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22 October - 9 November, 2007

Hydrological approach to soil and water conservation 6

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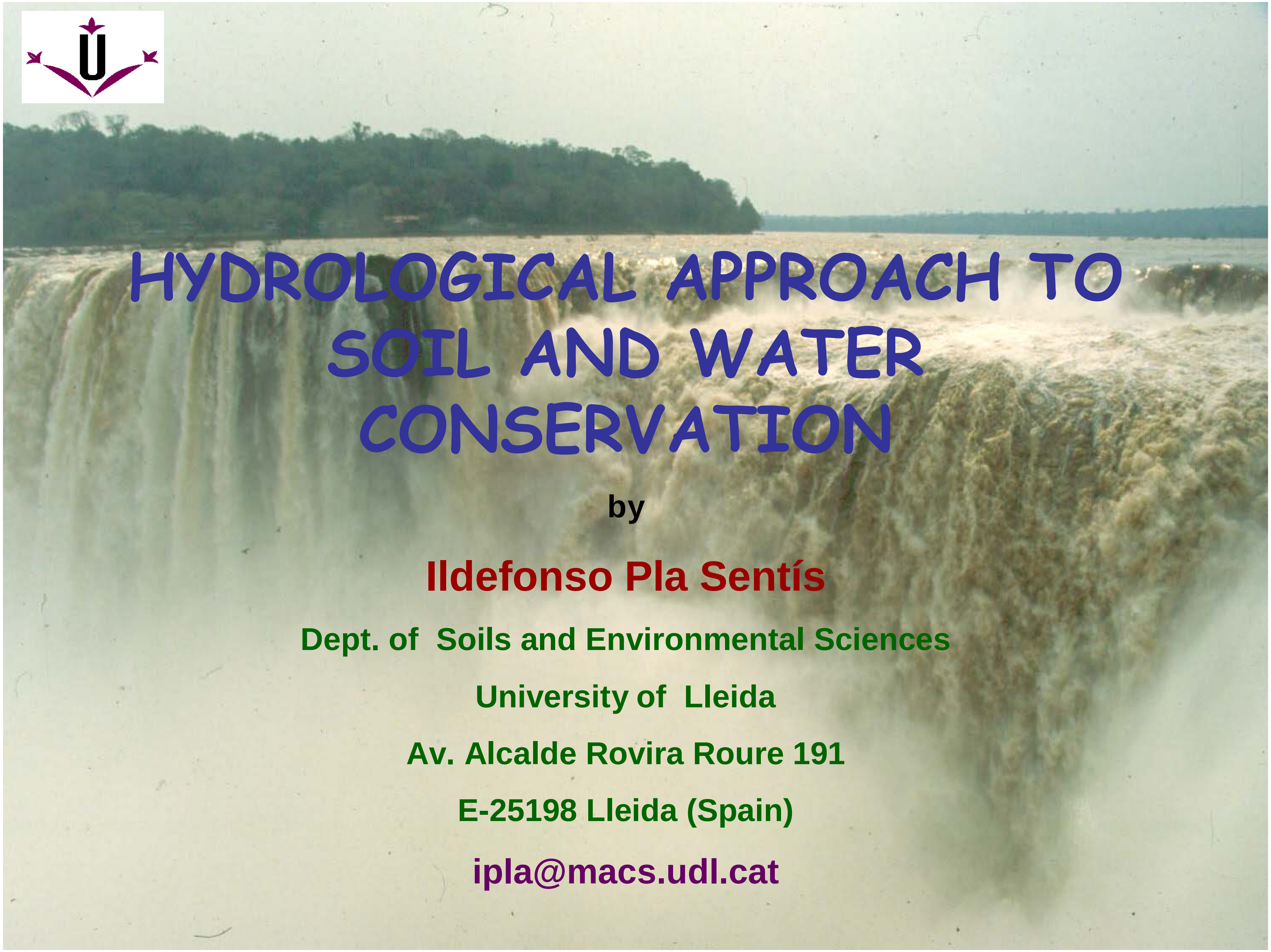

HYDROLOGICAL APPROACH TO SOIL AND WATER CONSERVATION

by

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Water, that is often the main limiting factor of plant growth, is also the main factor directly or indirectly responsible for soil and land degradation processes

The soil moisture regime, determined by the changes in soil water content with time, is the main single factor conditioning plant growth and crop production

The processes of soil and water degradation, leading to desertification, are strongly linked to unfavorable changes in the hydrological processes responsible for the soil water balance and for the soil moisture regime

These are affected by the climate conditions and variations, and by the changes in the use and management of soil and water resources

Soil quality paradigm?

<u>Soil quality assessments of degradation</u> have been using in many cases mostly <u>subjective perceptions and soil quality indices</u>, scored from empirical judgements, generally <u>narrow in scope and with a taxonomic bias</u>, which do not allow to relate the evaluation to the overall sustainability of alternate land use systems (production, control of environmental impacts, etc).

This would be only possible if they were based on <u>clear and objective hydrological principles</u> and <u>quantitative measurements or estimations of hydrological parameters</u>, aimed at problem solving.

The evaluation of soil and water degradation processes must allow to:

-design sustainable and productive land use and management strategies, which guarantee protection of the environment,

-previewing the effects of different combinations of climate, slope and management, including extraordinary events with low return period.

That requires to change the present mostly empirical subjective and qualitative evaluations, by quantitative evaluations based on hydrological processes

The evaluations must take into consideration that soil degradation not only causes problems in-site, but it may cause serious probles off-site.

AN HYDROLOGICAL APPROACH DOES FACILITATE A MORE INTEGRAL EVALUATION AT BOTH LEVELS

The main objective must be to <u>evaluate such hydrological processes</u>, and to <u>select and develop methodologies and techniques to correct or to control them</u> under different conditions of soils, topography and climate.

This is required for <u>suppressing or alleviating the negative effects of soil and water degradation on sustainable agricultural production, on the supply of water</u> in adequate quantity and quality for the different potential uses, <u>and on catastrophic events</u> such as flooding, sedimentation, landslides, etc

Although the close interaction between the conservation of the soil and water resources is increasingly being accepted, still in most of the cases they are evaluated separately, and consequently the prediction and prevention of the effects derived from their degradation are inadequate in many situations.

This will become more important under the previewed effects of global climatic changes, which would mainly affect hydrological processes in the land surface.

Global climate change prediction, although still rather uncertain, will increase rainfall in some regions, while others might become drier, in a rather uneven spatial and time distribution.

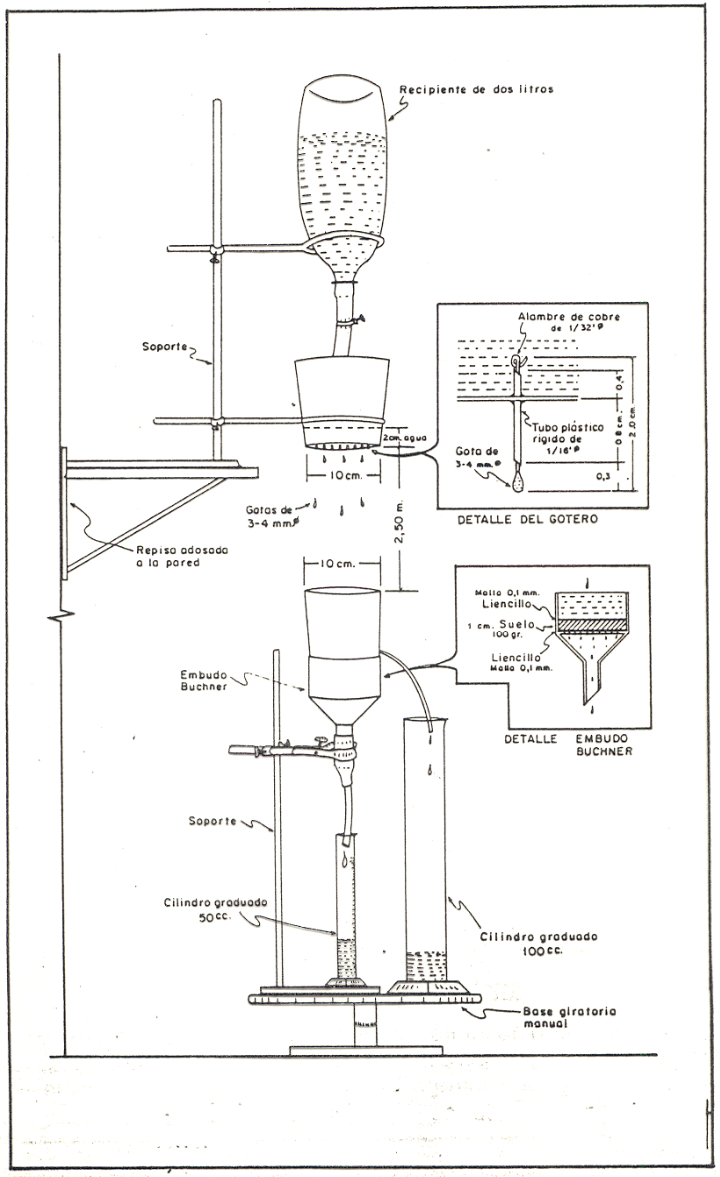
This may contribute to accelerate some land degradation processes leading to larger runoff and erosion, and to increased risks of floodings, landslides, mass movements and mud-flows in tropical regions, and to higher risks of crop production in subtropical and temperate regions.

But in any case, land use changes, including deforestations, and other human activities leading to soil degradation processes may affect more the soil hydrological processes and their effects on land degradation, than the previewed global climatic changes, or may increase the influence of these changes.

The <u>methods and techniques</u> applicable for predicting soil hydrological behavior under field conditions <u>should allow simple and direct measurements, based on comprehensive physical relations</u>, and should take into consideration the dynamic aspects of the soil hydrological properties, highly dependent on soil structure).

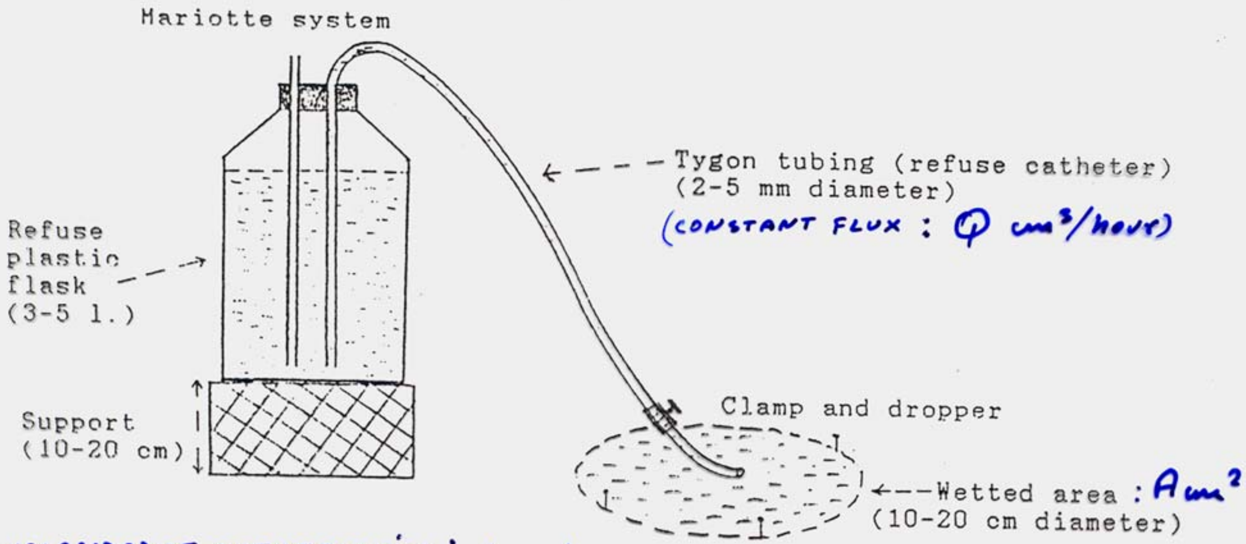
The objective has to be obtain <u>approximations acceptable within the limitations of the used methodologies</u>, which can provide <u>practical guidelines for field situations.</u>

Figure 2b



A SIMPLE LABORATORY EQUIPMENT FOR MEASURING THE SEALING SUSCEPTIBILITY OF SURFACE SOILS ("SEALING INDEX") CONSISTIN OF A RAINFALL SIMULATOR AND A DEVICE FOR MEASURING THE PERCOLATION OF WATER THROUGH A LAYER OF SOIL AGGREGATES WITH OR WITHOUT RAINDROP IMPACT AND PROTECTIVE COVER

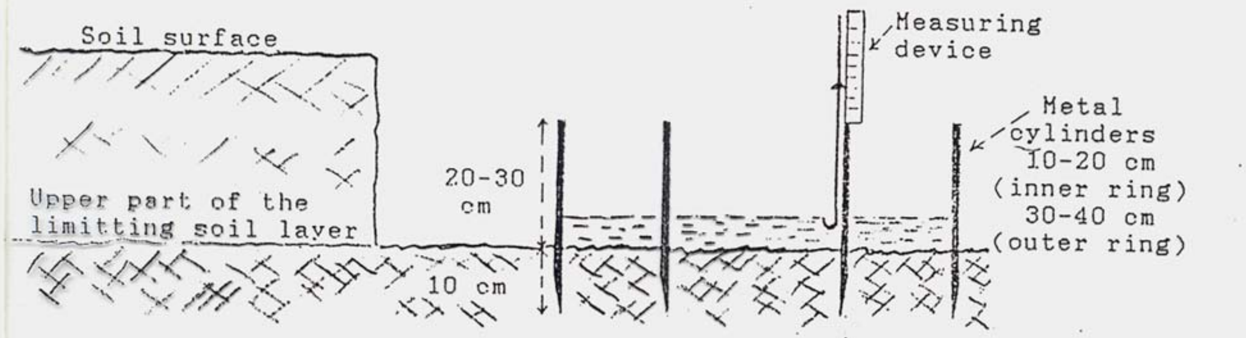
Figure 4a



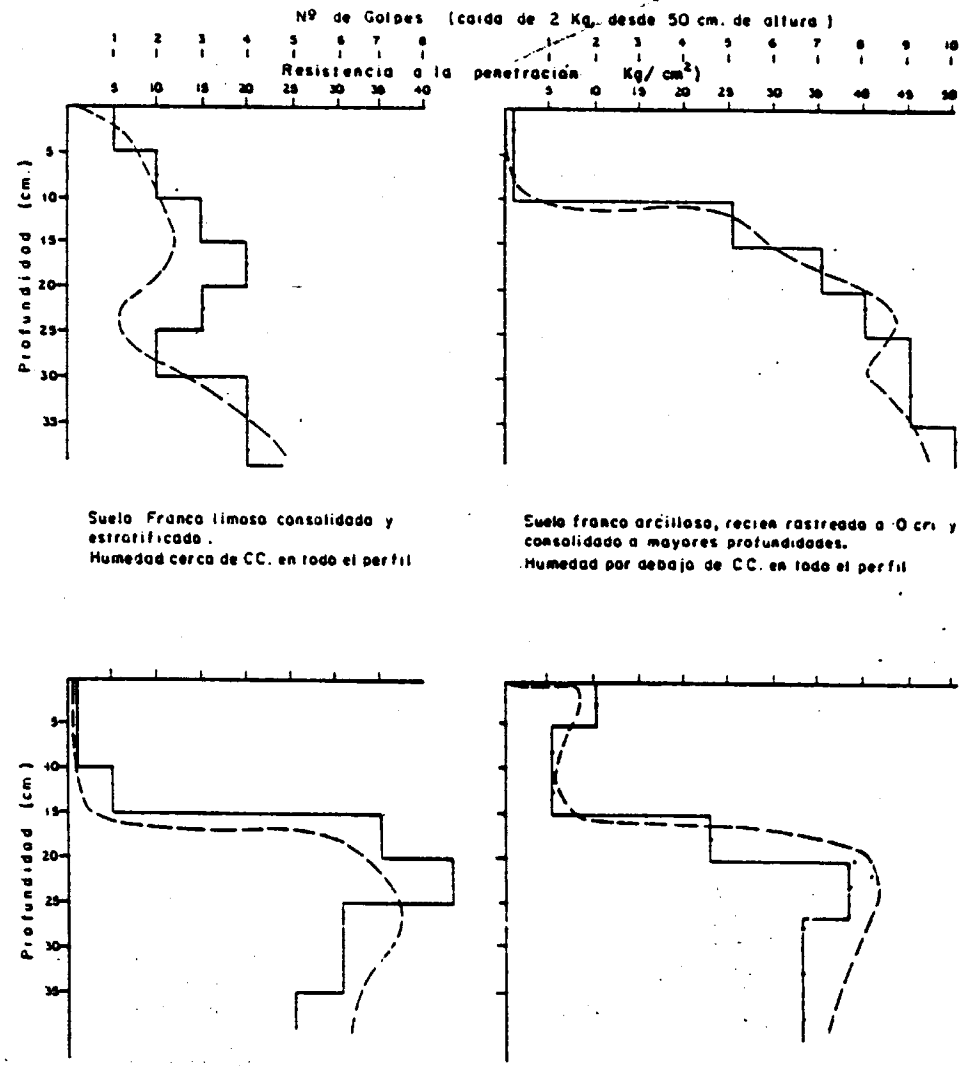
VELOCIDAD DE INFILTRACIÓN : i (mm/hour) $= 10\Phi/A$
(INFILTRATION RATE)

DEVICE FOR FIELD MEASUREMENT OF INFILTRATION IN A SEALED SOIL

Figure 4b



DEVICE FOR FIELD MEASUREMENT OF SATURATED HYDRAULIC CONDUCTIVITY OF THE LIMITTING LAYER



Suelo Franco limoso consolidado y estratificado.
Humedad cerca de CC. en todo el perfil

Suelo franco arcilloso, recien rastreado a 0 cm y consolidado a mayores profundidades.
Humedad por debajo de CC. en todo el perfil

Suelo franco limoso recien arado y rastreado con capa compactada de 15 a 25 cm —
Humedad por debajo de CC.

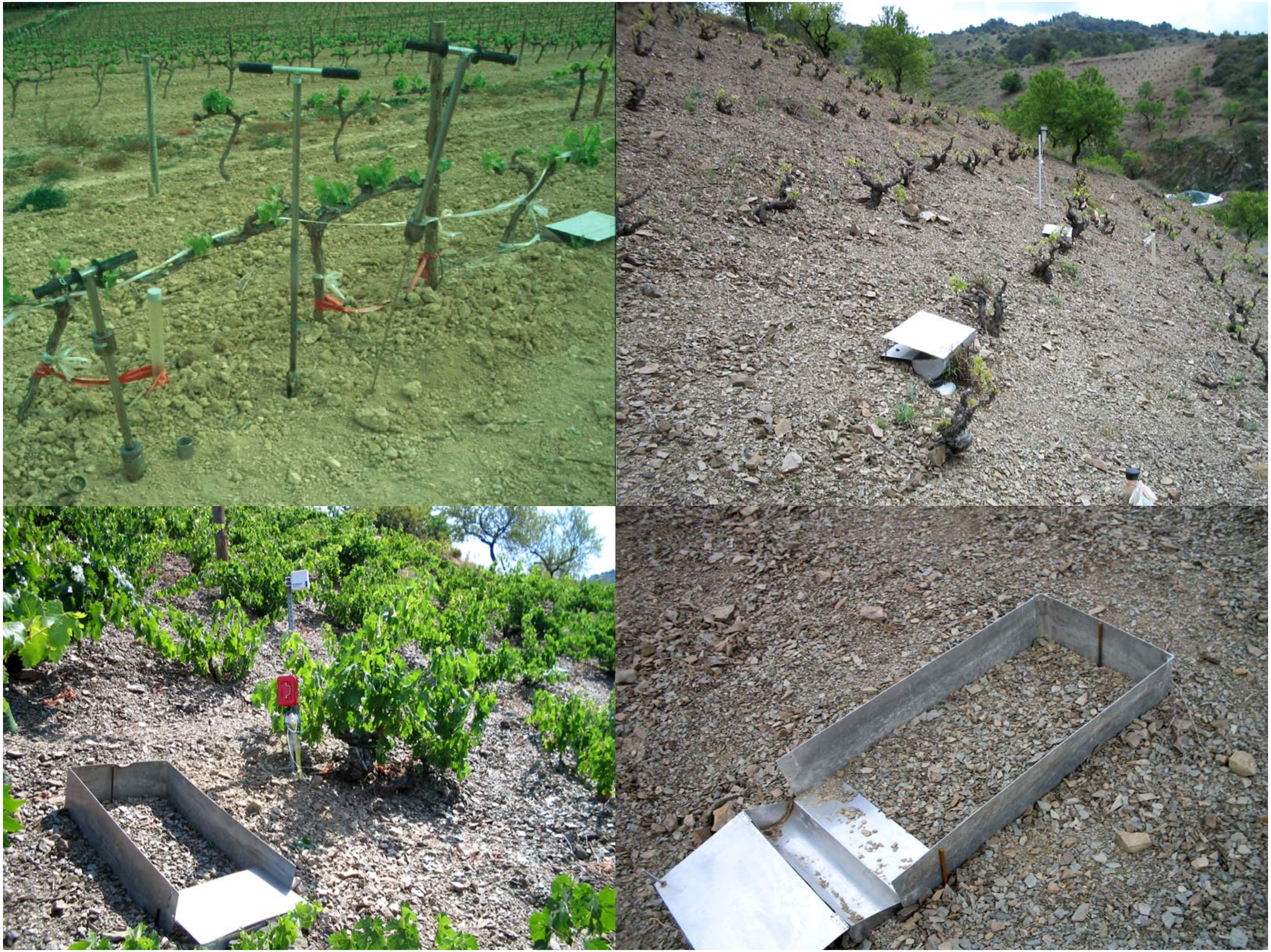
Suelo franco arcillo limoso, con costra superficial seca, suelo rastreado por debajo y capa compacta de 15-25 cm.
Humedad por debajo de CC.

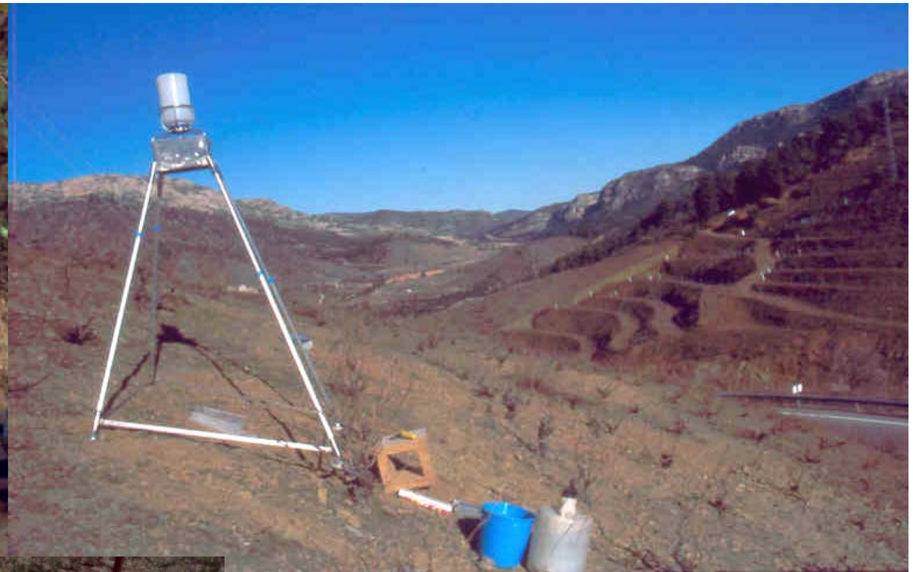
— — — Penetrógrafo

——— Penetrometro de impacto, Mod. Platte con lecturas cada 5 cm.

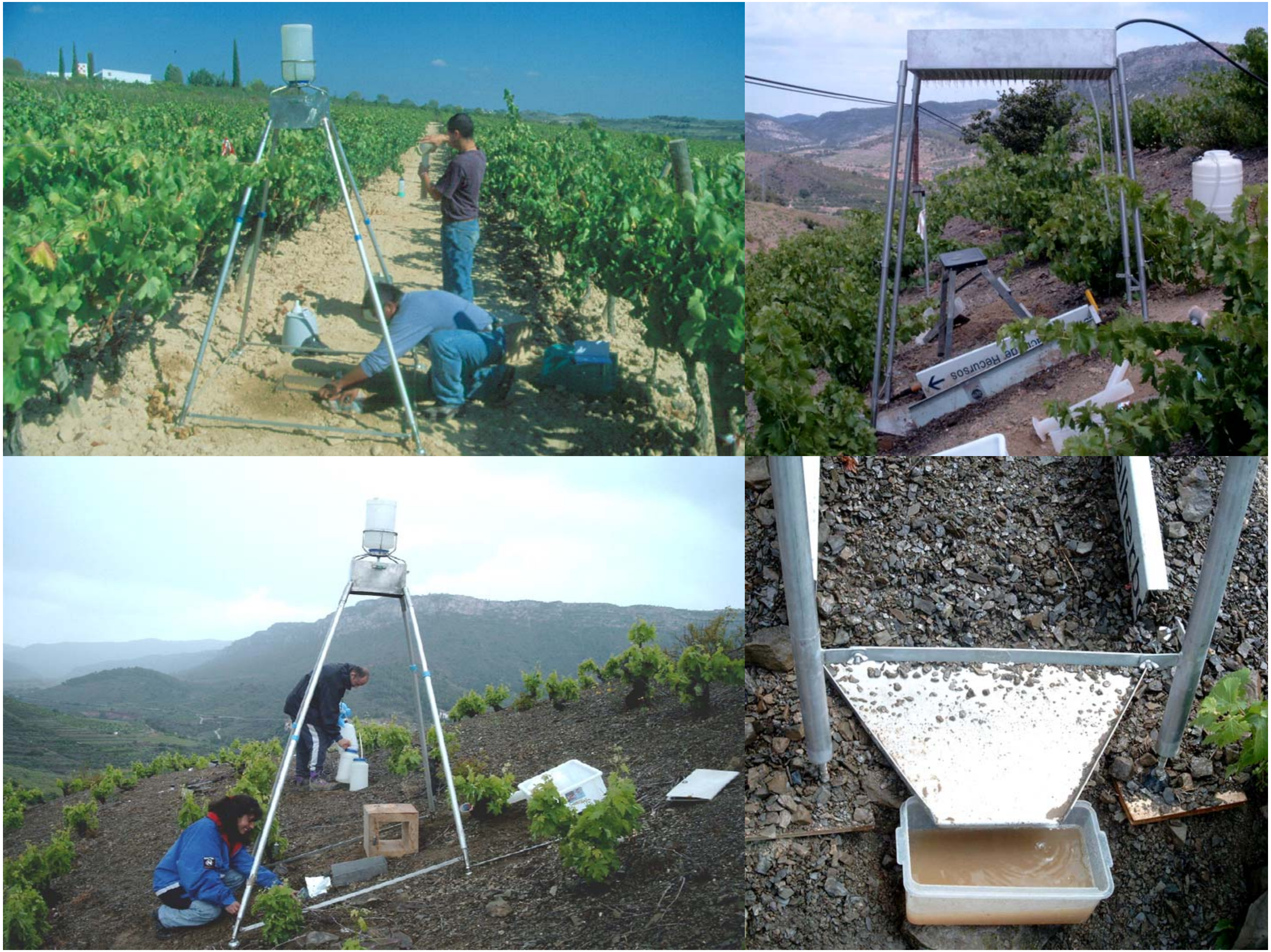
There are urgently required new methods and technologies for the effective evaluation of the soil physical properties required to simulate ever increasing complex systems at field level, and to improve the present methodologies of soil and water sampling.

