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Rainfall And Runoff Erosivity In Some Arid African Environments

BY

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ABSTRACT

This study was an empirical work conducted in the Laboratory by using rainfall simulator to know the effect of rainfall and runoff erosivity in some arid African environments.

Two types of soils were used, calcareous and sandy. The calcareous soil sample was obtained from "Kabelat Sammala" in south of Mersa Matrouh area. The sandy soil sample was obtained from "El-Sheikh Zouied area " at El-Areish, North Sinai. There were two types of raining periods on calcareous and sandy soils. They were short time rain and the long time rain . The slight, medium and high sloped areas in semi-arid African environments were represented by slope gradients of 8, 16 and 32% in this study.

The experimental plot and its blocky cover which contain the soil sample were designed in a way to prevent water and soil particles to splash out of them. IA/Rf . which is defined as the volume of infiltrated water divided by the rainfall amount, is a new term, developed to reflect one of the important soil response during rainfall. In calcareous soil, the IA/Rf values decreased when the slope gradient increased in both of the short and long time rain. But, it increased in sandy soil when the slope gradient also increased.

Wet depth decreased in calcareous soil when the slope gradient increased at short and long time rain. But, there was a possible increase in wet depth at I_{15}. In

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sandy soil, the wet depth was a fixed depth at the three slope gradients (8, 16 and 32%). It was 2.5 and 3 cm at rainfall intensities 120 and 90 mm/hr, respectively, and it was 14 cm with I_{15} and I_{30}.

In calcareous soil, water content increased at short time rain and decreased at long time when the slope gradient increased. In sandy soil, water content was at a fixed value at short time rain when the slope gradient increased. At I_{15}, it had similar values when the slope gradient increased. But, it decreased at I_{30} when the slope gradient increased.

Out let soil particles occurred only under the experimental plot in the case of sandy soil at long time rain conditions. In general, this kind of soil particles increased with the increase of slope gradient at I_{15} and I_{30}.

Water used in muoff process is the nunoff without suspension which runs on the sloped surface. W/Rf which is defined as the water used in runoff process divided by rainfall amount is another new value used to know the real trend of water used in ruoff process when the slope gradient increases. In this respect, the general nunoff trend on calcareous soil was toward the increase when the slope gradient increased at short and long time rain. But, in sandy soil, no runoff occurred at short time rain. But, the water used in runoff process increased by increasing slope gradient until 16%, then it decreased when the slope gradient reached 32% at long time rain.

"A/Rf "and "A/W" are two new values which lead to know the real trend of soil loss at different slope gradient. In general, they showed that calcareous soil loss increased when the slope gradient increased at the short and long time rain. The same behavior occurred in sandy soil at only the long time rain. But. in the short time rain. no sandy soil loss occurred.

INTRODUCTION

Water erosion is one of the natural processes that plays an important role in soil formation (Wild, 1993). It is considered a removal action of soil particles which differ in their physical and chemical properties from their original locations to new sites in valleys (Afift et al. 1992.-1). The physical and chemical properties of the soils are the most important factors to determine the water erosion ratio (Sharma and Biswas, 1972).

Water erosion process is divided into two important erosive agents: falling raindrops and runoff. Both of them have a complete erosive agent within itself. That is because each one of them will detach and transport soil materials (Ellison, 1947. Part II and V).

Detachability of soil particles, as an erosive agent, is directly related to rainfall intensity. It decreases with the large particles, but, increases with the medium and small size particles specially in the case of a reduction in rainfall intensity (Fanner, 1973). Both detaching and transporting capacities of an erosive agent may vary independently of each other. For example, maximum transporting capacity, and minimum detaching capacity result in very little erosion with the clear water. On the other hand, maximtum detaching capacity and minimum transporting capacity result in again very little erosion with water that is fully charged with soil particles. Maximum erosion will occur when detaching and transporting capacities of the flow are balanced (Ellison, 1947.Part I and IV).

Many laboratory experiments were done using simulated rainfall to know the relation between the erosive agents of falling raindrops and the factors that affect the detaching and transporting capacities in splash erosion. On a flat surface the splash was about the same in all direction, but on a soil with sloping surface the splash was greater downslope than upslope. The higher aggregate stability of the calcareous soil declined the splash erosion rate, and that was due to crusting or sealing of the soil surface (Mcintyre, 1958).

Runoff is the second erosive agent in water erosion process which is defined as flowing water from upslope to the downslope and gain a force from this flow. Once runoff starts, the force of flowing water detaches the soil aggregates and transports the soil particles downslope (Haan and Barfield, 1978). The quantity and size of transported soil particles increase when the velocity of runoff increases. But,this velocity may decrease at some points downslope resulting in sediment deposition. For this reason, the rainfall amount, rainfall duration, soil characteristics and topographic area have a large effect on the quantity of runoff (Wischmeier et al,1958; Minshall, 1962; Dedrick,1967; Walker et al.,1978).

Runoff yield can be estimated from rainfall records specially in arid regions that don't have reservoir of groundwater and seepage flow by using the following formula, (Hudson, 1993),:

$$Q = P - L$$

where:

Q is the runoff in mm, P is the rainfall in mm, L is the losses which represent infiltration and evaporation in mm.

A more accurate method to estimate the yield of runoff depends on the losses that are going to vary according to the amount of rainfall in a stone and also, the amount of moisture wllich can be absorbed by the soil. Therefore. the present experiments were conducted to examine the effect of variations rainfall intensities and slope gradient on quantities of infiltrated amounts of water, wetting depth and moisture content through the surface of calcareous and sandy soils.

MATERIALS & METHODS

Calcareous and sandy soils that represent the major areas in semi-arid African environments were chosen to conduct this study. The calcareous soil sample was collected from "(Kabelat Sammala)) farm, about 5km. South of Mersa Matrouh, and the sandy sample was collected from ((El-Sheikh Zowid, El-Areish, North Sinai)). These two samples were collected from the soil surface to a depth of 15 cm.

The experimental design

Four treatments were chosen as 5,6,50 and 50mm rainfall depths during raining period of 2.5, 4, 15 and 30 minutes, respectively. Their rainfall erosivity values were estimated as 19.38, 22.61, 203.54 and 190.4 joule/ha, respectively. Three slope gradients (8, 16 and 32%) were selected to demonstrate the low, medium and high sloping areas. The boundry conditions for all replications were no wind effect, lab temprature degree, flat soil surface and air dry soil, (Table 1).

Table 1: The experimental design for calcareous & sandy soil

Rainfall amount "mm"	5	6	50	50
Raining period "min"	2.5	4	15	30
Rainfall intensity "mm/hr" (calculated)	120	90	200	100
Slope gradient %	8,16&32	8,16&32	8,16&32	8,16& 32
Replications for each	3	3	3	3

Rainfall simulator

Rainfall simulator components are illustrated in Fig. (1). The water source vessel shape is an inverted completed cone. It has a ruler scale in its center. The ruler starts from zero until the maximum scale 90 mm. This maximum scale is not exactly in the bottom of the vessel. The water volume from bottom until scale 68mm is 15 liters, and from scale 68 mm to 5 mm is also 15 liters. So, calibration in relation to the size of water inside this vessel at each mm height was done and represented as in Table (2). The bottom base of water vessel has 404 breaches. The diameter of each breach is 1 mm. These breaches have been distributed on 4 diagonals and 8 rays.

Table 2: Calibrtion list of the water source vessel.

Ruler scale "mm"	Water height "mm"		Water volume "cm3	Ruler scale "mm"	Water height "mm"		Water volume "cm3
	Before calibration	After calibration			Before calibration	After calibration	
5	0	00.0	00..	37	32	30.9	07727
6	1	01.0	0250	38	33	31.8	07955
7	2	02.0	0500	39	34	32.7	08182
8	3	03.0	0750	40	35	33.6	08409
9	4	04.0	1000	41	36	34.5	08636
10	5	05.0	1250	42	37	35.4	08863
11	6	06.0	1500	43	38	36.3	09090
12	7	07.0	1750	44	39	37.3	09318
13	8	08.0	200	45	40	38.2	09545
14	9	09.0	2250	46	41	39.0	09773
15	10	10.0	2500	47	42	40.0	10000
16	11	11.0	2750	48	43	40.9	10238
17	12	12.0	3000	49	44	41.9	10476
18	13	13.0	3250	50	45	42.8	10714
19	14	14.0	3500	51	46	43.8	10952
20	15	15.0	3750	52	47	44.7	11190
21	16	16.0	4000	53	48	45..7	11428
22	17	17.0	4250	54	49	46.6	11667
23	18	18.0	4500	55	50	47.6	11905
24	19	19.0	4750	56	51	48.6	12143
25	20	20.0	5000	57	52	49.5	12380
26	21	20.9	5227	58	53	50.0	12500
27	22	21.8	5455	59	54	51.4	12857
28	23	22.7	5682	60	55	52.3	13095
29	24	23.6	5909	61	56	53.3	13333
30	25	24.6	6136	62	57	54.3	13571
31	26	25.5	6364	63	58	55.2	13810
32	27	26.4	6590	64	59	56.2	14048
33	28	27.3	6818	65	60	57.1	14285
34	29	28.2	7045	66	61	58.0	14524
35	30	29.0	7272	67	62	59.0	14762
36	31	30.0	7500	68	63	60.0	15000

