INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL SCIENTIFIC AND CULTURAL ORGANIZATION

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SMR/147 - 50

COLLEGE ON SOIL PHYSICS

15 April - 3 May 1985

COLLOQUIUM ON ENERGY FLUX AT THE SOIL ATMOSPHERE INTERFACE

6 - 10 May 1985

CONTROL OF INFILTRATION AND EVAPORATION IN THE SOIL SURFACE FOR REGULATING THE SOIL MOISTURE REGIME IN THE SEMI-ARID TROPICS

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"CONTROL OF INFILTRATION AND EVAPORATION IN THE SOIL SURFACE FOR REGULATING THE SOIL MOISTURE REGIME IN THE SEMI-ARID TROPICS"

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More than 700 million people around the world live in rainfed farming areas in the "semi-arid tropics".

The "semi-arid tropics" are characterized by:

1) Annual rainfall of 400-1900 mm. (L.D. Swindale, 1982) concentrated in 2-5 months, generally in high intensity storms.

2) Rainfall highly variable (coefficient of variability higher than 30%) from year to year and within the year. It cannot be predicted with any reasonable degree of confidence.

3) Temperature - with an average higher than 18°C in all months - and solar radiation with a coefficient of variability less than 5%

4) High values of potential evapotranspiration, (PET) with 100-120 mm/month in the rainy season, and 120-150 mm/month in the dry season.

Rainfall exceeds PET for 2-5 months a year, and in some cases from 5-7 months a year.

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(2) 5) Soils with surface soil structure very unstable to raindrop impact, with a high tendency to form seals and crusts.

The main problems of agricultural production derived from the previous characteristics, in the semi-arid tropics are:

1) Detrimental effects of drought or waterlogging on crop production, specially through its effect on plant growth during germination and seedling establishment.

2) Difficulties for, and delayed farm operations which may cause:

a) Damage to soil properties
b) Reduction in growing periods
c) Increased risk of water stress during the period of maturity of crops, reducing yields.
d) High losses of rainfall water by runoff causing erosion.

~~Thus~~ The interaction between precipitation and evaporation, and the resulting water regime is the dominant factor which affects productivity and management of lands and crops in the semiarid tropics. Therefore the proposed solutions to solve the problems of agricultural productivity must be directed to:

1) Prevent the formation of detrimental seals

(3) in the soil surface, which ~~causes~~ restricts infiltration with increase in runoff or waterlogging

2) Control of evaporation losses in the surface soil specially during the initial stage of the crop

These solutions become more difficult because lack of quantitative information on the role of soil and water conservation techniques, different from temperate regions.

Being the soil surface the zone where the distribution of the available rainfall water between runoff, evaporation and percolation is initiated, and also being this zone the only easily accessible to modification by man, effort all or must be concentrated in modifying the properties of it to promote infiltration and reduce evaporation, such modification may be achieved by tillage or conditioning. By keeping a high hydraulic conductivity in the lower suctions, where most of the infiltration of rainwater occurs, and also having a very low conductivities in the drier soil where ~~~~ most of the evaporation losses occurs, ~~and aggregated~~ a conveniently aggregated surface layer can have a favourable effect both for increasing infiltration and decreasing evaporation.

Improvement of aggregation through tillage alone generally is not long-lasting in the semi-arid tropics because of the low stability of surface soil aggregates to raindrop impact. The lasting effects may be achieved by the protection with mulches or by the use of soil conditioners, de-

(4) pending of the particular case.

The use of asphalt emulsions besides stabilizing the surface aggregates long enough to keep the beneficial effects on infiltration and evaporation during the critical periods of the crop helps to prevent losses of surface soil by erosion and to provide a more favorable soil environment – temperature and moisture regime – in the surface soil below the asphalt cover.

The "water budget" – Precipitation + infiltration – Runoff = Evapotranspiration ± Internal Drainage ± changes in Soil Moisture – along the year or the growing season of crops provides a means for theoretical estimates of the amount of water surplus or water deficit and periods of their duration for monitoring changes in the soil water status and storage within an assumed storage capacity of the soil profile. Erosion losses and reduced root penetration and development, decreases the effective storage capacity.

Figures 1-7 and table 1 presents examples of soil moisture regimes, and their effects on food crop production, for different growing periods of sorghum, corn and peanut, in three semi-arid agricultural areas of Venezuela, with a range of soils and climate common to many other semi-arid zones in the world. The effect of soil conditioning by asphalt emulsions in the soil moisture regime and crop production is also shown. This option of soil management showed a significant potential for soil water conservation.