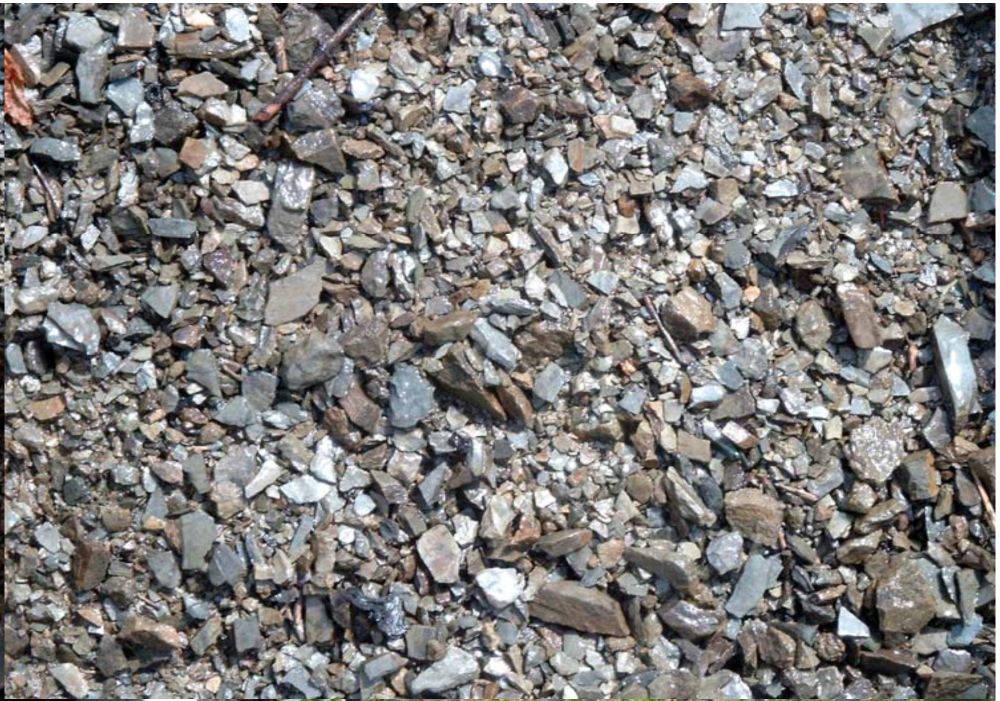
Field scale variation of physical properties needs to be understood. The spatial variability of processes tends to differ from the spatial variability of physical properties

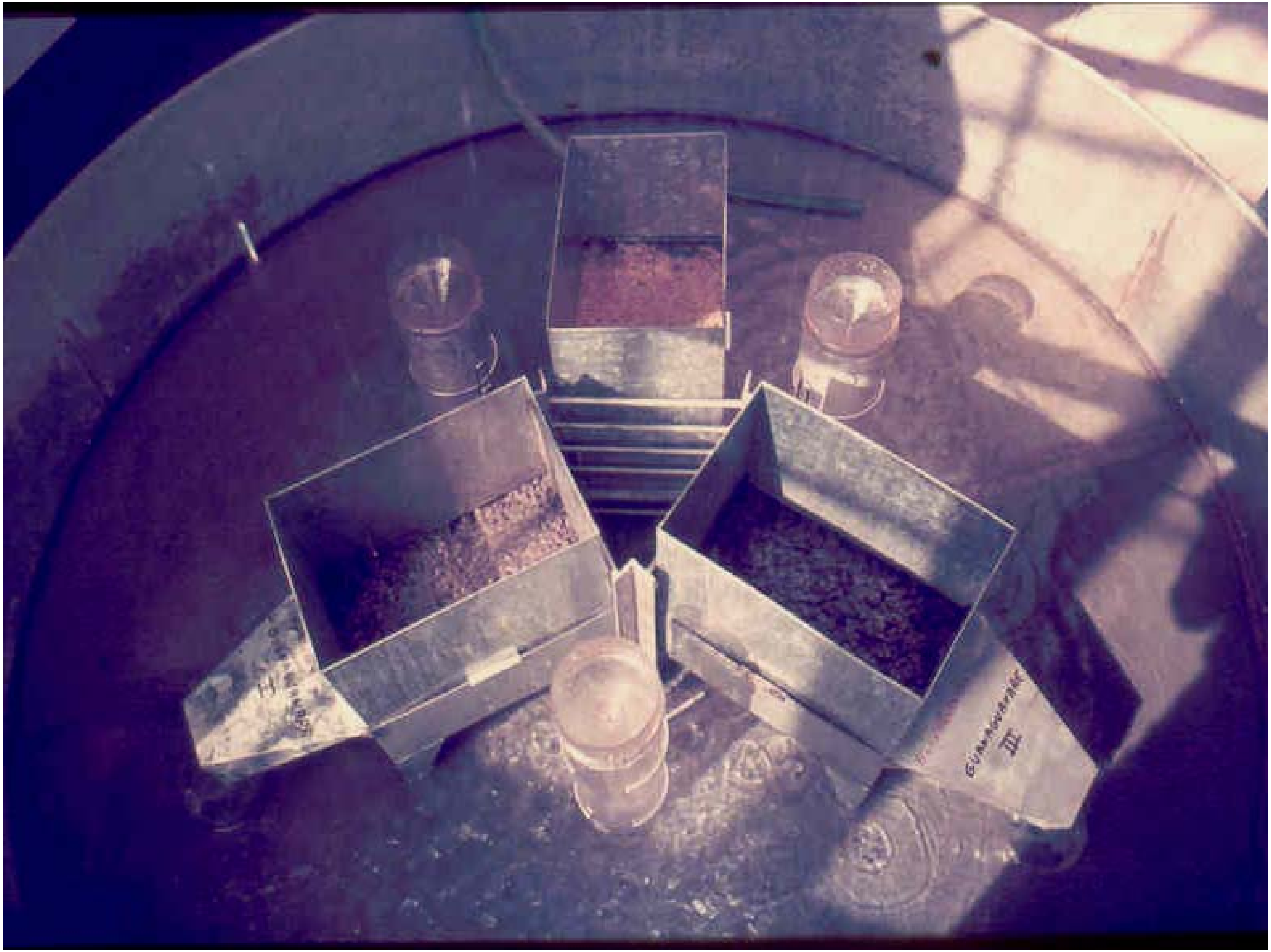


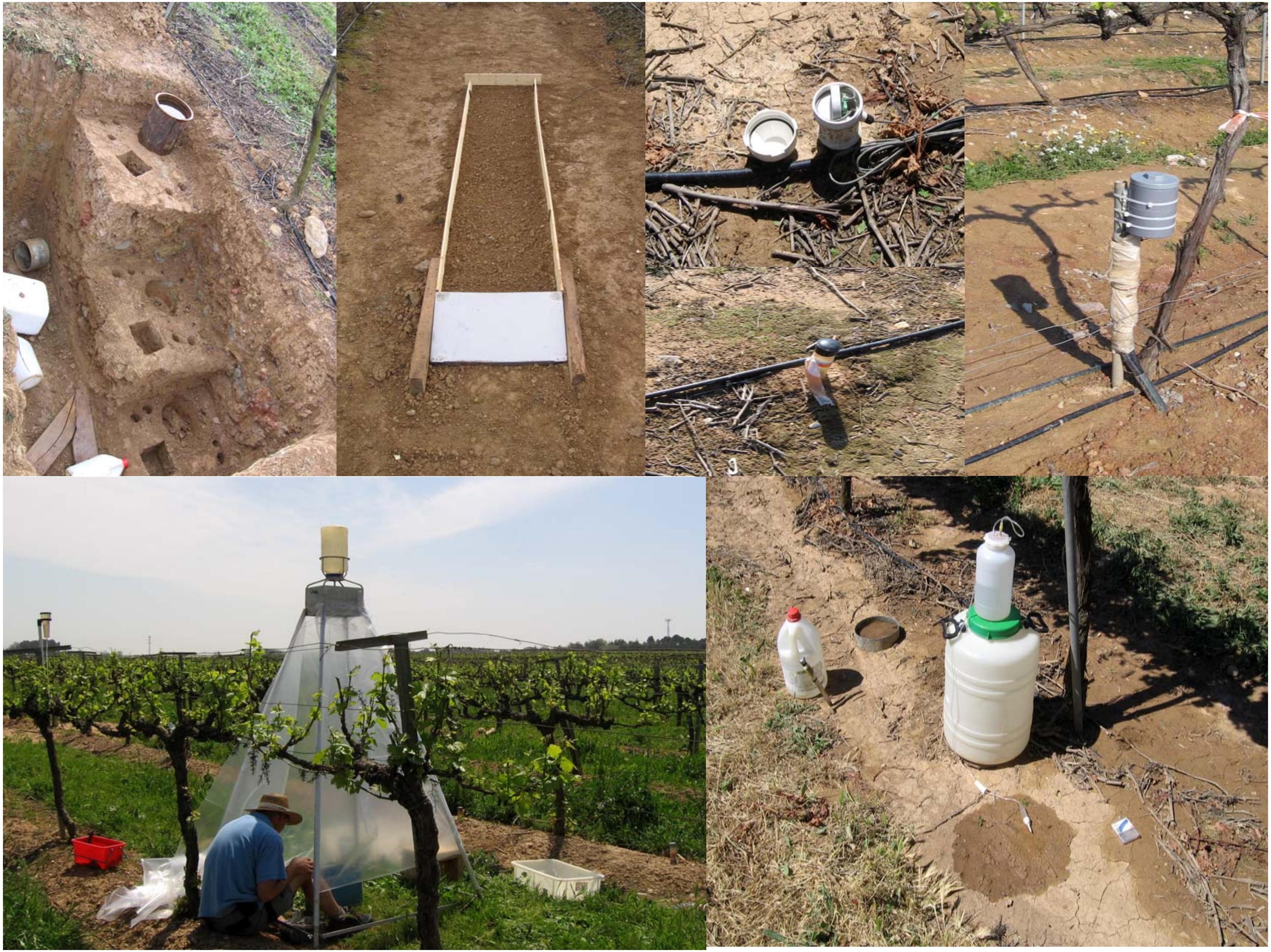



TRIME-FM





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Nacci, S. e I. Pla.1992. Estudios de la resistencia a la penetración de los suelos con equipos de penetrometría desarrollados en el país. Agronomía Tropical.42 (1-2).115-132

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Nacci, S., C. Ramos e I, Pla. 2002 .Dynamics of the soil physical properties in vineyards highly mechanized of the Anoia- Alt Penedes. Region. (Catalunya, Spain). En: "Man and Soil at the Third Millenium". (J.L.Rubio et al ,ed). II:1615-1624. Geoforma Ed. Logroño.(España).

The <u>simple field techniques</u> must be preferred, because of <u>operational considerations</u>, and because they are more <u>able to be adapted to the required sample volume and spatial variation</u> - there are possible more replicate measurements- of soil hydraulic properties <u>under field conditions</u>.

Although <u>modern indirect techniques</u> like <u>remote sensing, computerized data processing, GIS and simulation models</u> may help in the required evaluations, they will always <u>require of actualized and accurate direct measurements or estimations of soil hydraulic parameters</u> .

The increased requirements of <u>more quantitative results in probabilities and risks of soil degradation and its influence on crop production and environmental damage</u>, may be partially satisfied with the <u>use of modeling</u>, where the large number of important variables involved in the degradation processes, and their interactions, may be <u>integrated.</u>

<u>Direct measurements of runoff and soil loss in the traditional erosion field plots</u>, is a <u>slow and costly process</u>, due to the high variability of climate and soils in time and space, which makes it <u>not practical in places where the resources are scarce and there are required short term solutions.</u>

The presently used <u>empirical models must be replaced with process based event models</u>, which require a <u>better understanding of changing hydrological properties</u> as influenced by soil management, cropping sequences, vegetation, and climate.

<u>Simulation models based on hydrological processes</u> may be very helpful to <u>integrate and to convert the measured or estimated soil, climate, plant and management parameters into predicted soil water balances and soil moisture regimes</u> for each particular combination of them, actual or previewed.

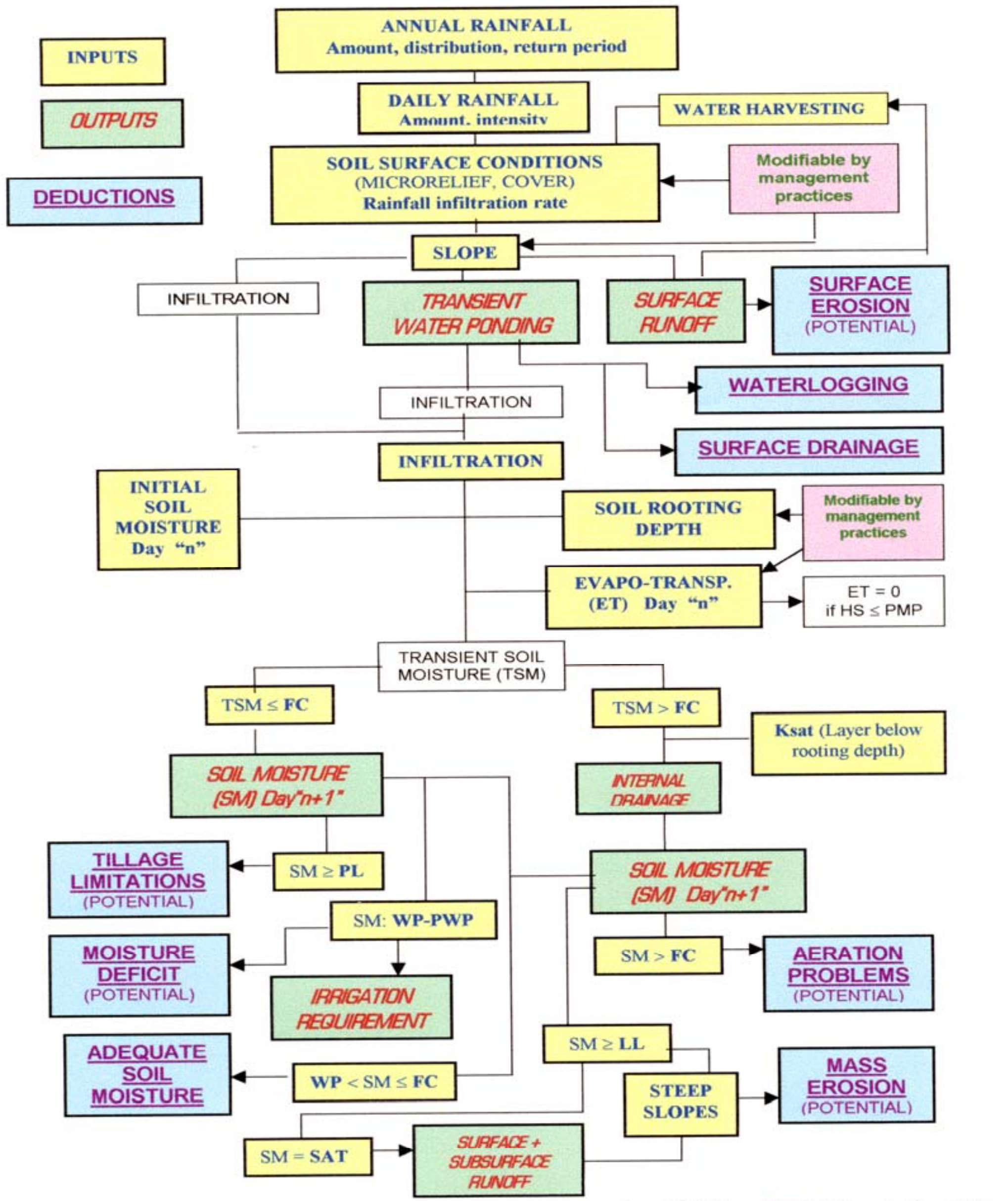
These models may be <u>very simple</u>, or they can be <u>extremely complex</u>.

<u>Simulation errors</u> derived from estimation errors in soil properties and <u>the sampling costs</u> are generally <u>lower when simple models are used</u> for predicting water balance in space.

Additionally, <u>simpler models require fewer input data</u>, and therefore they <u>allow larger samples and sampling densities</u> for a given field measurement.

They may be used to <u>predict the soil moisture regime</u>, including waterlogging, rainfall losses by surface runoff, and surface and internal drainage, <u>under different conditions of soils, topography, climate, vegetation, crops and management.</u>

The predictions may be used to <u>identify the more probable degradation processes,</u> and for the <u>selection of the best alternatives, with more probabilities of success, of soil and water conservation practices</u> for each combination of soils, climate and topography.



(**Ksat**: Saturated hydraulic conductivity; **FC**: Field Capacity; **WP**: Water retention at 0,15 Mpa; **PWP**: Water retention at 1,5 Mpa; **PL**: Plastic limit; **LL**: Liquid limit; **SAT**: Saturation)

Figure 1. Flow diagram of a conceptual simulation model, based on hydrological processes, to predict the soil moisture regime and to assess the potential soil degradation processes (adapted from : Pla, 1997)

Model "SOMORE" (Pla, 1997)

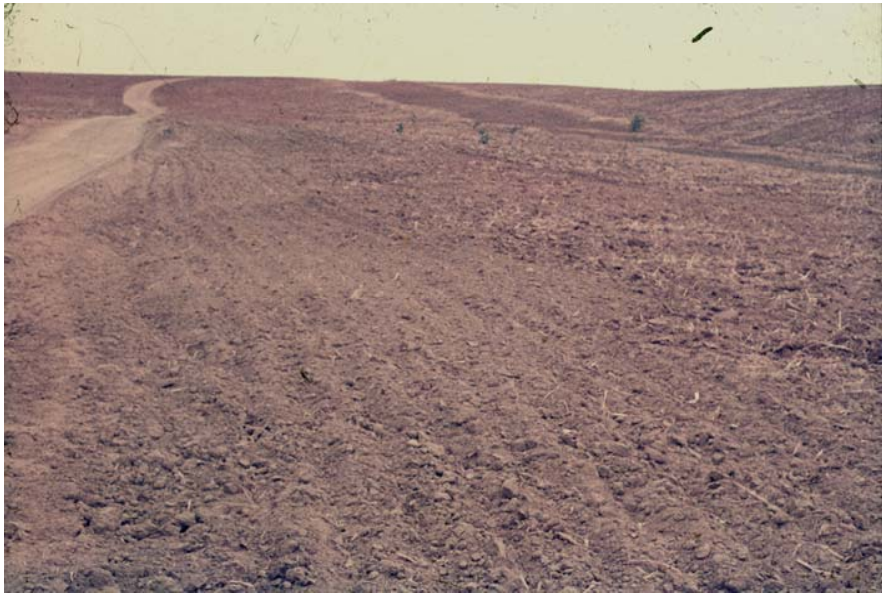
The simulation model SOMORE simulates the evolution of the soil water balance and regime in the soil

The predictions may be used to identify the more probable soil degradation processes, and for the selection of the best alternatives of soil and water conservation practices for each combination of soils, climate and topography

The main output of the model is the soil moisture regime at root depth, and the water losses by runoff and internal drainage

The predicted soil moisture regime may be interpreted in relation to problems of drought, at different times and growth stages of natural vegetation and crops

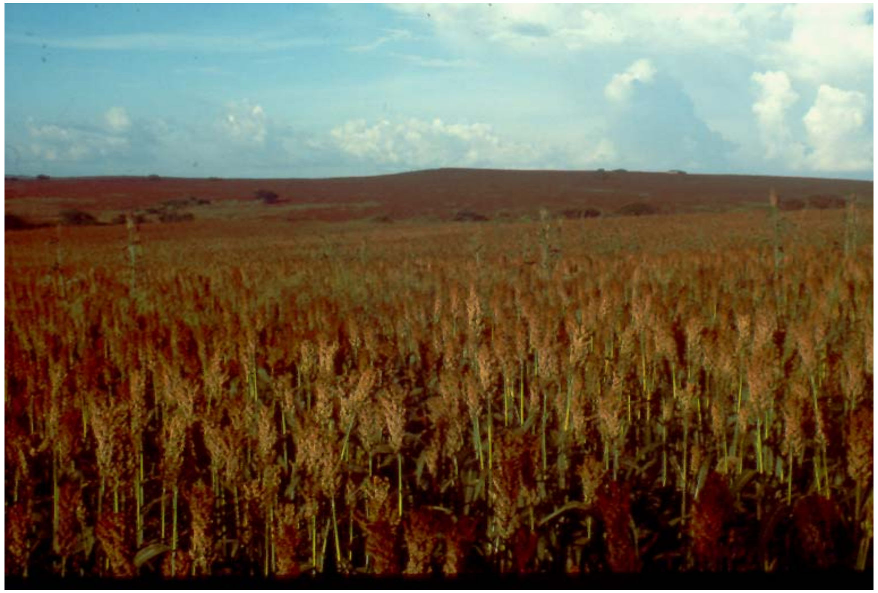


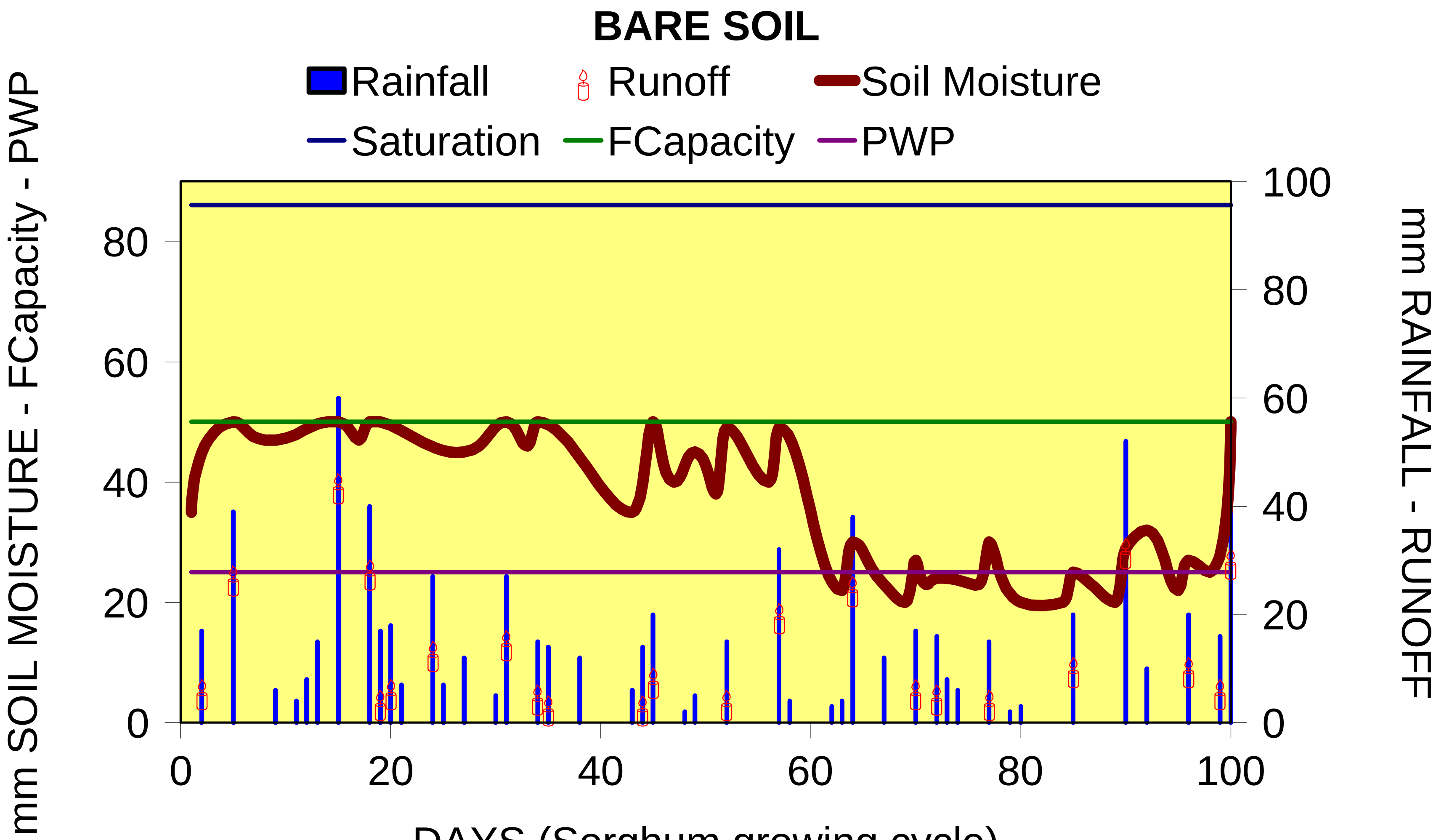












BARE SOIL
Rainfall
Runoff
Soil Moisture
Saturation
FCapacity
PWP
mm SOIL MOISTURE - FCapacity - PWP
mm RAINFALL - RUNOFF
DAYS (Sorghum growing cycle)
0
20
40
60
80
100

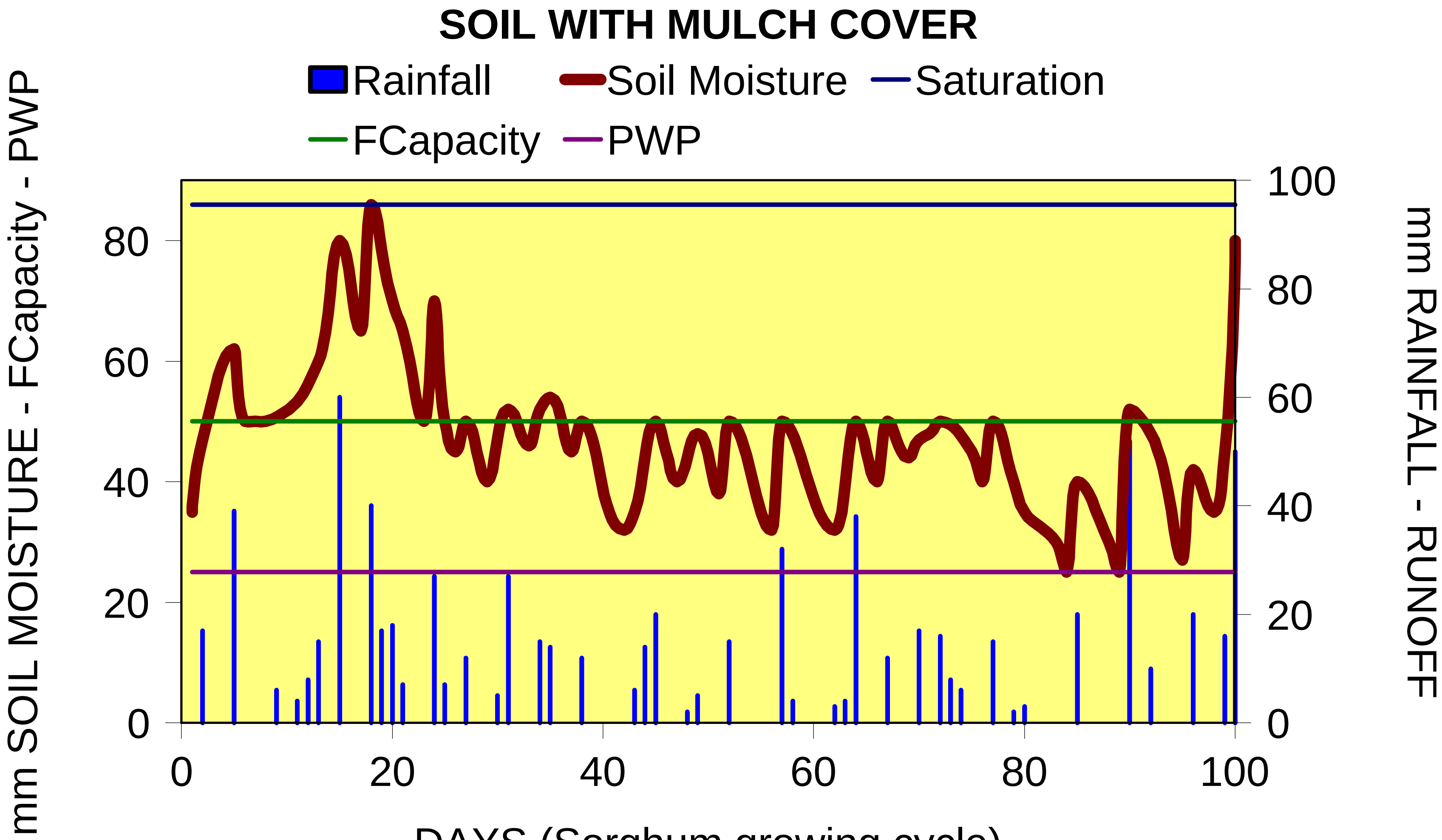
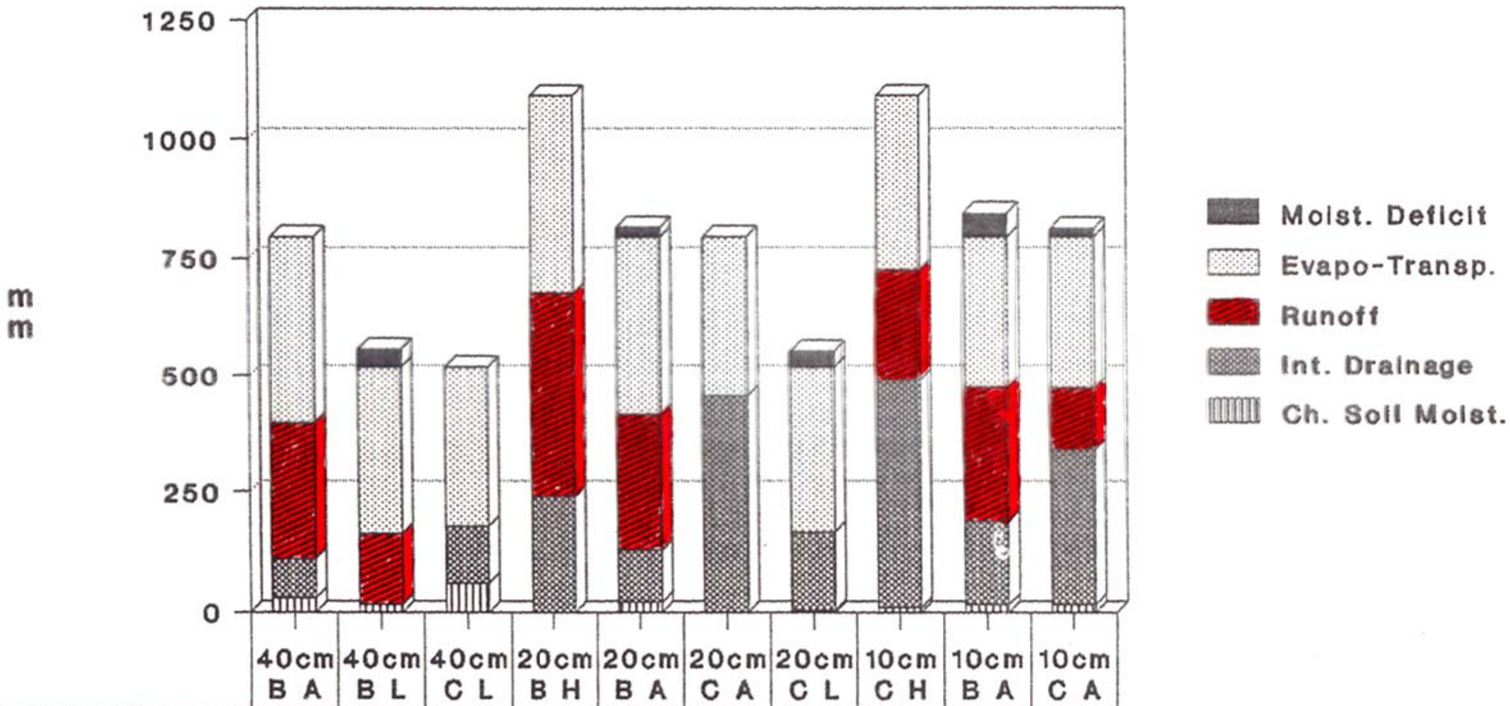

SOIL WITH MULCH COVER
Rainfall
Soil Moisture
Saturation
FCapacity
PWP
mm SOIL MOISTURE - FCapacity - PWP
mm RAINFALL - RUNOFF
DAYS (Sorghum growing cycle)
0
20
40
60
80
100

Fig.4.- Water Balance(Sand-Loam LIXISOL)
Sorghum grow. period/10-40cm Root Depth
B=Bare;C=Cover/Rain:H=High;A=Aver.;L=Low