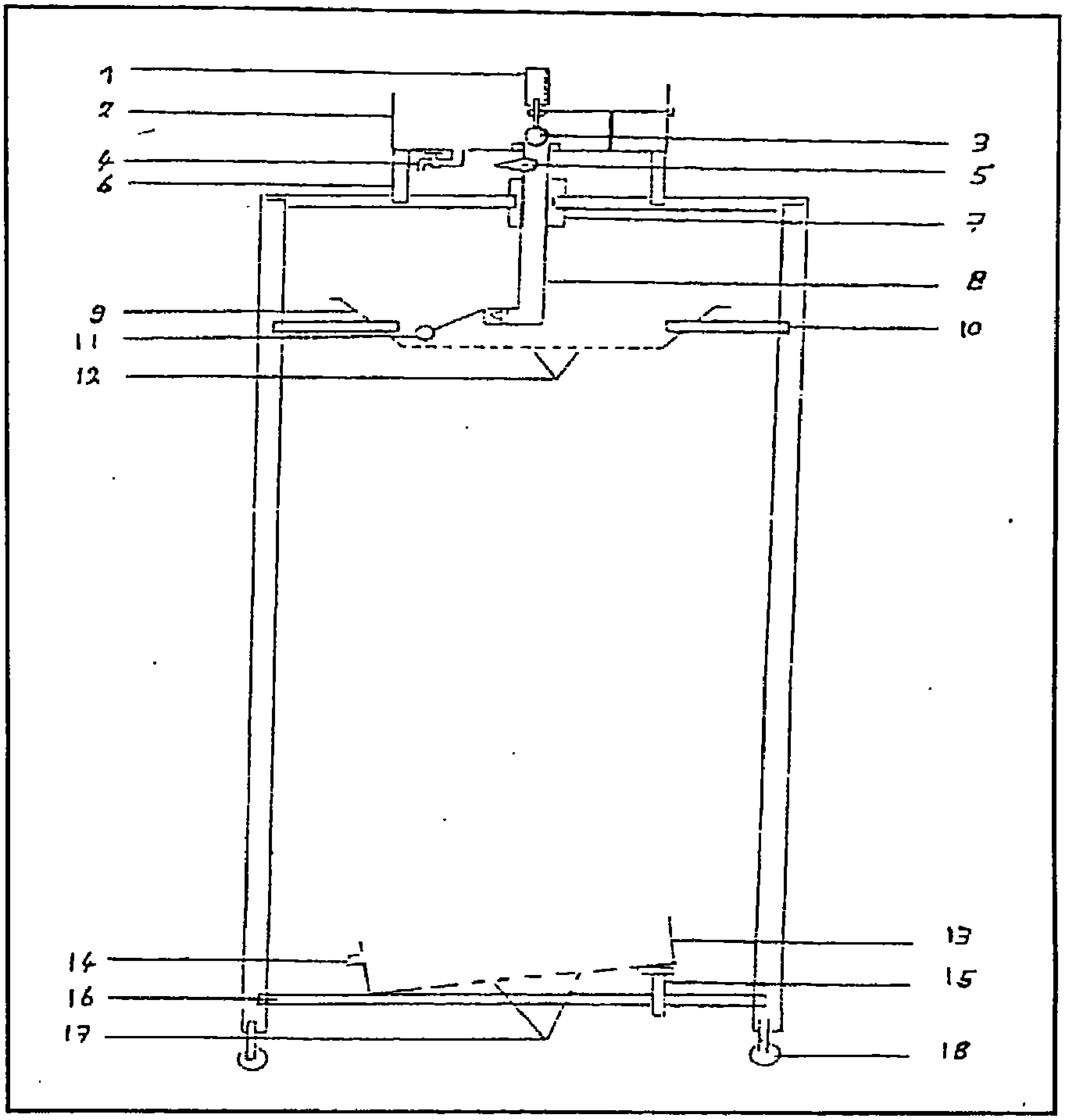

Fig. 1: Consistent rainfall simulator

1 Ruler	7 Washer	13 Plot
2 Water source vessel	8 Cylinder	14 RunoiRf opening
3 Buoy	9 Rainfall vessel	15 Slope nail
4 Tap	10 Fixed arm	16 Bar
5 Valve	1 1 Buoy	17 Breaches
6 Pivot	12 Breaches	1 8 Wheel

The number of the breaches is 63 on each diagonal and 19 on each ray. The distance between each breach and the next one on diagonal or ray is 6 mm. The distance between breaches in the rainfall vessel and the soil surface in the plot at slope gradient of zero is 140 cm. Logically, this distance decreases at the top slope when the slope gradient increases. So, the mean distance in relation to the distance at top and bottom slope at different slope gradients, besides the mean velocity of falling raindrops were calculated. (Table 3).

Table 3: Distance and velocity of falling raindrops under laboratory conditions

Slope gradient	Distance of falling raindrops ((cm))			Falling raindrops velocity "m/sec"
	Down slope	Top slope	Mean	
8%	140	136.4	138.2	5.21
16%	140	132.8	136.4	5.17
32%	140	125.0	132.5	5.1
Overall mean			135.7	5.16

The mean of this distance, whicl1 was 135.7 cm, did not allow the falling raindrops to reach their maximum velocities as in natural conditions. So, the velocity of a free falling mass that falls on the soil surface in the plot was calculated according to the equation proposed by Engelbert (1970)

$$V= 2gh$$

Where:

V is the velocity of free falling mass in m/see .

g is the gravetional acceleration in m/see.

h is the fall height of the free falling mass in m.

Logically, this velocity of 5.16 m/see affects the kinetic energy of the four falling raindrops in the laboratory which were used in this study and their radii were 1.41 and 1.48 mm at short time rain (90 and 120 mm/hr rainfall intensities) and 1.63 and 1.43 mm at long time rain (I_{15} and I_{30}), respectively. There fore, t-test was done between the kinetic energies of the three raindrops which have the similar radii average in natural condition and the kinetic energies of the same three raindrops under laboratory condition for 5.16 m/see of mean velocity. The calculated ((t)) values were less than the tabulated ones at both significance levels of 0.05 and 0.01, (Table 4)

Table 4: t-test on kinetic energy of raindrops under natural and laboratory conditions.

Raindrop radius "mm"	Raindrop velocity "m/sec"		Kinetic energy "j/m2"	
	Natural	Laboratory	Natural	Laboratory
1.400	7.82	5.16	0.351626	0.153097
1.500	8.06	5.16	0.457993	0.187710
1.800	8.60	5.16	0.903791	0.325365
Calculated " t "			1.302	
Significance level			Tabulated " t "	
0.05			3.182	
0.01			5.841	

Thus, t-test value was insignificant, which means that the effect ot the kinetic energy of these raindrops in laboratory was from the same population of the effect ofthe kinetic energy of the same raindrops, under natural conditions.

The experimental plot

The experimental plot used in this shudy is a micro plot type. Its dimension was 50 cm. length, 50 cm. width and 14 cm. depth. It is made of wood and covered from inside by plastic material and wax. The plot base has 49 breaches. The diameter of each one is 12 mm. Each one of these breaches has been allowed to stay at one sideof the right capillary tube to pass through it, while the other side touches the surface of the interior plot base.

This right capillary tube has a diameter of 10mm. Its top opening touches the surface of the plot base from the interior direction and has been directed opposite to the runoff direction. The down opening is in the bottom of the plot base from the exterior direction. The directions of these two openings of the right capillary tube easily allow to move down the plot, to collect the infiltrated water that exceeds the field capacity, and also, to outlet soil appears down the plot. The quantity of this out let soil depends on the area of the two openings of the right capillary tube. The area of each of these two openings is 1.57 mm^2, and the total area for all 49 top or bottom openings is about 7.69 cm^2.

The runoff opening may have two positions. In the first position, the down level of a runoff opening shape is at the same level of soil surface in the plot. This position may decrease the value of sediments in runoff, especially, with more soil erosion near the runoff opening. However, in the second position, the down level of the runoff opening shape is under the soil surface level. This position may increase the value of sediments in runoff. So, the second position was chosen with some methodical solutions to decrease the exposed area towards soil in runoff opening as follows: -

* The circle shape for runoff opening was chosen instead of the rectangle shape.

* The height of exposed area towards soil in runoff opening is 1 cm.

* Three runoff openings with each one of them has a diameter of 5 cm. were chosen, instead of one runoff opening only, in order to prevent runoff accumulation and sediments deposition at the plot corners in the down slope.

Finally, the soil samples were put in the plot tray according to their bulk densities in the field.

3- RESULTS & DISCUSSION

Several relations were investigated in this study under the simulated rainfall erosivity values that represent the semi-arid African regions. This rainfall erosivity values were 19.38 and 22.61 jouls/ha in short time rain, and 190.4 and203.54 jouls/ha in long time rain (I_{15} and I_{30}) at slope gradients of 8, 16 and 32%. These treatments were performed on calcareous and sandy soil samples.

3.1 Characterization of the investicated soil samples

In calcareous soil sample, the textural class was sandy clay loam. The sandy particles represent the major value in mechanical soil analysis. The values of fine sand and coarse sand were 52.98%, and 8.5%, respectively. On the other hand, the values of silt and clay were 18.4 % and 20.12 %, respectively. Soil structure was massive and its bulk density was 1.71 gr/cm3. The wet stable aggregates was about 68.55%, and this was due to the high total calcium carbonate (19.6%) which worked as a cementing agent among soil particles. The organic matter was too little (0.25%). The hydraulic conductivity was 0.89 cm/hr.

In sandy soil sample, the textural class was sand. The coarse sand and fine sand particles were 92.5 % and 5.5 %, respectively according to the pipette method of mechanical analysis. But, the silt and clay were too little (1.4 % and 0.6 %, respectively). The soil structure was massive and its bulk density was 1.63gr/cm3. The wet stable aggregates (W. S.A.) was about 23.8%. The total calcium carbonate and the organic matter were too little. Their values were 2.4% and 0.05%, respectively. The hydraulic conductivity was 16 cm/hr. (Tables 5,6 and 7).

Table 5: Some physical and chemical properties of the soil samples.

