GESTION CONSERVATOIRE DE L' EAU ET DE LA FERTILITE DES SOLS EN MONTAGNE SEMI ARIDE ALGERIENNE.

par

MOURAD ARABI *
et
ERIC ROOSE.**

RESUME

Depuis 1950, des pressions démographiques et socio-économiques ont contribué à développer une sévère dégradation des sols, de la couverture végétale et des rivières dans la zone septentrionale de l'Algérie. Les processus en cause sont variés. Dégradation suite au surpâturage, au défrichement et à la minéralisation accélérée des matiéres organiques. Erosion en nappe sélective (0.1 à 20 t/ha/an) et décapage des horizons humifères par rigoles et surtout par érosion mécanique sèche durant le travail du sol (10 à 50 t/ha/an), ravinement (100 à 300 t/ha/an) et glissement des terrains marneux, déstabilisation des berges et des versants.

Des mesures sur 15 parcelles d'érosion (100 m2) sur 4 systèmes de production et 4 types de sols sur des versants à fortes pentes ont fait ressortir l'originalité des problèmes de lutte antiérosive en zone méditerranéenne:

Les pluies sont beaucoup moins énergétiques qu'en région tropicale, à part quelques orages de fréquence rare (100 à 400 mm en 1 à 5 jours) qui laissent des blessures profondes dans le paysage;

Les sols (vertisols, lithosols, sols fersiallitiques et sols bruns calcaires) sont très résistants à la pluie car ils sont argileux, saturés en calcium et souvent caillouteux;

L'érosion en nappe, négligeable sous végétation naturelle (0.1 à 0.5 t/ha/an), est modérée sous cultures peu couvrante (0.1 à 20 t/ha/an);

Le ruissellement par contre, peut être trés abondant lorsque le sol est saturé, compacté ou peu couvert en hiver. C'est ce ruissellement venant des versants qui est à l'origine du fort ravinement et des transports solides des oueds qui envasent rapidement les barrages;

Les rendements en culture améliorée passent de 7 à + de 45 quintaux pour le blé d'hiver, de 2.8 à 4 t/ha/an pour le raisin auxquels il faut ajouter 3 t/ha/an de blé ou de fèves en culture associée. De plus, la paille et les autres résidus de culture augmentent nettement (de 0.2 à 2 ou 3 t/ha/an) de telle sorte que la production animale et la disponibilité en fumier, si important pour améliorer la fertilité et la stabilité du sol, peuvent aussi s'améliorer;

Le revenu net peut être multiplié par 3 à 20 selon le type de système de production choisi. Avec un tel bénéfice en vue (même s'il sera plu modeste en grande parcelle), it doit être assez facile de convaincre un paysan d'adopter de nouvelles pratiques culturales parmi lesquelles sont incluses les techniques antiérosives les mieux adaptées aux conditions écologiques et économiques du paysan.

Les stratégies de LAE ont beaucoup évolué. Les stratégies traditionnelles, nombreuses dans cette région semi-aride, disparaissent pour des raisons économiques (meilleure valorisation du travail à l'usine). Les stratégies d'équipement hydraulique rural (RTM, DRS et même CES) sont mal acceptées par les paysans (beaucoup de travail à la mise en place et à l'entretien, perte de terrain de culture sans amélioration sensible de la productivité du sol et du travail). La gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols répond mieux à l'attente des paysans.

Mots clés: Algérie, montagne méditerranéenne, semi-aride, lutte antiérosive, stratégie G.CES, érodibilité des sols, érosivité des pluies, amélioration des techniques culturales, érosion, ruissellement, revenu net.

---

* M. ARABI - Ingénieur de Recherche à l' INRF, BP 16, Ouzera, 26100 Medea, Algérie.

** E. ROOSE - Directeur de recherche en Pédologie à l'ORSTOM, BP 5045, Montpellier, 34032, France.

"WATER AND SOIL FERTILITY MANAGEMENT" (G.C.E.S.) A NEW STRATEGY TO FIGHT EROSION IN ALGERIAN MOUNTAINS

BY

DR. MOURAD ARABI *

AND

DR. ERIC ROOSE **

(*) INRF: Institut National Algérien de Recherches Forestières, BP 37 CHERAGA, Alger, Algérie

(**) ORSTOM : Institut Français de Recherches Scientifiques pour le Développement en Coopération, BP 5045, 34032 Montpellier cedex, France.