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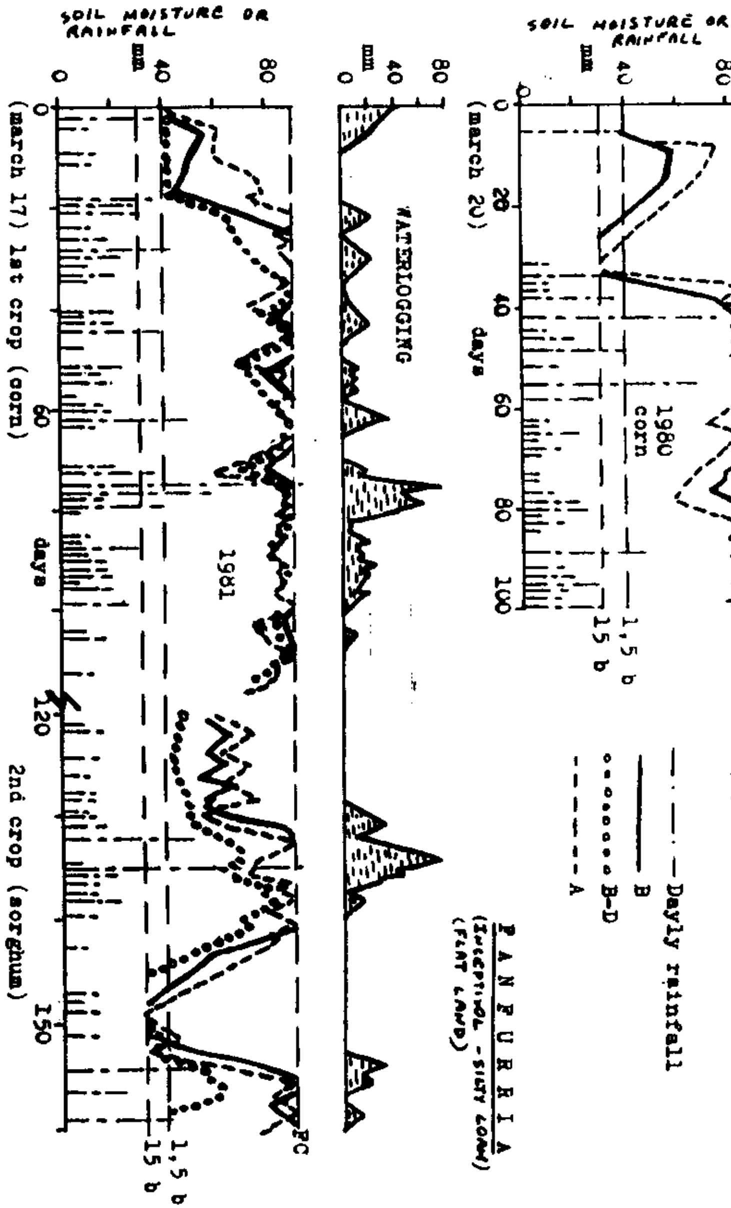


Figure 1
Soil moisture regime between field capacity (FC), 1,5 bar and 15 bar water suctions in the root zone assumed to be in the surface 25 cm, of rainfed corn (1980), and corn followed by sorghum (1981), for non treated (B), artificially drained (B-D), and asphalt treated (A) soil.

(8)