	Soil property		Calcareous	Sandy
Mechanical analysis	**A: Dry sieving method**			
	Very coarse sand	2.0-1.0 mm	16.03	00.07
	Coarse sand	1.0-0.5 mm	09.59	01.53
	Medium sand	0.05-0.25 mm	13.13	78.09
	Fine sand	0.25-0.1 mm	13.80	18.93
	Very fine sand	0.1-0.05 mm	46.15	00.37
	Silt		00.61	00.07
	Clay		00.9	00.03
	B: Pipette method			
	Coarse sand	2.00 - 0.20 mm	08.50	92.50
	Fine sand	0.20 - 0.02 mm	52.98	05.50
	Silt	0.02 - 0.00 mm	18.40	01.40
	Clay	< 0.002 mm	20.12	00.60
	Textural class		Sandy clay loam	Sand
	Structure		Massive	Massive
	Organic matter		00.25	00.05
	Hydrauiic conductivity, cm/hr		00.89	16.00
	Total calcium carbonate, %		19.60	02.40
	Bulk density & soil samples, gr/cm3		01.71	01.63
	Bulk density of soil loss, gr/cm3		01.744	01.673

Table 6: Wet stable aggregates (W.S.A.) in calcareous soil

Size of particles ((mm))		Without dispersion ((%))	With dispersion ((%))	W.S.A.%
Gravel	> 2.0	01.05	00.71	00.34
Very coarse sand	2.0- 1.0	01.33	00.93	00.40
Coarse sand	1.0- 0.5	05.10	01.47	03.60
Medium sand	0.5- 0.25	24.50	06.46	18.04
Fine sand	0.25- 0.125	26.60	10.48	16.12
Very fine sand	< 0.125	41.42	11.40	30.02
Total		100	31.45	68.55

Table7: Wet stable aggregates(W.S.A.) in sandy soil

Size of particles ((mm))	Without dispersion ((%))	With dispersion ((%))	W.S.A.%
Gravel>2.0	-	-	-
Very coarse sand 2.0	00.21	00.18	00.03
Coarse sand	01.50	01.24	00.26
Medium sand	64.00	48.13	15.90
Fine sand	31.90	24.50	07.40
Very fine sand < 0.125	02.39	02.15	00.24
Total	100.00	76.20	2.8

3.2 The relation between infiltrated water amounts and slope aradient

Slope gradients played an important role under the various rainfall intensities to influence the quantities of infiltrated water through the surface of calcareous soil. Infiltrated water decreased when the slope gradient increased at short time rain (90 and 120 mm/hr rainfall intensities) and long time rain (I_{15} and I_{30}), (Fig. 2).

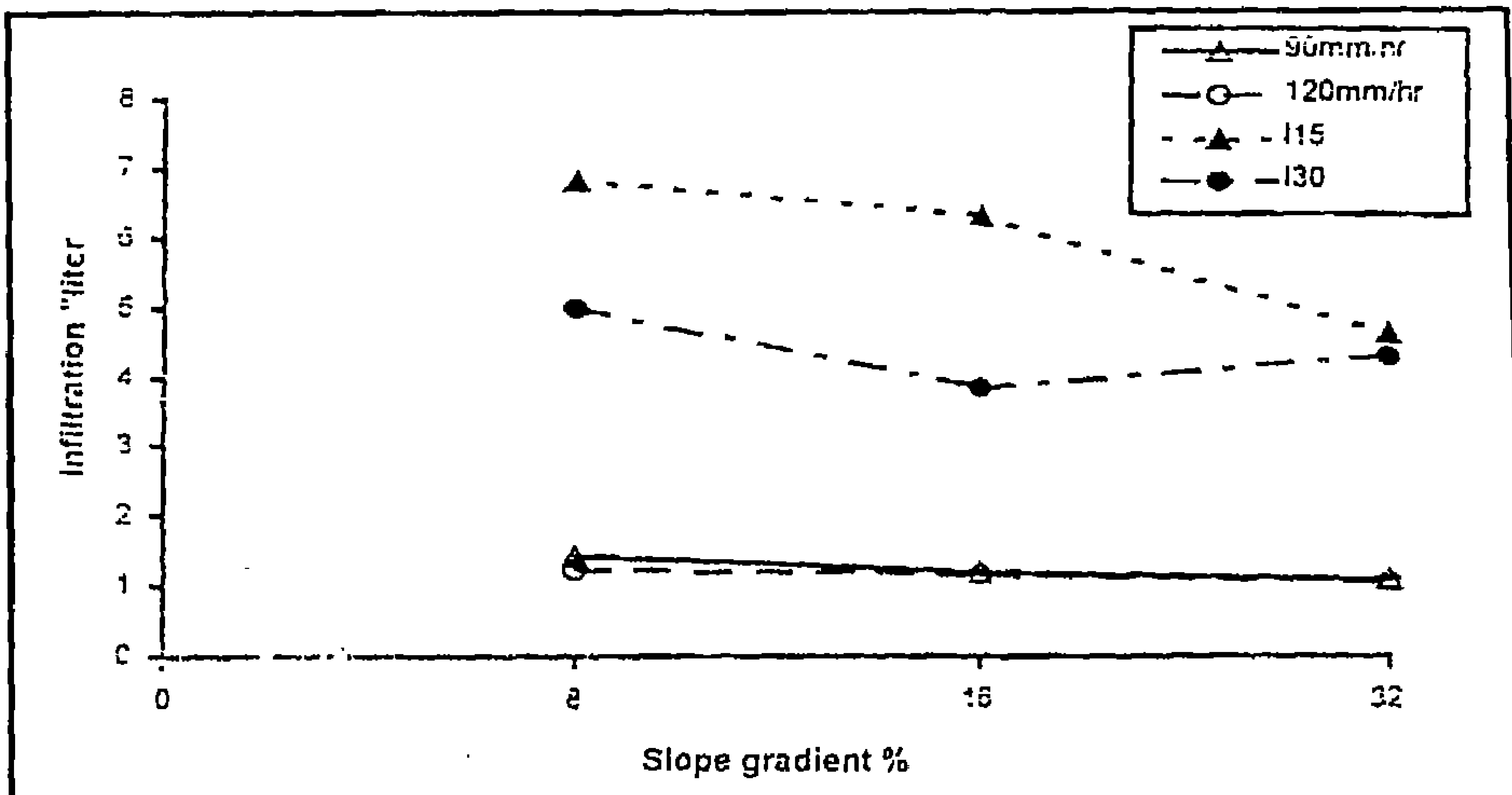

Fig. 2 : Infiltrated water in calcareous soil at different intensities

There is a relation between this infiltrated water and the rainfall amount (IA/Rf) which is defined as the volume of infiltrated water through the soil surface divided by the rainfall volume. ((IA/Rf)) values at 90, 120 mm/hr rainfall intensities, I_{15} and I_{30} decreased when the slope gradient increased. However, these values at 90 and 120 mm/hr rainfall intensities were higher than that values at I_{15} and I_{30} On the other hand, the rainstorms, which had higher rainfall intensities at both of short and long time rain, had higher values of ((LA/Rf), (Fig. 3).

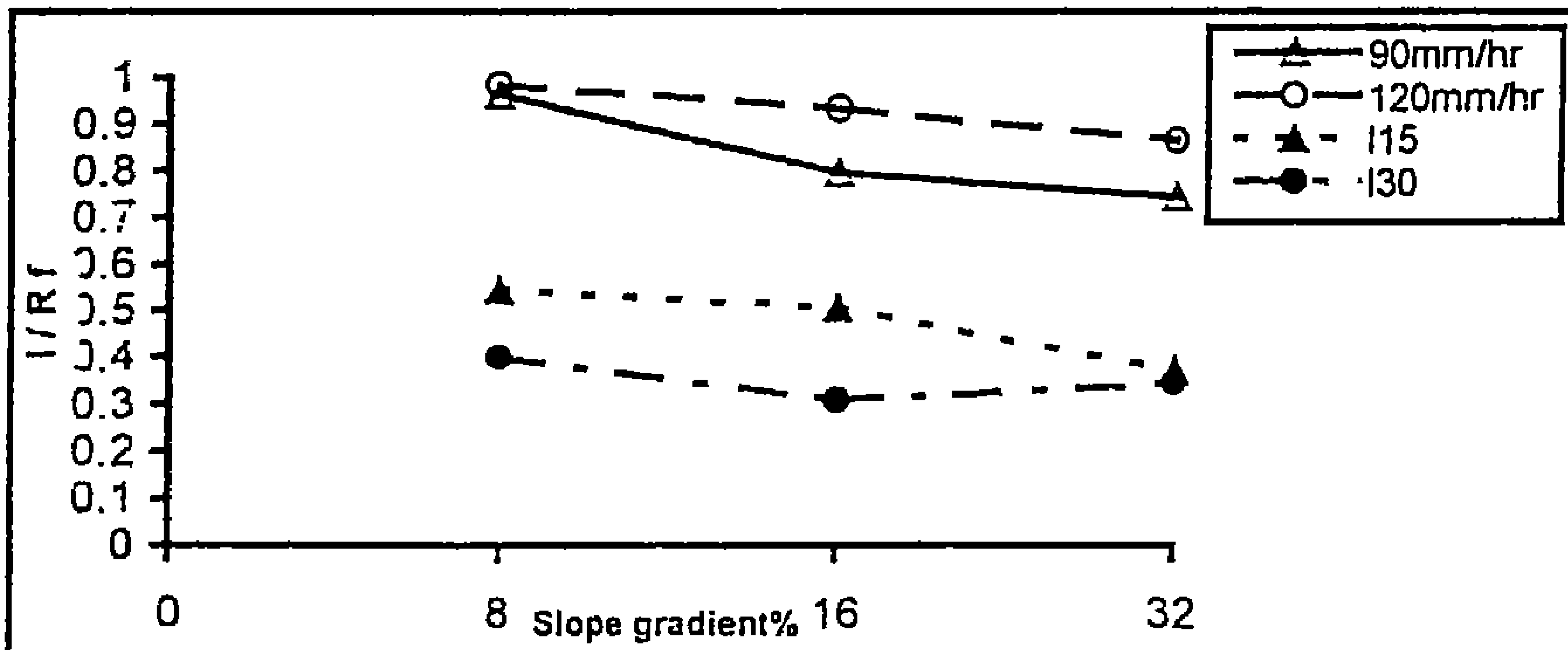

Fig.3:The relation between "I / Rf " and slope gradient at different intensities in calcareous soil

In sandy soil, it is evident that the influence of slope gradient on infltrated water through the sandy soil surface represented by horizontal-line relations under rainfall intensities of 90 and 120 mm/hr and a regular increase under I_{15} and I_{30} when the slope gradient increased, (Fig. 4).