1-INTRODUCTION

The Northern part of Algeria is the most productive, but very fragile area: young mountains, often soft argilites, marl and schist alternating with calcareous sandstone hardrocks. The climate is Mediterranean, semi-arid with low energetic but saturating rainfalls during the cool Winter and with dangerous storms in the hot Summer. The soils (regosoils, vertisols, brown calcareous, red fersiallitics soils) are sealing and often stony. They have low nitrogen and phosphorus content. After successive colonizations (Romain, Turkish, French) and a recent very high demographic pressure (51 inhabitants per Km2), there is seen overstoking (6 sheep per hectare) vegetation and soil cover degradation in the mountains, sheet, gully and mass erosion, Wadi river embankment migration, road destruction and rapid silting of reservoirs (in 15 to 50 years).

Facing these serious erosion problems, a strategy of heavy rural equipment (the D.R.S. = Défense et Restauration de Sols = defence and soil restoration) was developped (between 1940 -70) which included:

- reforestation of steep slopes and higher areas of watersheds,
- gully correction and
- terracing cropped fields (banquette Algérienne = graded channel terraces) covering more than 300,000 hectares at a cost of 5 to 10,000 FF/ha.

The main objective was to delay soil degradation and reservoir siltation. But in 1977, the failure of this "equipment approach" was clear. The farmers rejected the terracing system, wood production remained quite low and the reservoir siltation rate remained high. Terracing was abandoned for economic reasons (Heusch, 1986). Foresters continued the reforestation and gully restoration, but the farmers were not assisted except for some land improvements (subsoiling calcareous crusts) (Roose, 1987).

Initial data on runoff plots (Kouidri, Arabi, Roose, 1989) confirmed that sheet erosion from hillslopes gave only a very small part (0,2 to 1 t/ha/year) of river sediments (Heusch, 1970; Demmak 1982). That would explain why terracing was not efficient to reduce silting. Nevertheless, runoff from hillslopes can be very high (up to 80%) during exceptional storms falling on sealed or compacted soils (overstocking of pastures, roads, paths, abandoned fallows, etc...). Consequently runoff water flowing on steep bare slopes create gullies, high wadies peak flows, mass movement and important sedimentation in reservoirs.

Currently, urban industries are experiencing difficulties and the Algerian Government proposes a strategy to maintain the population in the countryside and to intensify the mountain agriculture without degrading dams and water reservoirs essential for the expensing cities and for crop irrigation.

Since 1985 a cooperative program has developed research and training with the participation of dozen researchers of the National Algerian Institute for Research in forestry (INRF) and the French Institute for Research in Cooperation (ORSTOM). This program, named " Water and Soil fertility management" (G.C.E.S. = Gestion Conservatoire de l'eau et de la fertitlite des Sols) covers three sub-programs:

1. Survey on the D.R.S. approach efficiency, first by the Forestry Administration and then by interdisciplinary groups of researchers;
2. Management of microwatersheds (20 to 300 ha) near Medea, Mascara and Tlemcen;
3. Measurement of various erosion processes with a network of runoff plots and gullies.

The objective of this program is to develop a new strategy to fight erosion in Algeria with the agreement of farmers (G.C.E.S.). The program will investigate how to increase the biomass production (the yield and the farmers income) by improving the soil infiltration capacity, the structural stability and the soil fertility, the green cover and consecutively by reducing runoff and erosion losses on the cropped fields and in the drainage system (Roose, 1987; Arabi, 1991).

In this paper, we present the main results obtained at the Ouzera Station (1987-90) (Arabi et Roose, 1990), but similar results were obtained near Tlemcen (Mazour, 1992).