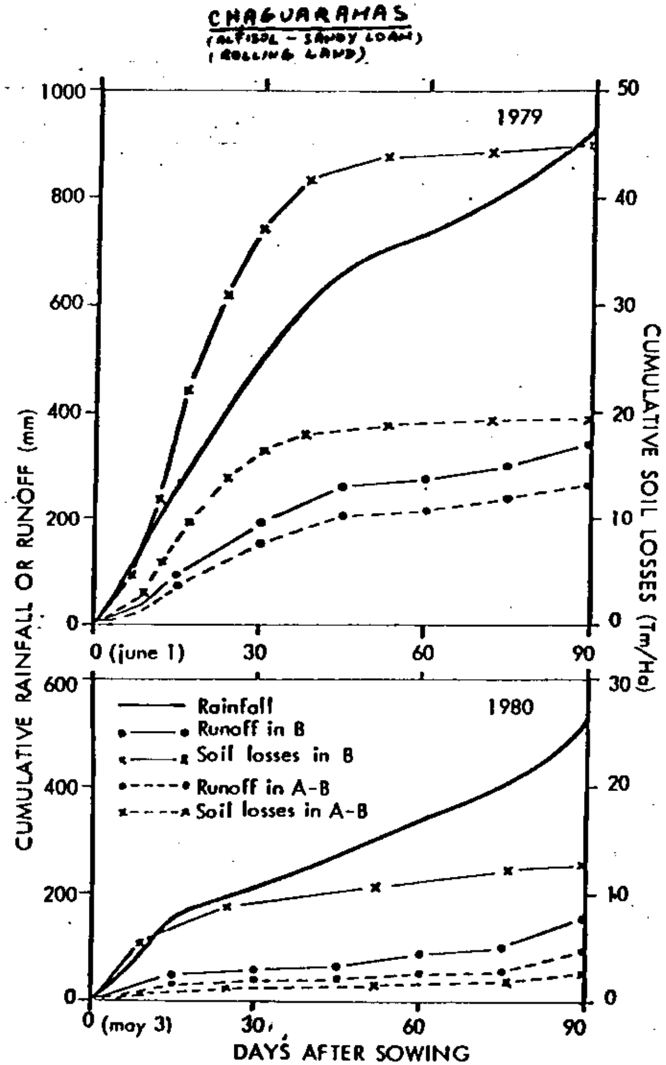


Figure 2.- Cumulative rainfall, runoff, and soil erosion losses during the growing season of rainfed sorghum the years 1979 and 1980, for the treatments identified in table 1. Runoff and soil losses in 1981, and for the treatments not shown in the figure, were not appreciable.

(9)