((IA/Rf)) alues in sandy soil at 90 and 120 mm/hr rainfallintensities were similar. They possessed maximum value (1.0) at 8, 16 and 32% slope gradients, whereas ((IA/Rf), values at I_{15} increased when the slope gradient increased. But, at I_{30} ((IA/Rf)) a a value possessed a sharp decrease at 16% slope gradient, then a higher.

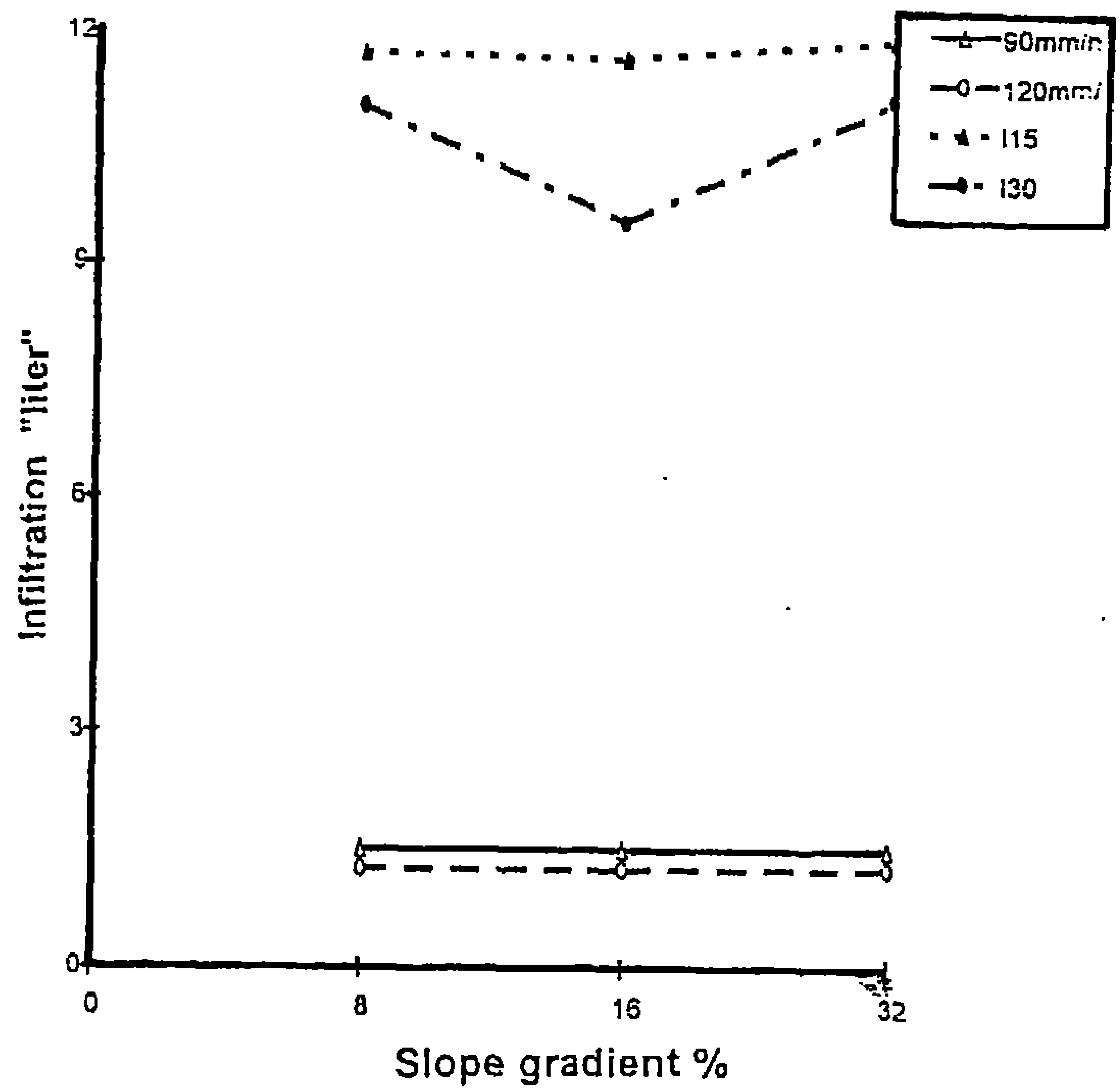

Fig4 The relation between infiltrated water and slope gradient at different intensities

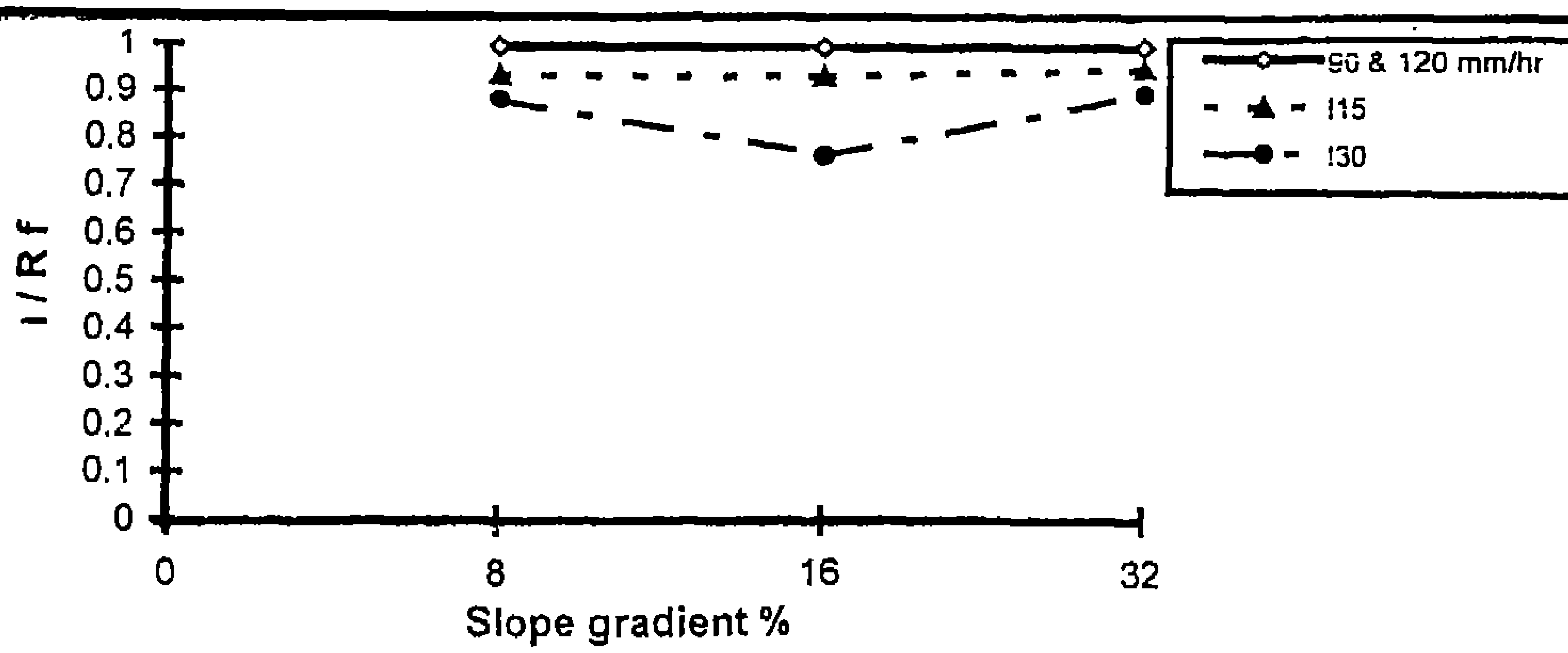

Fig.5 :The relation between I/Rf and slope gradient at different intensities in sandy soil

3.3 The relation between wet dentin and slope aradient

In calcareous soil, the wet depth decreased when the slope gradient increased at the short time rain 90 and 120 mm/hr rainfall intensities. The same trend occurred at I_{30} with a peak of decrease at 16% slope gradient. This peak of decrease is due to the smaller amount of the infiltrated water at 16% slope gradient than those of 8 and 32% slope gradients (4.999 and 4.3051iters, respectively). At I_{15} the wet depth increased when the slope gradient increased with a peak of increase at 16% slope gradient, (Fig.6).