2- "G.C.E.S." A NEW STRATEGY FOR SOIL AND WATER CONSERVATION

In Algeria, water disposal (and reservoir siltation) is a priority problem. Due to 30 years of industrialization the urban population has grown very fast. However soil conservation and terracing do not interest farmers very much because they do not return profit to the supplemental labour and do not increase significantly the land productivity. Degraded soils are already so poor... why preserve them? Without significant investment they will produce little. Therefore in order to interest farmers to preserve their land and the water quality it seems necessary to answer first to their immediate problems: how to increase income and reduce production risks by improving first water and nutrients management on their productive fields? At the same time, the green cover will increase and the runoff + erosion risks will decrease. This approach changes completely the point of view of the planners and the extension staff. With farmers, the first action is to look to the production system, the water and nutrient balance, which are the main obstacles to the productivity of the best fields. If necessary he will stop gully erosion and valorize the sediment management but bad land treatment will generally not be the main objective of the farmers. It was for traditional planners. The Governmental priority is to restore the forest and manage sediments in the torrential wadies.

The new cooperative strategy must be applied in 3 steps:

1 - **Dialogues to develop confidence between farmers, researchers and technicians.** Farmers generally know the local environment better than technicians, but technicians have complementary knowledges. Surveys should be undertaken to determine:

- What are the farmer opinion on their problems (and their solutions) relating to soil degradation? Physical, chemical, biological problems?
- What type of erosion: is present when (what season), where (on the toposequence) and associated with which cultural practice?
- where is the runoff source? How to reduce the runoff volume and manage the drainage?
- What is the importance of erosion and runoff risks?
- What are the locally available resources to reduce runoff and erosion risks?

2 - **Experimentation of improved farming in farmer's fields**

- Evaluation of feasibility, efficiency and risks of antierosive practices.
- Economic aspect: increase of production in relation to labour and cost surplus availability.

3 - General survey of the small-scale watershed management with the rural community:

Comparison of the capability and land use maps to determine where it is necessary to intervene to modify the production system.

In this paper, we present the first results of this GCES approach in Algeria where only the two first steps of inquiries and experimentation have been applied.

3 - FIRST RESULTS FOR STEEP SLOPES FARMING SYSTEMS IMPROVEMENT NEAR MEDEA (fig. 1)

3.1. Experimental conditions

Fifteen runoff plots (22.2 m x 4.5 m) were built on farmers fields around the INRF research station of Ouzera at 90 Km south of Algiers. The landscape is a succession of plateaus (900 to 1,200 m of altitude), steep hillslopes (12 to 40 %) and deep wady valleys. Soils are related to with lithology and the topographic situation (Pouget, 1974; Aubert, 1987). The main soils are:

- clear lithosoils on calcareous sandstone colluvium, rich in $CaCO_3$ but poor in organic matter,
- grey vertisoils on limestone well structured, 2% of O.M., pH 7 to 8, calcium satured, very resistant to splash but sensitive to gully and mass movement,
- red leached fersiallitic soils on soft sandstone, poor in O.M., very fragile, unstable,
- brown calcareous soils on colluvium, 2 -3 % of O.M. well structured topsoil but thin profile.

In this mountainous area, between 1982 and 1991, forest cover decreased from 18 to 13 % and vineyards and orchards surface increased from 2 to 7% and 8 to 14%. That indicates that more people are earning their living in the mountains. Cultural practices are limited: generally plowing for weed control, followed by cross cover cropping to bury fertilizers (N33, P45, K90) and break clods. The average rainfall over 40 years is 680 mm at the Medea Station but between 1986 to 1990 rainfall at Ouzera Station varied between 408 to 566 mm. The erosivity index (RUSA) is about 46.

The objective of this research is to compare the bare cultivated standard plot with four production systems (vineyard, orchard, cereals/leguminous pasture and sylvopastoral systems) on 4 soils representative of this area. The improvements introduced are correct plowing herbicides, pesticides, selected seeds, correct fertilization, leguminous fallow, mixed cropping and rotations under orchards. The parameters measured are rainfall (amount, intensity erosivity), runoff (KRAM % is the yearly average coefficient of runoff and KRMax %, the max, coefficient for one storm), soil erosion (suspension and coarse sediments), biomass production, net income and soil surface parameters.

3.2. Results and discussion

Rainfall was 100 to 250 mm (see fig. 1 and table 1) less than the long term average (680 mm). There was no exceptional storm event.

