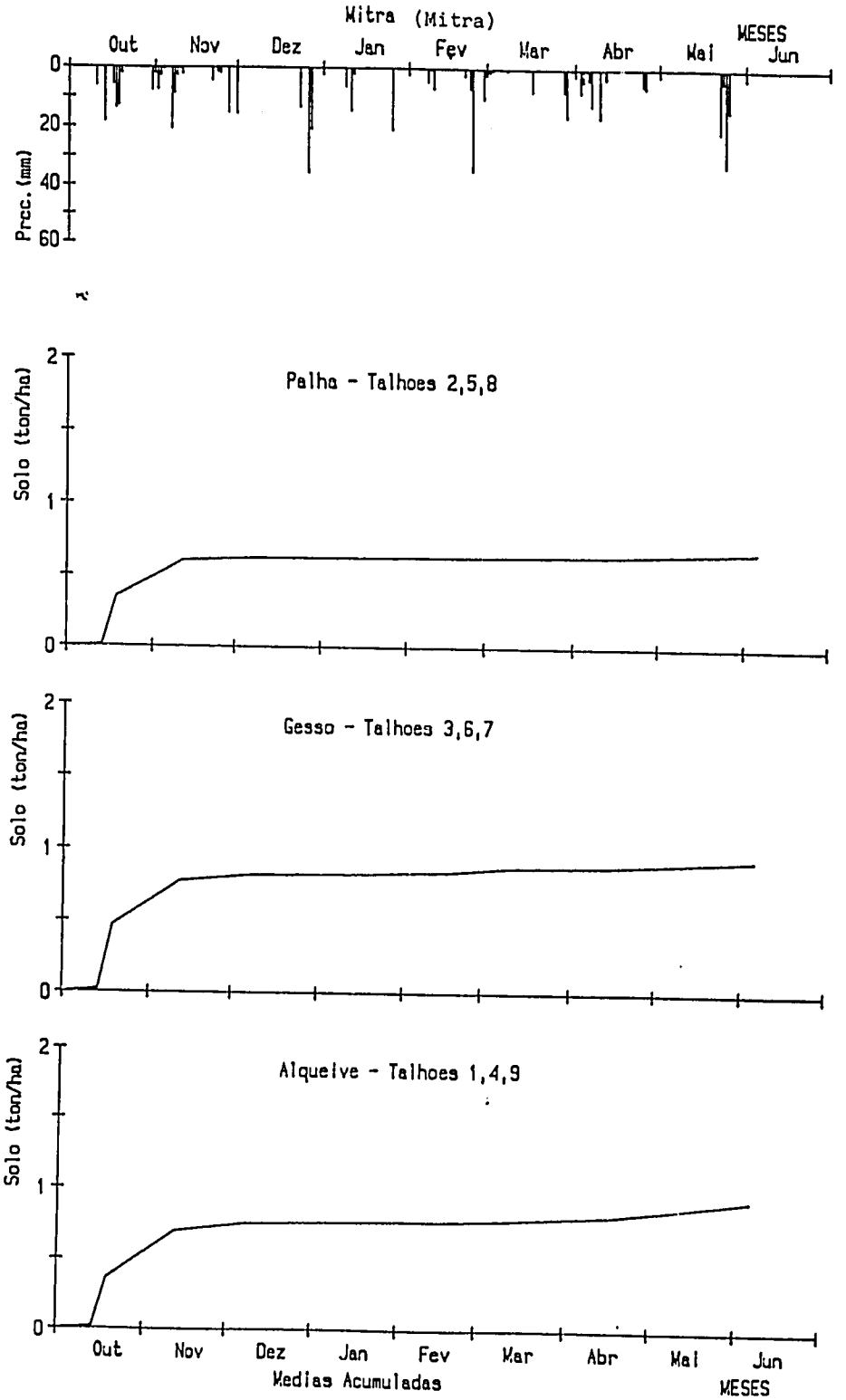
(Fig. 12)


500
50
10
0
MEQ/l
0.0
0.1
0.2
0.3
0.4
0.5
CH (cm/h)
Solo: Al
+...SAR20
*...SAR10
o...SAR5
#...SAR0