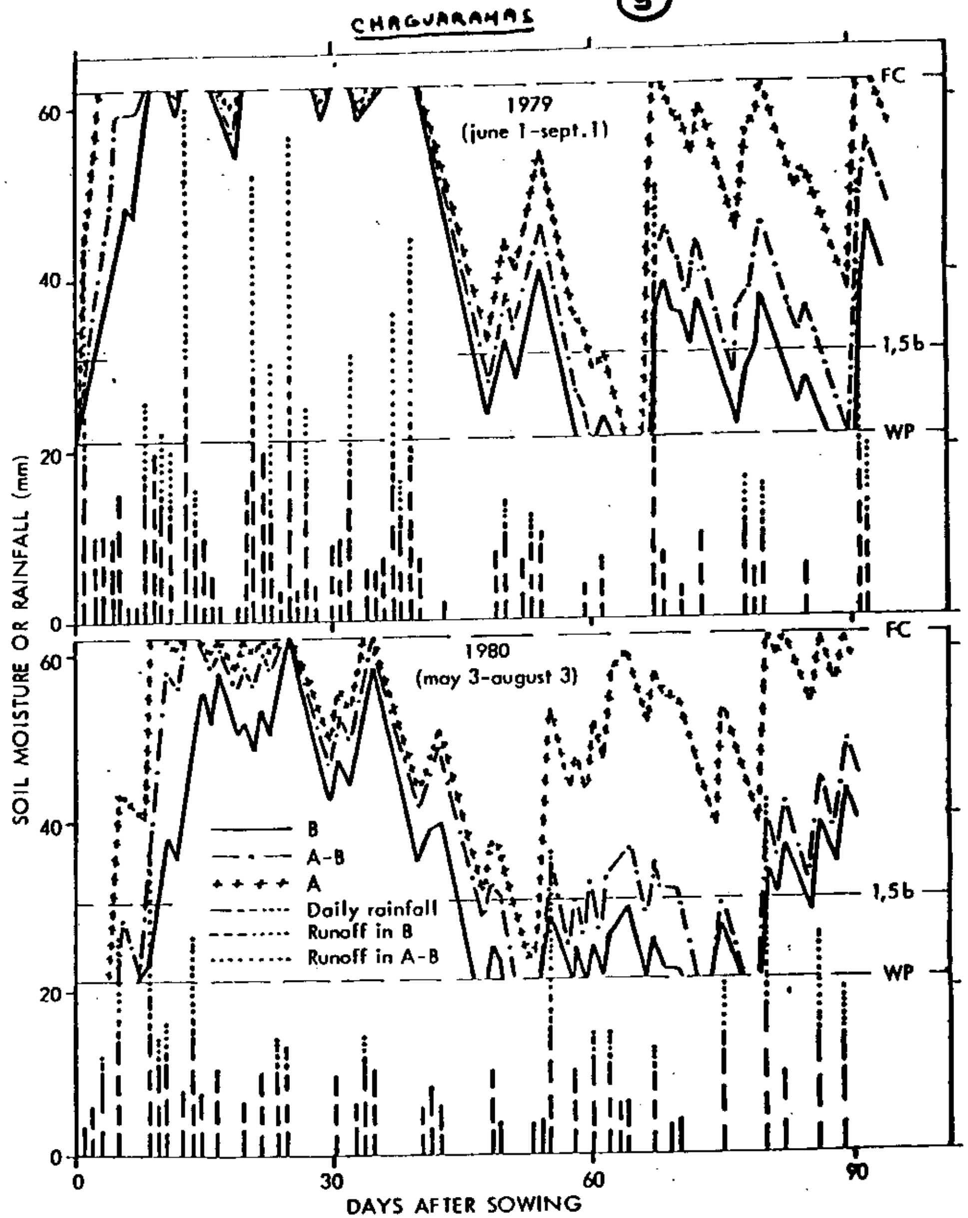


Figure 3.- Soil moisture regime between field capacity (FC); 1,5 bar soil water suction (1,5b), and wilting point (WP) in the root zone (25 cm depth) of rainfed sorghum during the growing period (90 days) in the rainy seasons of 1979 and 1980, for the different treatments identified in table 1.

(11)