The Ram/Ham ratio (Ram = average annual rain erosivity; Ham = average annual rainfall amount for the same ten years) was 0, 1 for Medea Station. Therefore, rainfall is much less energetic than in tropical African countries, where Roose (1977-88) found 0,5 for Ivory Coast and 0,25 for mountains of Cameroon, Rwanda and Burundi.

Runoff: on cultivated plots the average annual runoff (KRAM % see table 1) was small (0.5 to 4% of the rains) and the maximum for one storm (KRMax) increased from 8 to 36%. On bare plots KRAM were still small (10 to 18%) compared to tropical situations (25 - 40% in Ivory Coast). However on bare or compacted and saturated ground the runoff can exceed 80% in the Winter. Here begin the risks of gullies, wady peak flow and mass movement.

As cultural practices were similar on both bare and cropped plots, it appears that crop cover and crop improvement, were efficient at reducing runoff rate (see tables 2 and 3).

As many authors, it was observed that deep plowing increased infiltration. For instance in vineyards, if herbicides replaced plowing to destroy weeds the runoff increased significantly and the topsoil became very compact so that erosion decreased. However for exceptional storms, the soil water capacity would be saturated: the runoff would increase and the soil resistance to runoff aggressivity would be less important on plowed soils, principally on steep slopes.

Under natural vegetation, cover was important (more than 80% of litter) so that runoff was frequent but never dangerous (< 7%). Nevertheless, runoff and gullies coming out from degraded, overgrazed pasture land, chiefly on paths used by animals (or even between trees plantations) are often observed in Algeria.

The runoff begins generally after 20 mm of rainfall on dry soil conditions and 3 mm on wet or compacted soil surface. This threshold and the runoff amount depend partly on rainfall characteristics (intensity but also volume of rains after saturating the soil water storage capacity), but mainly on soil surface characteristics (moisture on 10 first centimeters, cracks, sealing crust, green cover litter, rocks and clods). The largest runoff event occur only when all conditions are optimal, generally between November and March, or during an exceptional intensive storm in Summer (once in 1 to 5 years).

Sheet erosion: was very moderate (0.1 to 2 t/ha/year) on cropped fields and 1.5 to 9 t/ha/year for cultivated bare fallow, even on 40% slopes because rainfall aggressivity was weak (R<50) and soils are very resistant (K= 0.02 to 0.01), rich in clay saturated with calcium and often stony. Even if erosion reaches 9 t/ha/year (0.6 mm) more than 3 centuries would be needed to scour the 20 centimeters humiferous plowed horizon. Experimentally, it was proved that sheet erosion is selective for organic and mineral colloids and nutrients, but rill erosion is not selective. Consequently where rill erosion increases, the humiferous horizon is generally scroured. If sheet erosion is not the major process, rill erosion is important. However dry mechanical creeping caused by cultural practices seems to be the most efficient in that mountainous landscapes.

For instance, near Ouzera station, in an orchard that was planted 30 years ago, there is now 30 centimeters of soil missing between trees ! Even if the sheet erosion currently measured of 1.5 t/ha/year (0.1 mm) continued for thirty years, only 3 cm would be lost, while 27 centimeters would be removed by dry creeping (crossed deep plowing twice a year with the tractor!).

It is likely that the rate of dry mechanical creeping by cultural practices increases with increases in slope (ROOSE, Bertrand, 1971).

Influence of soil type and slope (table 2)

The soil erodibility was small, even after three years of bare cultivated fallow (K = 0.01 to 0.02). Sheet and rill erosion increased from year to year: it was maximum on red fersiallitic soil (9 t/ha/year), medium for grey vertisoil (2.7 t/ha/year) and minimum on brown calcareous soils (1.5 - 18.8 t/ha/years) The stone protection seems efficient. It is however diffiçult to compare the runoff risk because the slope steepness changes with soils!

On the other hand, it now seems clear that, contrary to commonly held opinion, the average and the maximum runoff coefficient decrease when the slope steepness increases... on bare cultivated fallow. That type of result was already found in Morocco by Heusch (1970) and by Roose (1973 in Ivory Coasr.