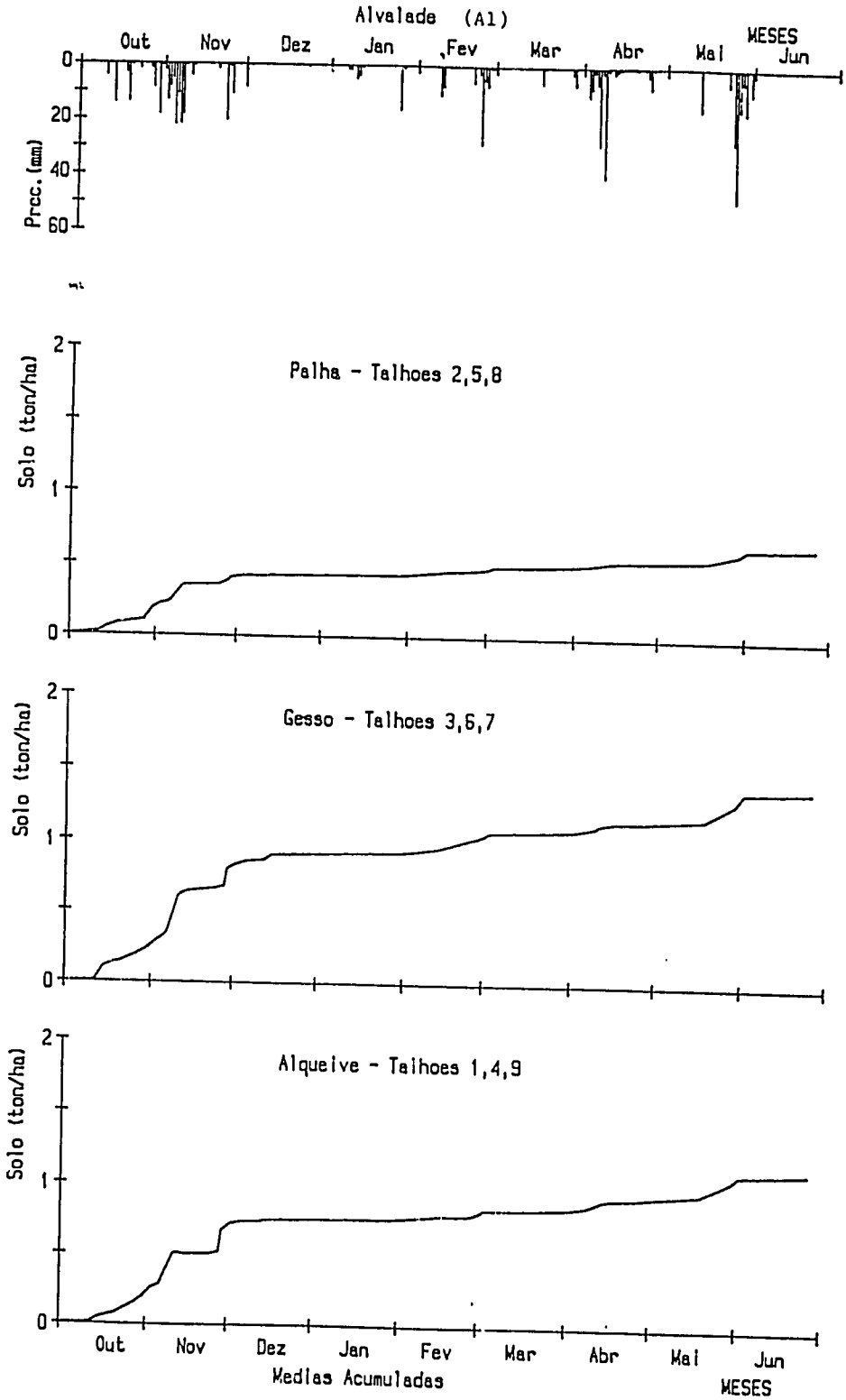
(Fig. 13)


Vale Formoso (Vx)
Out
Nov
Dez
Jan
Fev
Mar
Abr
Mai
Jun
MESES
Prec. (mm)
0
20
40
60
Palha - Talhoes 2,5,8
Gesso - Talhoes 3,6,7
Alqueive - Talhoes 1,4,9
Solo (ton/ha)
80
60
40
20
0
Medias Acumuladas

(Fig. 14)


Mitra (Mitra)
Out
Nov
Dez
Jan
Fev
Mar
Abr
Mai
MESES
Jun
0
20
40
60
Prec. (mm)
Palha - Talhoes 2,5,8
Solo (ton/ha)
2
1
0
Gesso - Talhoes 3,6,7
Solo (ton/ha)
2
1
0
Alqueive - Talhoes 1,4,9
Solo (ton/ha)
2
1
0
Out
Nov
Dez
Jan
Fev
Mar
Abr
Mai
Jun
Medias Acumuladas
MESES

(Fig. 15)


Alvalade (A1)
Out
Nov
Dez
Jan
Fev
Mar
Abr
Mai
Jun
MESES
Prec. (mm)
0
20
40
60
Palha - Talhoes 2,5,8
Gesso - Talhoes 3,6,7
Alqueive - Talhoes 1,4,9
Solo (ton/ha)
2
1
0
Medias Acumuladas

(Fig. 16)