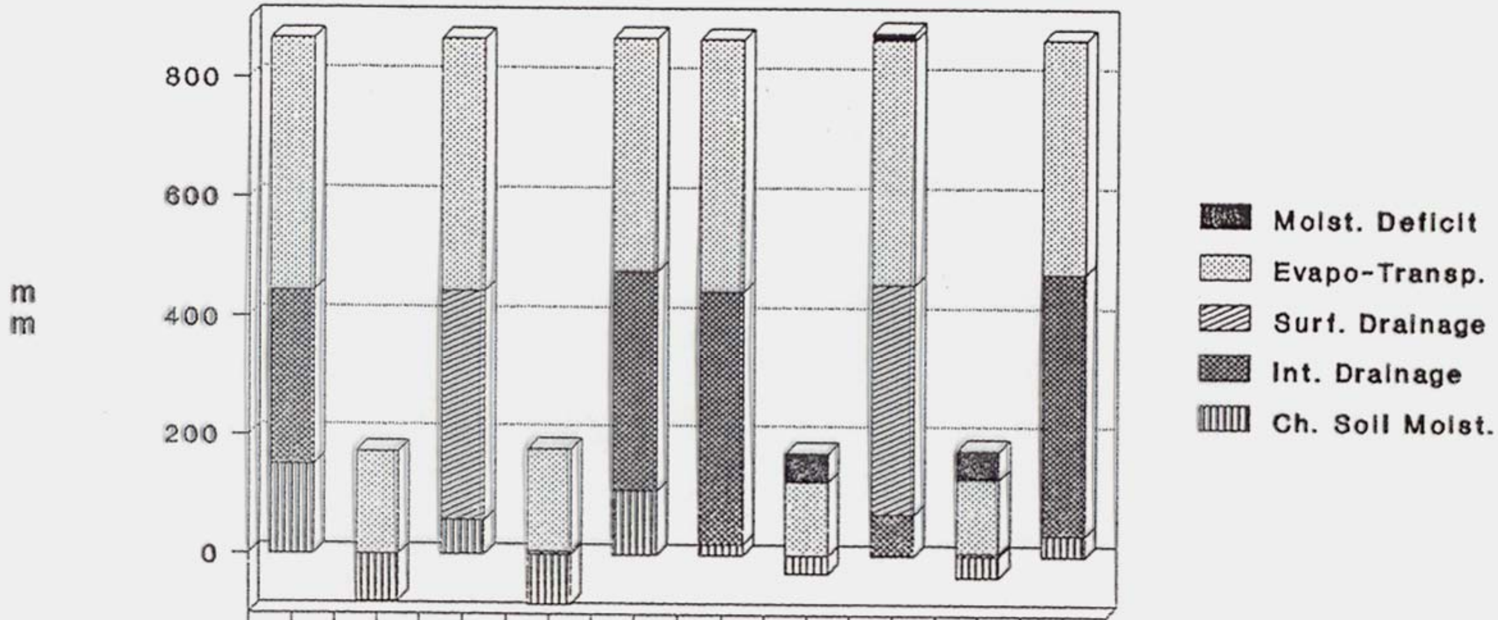


	40cm B A	40cm B L	40cm C L	20cm B H	20cm B A	20cm C A	20cm C L	10cm C H	10cm B A	10cm C A
Moist. Deficit	0	38	0	0	19	0	34	0	49	17
Evapo-Transp.	399	355	340	416	381	340	352	367	321	323
Runoff	285	147	0	436	285	0	0	233	285	133
Int. Drainage	82	0	118	240	109	454	162	482	174	324
Ch. Soil Moist.	30	17	61	0	21	2	5	10	16	16

Water Balance (Silty Loam CAMBISOL)

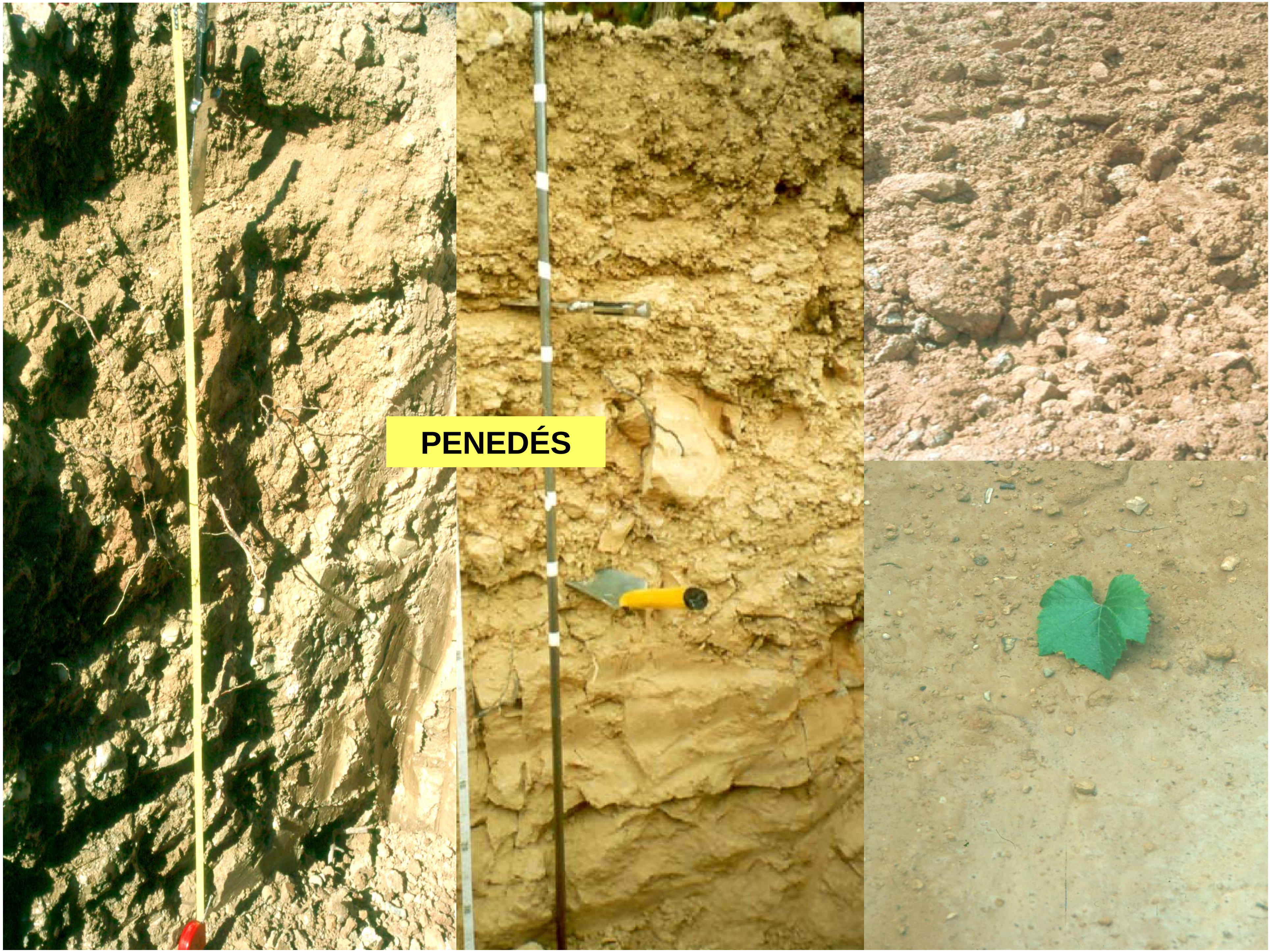
(Corn (M)-Sesame (S) growing periods)

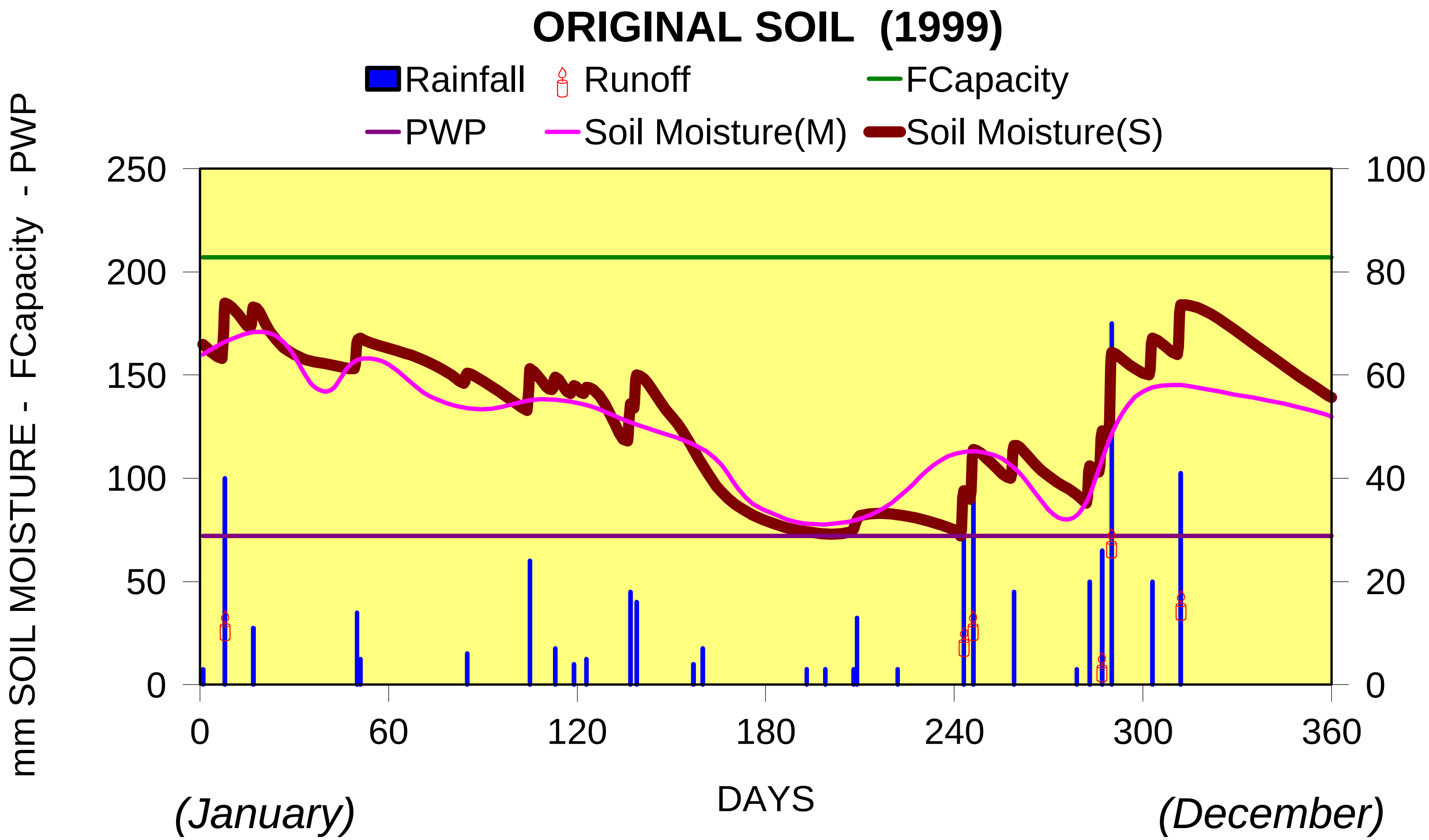
Rain: Average /B=Bare;C=Cover;D=Drainage



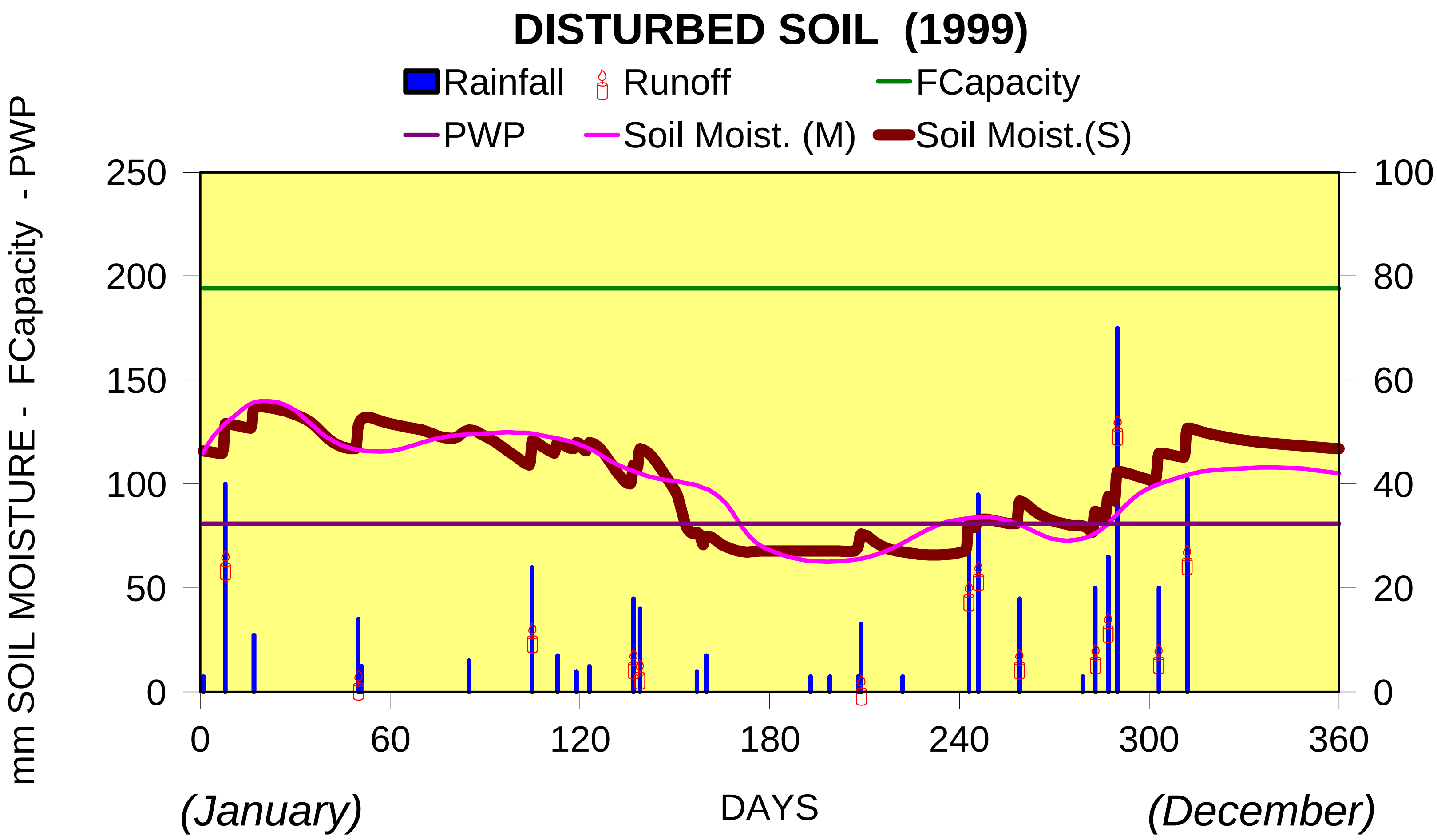
	60cm B M	60cm B S	60cm BDM	60cm BDS	60cm C M	15cm B M	15cm B S	15cm BDM	15cm BDS	15cm C M
Moist. Deficit	0	0	0	0	0	0	49	12	49	0
Evapo-Transp.	422	173	422	173	390	422	124	410	124	390
Surf. Drainage	0	0	388	5	0	0	0	388	5	0
Int. Drainage	295	0	0	0	372	427	0	69	0	442
Ch. Soil Moist.	150	-79	57	-84	107	18	-30	0	-35	35


CATERPILLAR


PENEDÉS



ORIGINAL SOIL (1999)
Rainfall
Runoff
FCapacity
PWP
Soil Moisture(M)
Soil Moisture(S)
mm SOIL MOISTURE - FCapacity - PWP
mm RAINFALL - RUNOFF
250
200
150
100
50
0
100
80
60
40
20
0
0
60
120
180
240
300
360
DAYS
(January)
(December)


DISTURBED SOIL (1999)
Rainfall
Runoff
FCapacity
PWP
Soil Moist. (M)
Soil Moist.(S)
mm SOIL MOISTURE - FCapacity - PWP
mm RAINFALL - RUNOFF
250
200
150
100
50
0
100
80
60
40
20
0
0
60
120
180
240
300
360
(January)
DAYS
(December)

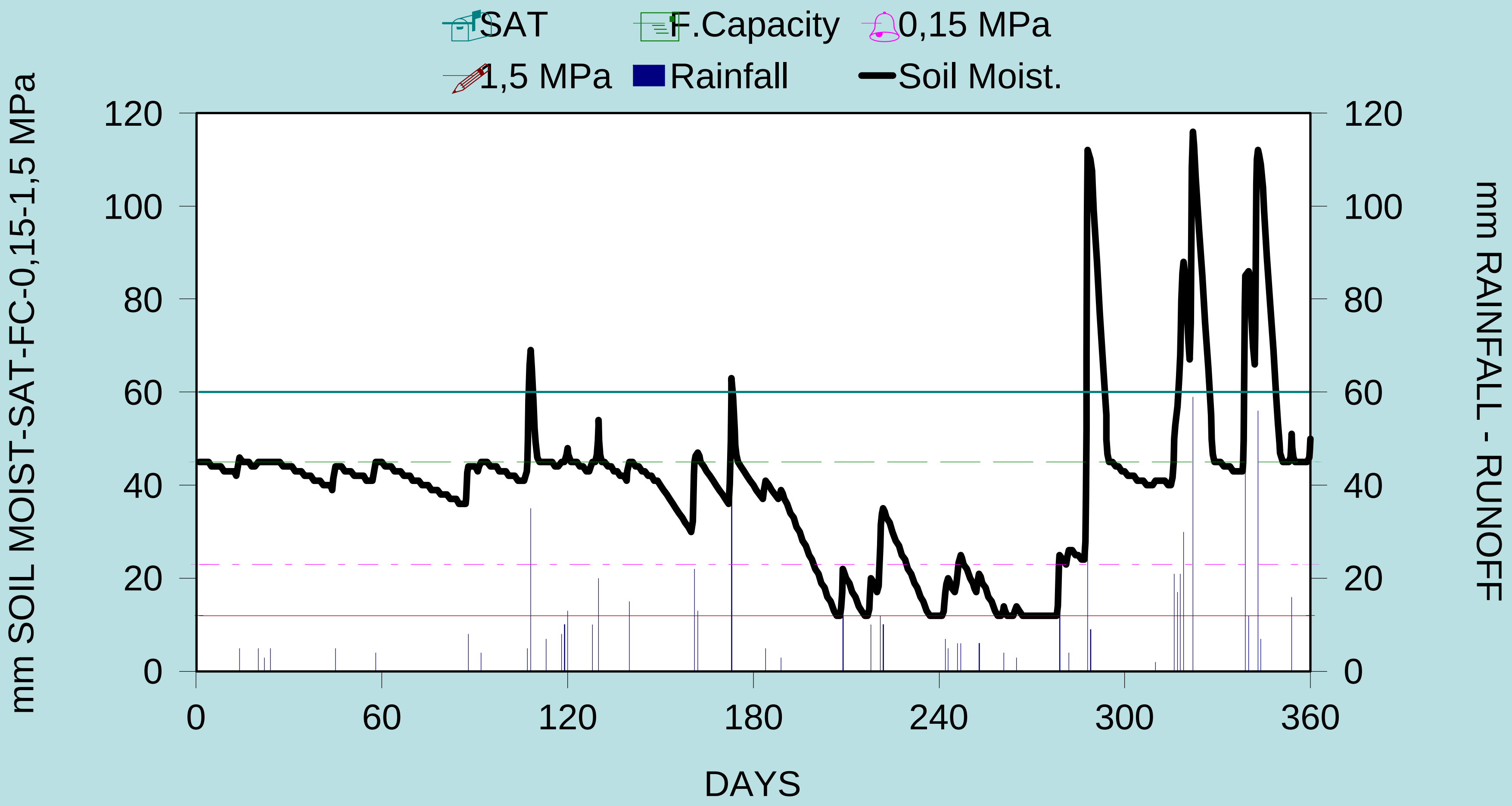
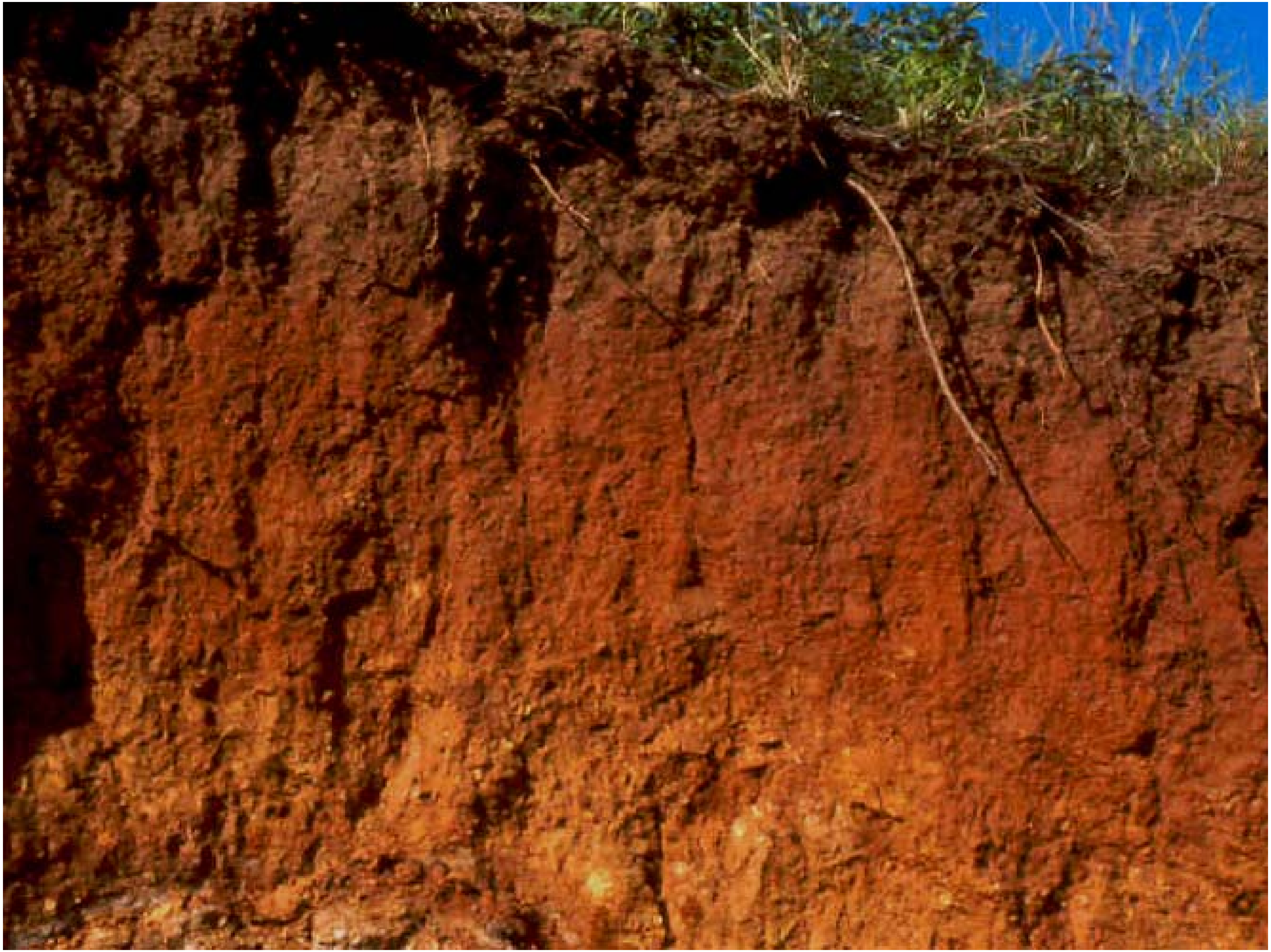
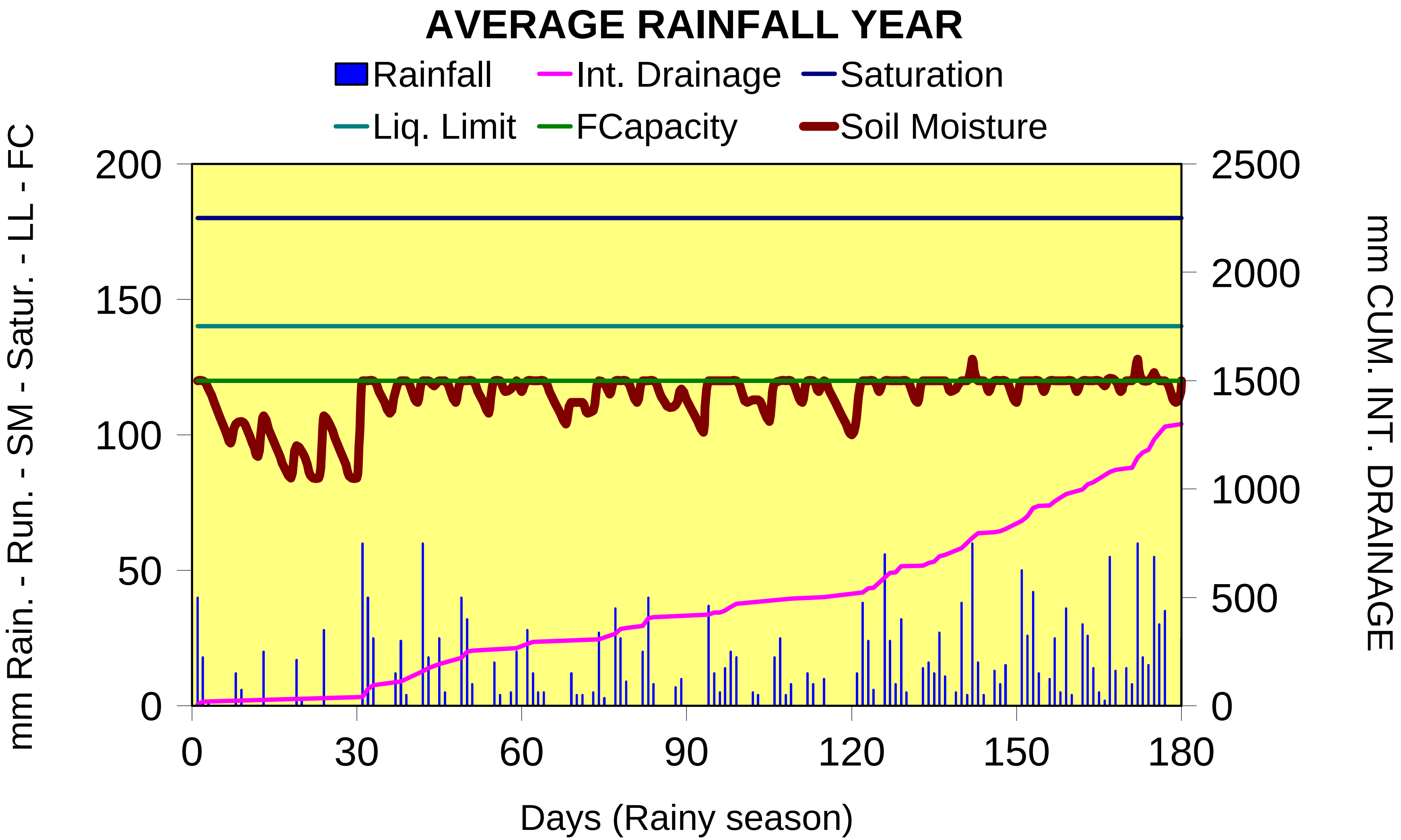
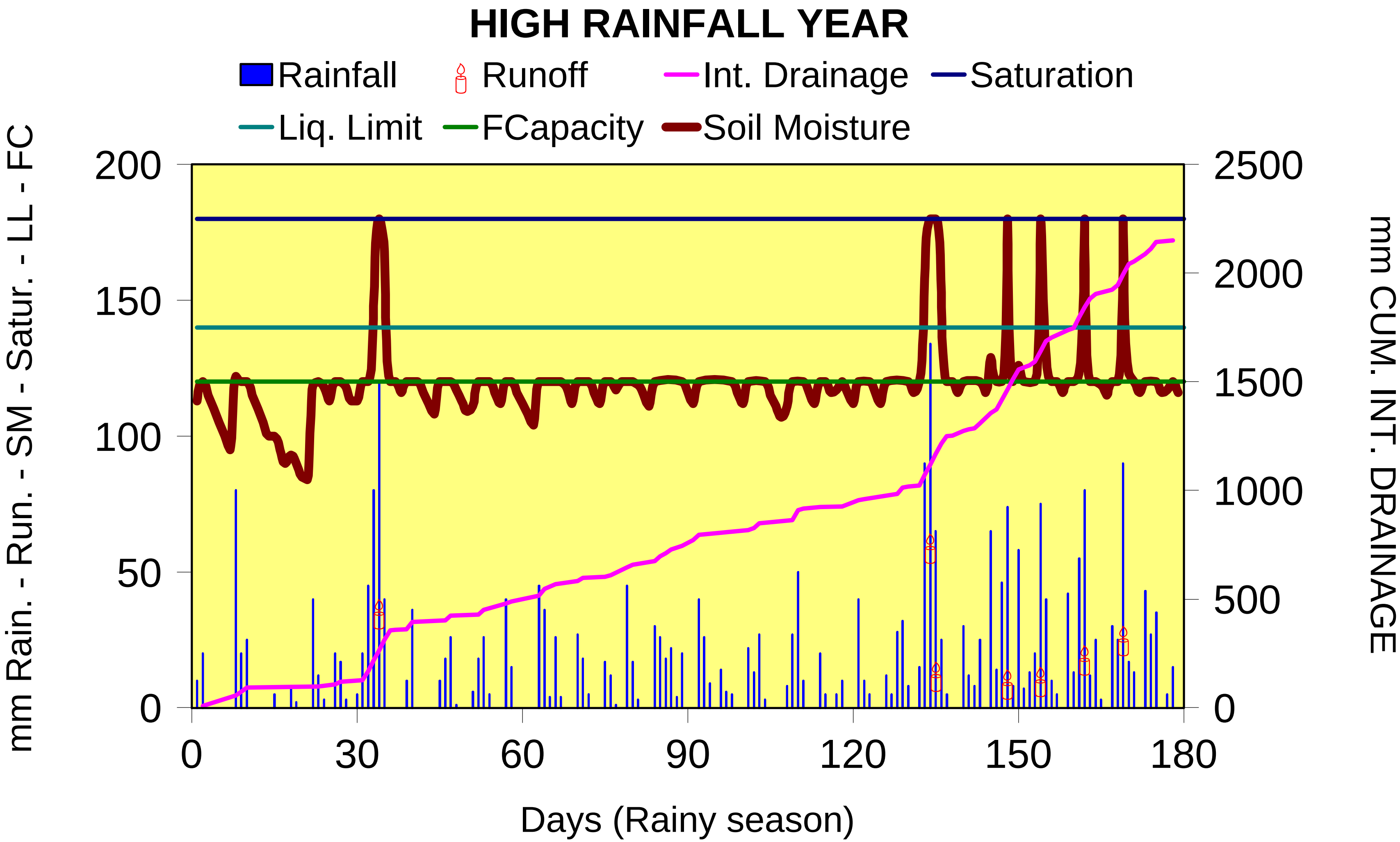


Figure 3.- Soil moisture regime in the terraces of a vineyard (Anoia-Alt Penedés) during the year 1996 (Rain above average: 760 mm. Return Period: 5 years). Compacted layer (Ksat: 0,4 mm/h) at 15 cm depth. No surface sealing (Minimum water intake rate: 20 mm/h)