This shows that many equations (Ramser, Saccardy, etc...) increasing the terrace frequency on increasing slope steepness are not adapted to these Mediterranean conditions. Heusch (1970) has already shown that plot position in the toposequence is sometimes more important on runoff and erosion than slope steepness.

Influence of improved cultural system (table 3)

The improvement of crop cover (plant density, fertilizers use, leguminous rotation, cropping in the Winter between vineyards and orchards) seems to be moderately efficient at controlling runoff and erosion. But the most interesting aspect of these techniques is the significant increase of net income: from 2,500 dinars per hectare for traditional cereal cropping 35,800 and even 42 and 65,000 da/ha if crops are associated under orchards and vineyards. These data show it is possible simultaneously to intensify profitable mountain agriculture and to reduce environment degradation.

Yield and net income (table 1)

Yields observed on traditional systems runoff plots are as low as on the farmers fields (0.7 t/ha/year for Winter wheat, 2.8 t/ha of grapes and 0.8 t/ha for apricot). On runoff plots (100 m2) with improved cultural practices, the yield of wheat increased to 4.8 to 6.5 t/ha/year and that of grapes to 4 t/ha. In addition, there were 3.4 t/ha of beans or 3 t/ha of wheat associated Winter crops.

At the same time straw, leguminous leaves and other crops residues production also increased significantly (from 0.2 to 2 or 3 t/ha/year) so that animal production can improve and increased manure and other organic residues are available to improve the soil fertility and their resistance ability to erosion.

The yield increase will probably not be so important on large fields than on small runoff plots (100 m2), but the first step was to demonstrate that is possible to improve significantly the production and also the rural environment.

The next step is to show it is profitable! if you exclude the price of improved seeds fertilizers, pesticides, herbicides, labour increase for cropping and yielding, it remains to the farmers a net income much higher than for traditional fields:

1.	for extensive grazing in the woodland you can earn about	500 dinars/ha
2.	for traditional Winter wheat	2,500 da/ha
3.	for extensive apricot or vineyard	10 to 17,000 da/ha
4.	for intensive improved wheat and leguminous forage	28 to 33,000 da/ha
5.	for associated beans under apricot or vineyard	42 to 65,000 da/ha

This means that in the same production system you can increase the net income by ten for cereals or by 3 for vineyards after intensification. If you change of production system and intensify you may earn more than 20 times the original income.

With that benefit in view it should not be difficult for the farmers to appreciate their interest in changing their traditional system to improved cultural practices. At the same time, it is easy to propose a package of improved practices where water and soil conservation are included.

We were not surpirsed to observed after 4 years experiments that neighbouring farmers have copied our improved system without any pressure!

CONCLUSIONS:

This paper summarizes the results of 3 years data on 15 runoff plots, on 4 soils, 4 production systems representative of a very steep hilly area of limestone, sandstone and calcareous stone on Mediterranean mountains.

Introducing a package of improved cultural practices, it was shown that it is possible to reduce somewhat runoff and erosion risks and to increase significantly yields and farmers net income without degrading the environment.

The intensification of mountain agriculture seems to be possible without risk of soil fertility degradation or silting the reservoir if developping a new strategy of Water and Soil Fertility Management.

BIBLIOGRAPHY

Arabi, M & Roose, E. (1989). Influence de 4 systèmes de production en zone méditerranéenne de moyenne montagne en Algérie. Bulletin Réseau Erosion, 9:39-51.

Arabi, M. (1991). Influence de 4 systèmes de production sur le ruissellement et l'érosion en milieu montagnard méditerranéen. Thèse doctorat géographie, Grenoble, 276 p.

Aubert, G. (1987) Erodibilité des sols de la région d'Ouzera. Bulletin Réseau Erosion, 8: 97 - 99.

Demmack, A. (1982). Contribution à l'étude de l'érosion et des transports solides en Algérie septentrionnale. Thèse doct. ing Paris, 323 p.

Heusch, B. (1970). L'érosion du Pré-Rif. Une étude quantitative de l'érosion hydrique dans les collines marneuses du Pré-Rif occidental. Annale Rech. Forestière du Maroc, tome 12, 76 p.