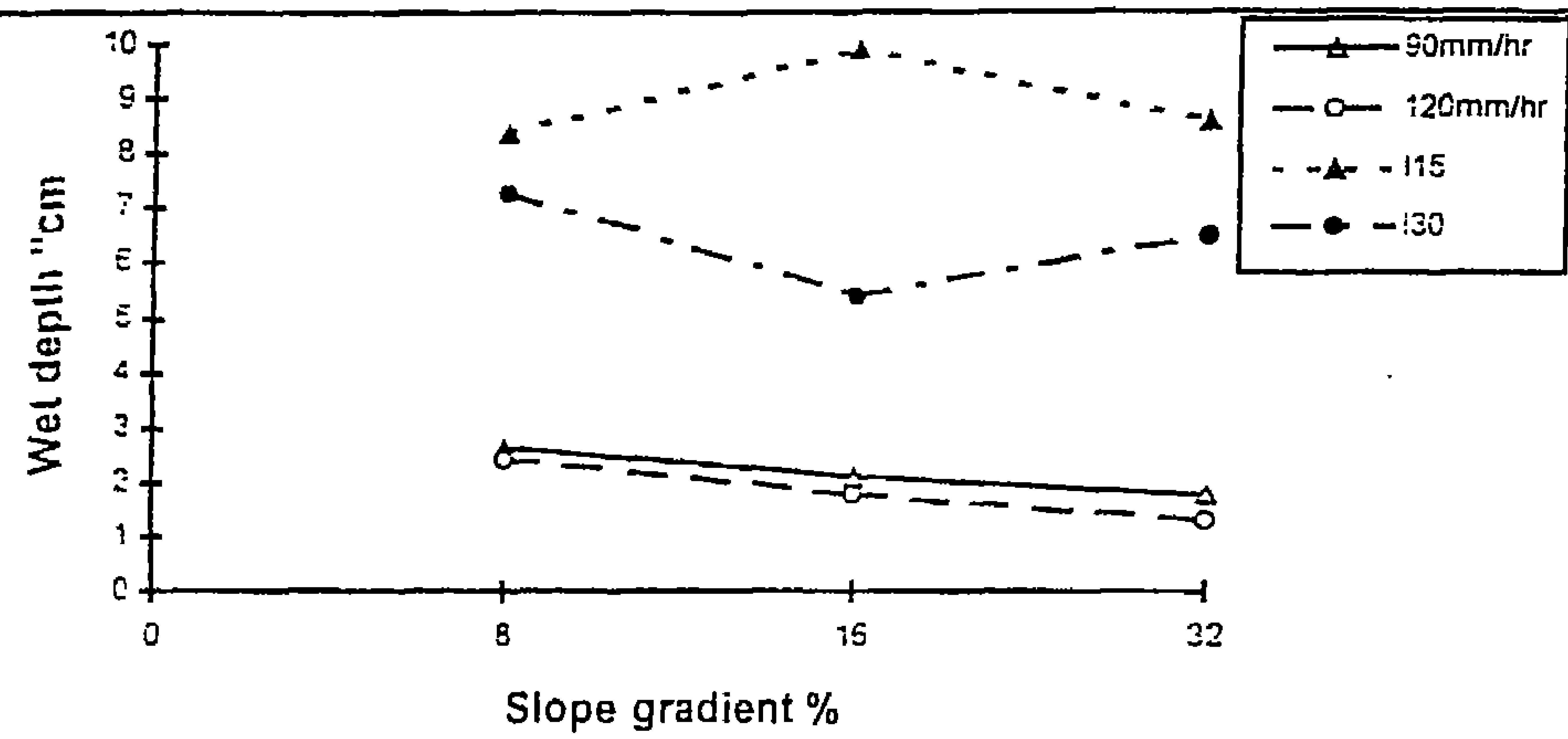

Fig.6 :The relation between wet depth and slope gradient in calcareous soil at different intensities.

In sandy soil, no change was noticed in the wet depths as the slope gradient increased. They were 2.5 and 3 centimeters under short time rain (90, 120 mm/hr rainfal l intensities) and 14 centimeters under long time rain (I_{15}, 130), (Fig.7).

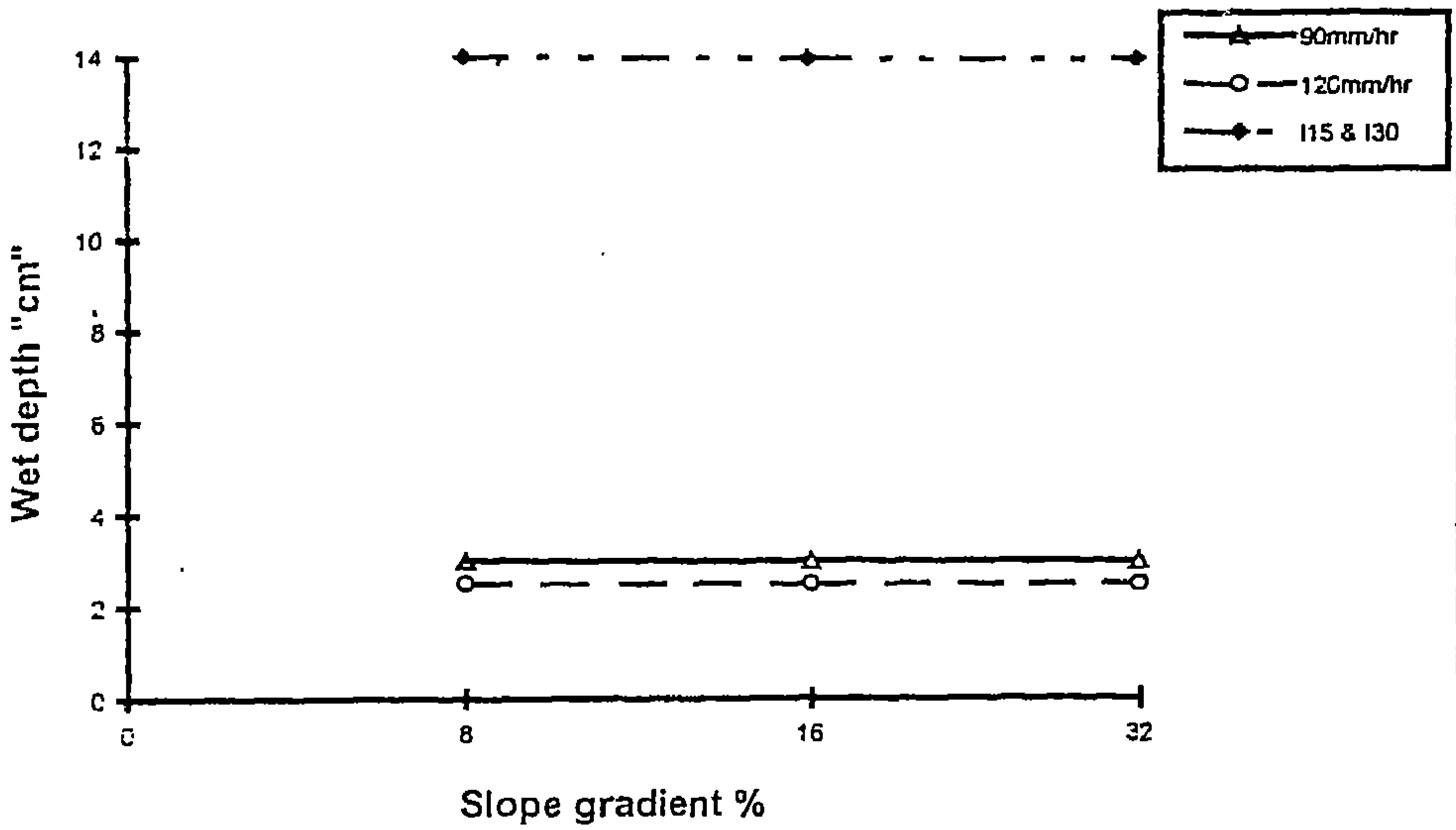

Fig. 7 :The relation between wet depth and slope gradient in sandy soil.

3.4 The relation between water content and slope gradient.

The percentage of water content in calcareous soil after simulated rainfall increased under short time rain (90 and 120 mm/hr rainfall intensities) as the slope gradient increased, because the decrease of wet depth at 8,16 and 32% slope gradients was more than the decrease of the infiltrated water volume at the same slopes. At I_{15} and I_{30}, water content decreased when the slope gradient increased, because the decrease rate of the wet depth volume at 8,16 and 32% slope gradients was less than the decrease rate of the infiltrated water volume at the same slope gradients. The exception was in I_{30} at 16 % slope gradient, where the water content had the maximum value (28.5 %), (Fig.8).