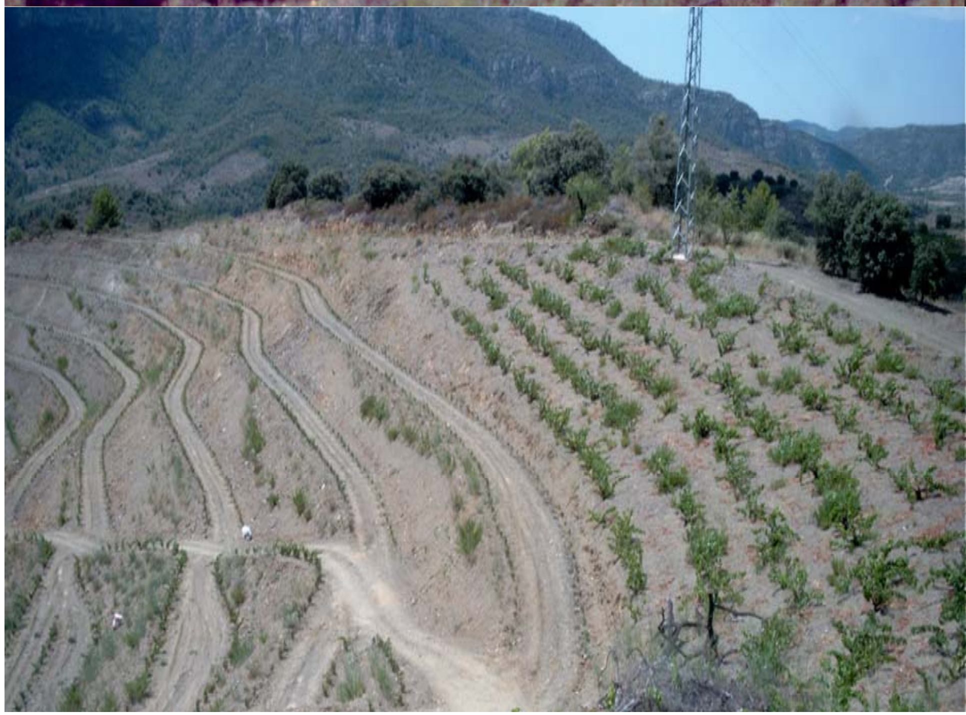


AVERAGE RAINFALL YEAR
Rainfall
Int. Drainage
Saturation
Liq. Limit
FCapacity
Soil Moisture
mm Rain. - Run. - SM - Satur. - LL - FC
mm CUM. INT. DRAINAGE
Days (Rainy season)
0
50
100
150
200
0
500
1000
1500
2000
2500
0
30
60
90
120
150
180



HIGH RAINFALL YEAR
Rainfall
Runoff
Int. Drainage
Saturation
Liq. Limit
FCapacity
Soil Moisture
mm Rain. - Run. - SM - Satur. - LL - FC
200
150
100
50
0
2500
2000
1500
1000
500
0
mm CUM. INT. DRAINAGE
0
30
60
90
120
150
180
Days (Rainy season)







PRIORAT
Image © 2005 DigitalGlobe
N
W
E
S
Pointer 41°12'05.24" N 0°52'07.52" E elev 1563 ft Streaming |||||||||| 100%Eye alt

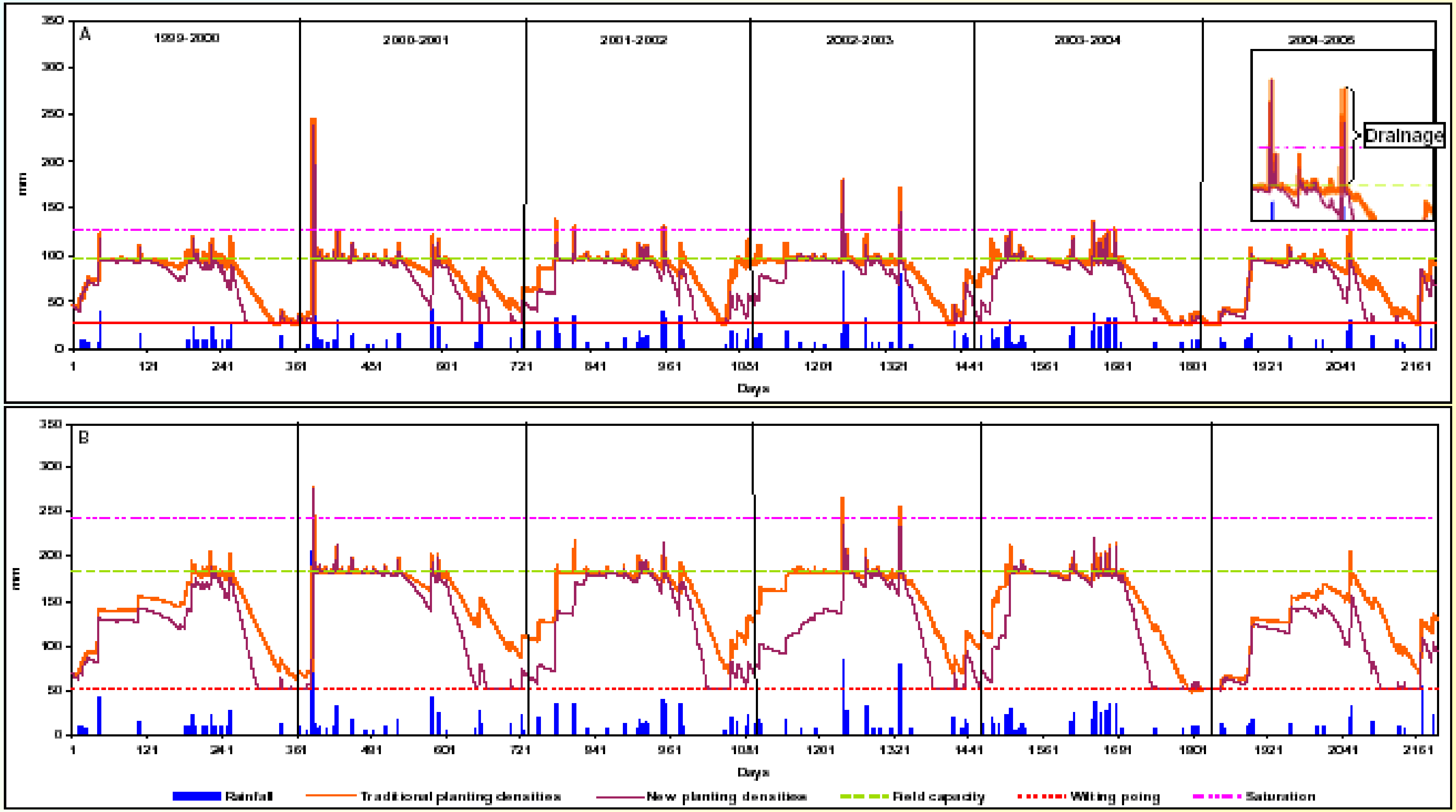


Figure 3. Simulated soil moisture regime in six (1999-2005) consecutive agricultural years (starting in October and finishing in September) with different plantation densities and different effective rooting depths. (A: 60 cm rooting depth; B: 80 cm rooting depth).

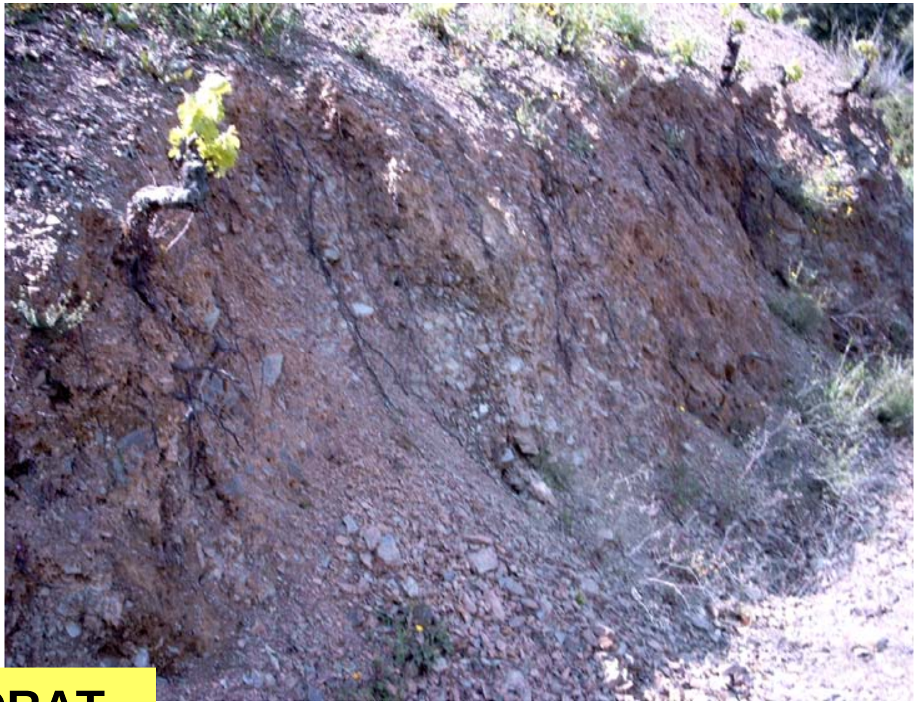
PENEDÉS

PRIORAT


RAIMAT
RAIMAT

Such changes have mainly affected the soil moisture regime which especially under Mediterranean climate is the main factor determining the quantity and quality of grape production

PENEDÉS

PRIORAT


COSTERS DEL SEGRE

The objective of this research has been:

-to study the effects on the soil moisture regime of the soils of the changes in land and crop management in three of the main regions

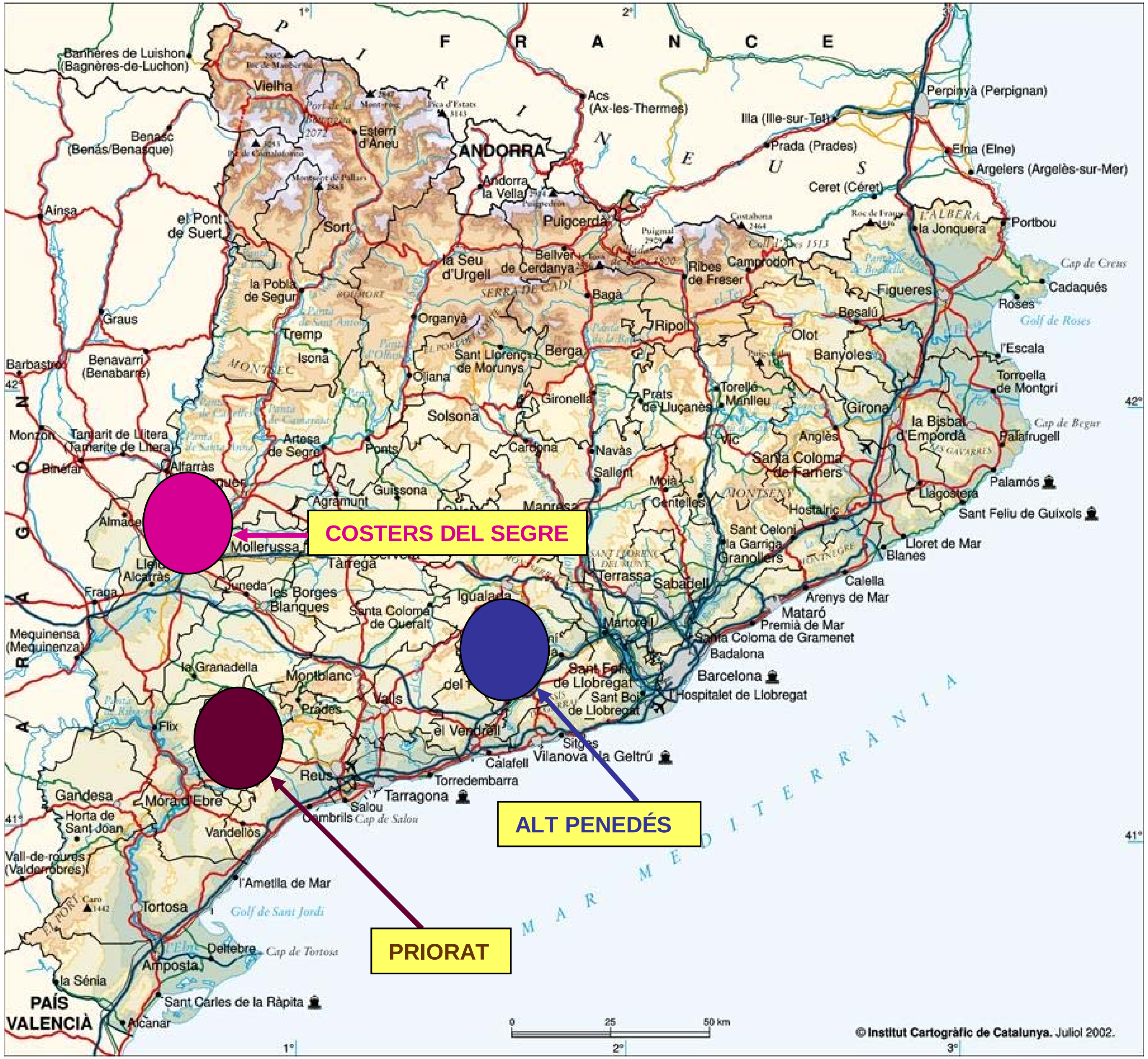
Alt Penedés (Barcelona)

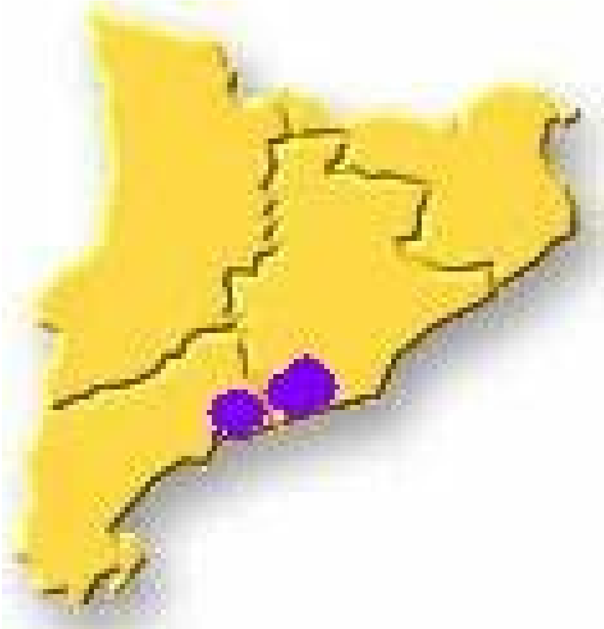
Priorat (Tarragona)

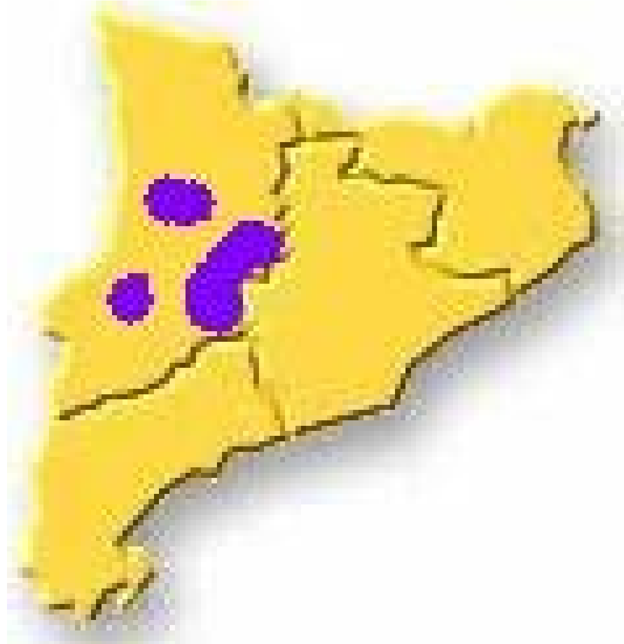
Costers del Segre (Lleida)

with vineyards dedicated to the production of high quality wines and cava in Catalonia

FRANCIA
ANDORRA
GALICIA
ASTURIAS
CANTABRIA
PAÍS VASCO
NAVARRA
RIOJA
CATALUNYA
ARAGÓN
CASTILLA Y LEÓN
MADRID
CASTILLA-LA MANCHA
EXTREMADURA
COMUNIDAD VALENCIANA
MURCIA
ANDALUCÍA
ISLAS BALEARES
CANARIAS
PORTUGAL
Océano Atlántico
Mar Mediterráneo
La Coruña
Oviedo
Santander
Bilbao
San Sebastián
Lugo
Santiago de Compostela
Pontevedra
Orense
León
Burgos
Vitoria
Pamplona
Logroño
Huesca
Girona
Lleida
Barcelona
Tarragona
Zaragoza
Palencia
Soria
Valladolid
Zamora
Salamanca
Segovia
Avila
Guadalajara
Madrid
Teruel
Castellón de la Plana
Cuenca
Toledo
Valencia
Cáceres
Ciudad Real
Albacete
Mérida
Badajoz
Alicante
Murcia
Córdoba
Jaén
Huelva
Sevilla
Granada
Almería
Cádiz
Málaga
Ceuta
Melilla
Palma de Mallorca
Santa Cruz de Tenerife
Las Palmas de Gran Canaria
0
100
200 km.


COSTERS DEL SEGRE
ALT PENEDÉS
PRIORAT
F R A N C E
ANDORRA
Barcelona
Tarragona
Lleida
Girona
Reus
Tortosa
Figueres
Vic
Manresa
Sabadell
Terrassa
Mataró
Badalona
Igualada
Valls
Tàrrega
Mollerussa
Cervera
Solsona
Puigcerdà
la Seu d'Urgell
Vielha
Sort
Tremp
Olot
Ripoll
Berga
Salou
Cambrils
Calafell
el Vendrell
Vilanova i la Geltrú
Sitges
Amposta
Deltebre
Gandesa
Móra d'Ebre
Flix
PAÍS VALENCIÀ
M A R M E D I T E R R À N I A
© Institut Cartogràfic de Catalunya. Juliol 2002.





PENEDÉS

CHARDONAY

PRIORAT

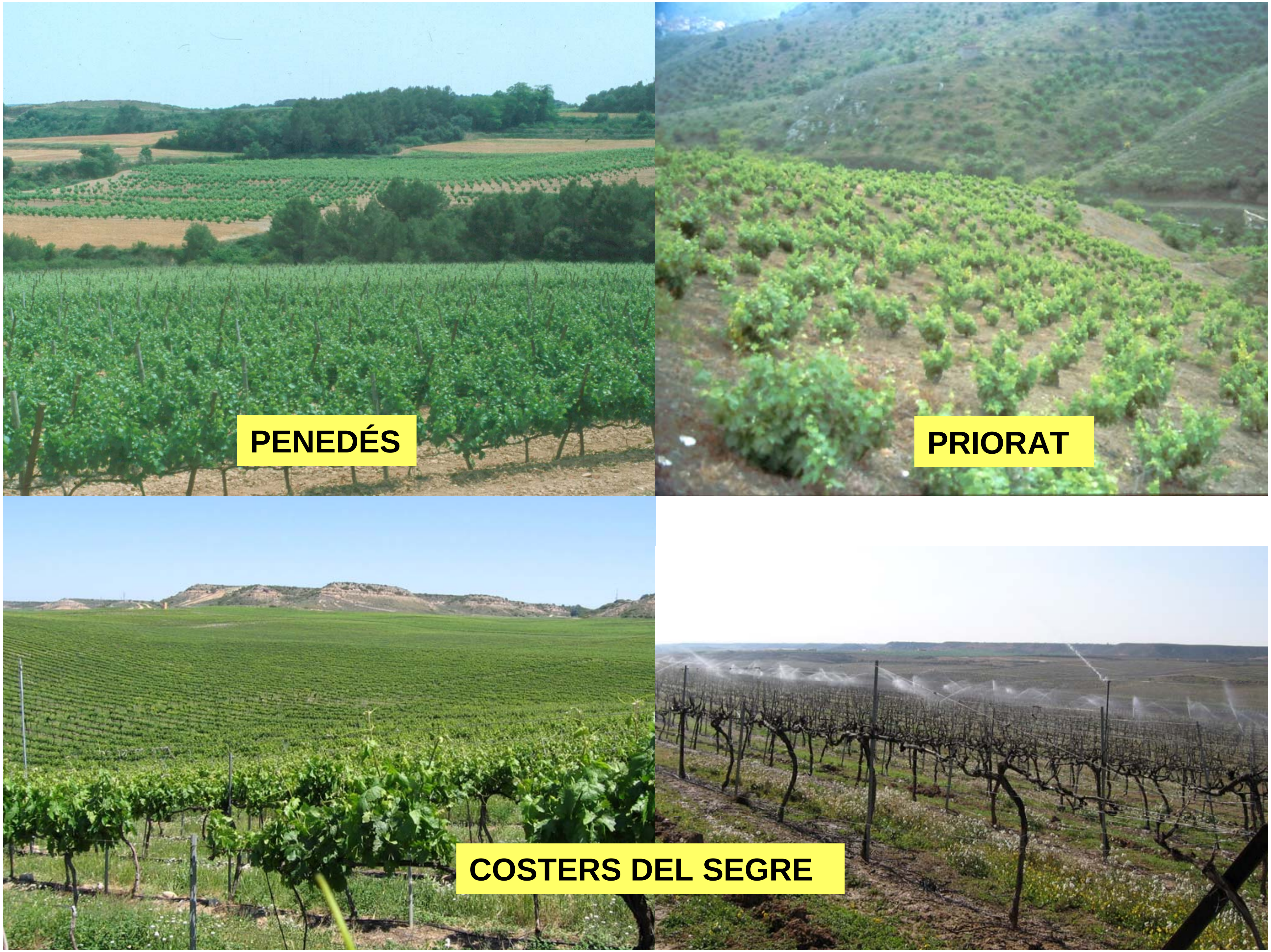
CARIÑENA

GARNACHA NEGRA

COSTERS DEL SEGRE

CHARDONAY

TEMPRANILLO


PENEDÉS
PRIORAT
COSTERS DEL SEGRE

The main changes in land management in those three regions include:

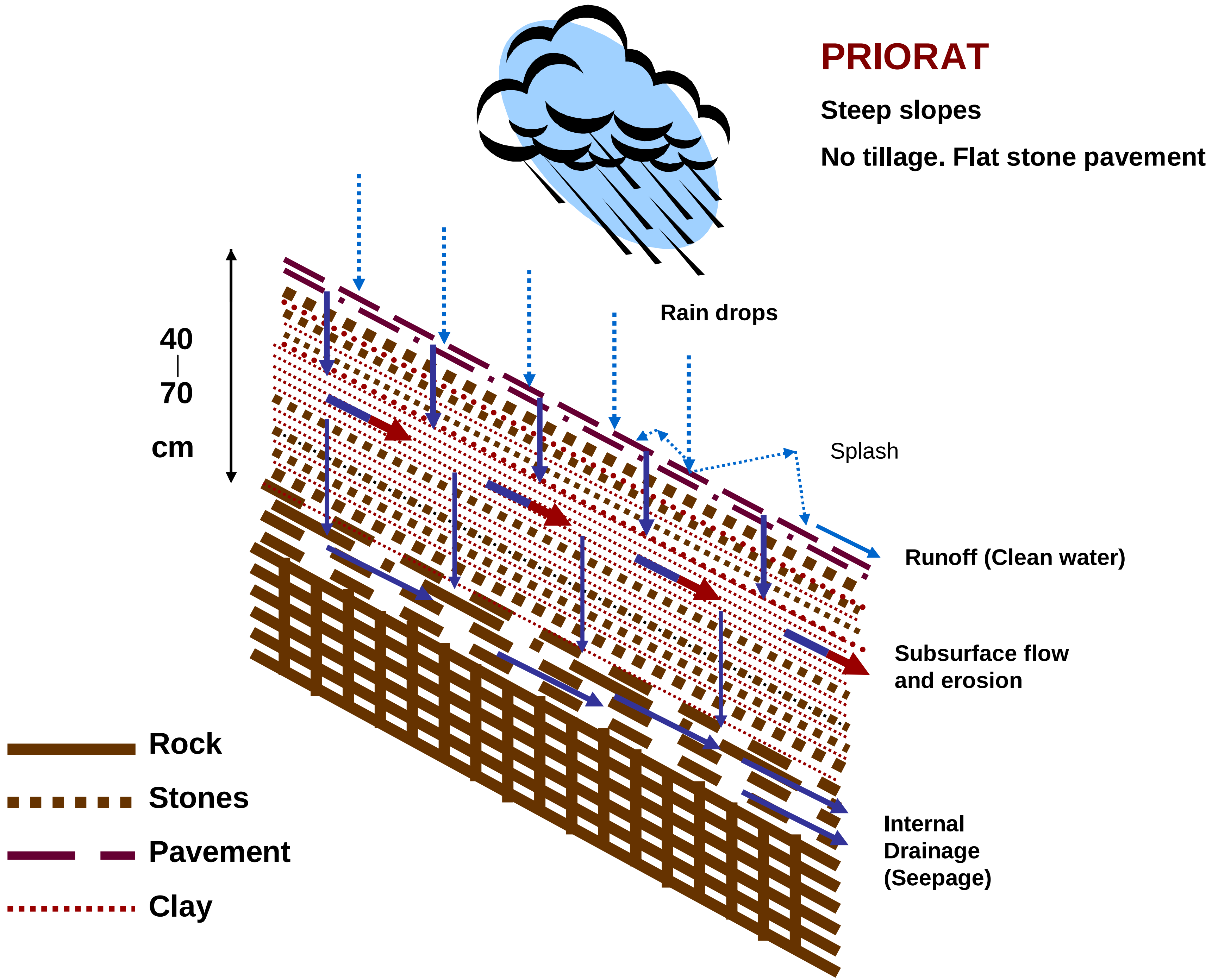
-levelling and use of green cover in rainfed vineyards of the Alt Penedés

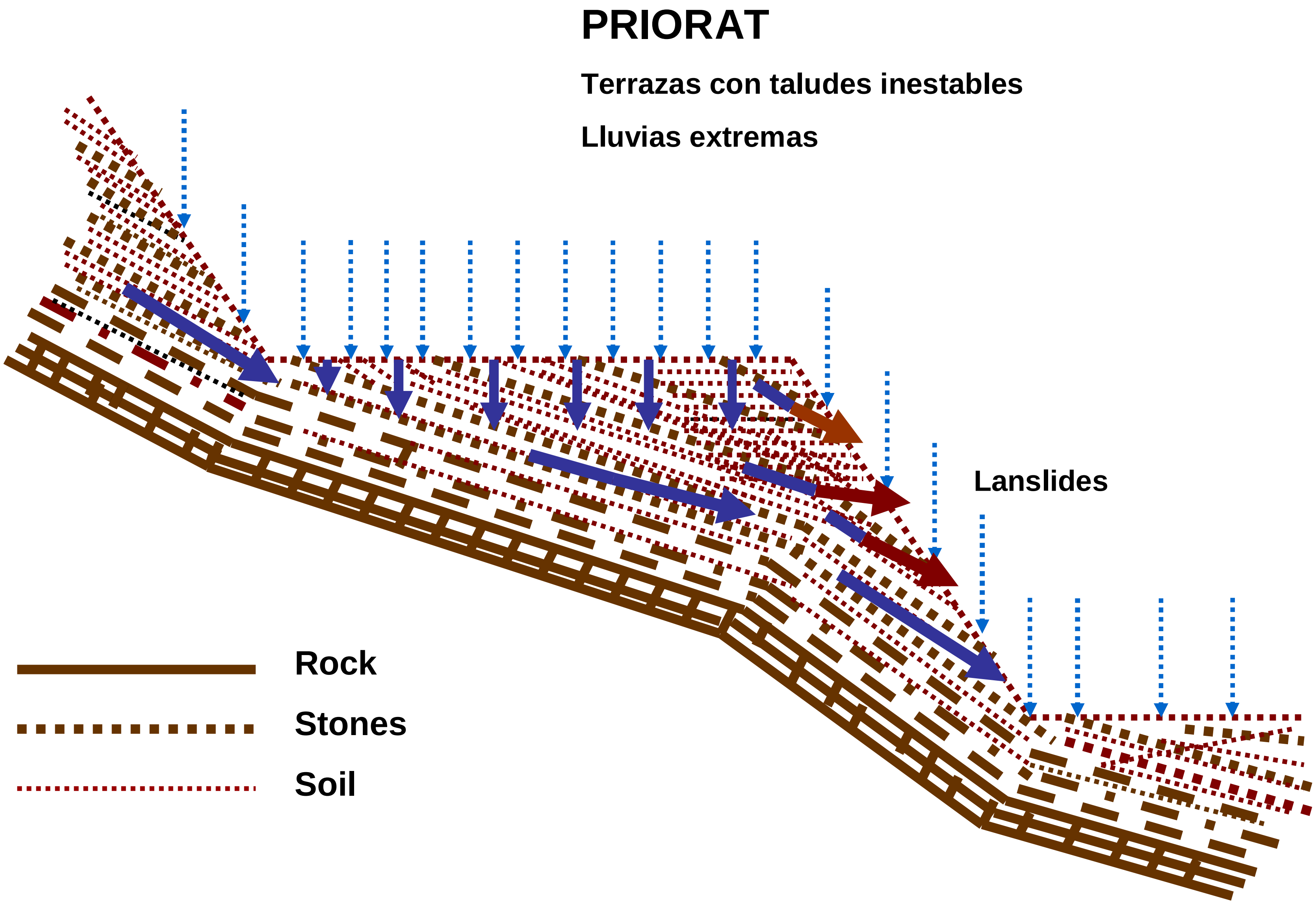
-terracing and tillage in rainfed vineyards (ocassionally with a limited complementary irrigation) of the Priorat

-complementary irrigation and use of green covers in the Costers del Segre

PENEDÉS

PRIORAT


PRIORAT
Steep slopes
No tillage. Flat stone pavement
Rain drops
Splash
Runoff (Clean water)
Subsurface flow
and erosion
Internal
Drainage
(Seepage)
40
70
cm
Rock
Stones
Pavement
Clay


PRIORAT
Terrazas con taludes inestables
Lluvias extremas
Lanslides
Rock
Stones
Soil