Heusch, B. (1986). Cinquante ans de banquettes de DRS en Afrique du Nord: un bilan. Cah. ORSTOM. Pédol., 22 (2).: 153 - 162.

Kouidri, R., Arabi, M.; Roose, E. (1989). Premiers résultats de mesure du ruissellement et de l'érosion en nappe: Medea, Algérie. Bull. Réseau Erosion, 9 : 33 - 38.

Mazour, M. (1992). Les facteurs de risque de l'érosion en nappe dan le bassin versant d'Isser: Tlemcen, Algérie. Bull Réseau Erosin, 12 : 300-313.

Pouget, M. (1974). Etude agro-pédologique de la région d'Ouzera. ANRH, Alger, 72 p.

Roose, E. (1977). Erosion et ruissellement en Afrique de l'Ouest : 20 années de mesures. In: Travaux et Documents ORSTROM, Paris, no 78 : 108 p.

Roose, E. (1987). Evolution des stratégies de lutte antiérosive en Algérie; nouvelle démarche : la GCES. Séminaire INRF de Medea (Algérie). Bull. Réseau Erosion, 7 : 91-96.

Roose, E. (1988). Water efficiency and soil fertility conservation on steep slopes of some tropical countries. Workshop SWCA Puerto Rico. Edit. Moldenhauer and Hudson, Ankeny USA: 296 p.

Saccardy, L. (1949). Nécessité de la lutte contre les érosions. Méthodes modernes de conservation des sols et des eaux. Bull. Techn. des ISA, n° 142, Revue Terres et Eaux, n° 9, Alger.

Table 1: Runoff (% of rains), *Erosin* (t/ha/year) yeilds (t/ha) and net income for 15 runoff plots (22 x 4.6m) of INRF Ouzera Research Station Algeria.

Average value for 3 years: observed rainfall: 579-530-405mm

	KRAM % Average Runoff %	KRMax % Max. Runoff %	EROSION t/ha/year Med - Max ()	Yields t/ha/year	• Net income Dinar/ha/year 28 Da = 1 US$
AGRO-PASTORAL System VERTISOIL, 12 % slope					
1° Internat. Reference bare cultivated fallow	18.2	7 to 86	2.7 (6)	0	0
4° Local reference wheat, extensive grazing	2.1 ↗	7 to 16	0.19 (0.3)	0.7 grain 0.2 straw	2500
2° Improved: wheat + leguminous	0.6 ↘	1 to 8	0.11 (0.2)	4.8 grain 3.1 straw 5 beans	36200
3° Improved pasture *Medicago*	0.6 ↘	0 to 9	0.05 (0.3)	6.5 grain 2.2 straw	35800
Sylvo-Pastoral System Brown calcareous soil, 40% slope					
8° Internat. reference bare	11.3 ↗	- 34 ↗	1.8 (2.7)	-	-
6° Very overgrazed mattoral	12.0 ↗	3 to 25	1.7 (2.1)	-	-
5° Pine forest = litter	0.5	1 to 3	0.02 (0.04)	-	-
7° Diss pasture + litter	0.8	2 to 7	0.03 (0.04)	-	-
APRICOT ORCHARD Red fersiallitic soil, 35% slope					
9° Internat. reference bare	15.5 ↗	25 to 50	9 (20) ↗		
11° local reference: apricot 8 x 8m	3.1 ↗	11 to 12	0.66 (1.3)	0.7 fruit*	10000*
10° improved apricot + wheat/beans rotation + fertilizers and buffer strips	0.6 ↘	0 to 9	0.09 (0.2)	0.8 fruit* 6.0 beans 2.0 straw	42200
Vineyard 30 % slope Brown stony calcareous soil					
15° Internat. reference, bare	9.5 ↗	16 to 36	1.53 (2.3) ↗		
12° Local ref: vineyard 30 years + 2 tillage	1.5	3 to 8	0.11 (0.2)	2.8 grapes	34300
13° Improved vineyard zerotillage + herbicides	4.3	8 to 26	0.13 (0.2)	3.0 grapes	35100
14° Improved vineyard + wheat/beans rotation + 2 tillages + fertilizers	0.2	0 to 3	0.004 (0.1)	4.0 grapes 3.4 beans 1.5 straw	65400