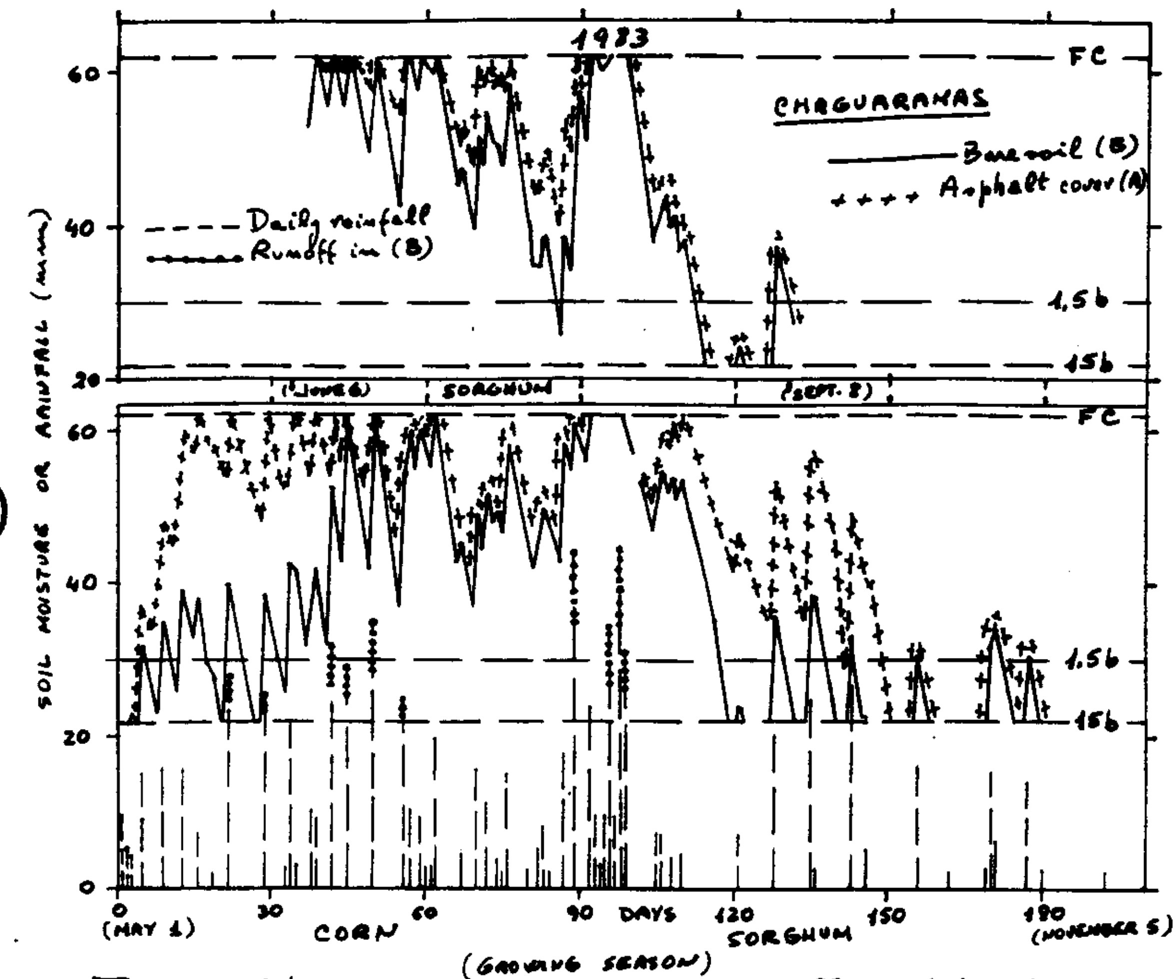
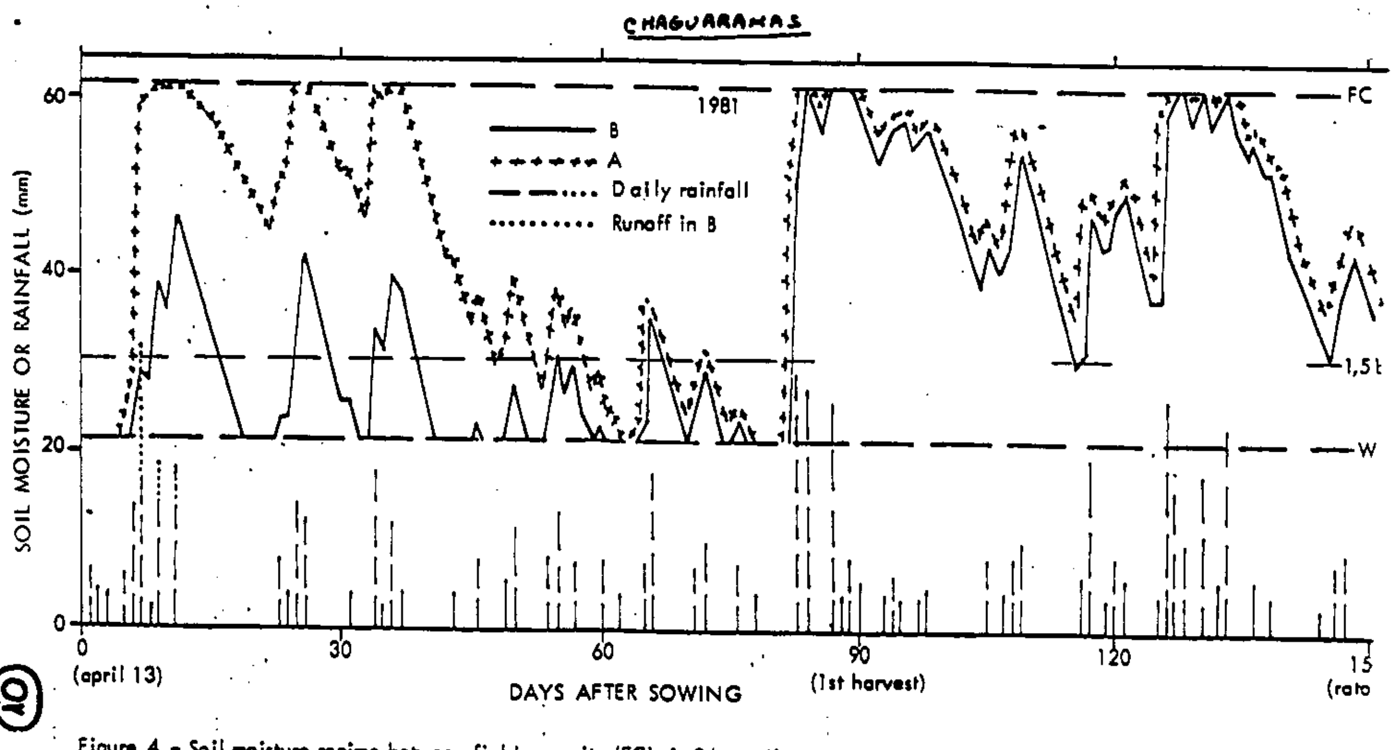