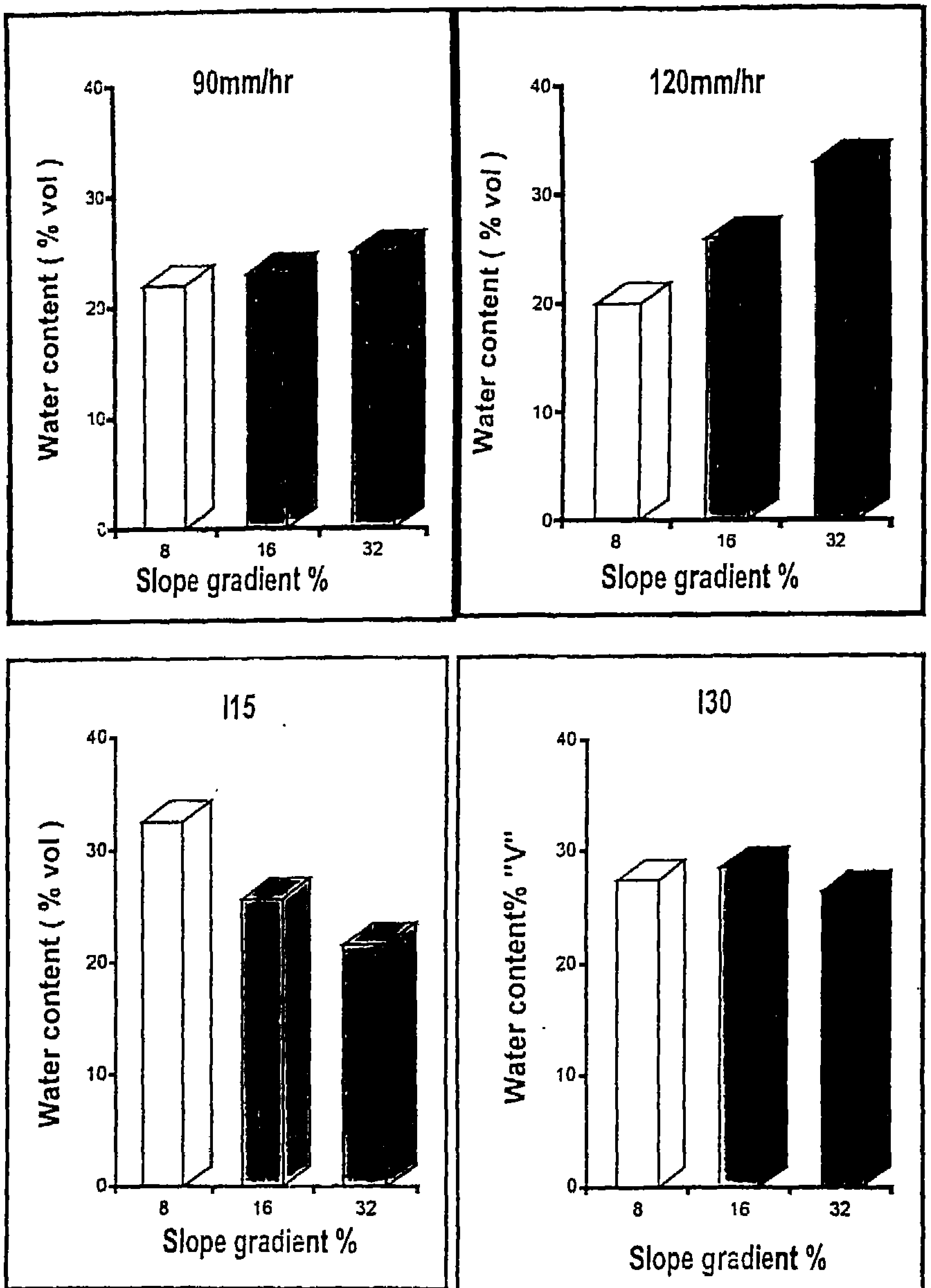

Fig.8 : The relation between water content and slope gradient in calcareous soil at different intensities.

In sandy soil, the percentage of water content also was used to reflect the state of sandy soil suction at different types of rainfall and slope gradients. It was a fixed percentage in the short time rain (90 and 120 mm/hr rainfall intensities) at 8, 16 and 32% slope gradients. At I_{15}, the water content values were similar when the slope gradient increased. But, at I_{30}, the water content decreased as the slope gradient increased with a maximum decrease at 16% slope gradient, (Fig.9).

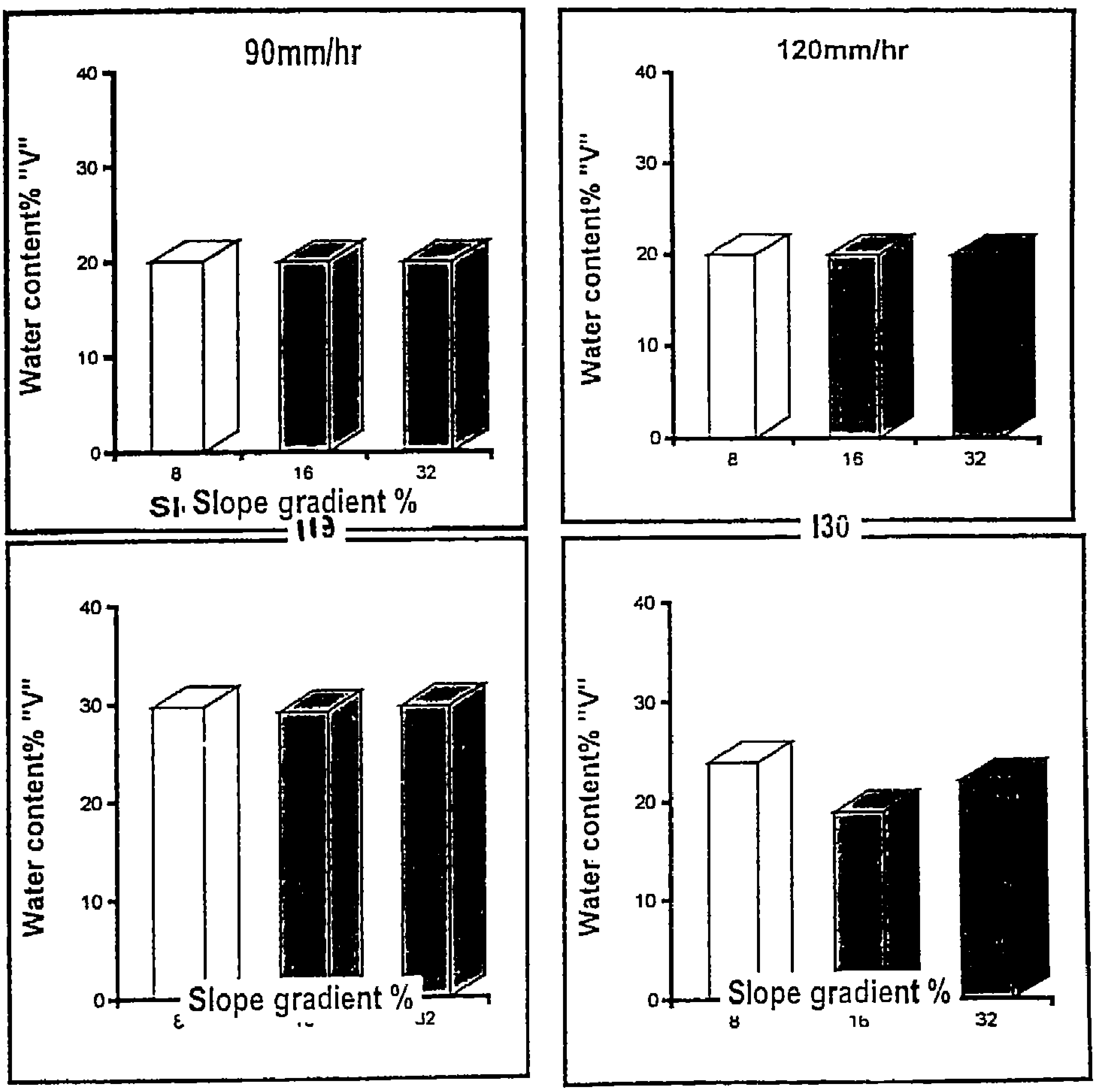

Fig. 9: The relation between water content and slope gradient in sandy soil.

3,5 The relation between capillary moisture after rainfall and slope garadient

The capillary moisture in the soils depends on many factors that related to the physical and chemical soil properties. After rainfall, capillary moisture in subsurface soil layer until 14 cm depth of dry calcareous and sandy soils has been studied in this research to know the effects of rainfall intensity, infiltration and wet depth on it at different slope gradients. The percentage of capillary moisture was calculated by dividing the real volume of infiltrated water that was held at 1/3 atmospheric pressure in wet depth by the total infiltration. In dry calcareous soil, the capillary moisture after rainfall was 100% at different rainfall intensities and slope gradients, (Table 8).

In dry sandy soil, tl e capillary moisture after rainfall was 100 !/O in short-time rain (90 and 120 mm /hr rainfall intensities) at different slope gradients, (Table 9).

Table 8: Capillary moisture in calcareous soil after rainfall at different rainfall intensities and slope gradients

Slope grndient	8%				16%				32%			
Type of rainfall	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}
infiltration water in wet depth liter	1.446	1.229	6.816	4.999	1.193	1.166	6.332	3.852	1.115	1.082	1.082	4.305
Total infiltration liter	1.446	1.229	6.816	4.999	1.193	1.166	6.332	3.852	1.115	1.082	1.082	4.305
Capillary moisture %	100	100	100	100	100	100	100	100	100	100	100	100

Table 9: Capillary moisture in sandy soil after rainfall at different intensities and slope gradients

Slope grndient	8%				16%				32%			
Type of rainfall	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}
Infiltrnted water in wet depth ((liter))	1.500	1.250	10.412	8.368	1.500	1.250	10.332	6.634	1.500	1.250	10.425	7.699
Total infiltration ((liter))	1.500	1.250	11.736	11.053	1.500	1.250	11.706	9.573	1.500	1.250	11.938	11.154
Capillary moisture %	100	100	89	79	100	100	87	69	100	100	87	69

But at I~s and I30 the capillary moisture in dry sandy veil decreased es the slope gradient increased, until 16% slope gradient, then its values were constant until 32% slope gradient, (Fig.10).