Med = median Max = maximum in 1990

* Apricot fruit yield was very low because of severe insect attacks

Table 2: Influence of soil type and slope steepness % on runoff and erosion on bare cultivated fallows

	Stone cover %	slope %	KRAM %	KRMax %	Erosion t/ha/year
brown calcareous SPK8	16	40	11	34	1.8
brown calcareous colluvial VK15	20	35	10	36	1.5
red fersiallitic ARK9	0	30	16	50	9.0
grey vertisoil APK1	4	12	18	86	2.7

Tables 3: Effect of improved cultural system on runoff (average and max in % of rainfall), erosion (t/ha/year) and net income (1US dollar = 28 dinars)

Situation		KRAM	KRMax	Erosion	net income
		%	%	t/ha/year	DA/ha
Agropastoral on vertisoil	tradit	2.1	16	0.189	2504
	improved	0.6	8	0.054	35810
Sylvo pastoral on brown soil	degraded	12	25	1.740	?
	reforested	0.5	3	0.034	?
	regrassed	0.8	7	0.020	?
Orchard on red fersiallitic soil	traditional	3.1	12	0.656	10000
	improved	0.6	9	0.088	42187
Vineyard on brown colluvial soil	traditional	1.5	8.3	0.114	34333
	improved	0.2	2.7	0.009	65364