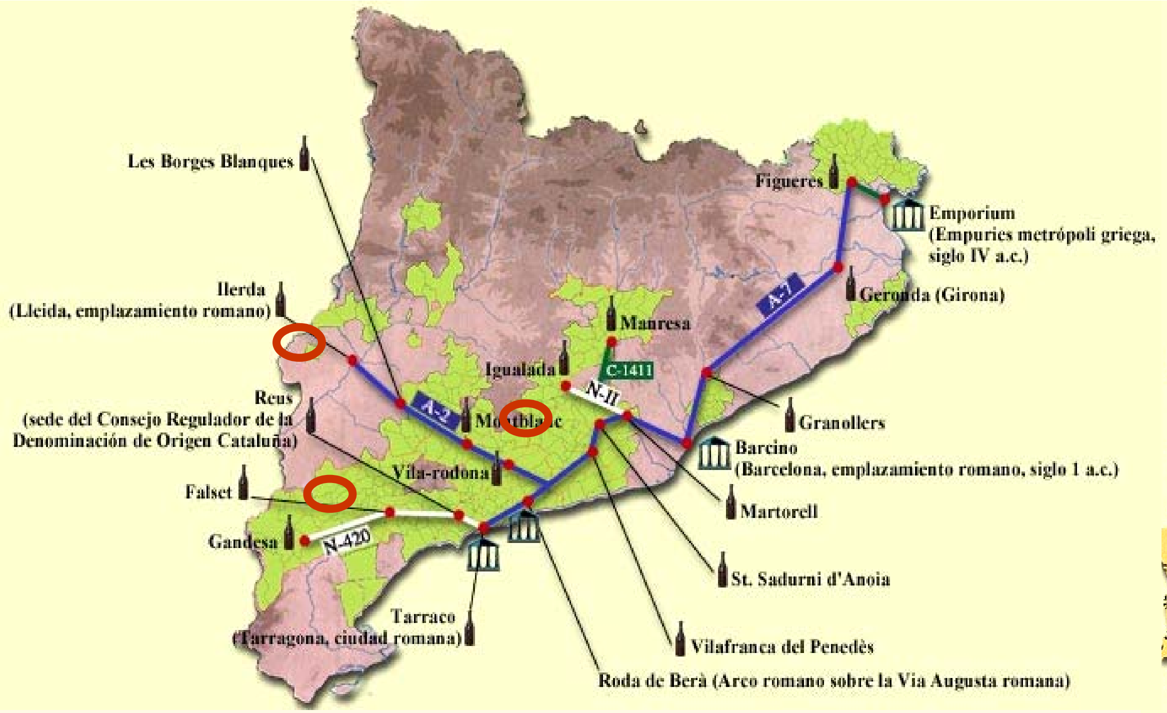

COSTERS DEL SEGRE

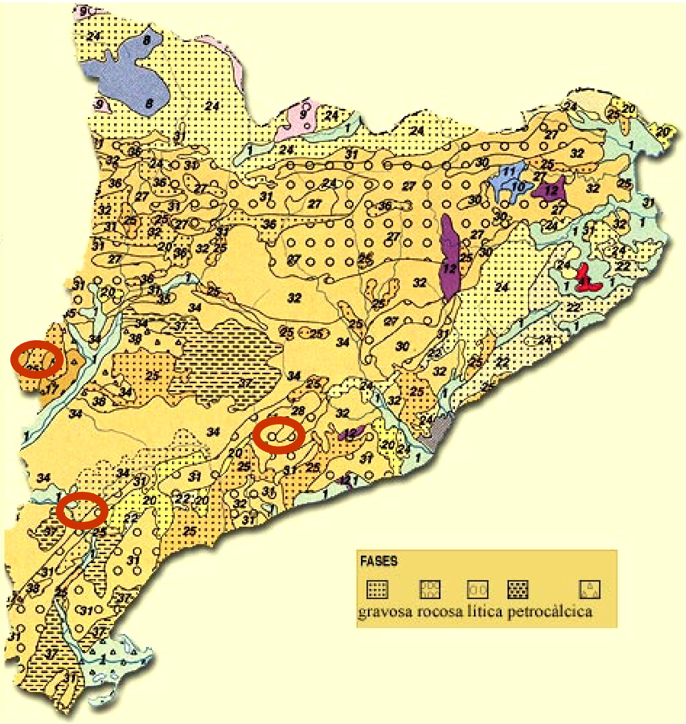

The climate in the three regions is Mediterranean semiarid, with average annual rainfall of:

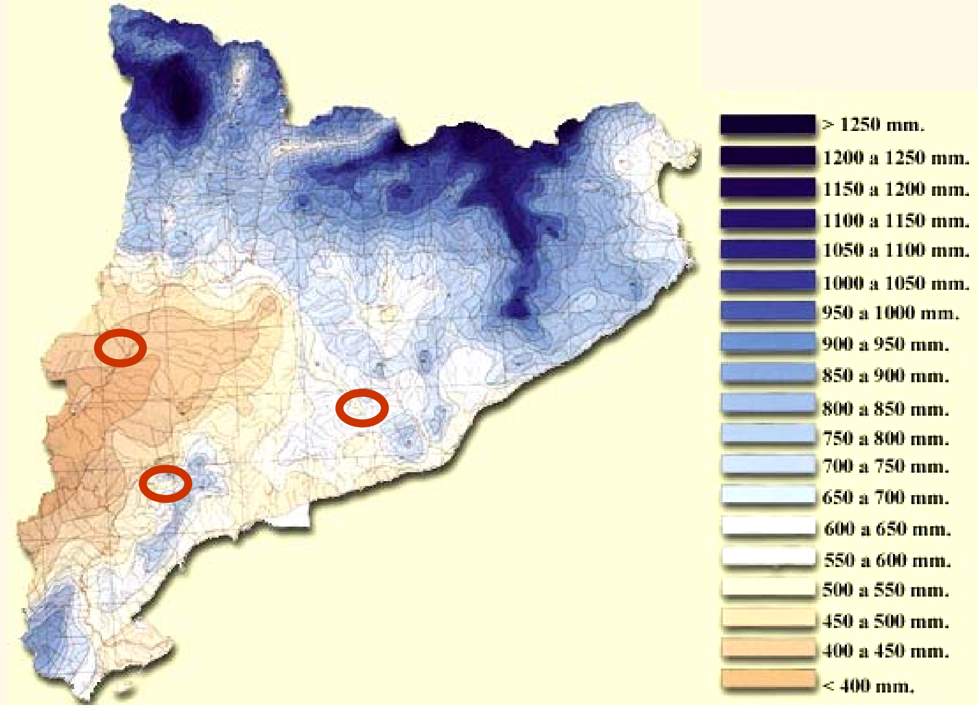
-500 to 600 mm in the Alt Penedés and Priorat regions

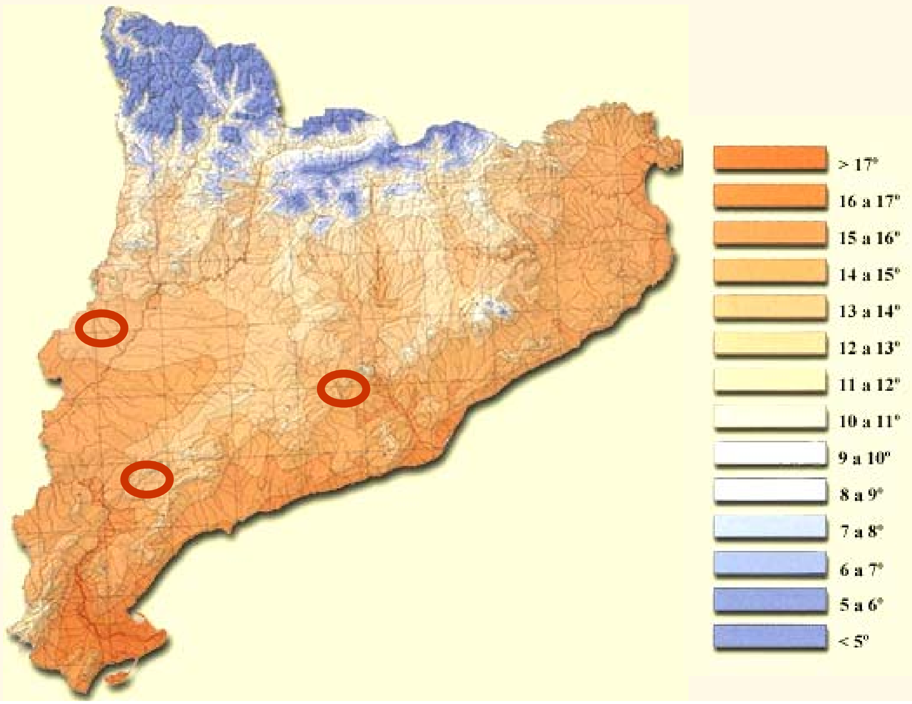
-300 mm in the Costers del Segre

very variable from one year to the other, and mainly concentrated in the fall and spring seasons

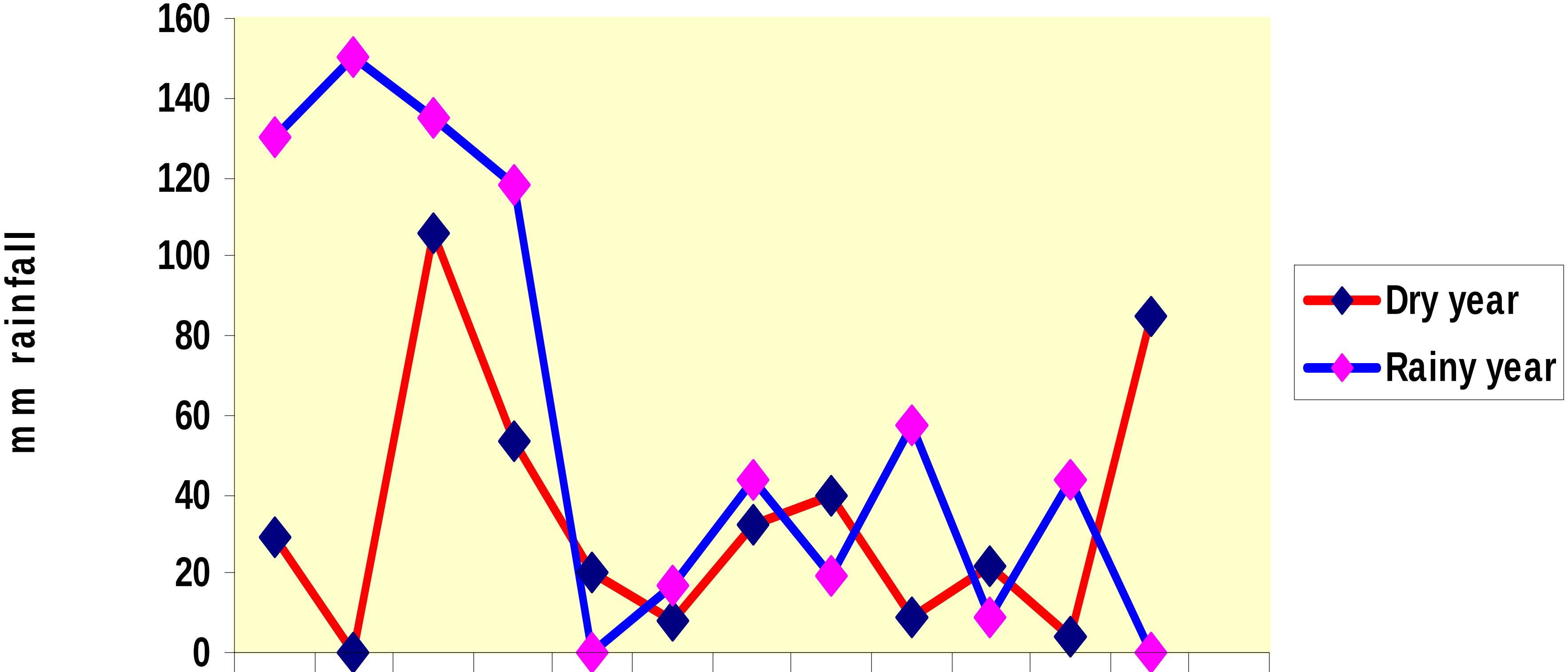

Les Borges Blanques
Ilerda
(Lleida, emplazamiento romano)
Reus
(sede del Consejo Regulador de la Denominación de Origen Cataluña)
Falset
Gandesa
N-420
A-2
Montblanc
Vila-rodona
Igualada
N-II
C-1411
Manresa
A-7
Figueres
Emporium
(Empuries metrópoli griega, siglo IV a.c.)
Gerunda (Girona)
Granollers
Barcino
(Barcelona, emplazamiento romano, siglo 1 a.c.)
Martorell
St. Sadurni d'Anoia
Vilafranca del Penedès
Tarraco
(Tarragona, ciudad romana)
Roda de Berà (Arco romano sobre la Via Augusta romana)


FASES
gravosa rocosa lítica petrocàlcica


> 1250 mm.
1200 a 1250 mm.
1150 a 1200 mm.
1100 a 1150 mm.
1050 a 1100 mm.
1000 a 1050 mm.
950 a 1000 mm.
900 a 950 mm.
850 a 900 mm.
800 a 850 mm.
750 a 800 mm.
700 a 750 mm.
650 a 700 mm.
600 a 650 mm.
550 a 600 mm.
500 a 550 mm.
450 a 500 mm.
400 a 450 mm.
< 400 mm.


> 17°
16 a 17°
15 a 16°
14 a 15°
13 a 14°
12 a 13°
11 a 12°
10 a 11°
9 a 10°
8 a 9°
7 a 8°
6 a 7°
5 a 6°
< 5°

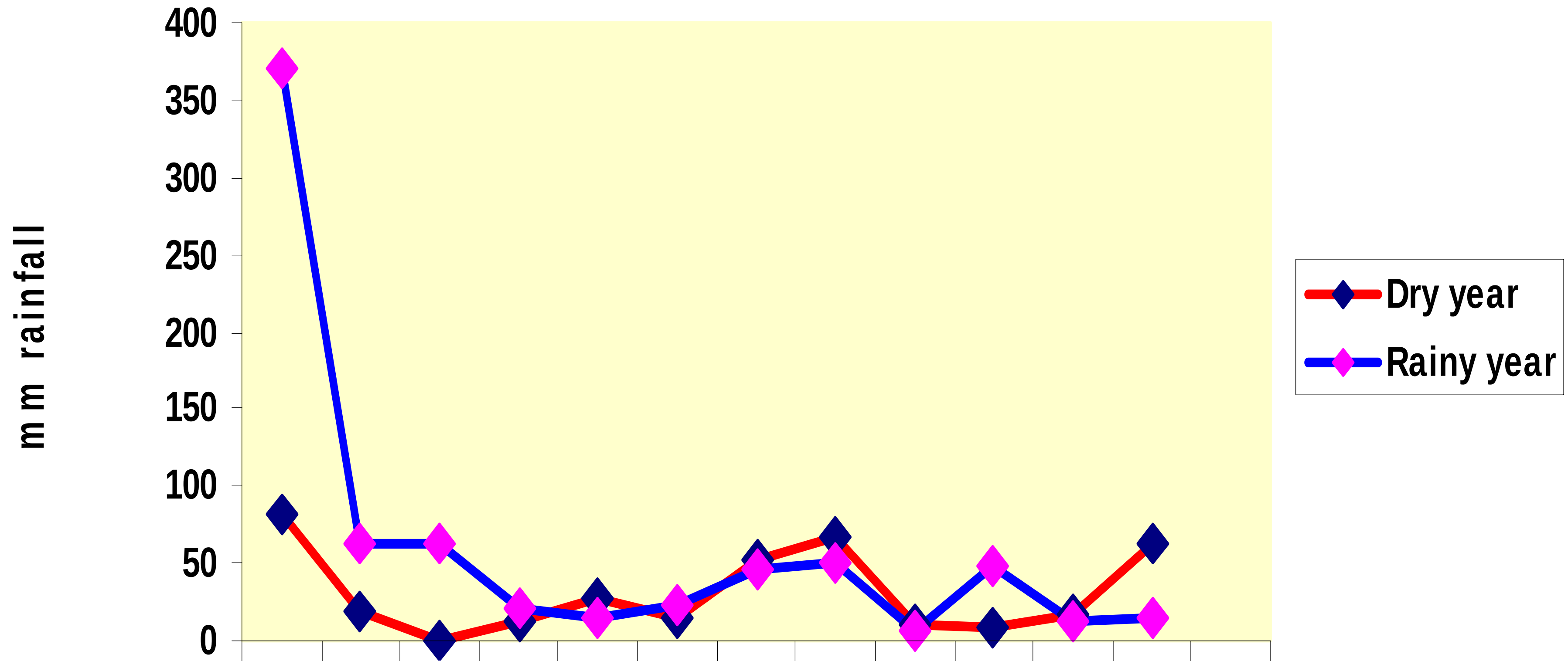
Rain Alt Penedes



	Oct.	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry year	29	0	106	53	20	8	32	40	9	22	4	85
Rainy year	130	150	135	118	0	17	44	19	57	9	44	0

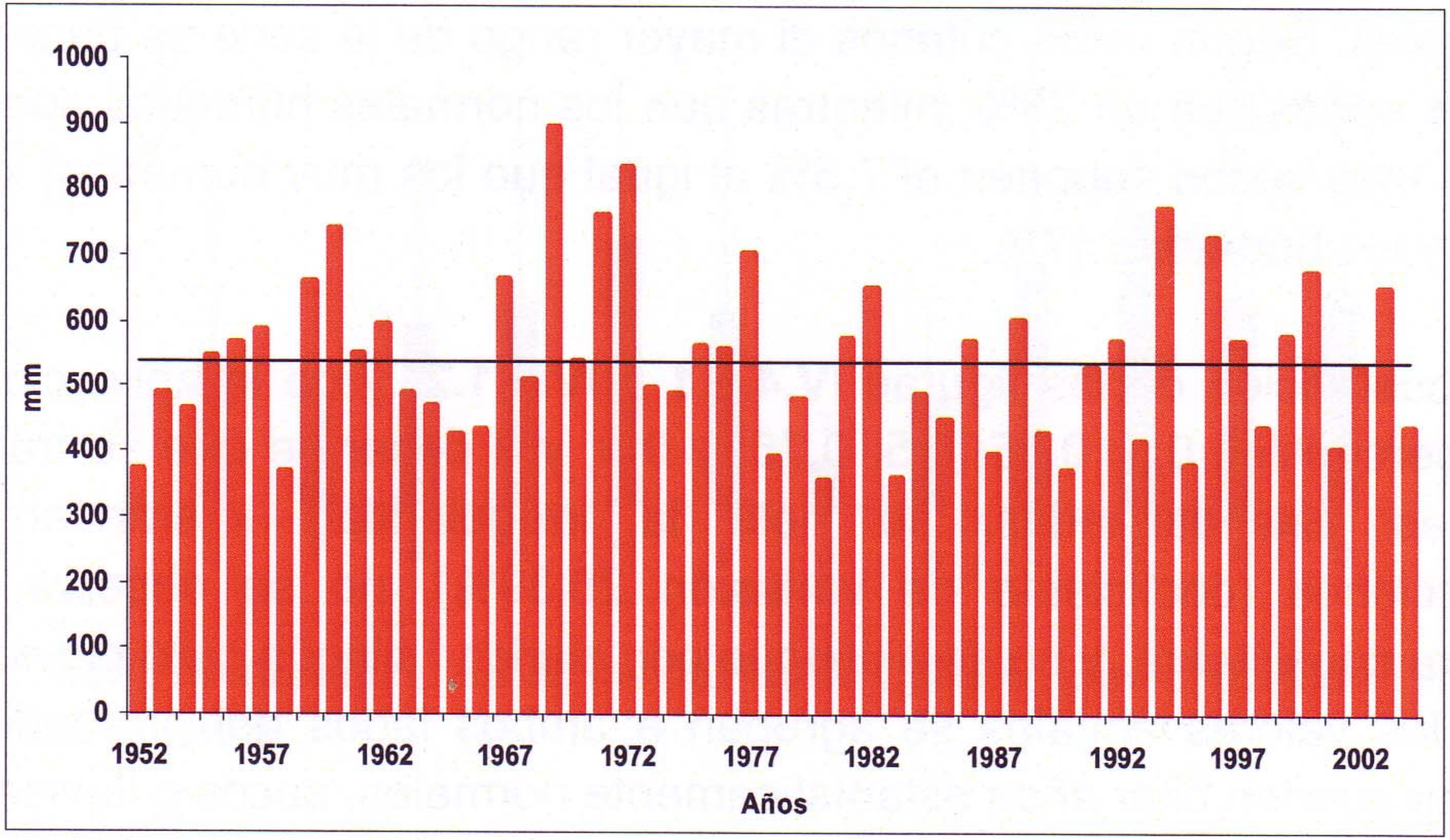
month

Rain Priorat

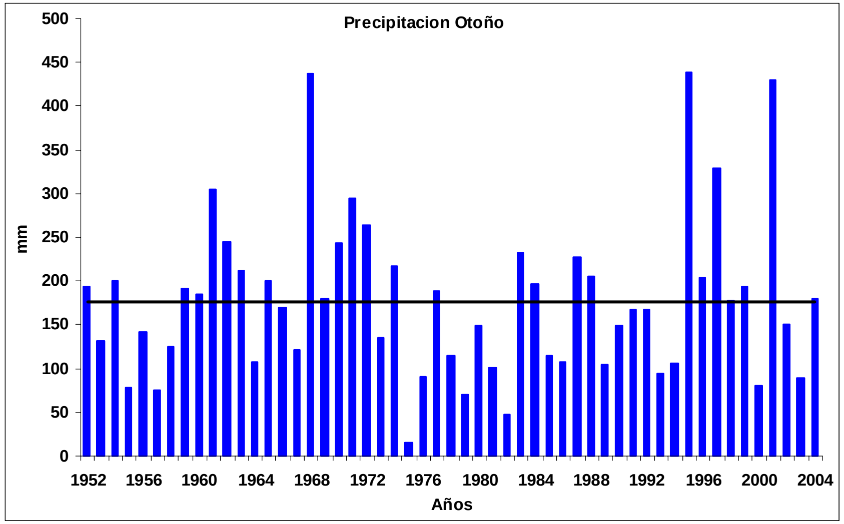


	Oct.	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry year	81	19	0	12	28	15	53	67	10	8	17	63
Rainy year	370	63	62	20	15	24	46	51	7	48	12	15

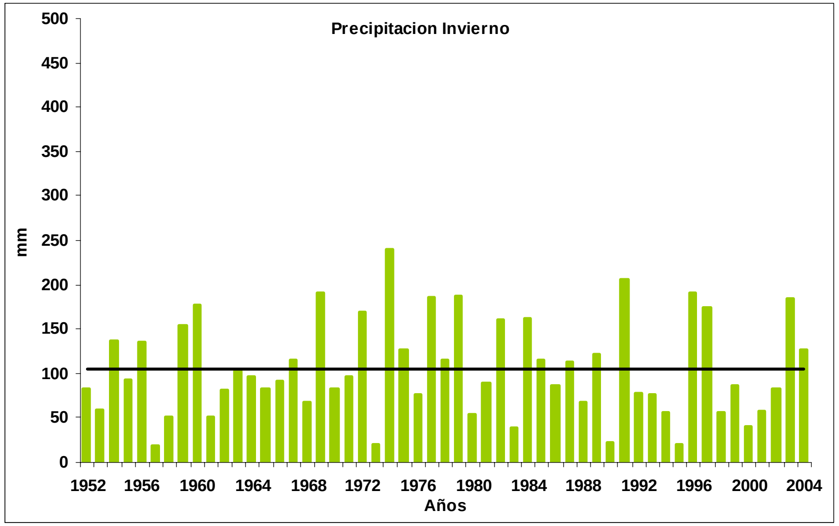
month



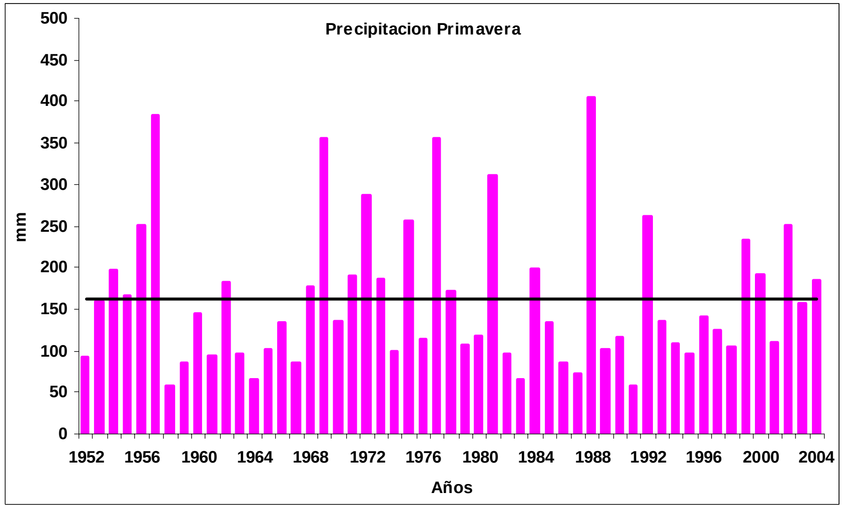
— Precipitación Media.



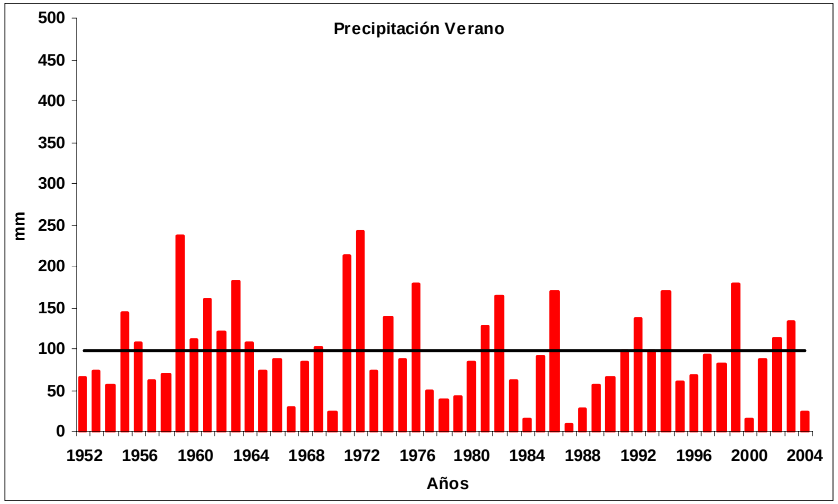
Precipitacion Otoño
mm
Años



Precipitacion Invierno
mm
Años

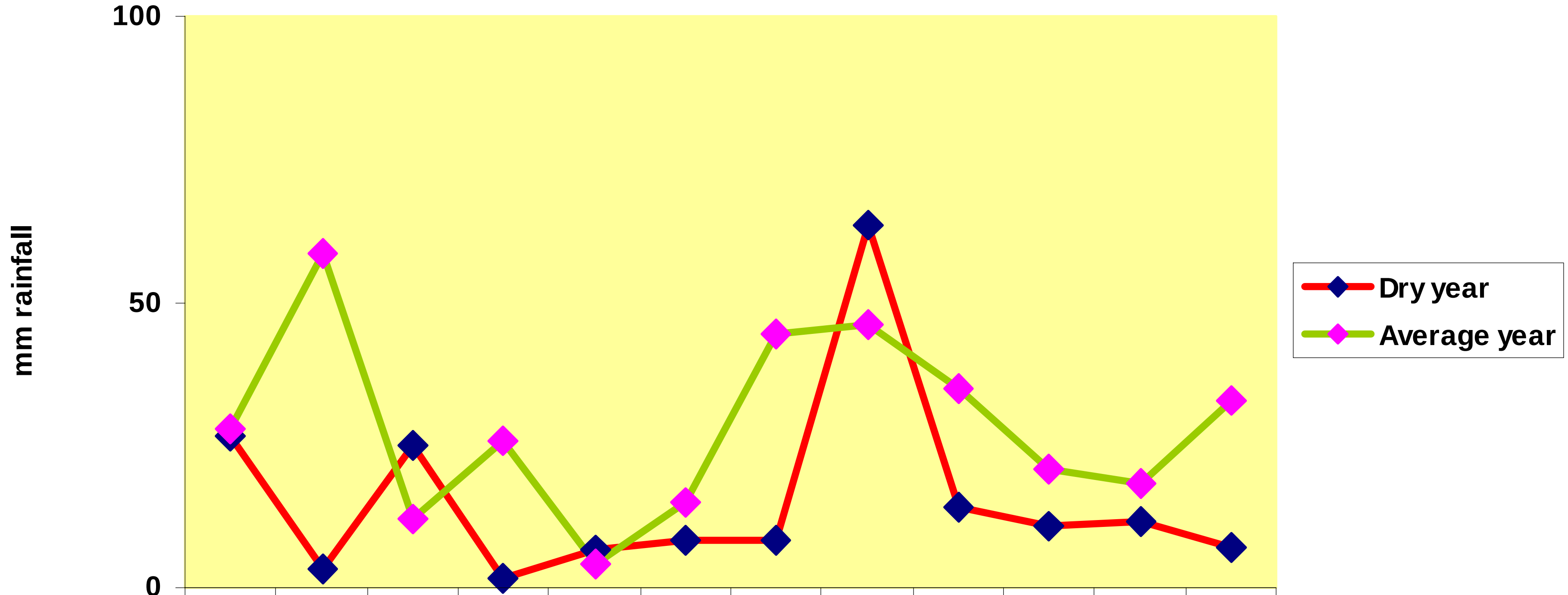


Precipitacion Primavera
mm
Años



Precipitación Verano
mm
Años

Rain Costers del Segre



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry year	27	4	25	2	7	8	8	63	14	11	12	7
Average year	28	59	12	26	4	15	44	46	35	21	18	33

month

The soils in Alt Penedés and Costers del Segre:

-mainly silty-loam textures

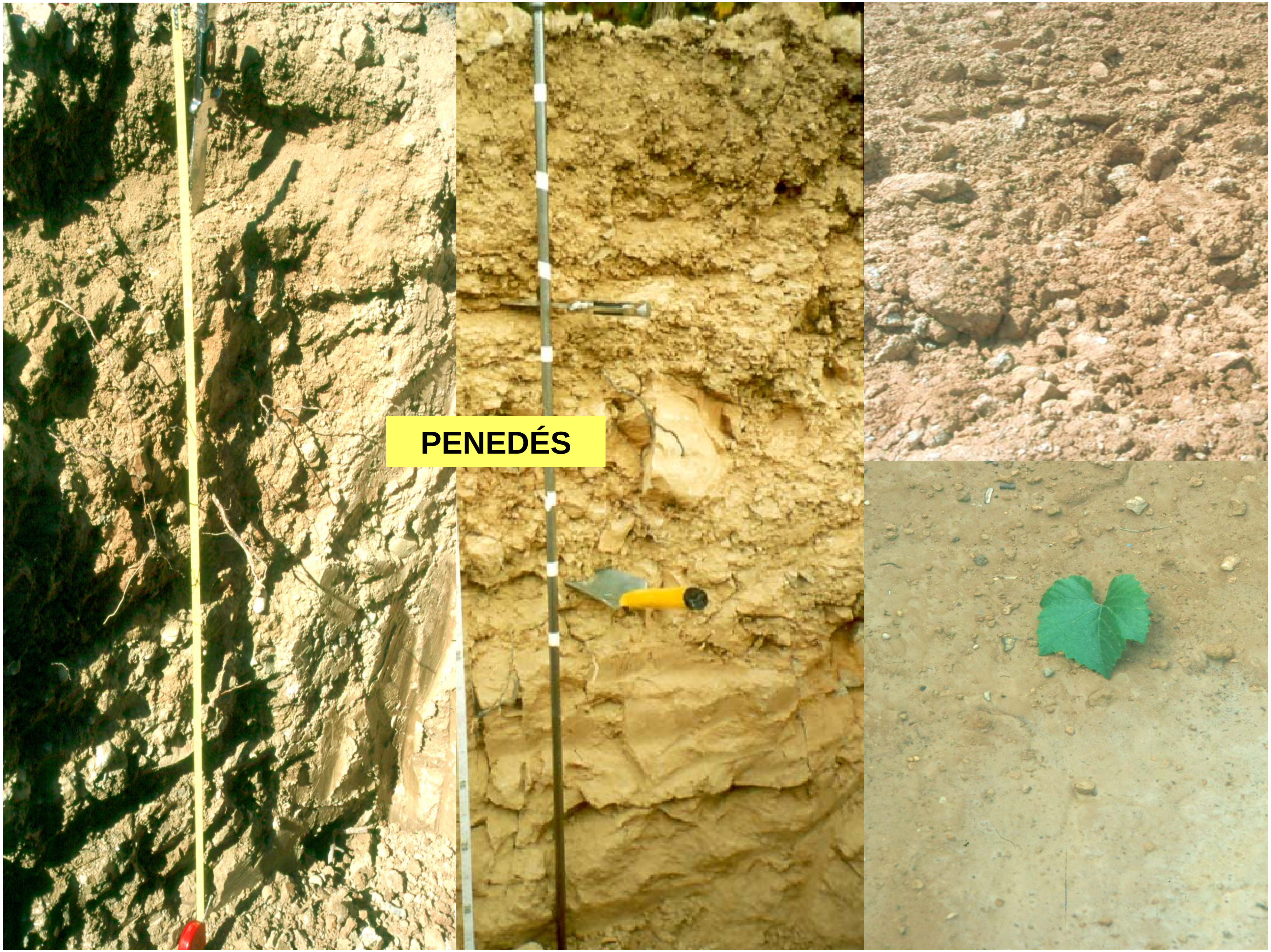
-derived of calcareous lutites

The soils in the Priorat:

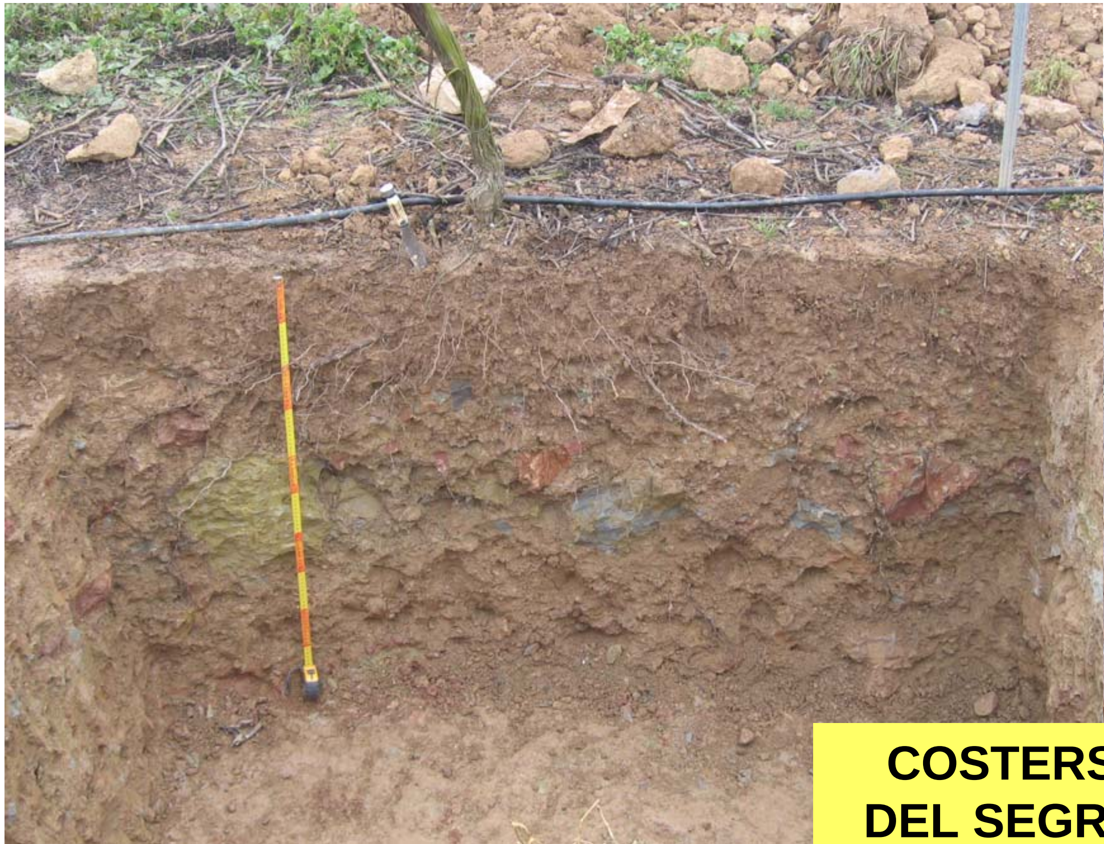
-very stony (>50% coarse fraction)

-derived of slates

-calcareous only in the deeper soil where the clay (smectites) content slightly increases


PENEDÉS


PRIORAT




COSTERS DEL SEGRE



The studies included:

-the continuous registration in carefully selected field sites of changes in the soil moisture regime, associated to:

- **different rainfall amount and distribution**
- **differents soils and land and crop management**

and its correspondence with the simulation for:

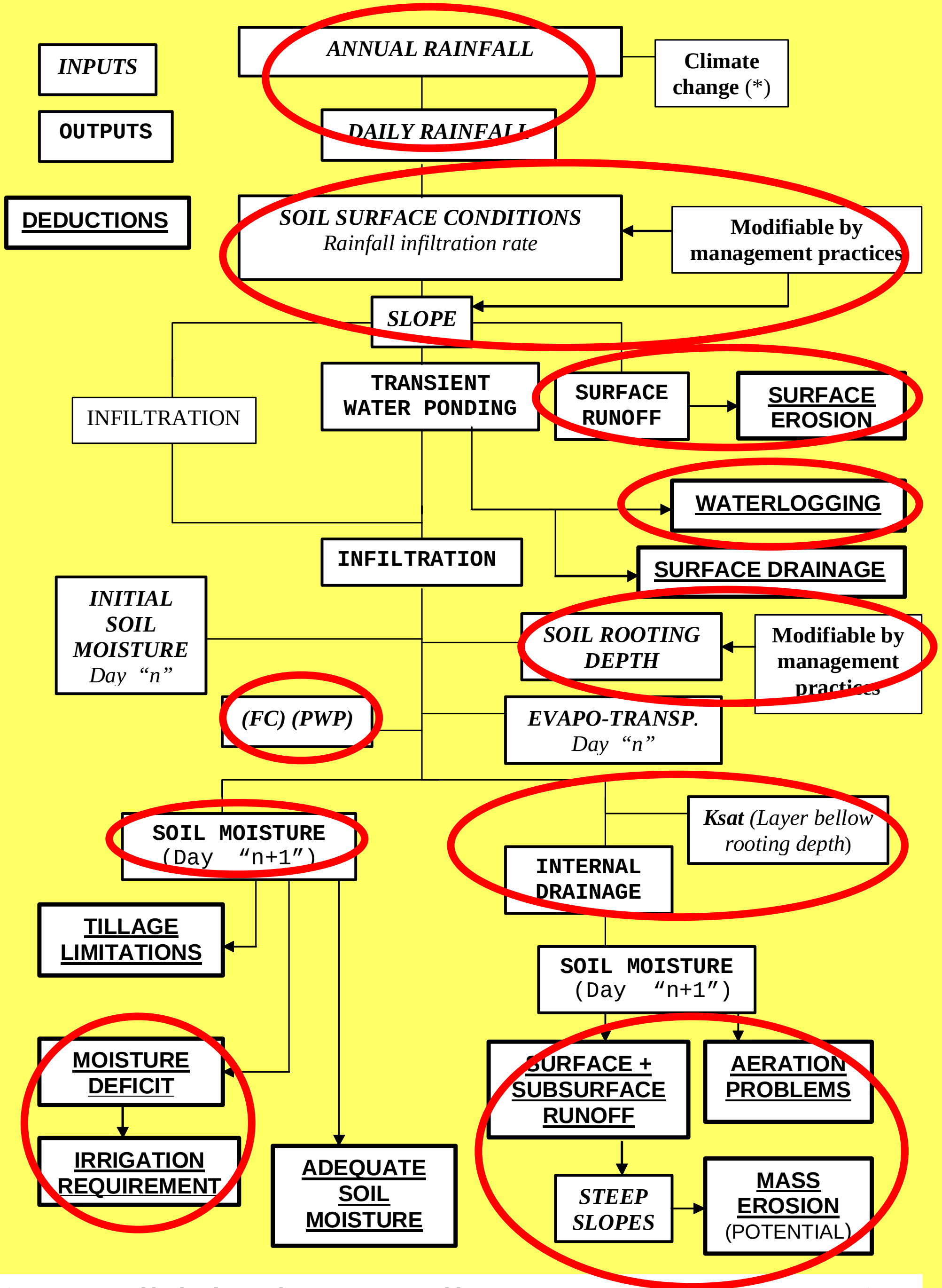
- **different climate conditions (based on historical records)**
- **hydrological properties (evaluated under field conditions)**

using the model SOMORE (Pla, 1997), based on hydrological processes

Model

SOMORE

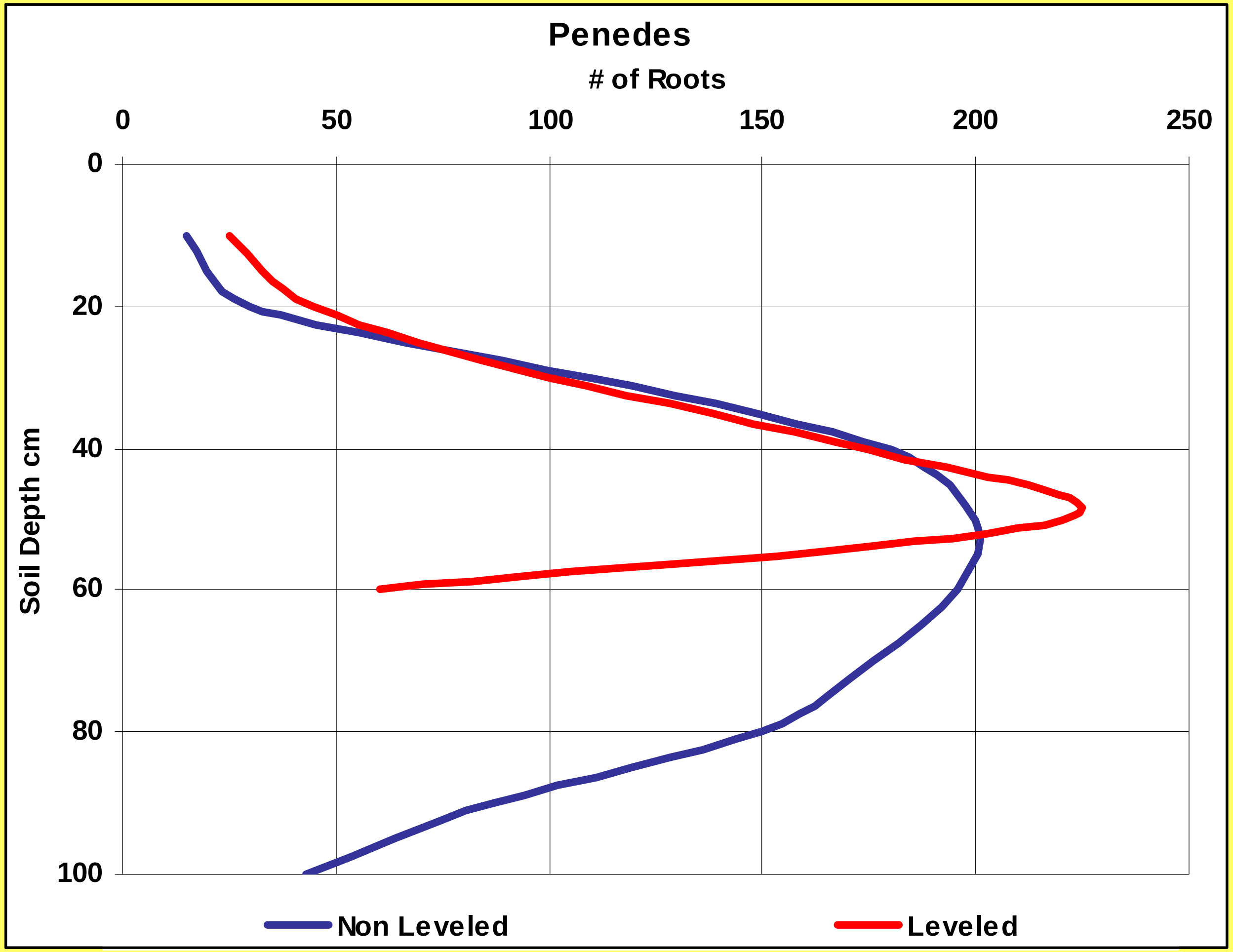
(Pla, 1997)

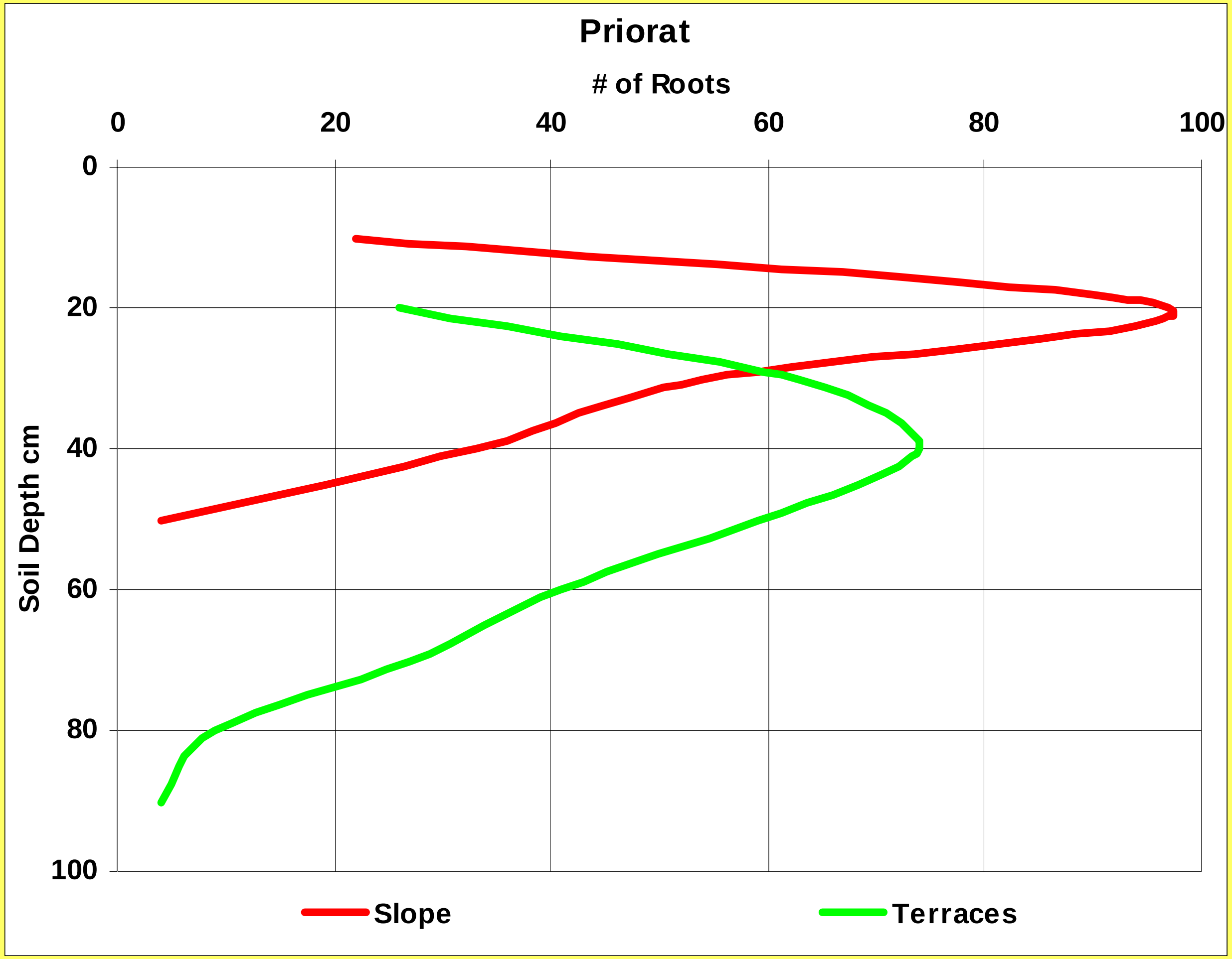


(*Ksat*: Saturated hydraulic conductivity; *FC*: Field Capacity; *PWP*: Water retention at 1,5 Mpa)

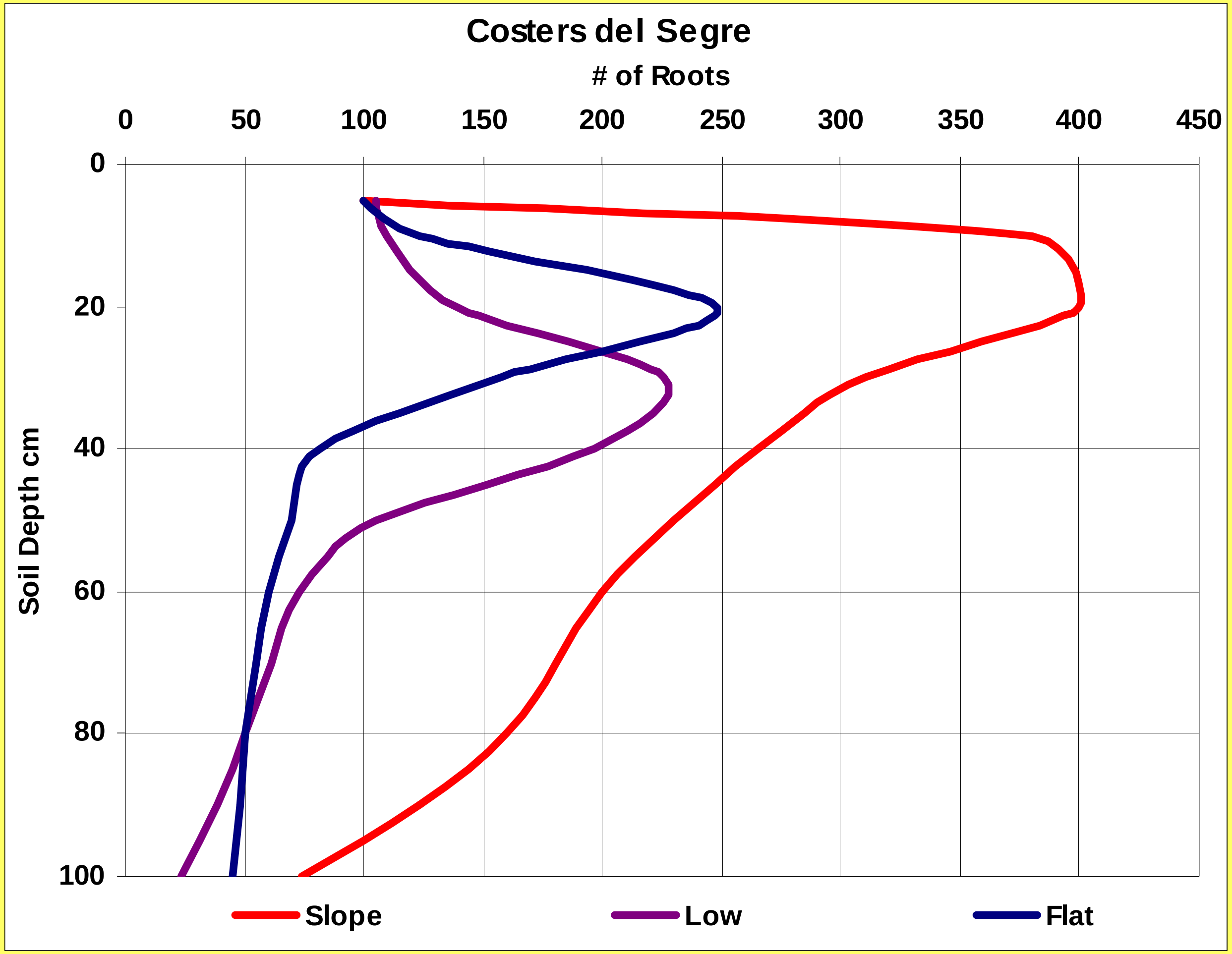
	Slope *%*	Coarse fraction *%*	Effective rooting depth *cm*	AWC *mm*	Rainfall Infiltration *mm/hour* No cover	Rainfall Infiltration *mm/hour* Cover	K sat (subsoil) *mm/hour*
PENEDÉS							
NON LEVELED	***10***	***<5***	***20 → 80***	***200***	***20***	***50***	***3***
LEVELED	***6***	***5-10***	***15 → 60***	***120***	***5***	***20***	***0,4***
PRIORAT							
SLOPES	***50***	***50-60***	***0 → 40***	***61***	***>200***	***>200***	***>200***
TERRACES	***0***	***30-60***	***10 → 70***	***110***	***>100***	***>100***	***>100***
COSTERS DEL SEGRE							
SLOPE	***10-12***	***10-15***	***10 → 100***	***160***	***6***	***18***	***2,4***
LOW LAND	***0***	***8-10***	***5 → 55***	***110***	***1***	***6***	***1,3***
FLAT LAND	***0***	***5-7***	***5 → 50***	***90***	***10***	***45***	***30***

(AWC: Available water capacity)

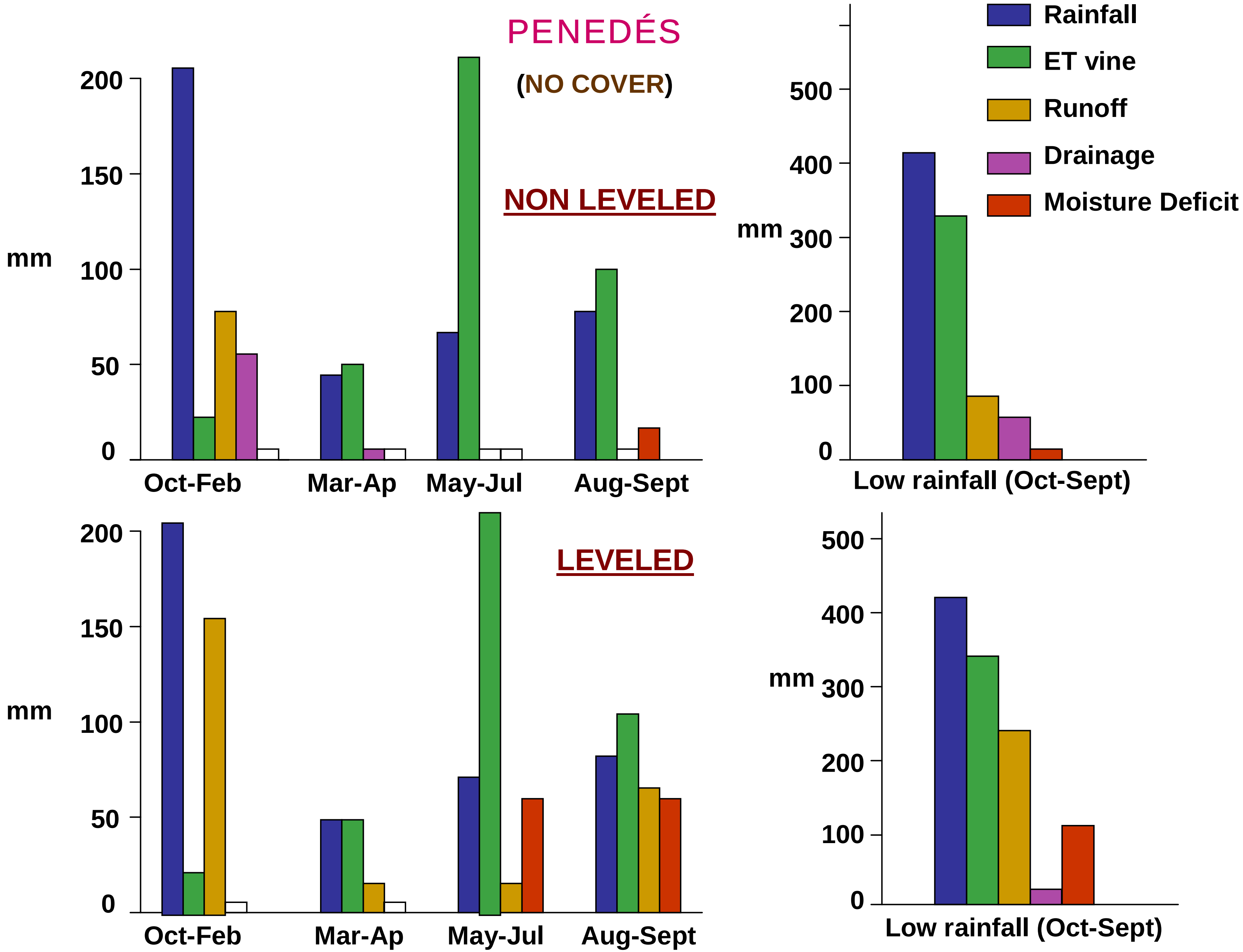

Penedes
# of Roots
0
50
100
150
200
250
Soil Depth cm
0
20
40
60
80
100
Non Leveled
Leveled

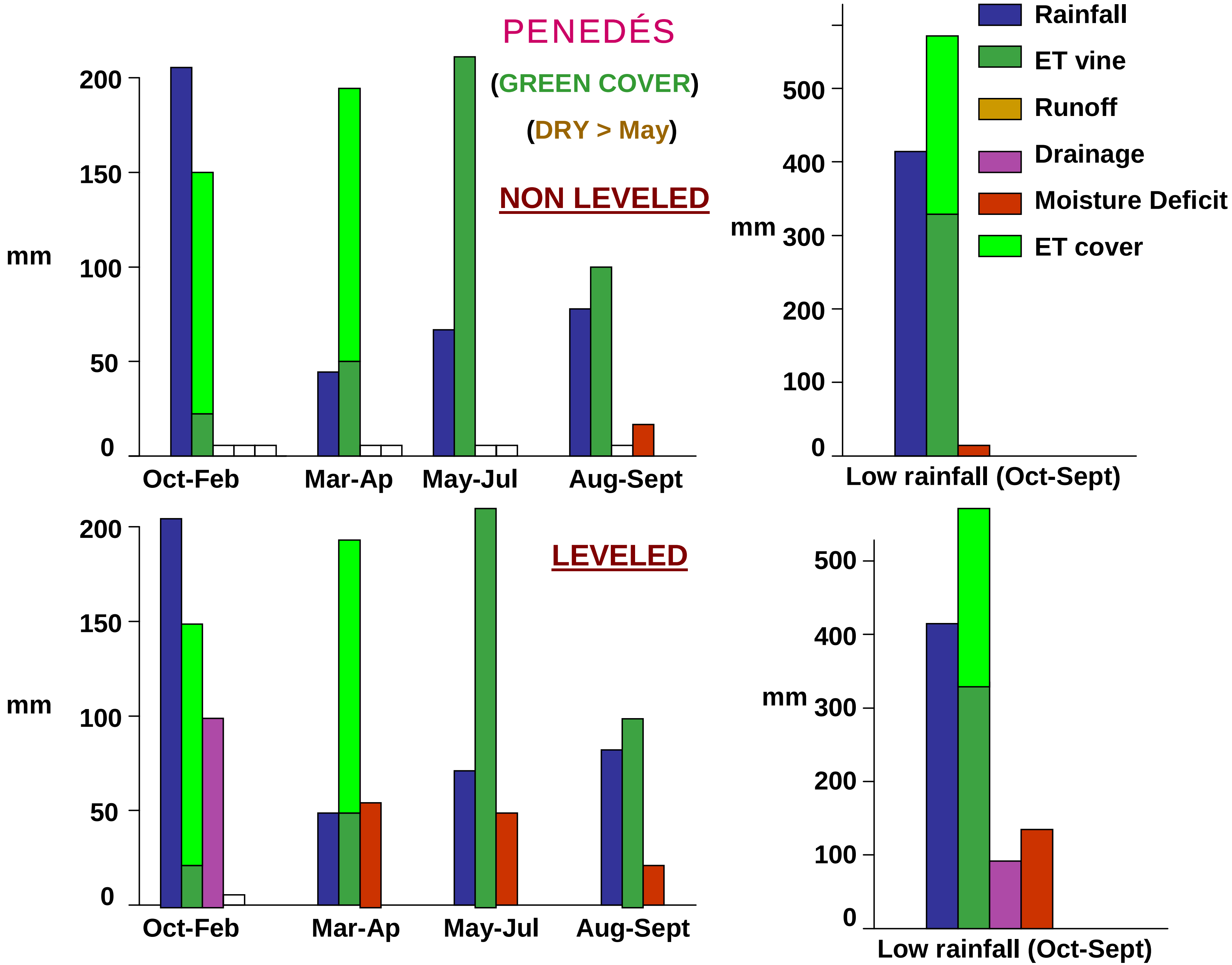


Priorat
# of Roots
0
20
40
60
80
100
Soil Depth cm
0
20
40
60
80
100
Slope
Terraces


Costers del Segre
# of Roots
0
50
100
150
200
250
300
350
400
450
Soil Depth cm
0
20
40
60
80
100
Slope
Low
Flat


PRIORAT


PENEDÉS
(NO COVER)
NON LEVELED
LEVELED
Rainfall
ET vine
Runoff
Drainage
Moisture Deficit
mm
200
150
100
50
0
500
400
300
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
Low rainfall (Oct-Sept)