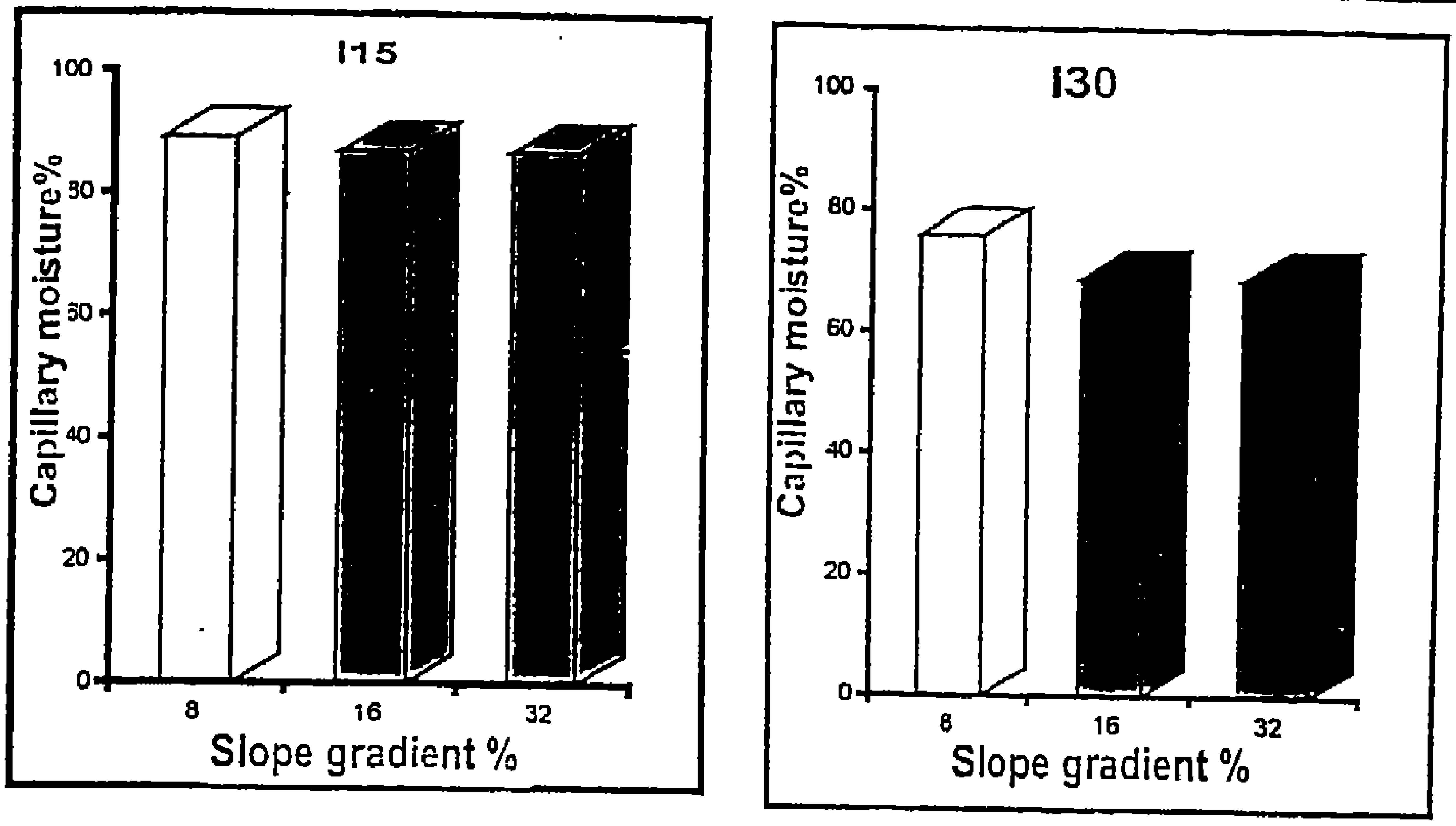

Fig.10: Capillary moisture in sandy soil after rainfall at I15 and I30

3.6 Runoff

3.6.1 The relationship between r unoff, water used in runoff process (W) and slope gradient

Water used in ruoff process (W) is defined as the runoff volume withot the sediment volume. It has been used to represent the real effect of the slope gradient on runoff and sediments yield.

3.6.1.1 At 90 mm/hr rainfall intensity

In calcareous soil, runoff, water used in runoffprocess (W) and sediments volume increased when the slope gradient increased at 90 mm/hr rainfall intensity, (Fig. 11).

On the other hand, in: sandy soil, the rainfall amount (1.5 liter) and its rainfall intensity (90 mm/hr) didn't produce any quantities of runoff at 8,16 and 32% slope gradients.

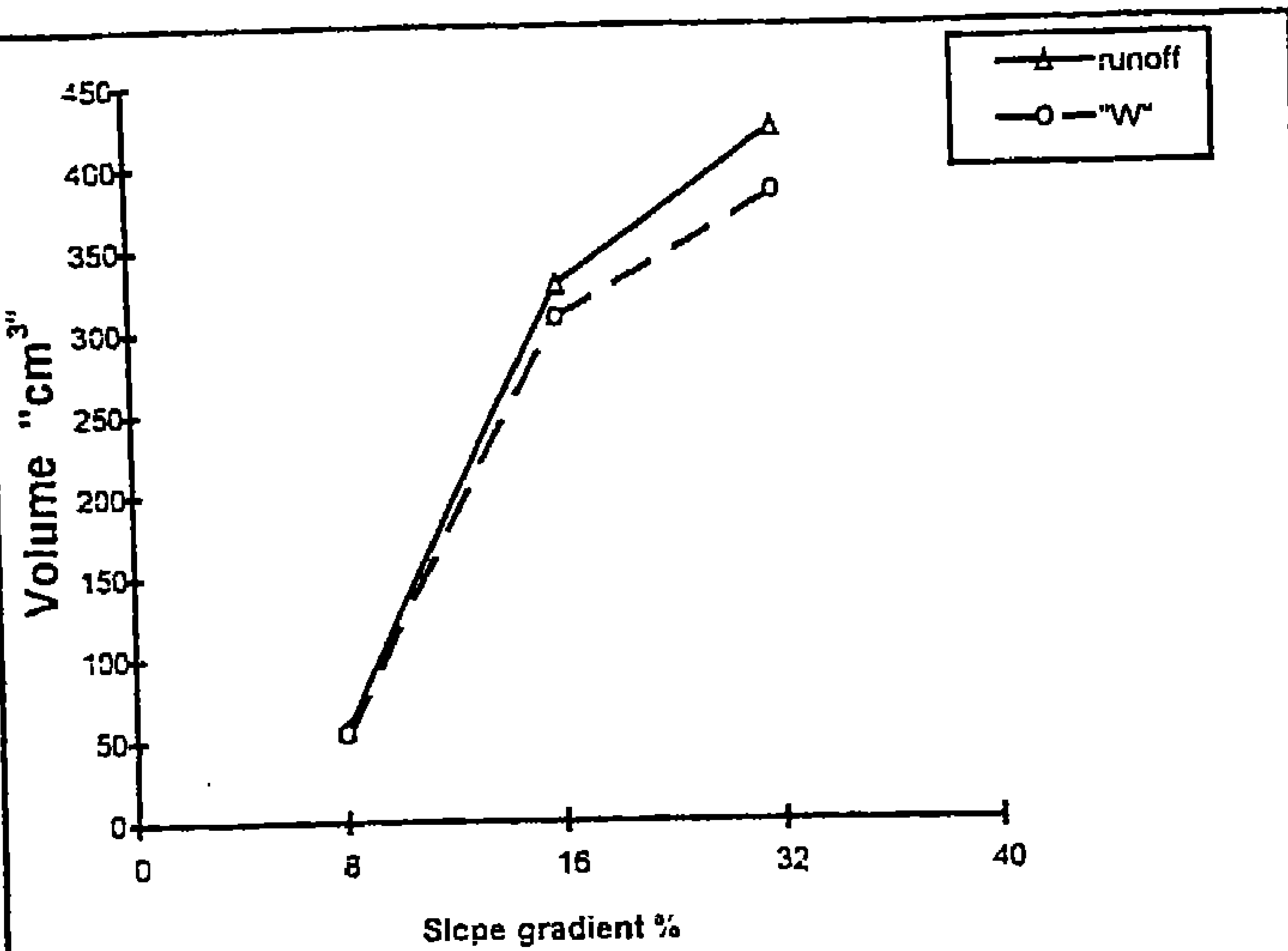

Fig11:The relation between runoff, water used in runoff process(W) and slope gradient in calcareous soil at rainfall intensity of 90mm/hr.

3.6.1.2 At 120 mm/hr rainfall intensity:

The influence of the fixed rainfall amount (1.250 liter) and its rainfall intensity (120 mm/hr) on runoff, water used in runoff process and sediments volume in calcareous soil is possessed in Fig. (12). Tlley increased when the slope gradient increased. In sandy soil, the same previous conditions didn't produce any quantities of runoff at any slope gradient.