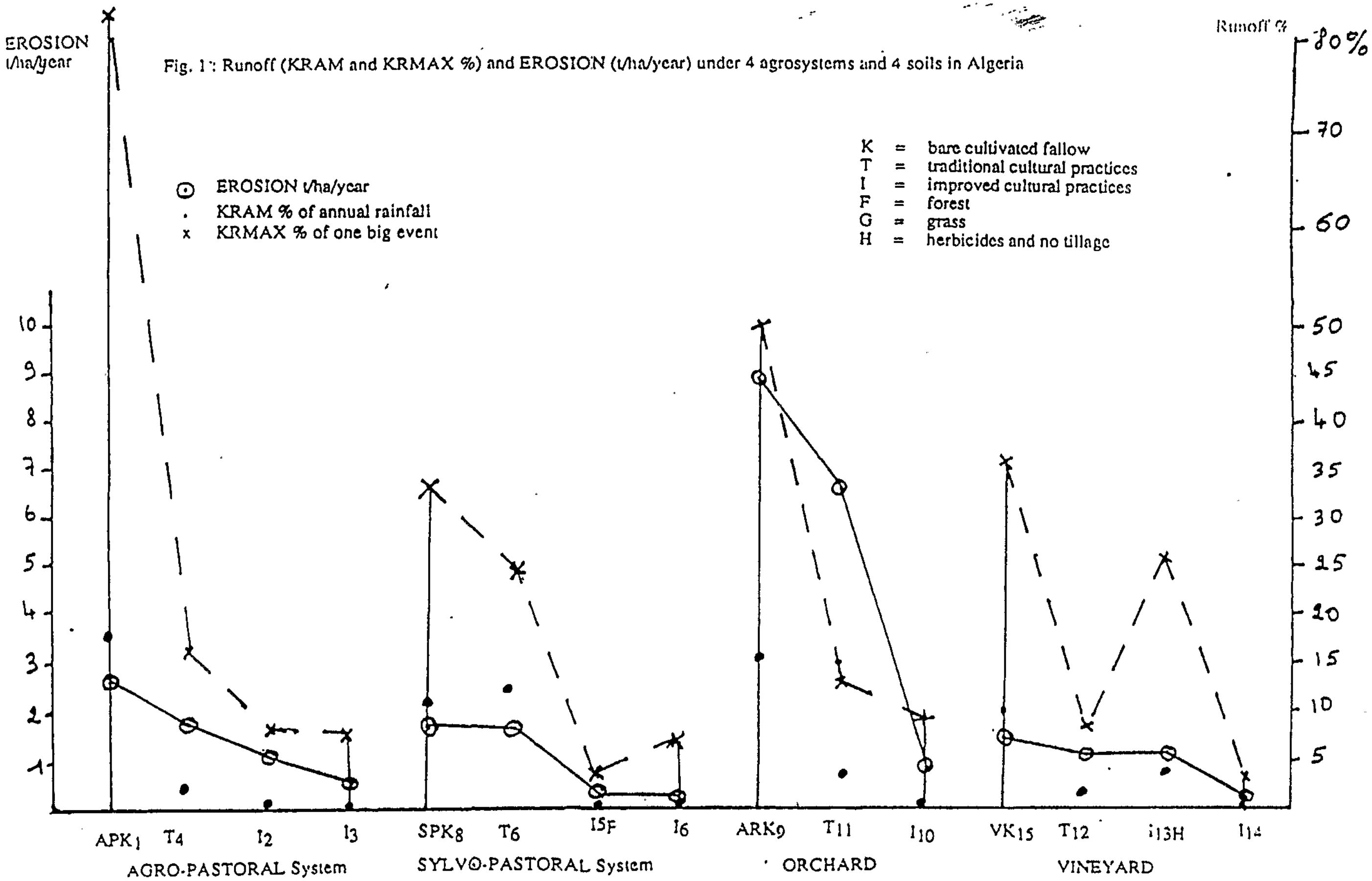


Fig. 1: Runoff (KRAM and KRMAX %) and EROSION (t/ha/year) under 4 agrosystems and 4 soils in Algeria

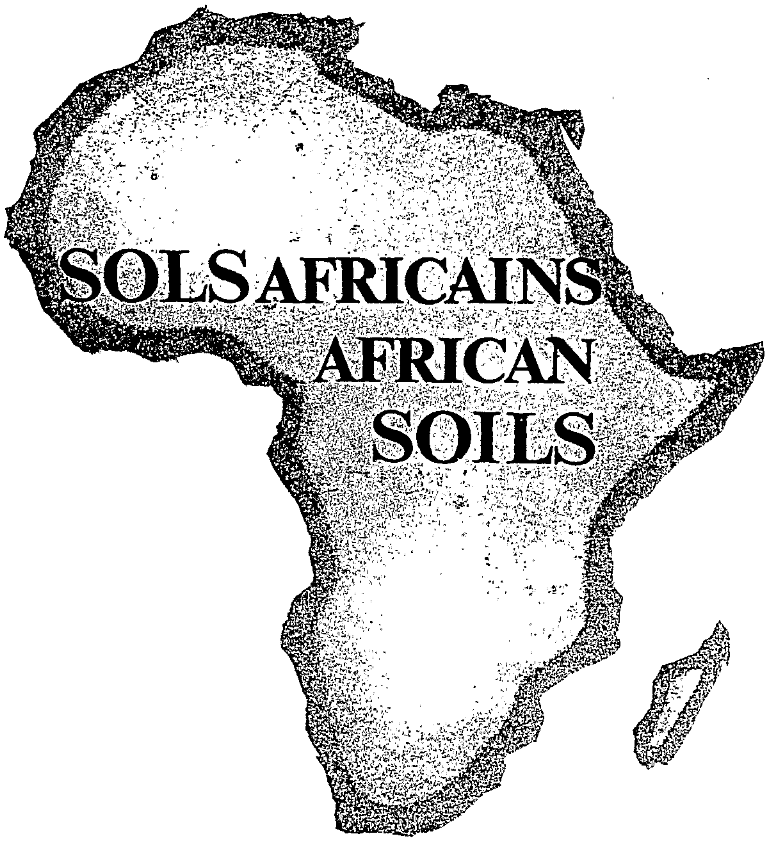
ORGANISATION DE L'UNITE AFRICAINE

COMMISSION SCIENTIFIQUE TECHNIQUE ET DE LA RECHERCHE

P.M.B. 2359, LAGOS - NIGERIA

OUA/CSTR

OAU/STRC



VOL XXVII

ORGANIZATION OF AFRICAN UNITY

SCIENTIFIC TECHNICAL AND RESEARCH COMMISSION

VOL 27 YEAR 1994