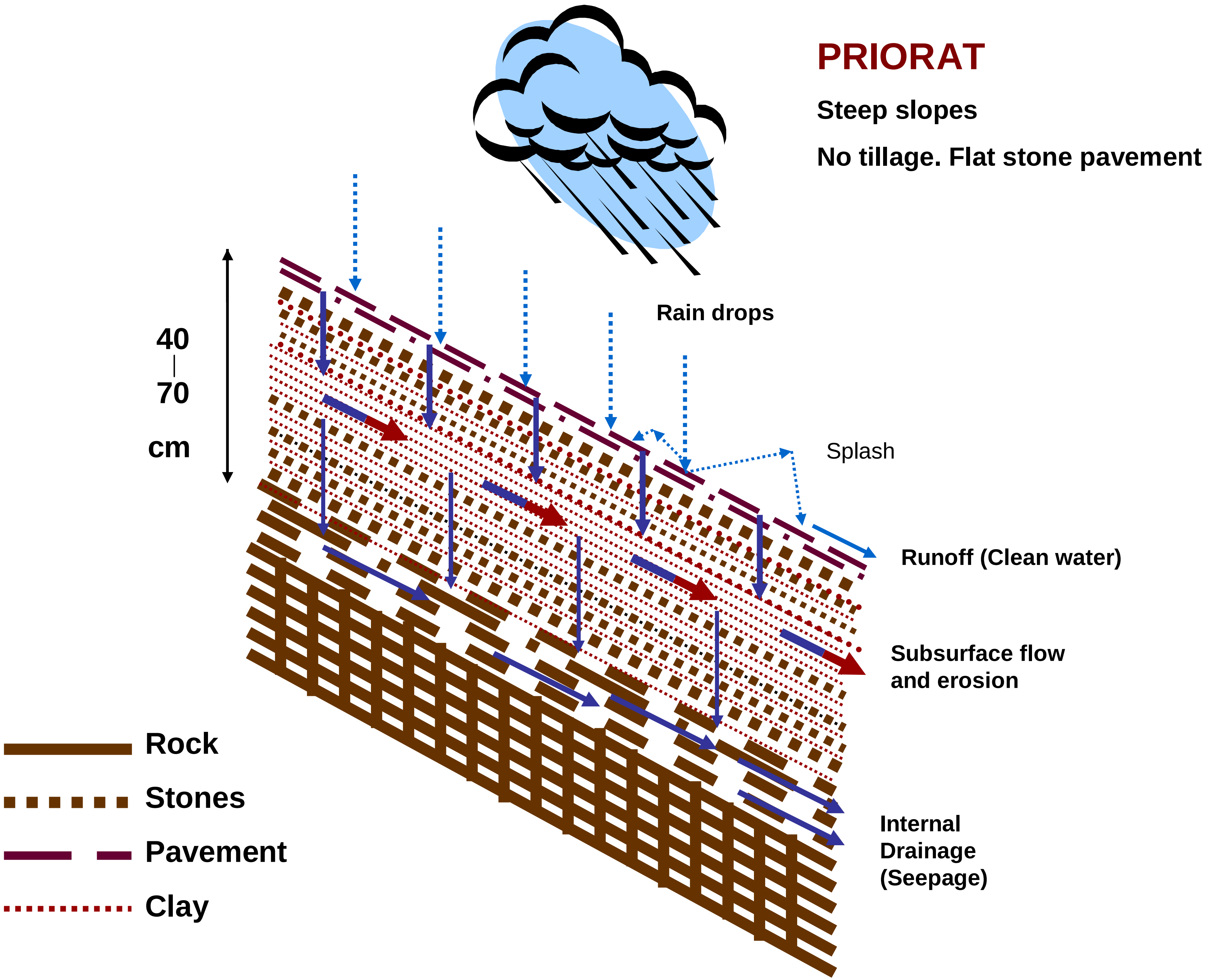


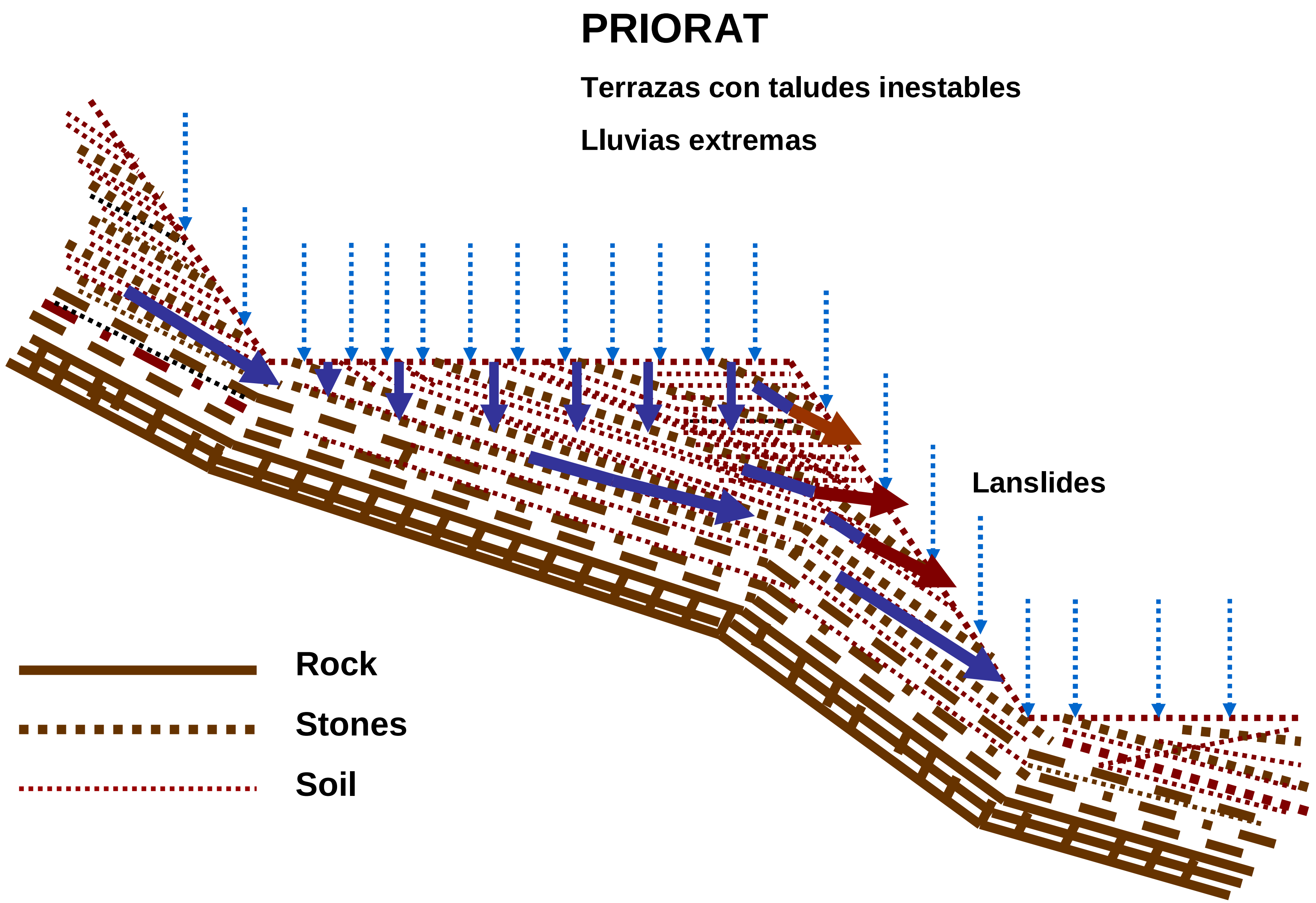
PENEDÉS
(GREEN COVER)
(DRY > May)
NON LEVELED
LEVELED
mm
200
150
100
50
0
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
500
400
300
200
100
Low rainfall (Oct-Sept)
Rainfall
ET vine
Runoff
Drainage
Moisture Deficit
ET cover

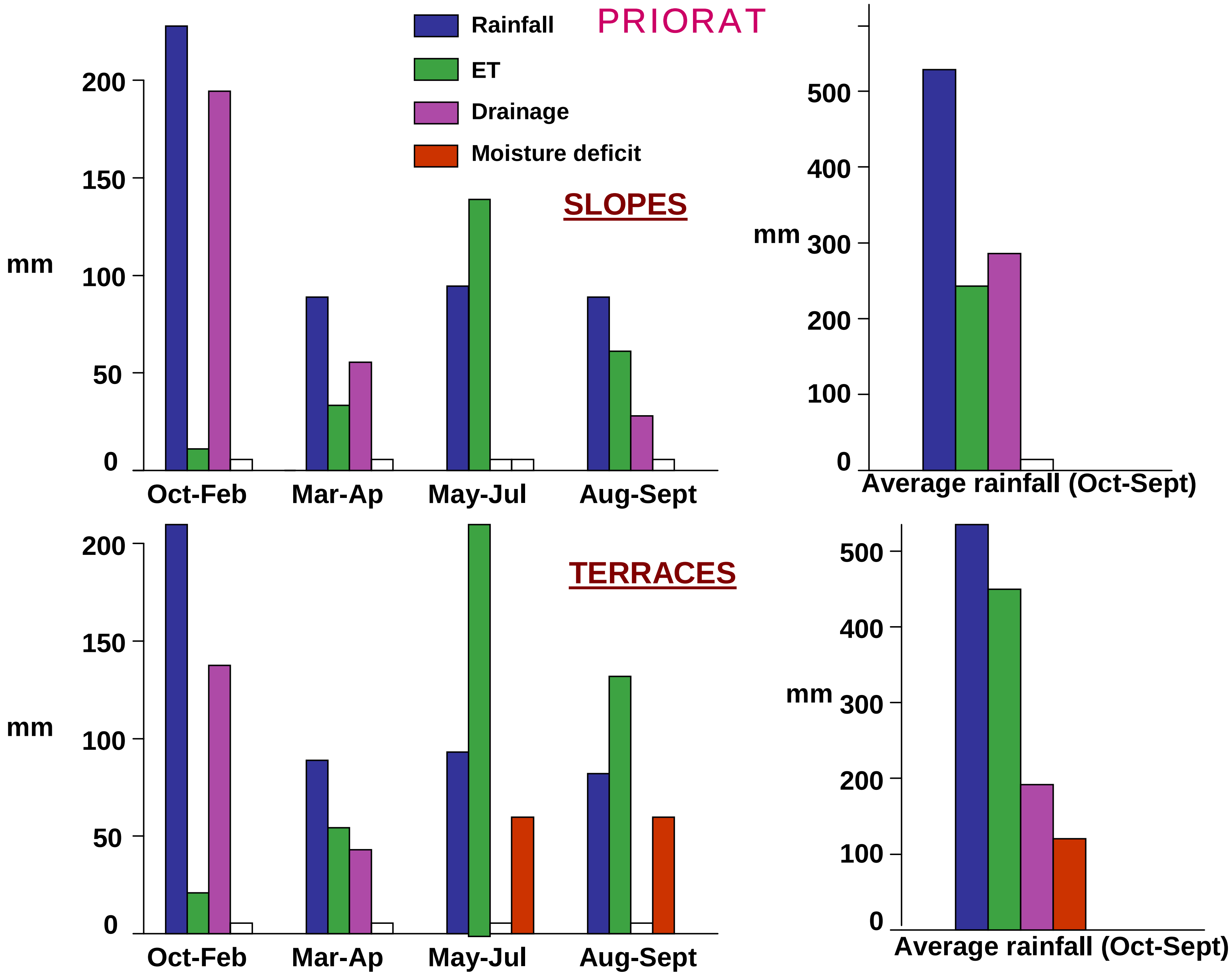

PRIORAT

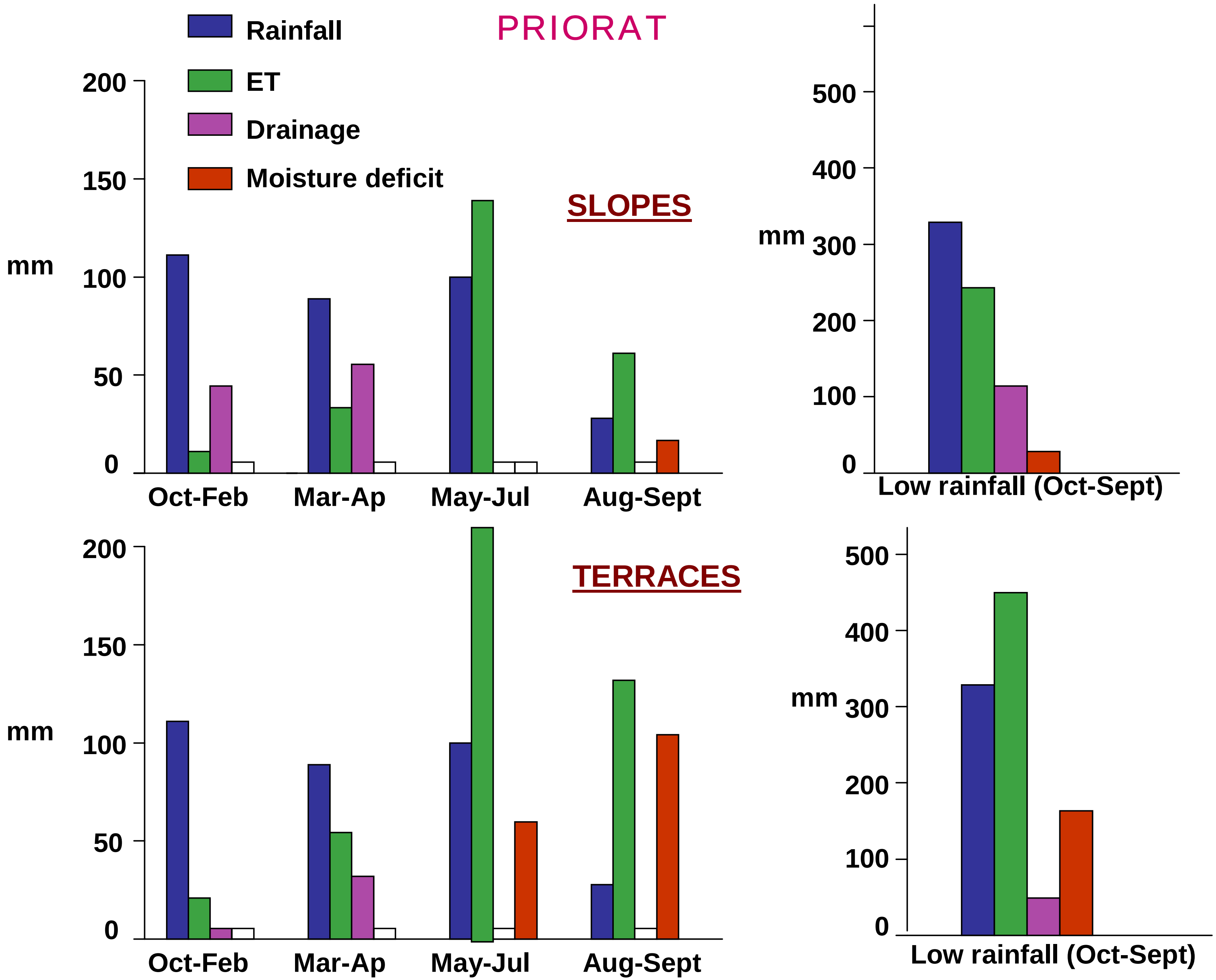


PRIORAT

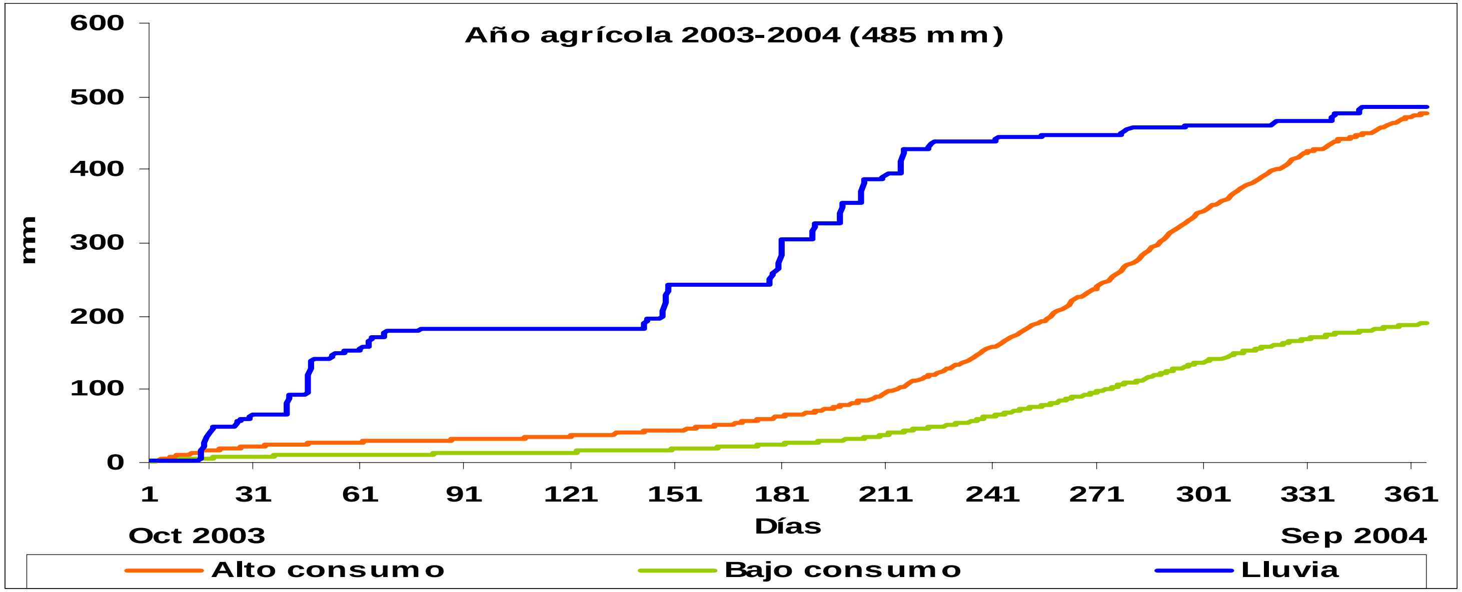


PRIORAT
Steep slopes
No tillage. Flat stone pavement
Rain drops
Splash
40
70
cm
Runoff (Clean water)
Subsurface flow
and erosion
Internal
Drainage
(Seepage)
Rock
Stones
Pavement
Clay

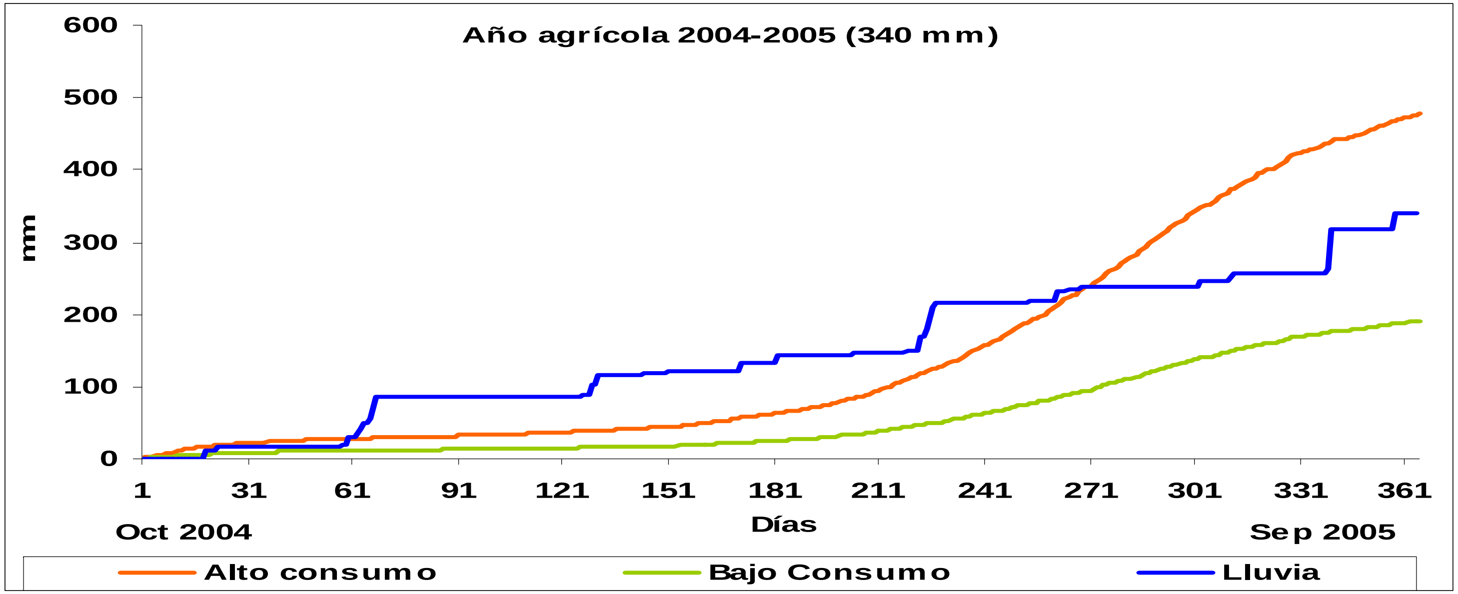

PRIORAT
Terrazas con taludes inestables
Lluvias extremas
Lanslides
Rock
Stones
Soil

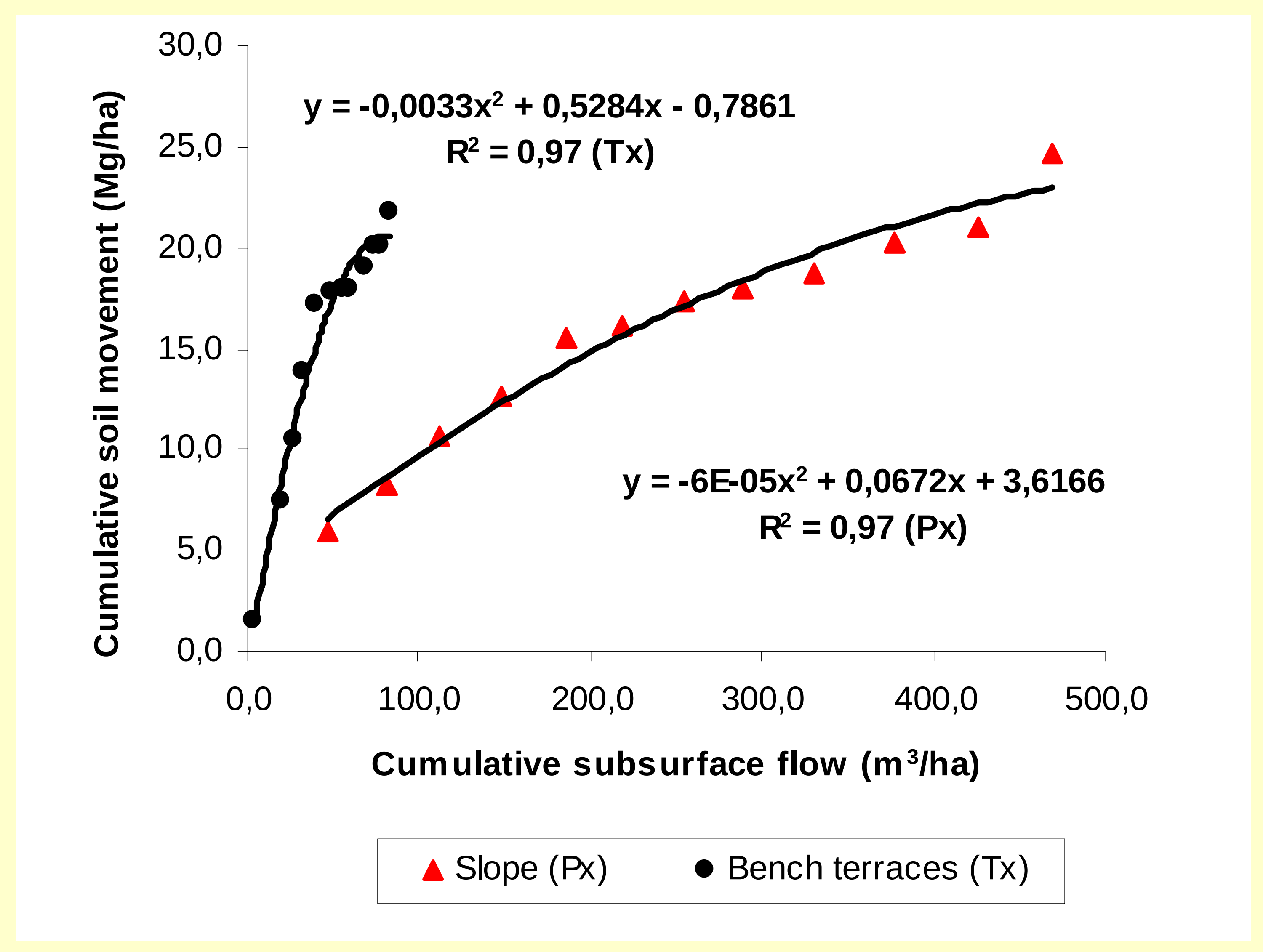

PRIORAT
Rainfall
ET
Drainage
Moisture deficit
SLOPES
TERRACES
mm
0
50
100
150
200
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
mm
0
100
200
300
400
500
Average rainfall (Oct-Sept)



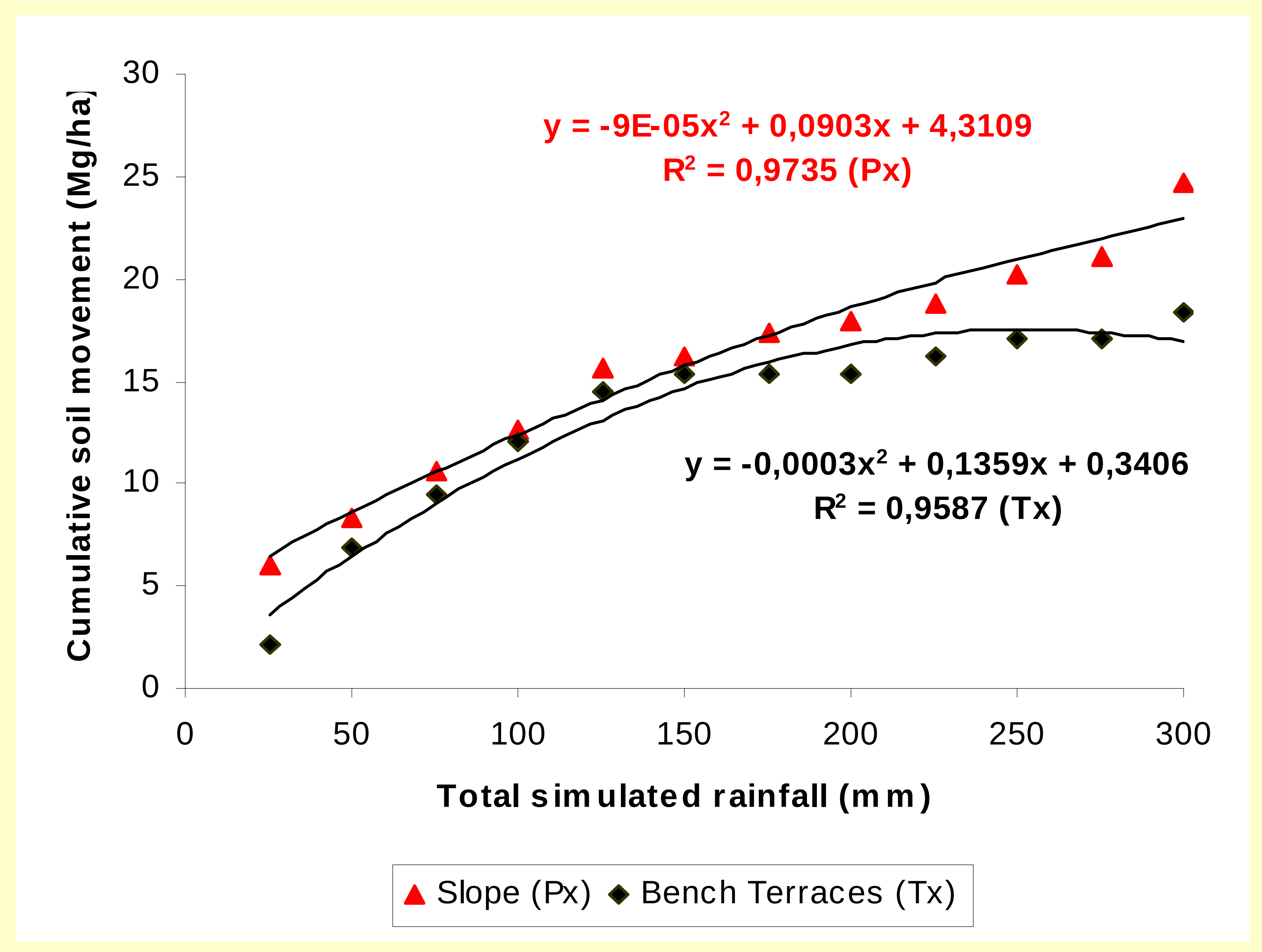
PRIORAT
Rainfall
ET
Drainage
Moisture deficit
SLOPES
TERRACES
mm
200
150
100
50
0
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
500
400
300
200
100
Low rainfall (Oct-Sept)


Año agrícola 2003-2004 (485 mm)
600
500
400
300
200
100
0
mm
1
31
61
91
121
151
181
211
241
271
301
331
361
Oct 2003
Días
Sep 2004
Alto consumo
Bajo consumo
Lluvia

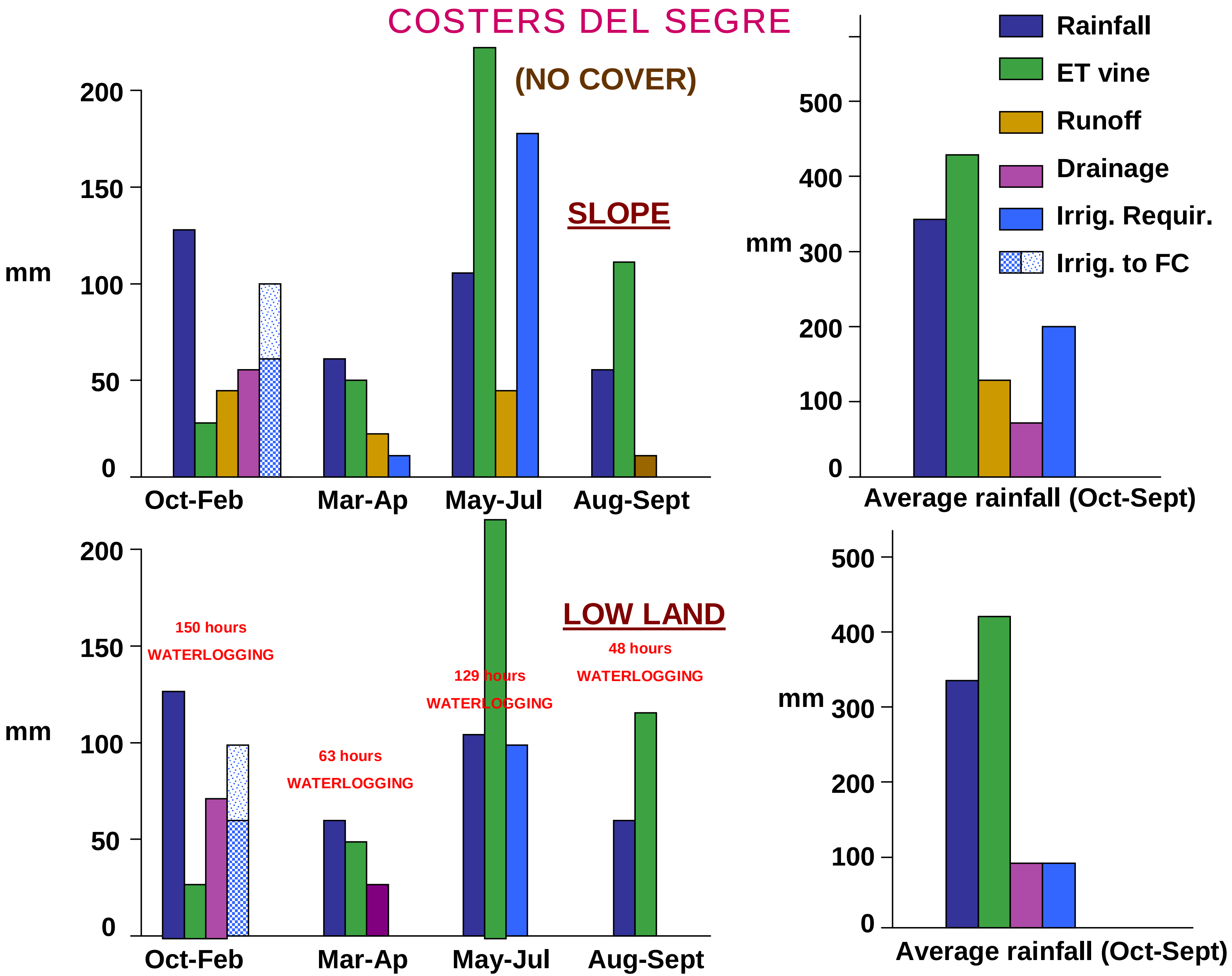

Año agrícola 2004-2005 (340 mm)
600
500
400
300
200
100
0
mm
1
31
61
91
121
151
181
211
241
271
301
331
361
Oct 2004
Días
Sep 2005
Alto consumo
Bajo Consumo
Lluvia