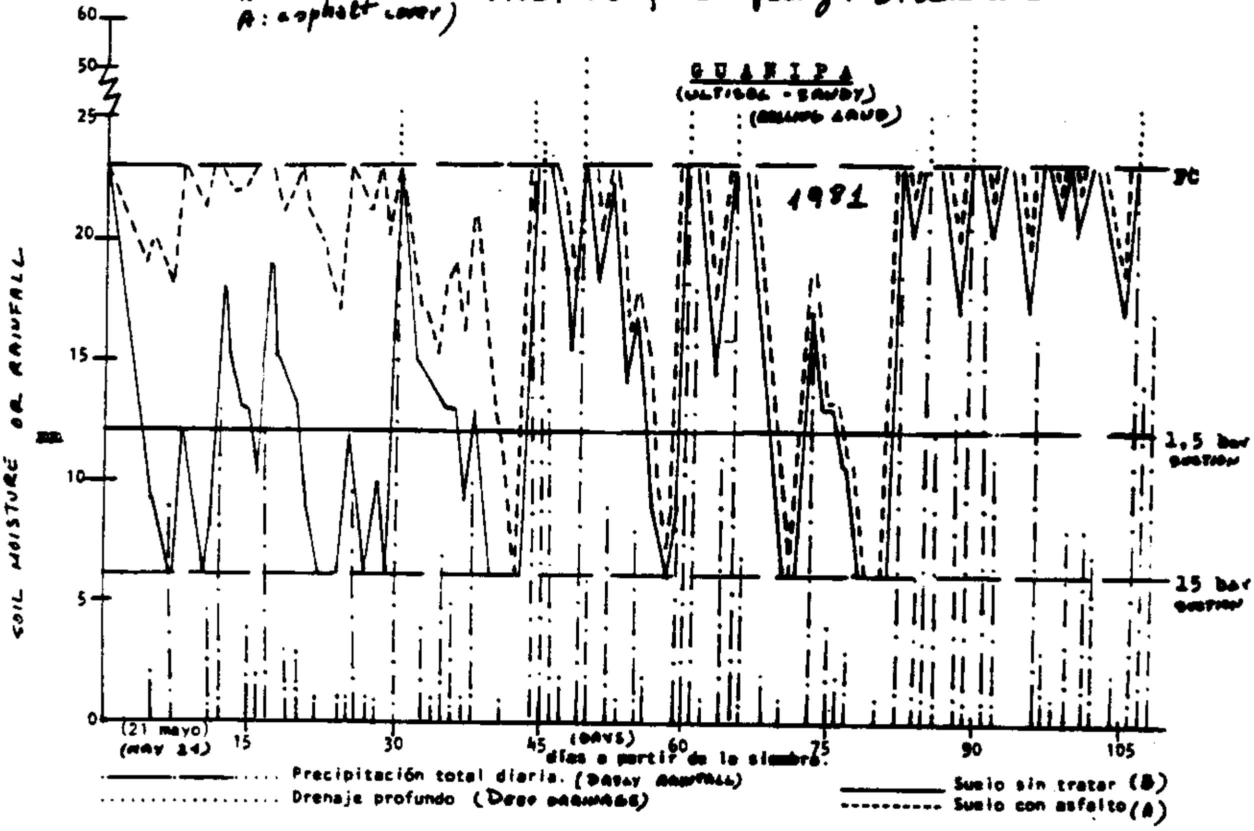
Figure 5.- The same of figures 3 and 4, for 1983 growing season.



(10)

Figure 4.- Soil moisture regime between field capacity (FC); 1, 5 bar soil water suction (1,5 b); and wilting point (WP) in the root zone (25 cm depth) of rainfed sorghum during the growing periods (0 - 90 days: first harvest; 90 - 150 days: ratoon) in the rainy season of 1981 for the different treatments identified in table 1.