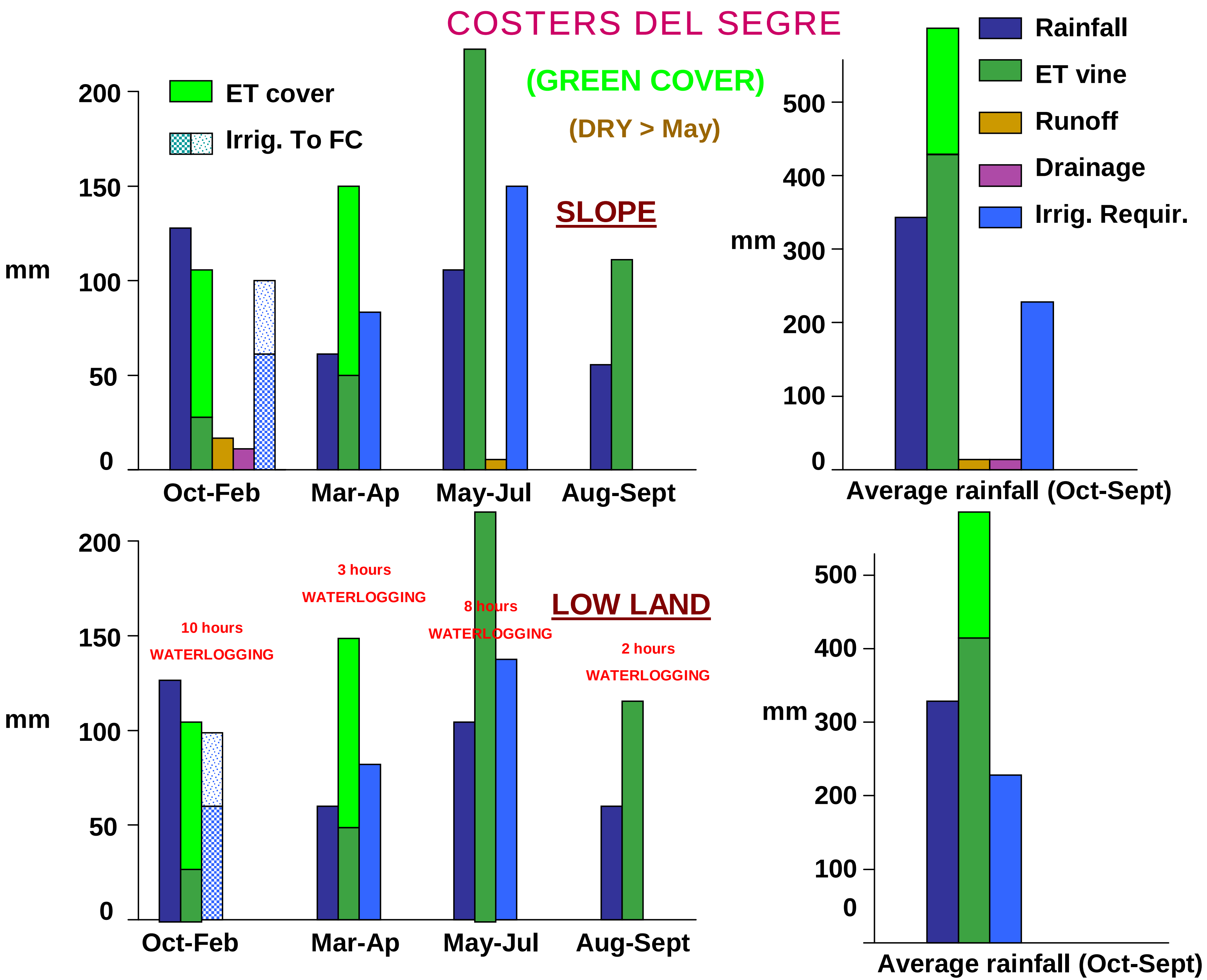


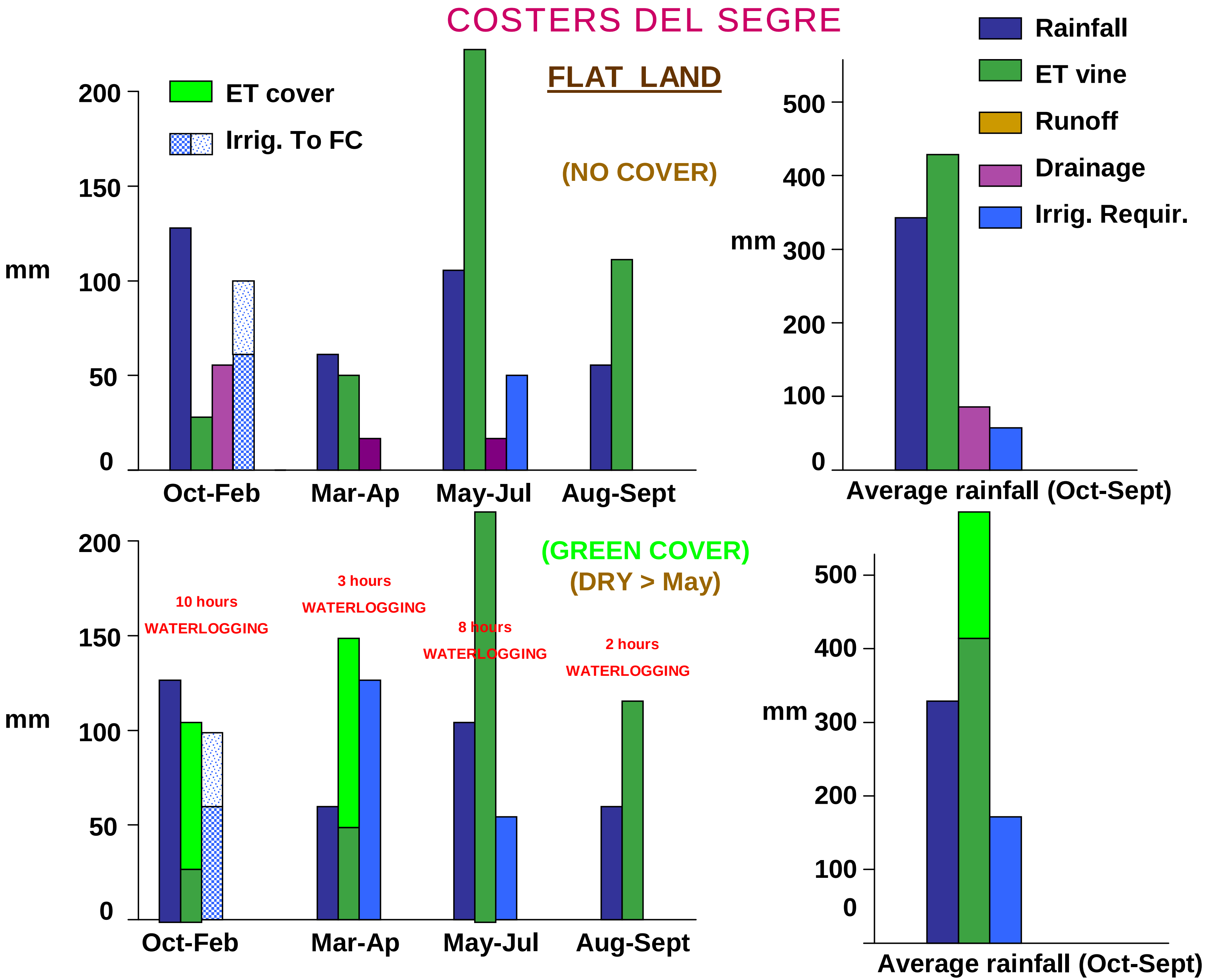
30,0
25,0
20,0
15,0
10,0
5,0
0,0
Cumulative soil movement (Mg/ha)
y = -0,0033x2 + 0,5284x - 0,7861
R2 = 0,97 (Tx)
y = -6E-05x2 + 0,0672x + 3,6166
R2 = 0,97 (Px)
0,0
100,0
200,0
300,0
400,0
500,0
Cumulative subsurface flow (m3/ha)
Slope (Px)
Bench terraces (Tx)



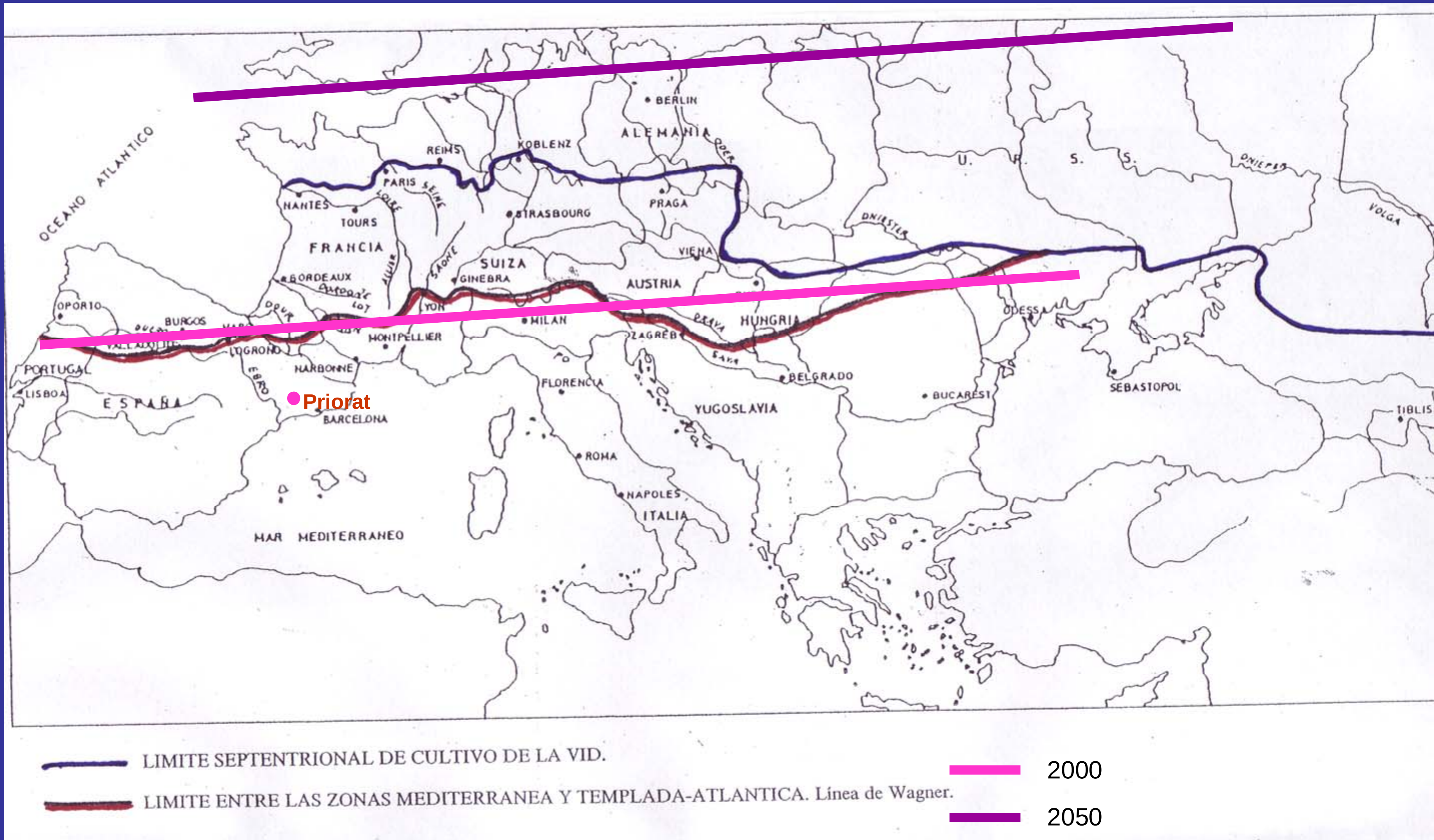
y = -9E-05x2 + 0,0903x + 4,3109
R2 = 0,9735 (Px)
y = -0,0003x2 + 0,1359x + 0,3406
R2 = 0,9587 (Tx)
Cumulative soil movement (Mg/ha)
Total simulated rainfall (mm)
0
5
10
15
20
25
30
0
50
100
150
200
250
300
Slope (Px)
Bench Terraces (Tx)


COSTERS DEL SEGRE
(NO COVER)
SLOPE
LOW LAND
mm
200
150
100
50
0
500
400
300
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
Average rainfall (Oct-Sept)
Rainfall
ET vine
Runoff
Drainage
Irrig. Requir.
Irrig. to FC
150 hours
WATERLOGGING
63 hours
WATERLOGGING
129 hours
WATERLOGGING
48 hours
WATERLOGGING


COSTERS DEL SEGRE
(GREEN COVER)
(DRY > May)
SLOPE
ET cover
Irrig. To FC
Rainfall
ET vine
Runoff
Drainage
Irrig. Requir.
mm
200
150
100
50
0
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
500
400
300
200
100
0
Average rainfall (Oct-Sept)
LOW LAND
10 hours
WATERLOGGING
3 hours
WATERLOGGING
8 hours
WATERLOGGING
2 hours
WATERLOGGING
mm
200
150
100
50
0
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
mm
500
400
300
200
100
0
Average rainfall (Oct-Sept)



COSTERS DEL SEGRE
FLAT LAND
(NO COVER)
ET cover
Irrig. To FC
Rainfall
ET vine
Runoff
Drainage
Irrig. Requir.
mm
200
150
100
50
0
Oct-Feb
Mar-Ap
May-Jul
Aug-Sept
500
400
300
200
100
0
Average rainfall (Oct-Sept)
(GREEN COVER)
(DRY > May)
10 hours
WATERLOGGING
3 hours
WATERLOGGING
8 hours
WATERLOGGING
2 hours
WATERLOGGING


OCEANO ATLANTICO
BERLIN
ALEMANIA
KOBLENZ
REIMS
PARIS
SEINE
NANTES
LOIRE
TOURS
STRASBOURG
PRAGA
ODER
U. R. S. S.
DNIEPER
VOLGA
DNIESTER
FRANCIA
SUIZA
GINEBRA
VIENA
AUSTRIA
BORDEAUX
OPORTO
BURGOS
VALLADOLID
LOGROÑO
NARBONNE
MONTPELLIER
YON
MILAN
ZAGREB
HUNGRIA
DRAVA
SAVA
BELGRADO
ODESSA
SEBASTOPOL
PORTUGAL
LISBOA
ESPAÑA
EBRO
Priorat
BARCELONA
FLORENCIA
YUGOSLAVIA
BUCAREST
TIBLISI
ROMA
NAPOLES
ITALIA
MAR MEDITERRANEO
LIMITE SEPTENTRIONAL DE CULTIVO DE LA VID.
LIMITE ENTRE LAS ZONAS MEDITERRANEA Y TEMPLADA-ATLANTICA. Línea de Wagner.
2000
2050

CONCLUSIONS

-The recent changes in land and crop management in dryland vineyards for wine production in the Mediterranean regions of NE Spain have mainly affected the hydrology of the cropped lands. These effects could be increased under the previewed future climate changes in the Mediterranean region

-The main effects are changes in the soil moisture regime, which under Mediterranean climate is the main factor affecting the quantity and quality of wine production

-The previewed influences of the different land and crop management practices on the soil water regime are required to rationally establish the basis for a more effective soil and water management and conservation, leading to a more sustainale and regular production of high quality wines

-The soil water regime under the different and variable climate, soils and land management of the study sites could be reasonably well predicted with the adequate simulation of the hydrological processes, based on climate information and on changes in the soil water balance derived from the soil hydrological properties properly evaluated under field conditions

-Many of the available commercial equipments and "standard" methodologies to evaluate soil physical and hydrological properties are useless or require major adaptations or changes to make adequate measurements in the field under the very particular soil characteristics, climate and topography in the areas with vineyards in the Mediterranean region. The same happens with the use of pedotransfer functions to deduce such properties.

-The use of data obtained with such equipment and pedotransfer functions, without a critical validation under the particular conditions of climate, topography and soils where they are used, may lead to great errors in the evaluation of the hydrological proceses and their effects, related to different land management systems in dryland vineyards.

It may be concluded that :

The <u>processes of soil and water degradation</u> are <u>closely linked through unfavorable alterations in the hydrological processes</u> determining the soil water balance and the soil water regime.

They are also <u>conditioned by the climatic conditions and by the use and management</u> of the soil and water resources.

Therefore, <u>an hydrological approach to the evaluation and prediction of the conservation of soil and water</u> against degradation processes would be <u>essential for an adequate development, selection, and application of sustainable and effective use and management practices.</u>

New research approaches based on the evaluation of the hydrological processes, under different scenarios on changing climate, soil properties, and soil and crop management, with the use of practical and flexible models and computer based programs, would help to select or develop more adequate packages of technologies to reduce soil and water degradation, and to control their growing negative effects on crop productivity, degradation of ecosystems, and on derived catastrophic events in the whole World

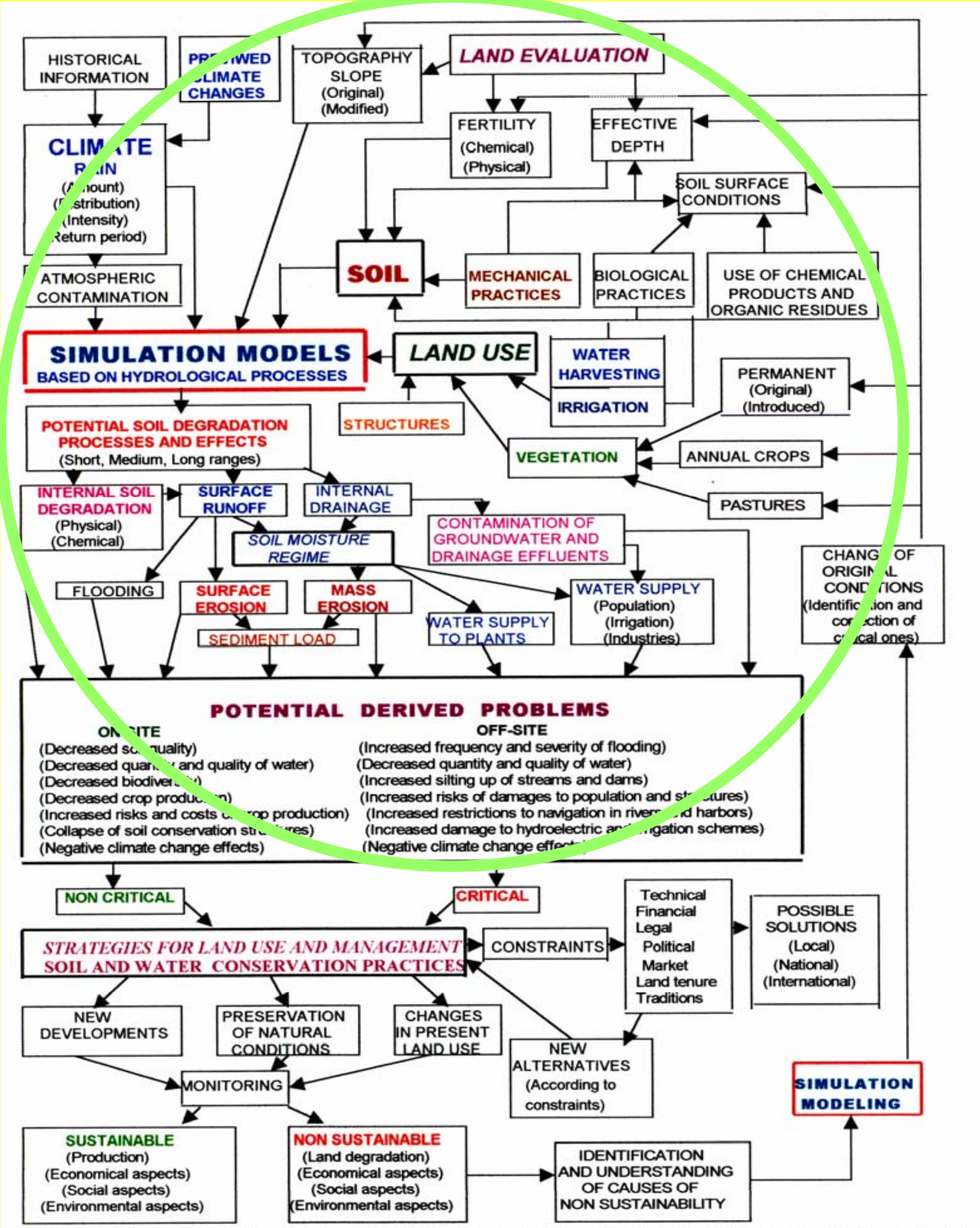


Figure 2. Simulation modeling for evaluating potential soil degradation processes, causes and effects on site and off site, and for planning land use, management and soil and water conservation practices.

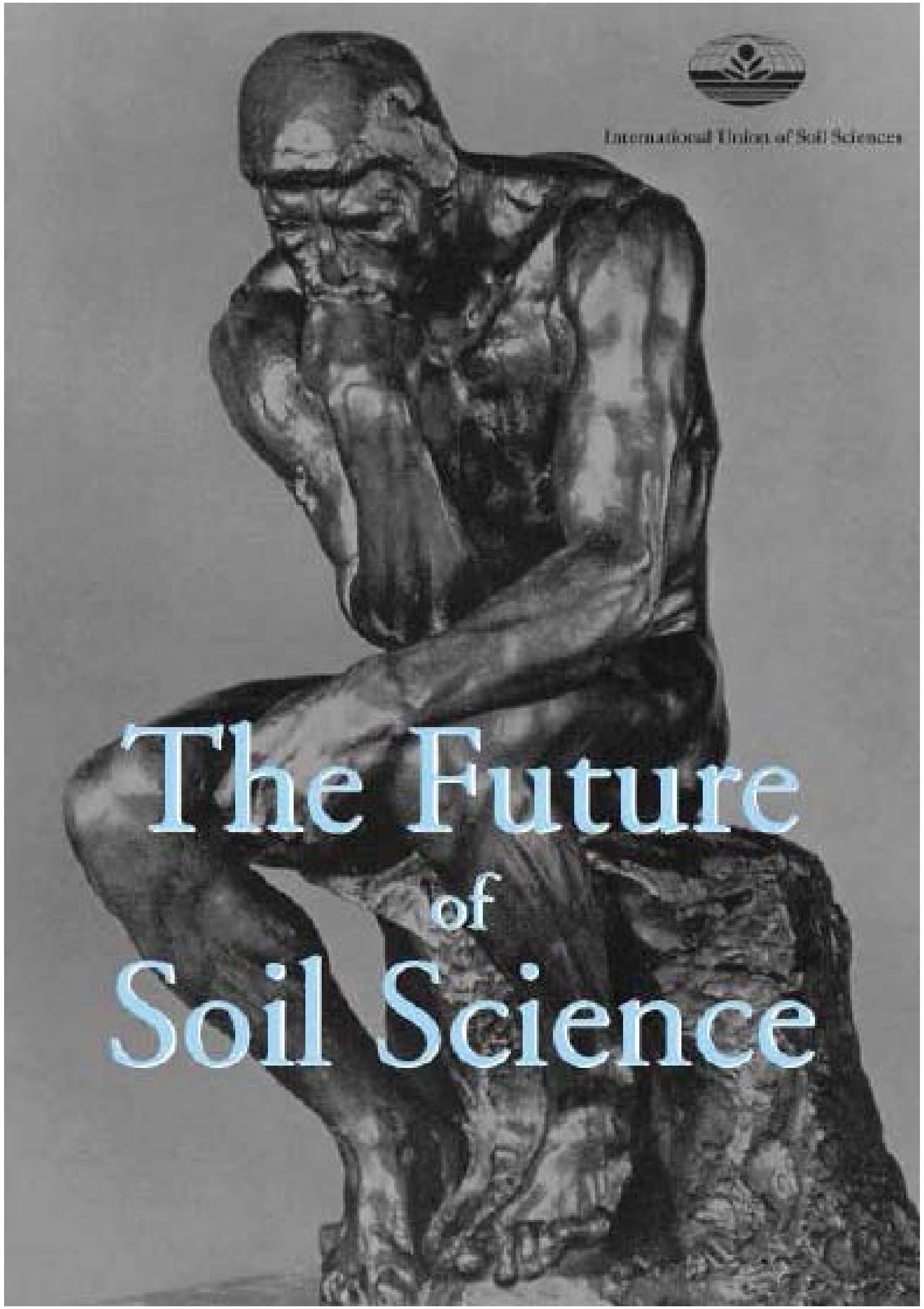
INFLUENCED BY

OR

WITH INFLUENCE

ON

SOIL PHYSICAL PROPERTIES



Future of soil science

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Soil is fundamental to the needs of man life, because it provides most of our basic needs and plays a central role in determining the quality of our environment, but this is not well appreciated by most of the population. In the future, the role of soils and soil cover in some crucial aspects for man's life like food production, the hydrological cycle, and air composition will further increase. Therefore, more soil information of good quality will be required for adequate decisions about land use and management. The main and final goal of soil science will continue to be the evaluation and prediction of the behaviour of soils in time and space, under a wide range of agricultural and non agricultural land uses, in relation to crop production, water supply and environment quality. At present, most of the major decisions about agriculture and environment, and in general about world development, are usually made without taking into consideration the prominent role of soil science.

Present situation

The rapid increase in population, with higher food and water demands, is causing more human influences on soils, both through the expansion and intensification of agricultural activities and the growth of number and size of populated areas. Frequently, it leads to widespread land and soil degradation, and increased production of farming, domestic and industrial wastes. The main consequences are a decrease in the reserves of arable lands, increasing agricultural developments in new lands with unfavourable climate and relief conditions. There is a decrease in available good quality water for agriculture, urban and industrial needs, and a decrease in biological diversity.

These problems may lead to dramatic environmental, social and economic consequences that in the poorer developing regions are manifested trough decreased crop productivity, increased poverty and migration. There are also increased risks and problems of desertification, flooding, landslides, sedimentation, etc. The shrinkage of water resources of good quality is limiting the development of irrigated agriculture, and is increasing the risks of salinization and contamination of soils. It is also worth to mention the contribution of changes in soil cover and soil degradation to global climate changes. The increased degradation of soils and their consequences may be attributed to the lack of awareness by most of the human society, and of the institutions where decisions of land use and management planning are taken, about the capital role and functions of soils for man life.

Although contributions of soil science have benefited humankind by increasing agricultural food production and enhancing the environmental quality, at present there is a dangerous general slowdown on those trends. Concurrently, there has been a decrease in resources dedicated to field oriented soil science studies, and much of the present research in soil science is dedicated to isolated aspects, not covering integral problems, due to limitations of time and funds, to the difficulties of interdisciplinary cooperation, and to the compulsion of publishing papers quickly. At the same time, there has been an increased tendency to rely on qualitative data and concepts, based on expert judgements, like indices of soil quality, with a very limited accuracy, insufficient for developing adequate policies for land use and management. Moreover, frequently land use planning is being based on empirical approaches coming from professionals with scarce formation in soil science.

Planning land use and management requires input data which is site specific, but in many cases the kind of required information is not available. One of the difficulties found in the assessment of soil conditions related to the performance of soils under different land use and management, and climate change, based on already existing data, is that most of the previously made soil surveys provided static information, while for soil functions there are necessary more dynamic soil parameters. Modelling is extensively used as a tool to integrate information, and to avoid measurements and field experiments for every soil and condition. Modelling is not a substitute for experimentation and models need input parameters of good quality, obtained not only in laboratory tests, but also under controlled field conditions. These studies are not common because they are time consuming, costly and difficult to finish in a publication fulfilling the requirements of soil science journals. Therefore, they are substituted in many cases by empirical approaches, or the use of data that are already available or easier to obtain, empirically deducing, by the use of pedotransfer functions, of properties and processes required for modelling. Much of the accepted and used methodology and instruments for evaluating parameters of soils in the laboratory do not give data which correspond to real, or even approximate, values under field conditions. In general, the progress in developing models and processing systems of information have been much faster than in the development and use of methodologies and equipment to get the adequate field information to feed them.

Challenges for the future

In general the future developments in soil science research must be directed to a better understanding of the processes and reactions in soils related with crop production, chemical recycling and water balance, over a range of spatial and temporal scales. Of particular importance will be the improved identification and description of important dynamic processes in soils critical for the supply of water and nutrients for plant growth and for soil degradation, as affected by external temporal factors like climate. This has to be followed by the development of simplified simulation models to find the best combination of management practices, integrating selected critical parameters of soils, crops and climate, for a more efficient and economical use of soil water and energy addressed to increased crop production, overcoming depletion and minimizing risks of soil, water and environmental degradation, including risks of natural disasters like flooding and landslides.

In order to assure the prominence that soil science should have in the future World development there will be necessary to improve the education and awareness of population at all levels about the relevant functions of soils for the life of mankind. There are also required an improvement and a reorientation in the training in soil science addressed to soil scientists and other professionals involved in the design and planning of land use and management, with a more holistic approach, reinforcement of hydrological aspects and a better integration of theory and field work. To guarantee an interdisciplinary approach there would be necessary an increased cooperation among soil scientists and scientists of related disciplines, and among institutions involved in research and application of soil and land use and management.

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