FIGURA 9. Evolución de las condiciones de humedad (m.m de agua retenida) en la zona radicular durante el ciclo de cultivo del maní en la estación lluviosa del año 1981. (CC: Capacidad de Campo; PMP: Humedad a 15 bares de tensión. Se asume una profundidad efectiva de suelo de 20 cms.). (Soil moisture around growing season of a peanut crop in 1981. FC: field capacity. B: bare soil. A: asphalt cover)



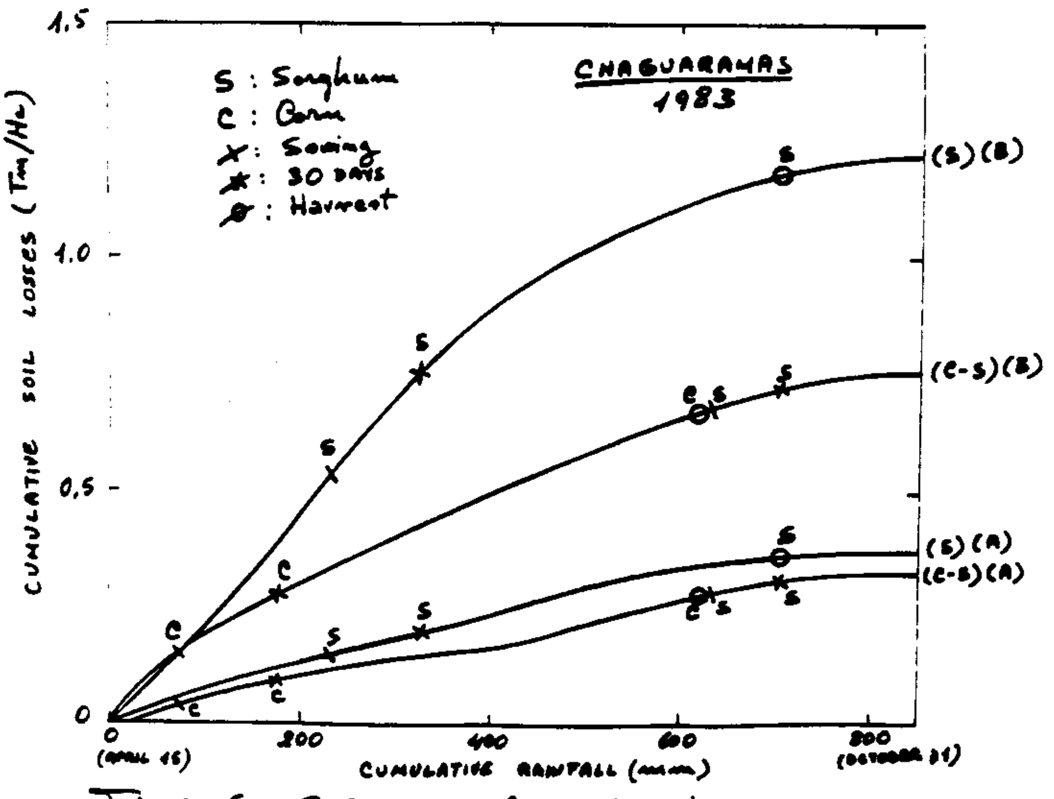


Figure 6.- Soil erosion losses for the crop sequences (S, C-S) and treatments (B, A) of figure 5, in the 1983 growing season.

(12)

SOIL	SEASON	RAINFALL (mm)	TREATMENT	CROP	YIELD (Kg/Ha)
	(M-J 1980)	679	B	Corn	3310
			A	Corn	4450
PANFURRIA 1471mm/year H:1248mm/My-Oct	(M-J 1981)	944	B	Corn	740
			B-D	"	1060
			A	"	1890
	(A-N 1981)	500	B	Sorghum	3530
			B-D	"	4020
			A	"	4980
GHAGUARAMAS 930mm/year H:850mm/My-Oct	(My-A 1979)	917	B	Sorghum	6300
			A-B	"	7000
			A	"	11300
	(My-A 1980)	514	B	Sorghum	4000
			A-B	"	7300
			A	"	10000
	(A-J 1981)	412	B	Sorghum	2800
			A	"	7000
	(J-S 1981)	258	B	Sorghum(ratoon)	3300
			A	" "	6200
	(Jn-S 1983)	507	B	Sorghum	1940
			A	"	2900
	(My-A 1983)	462	B	Corn	3320
			A	"	4390
	(A-N 1983)	305	B	Sorghum	1270
			A	"	2320
GUANIPA H:1006mm/year;848mm/My-Oct	(My-S 1981)	697	B	Peanut	1060
			A	"	2430
			B	Sorghum	1380
			A	"	2400

B:bare soil;B-D:drained;A:asphalt cover;A-B:asphalt cover in bands

Table 1.- Yields (grain) of sorghum and corn for the different soils, seasons, and treatments of Figures 1-7.