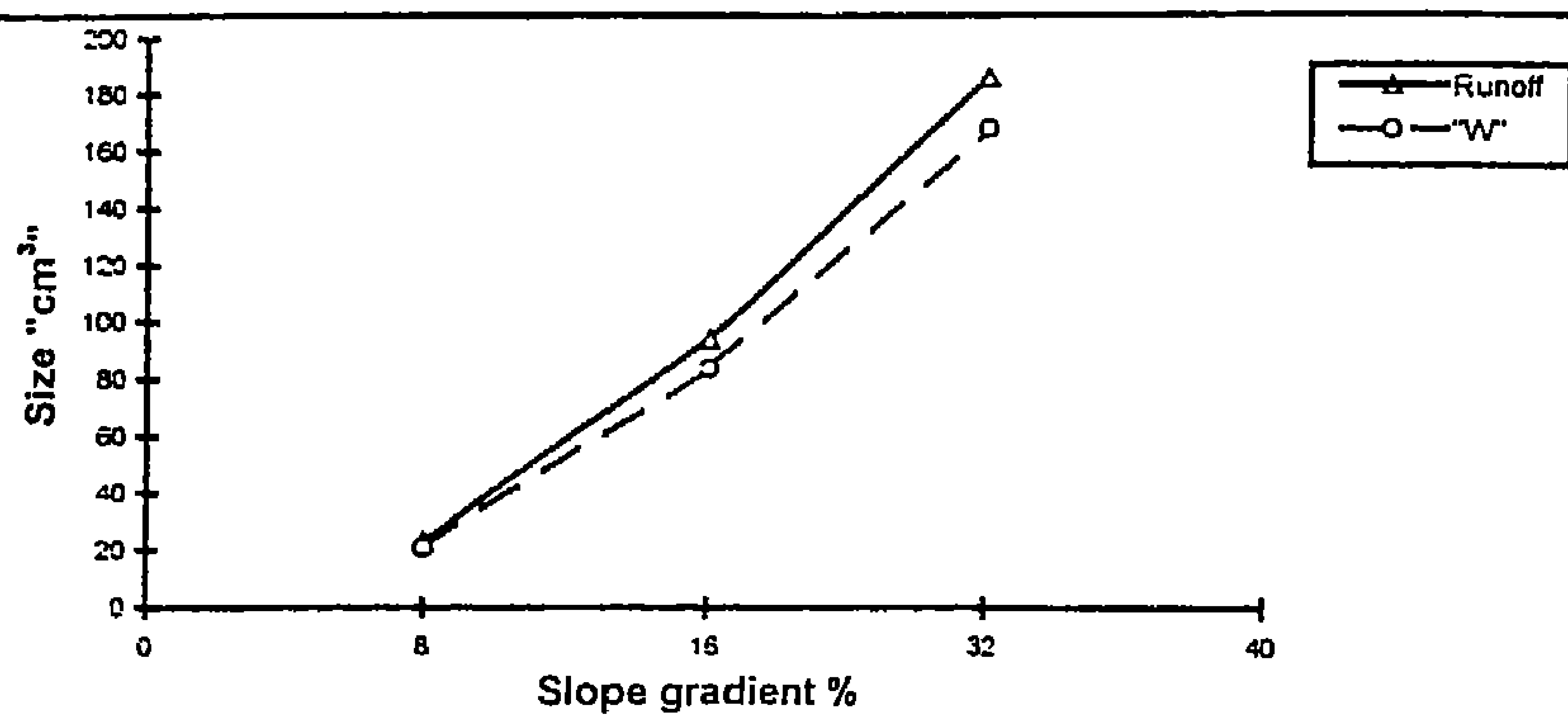

Fig.12: The relation between runoff, water used in runoff process "W" and slope gradient in calcareous soil at rainfall intensity of 120 mm/hr

3.6.1.3 At I15

The relation between runoff, water used in runoff process (w) and slope gradient in calcareous and sandy soil is illustrated in Fig. (13) .The runoff and ((W)) on sandy soil increased when the slope gradient increased until 16% slope gradient then they decreased at 32% slope gradient. But, incalcareoussoil,the runoff end water used in runoff process ((W)) increased wl1en the slope gradient increased,.

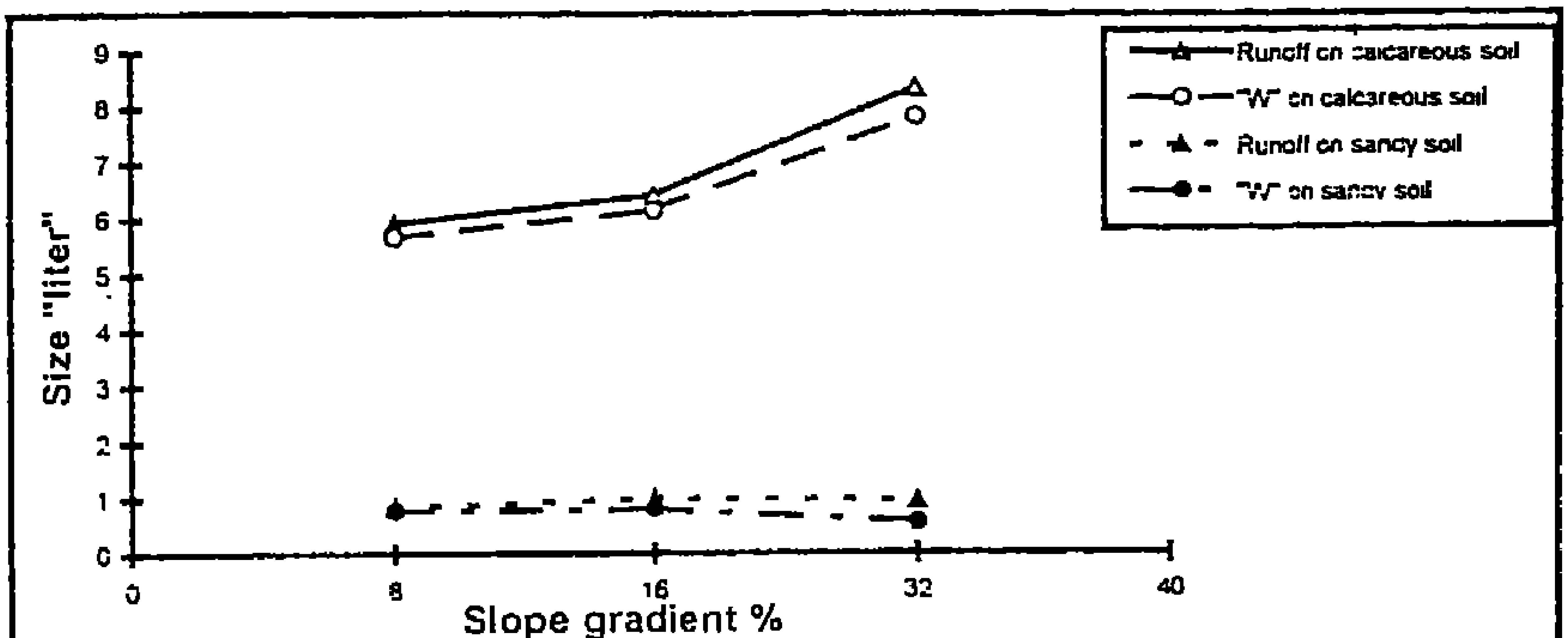

Fig.13: The relation between runoff, water used in runoff process "W" and slope gradient in calcareous and sandy soils at I15.

3.6.1.4 At I30

The runoff and water used in runoff process "W" in calcareous and sandy soil increased when the slope gradient increased with a maximum increase at 16% slope gradient, then they decreased when the slope gradient reached 32%, (Fig. 14).

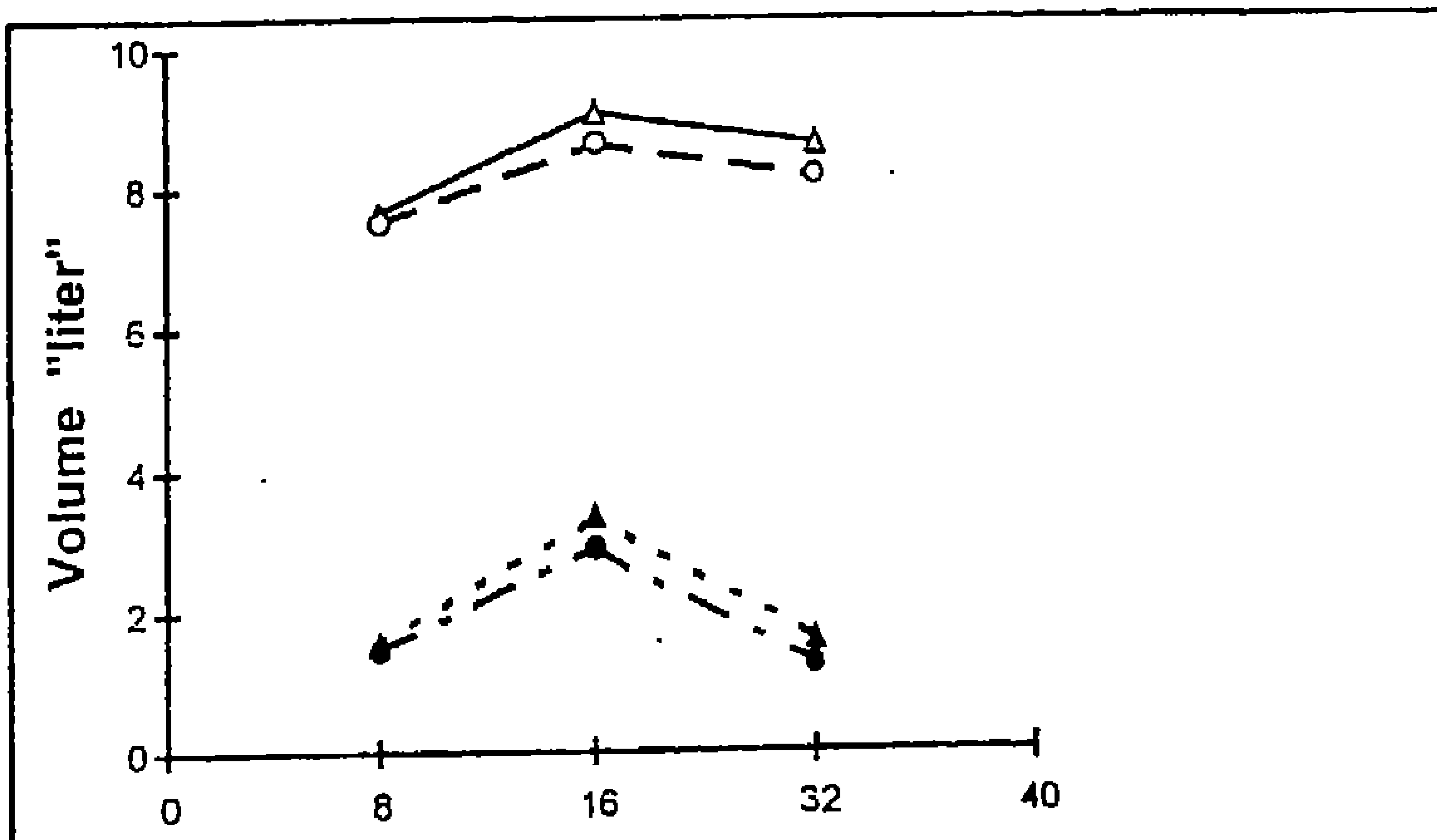

Fig.14: The relation between runoff, water used in runoff process "W" and slope gradient in calcareous and sandy soils at I_{30}.

There is a relation between water used in runoff process and rainfall amount (W/Rf) which is defined as the volume of water used in runoff process divided by the rainfall amount "W/R" increased in calcareous soil when the slope gradient increased. But, in sandy soil, it increased by increasing slope gradient unit 16% slope gradient, then, it decreased when the slope gradient reached 32%, (Fig. 15).

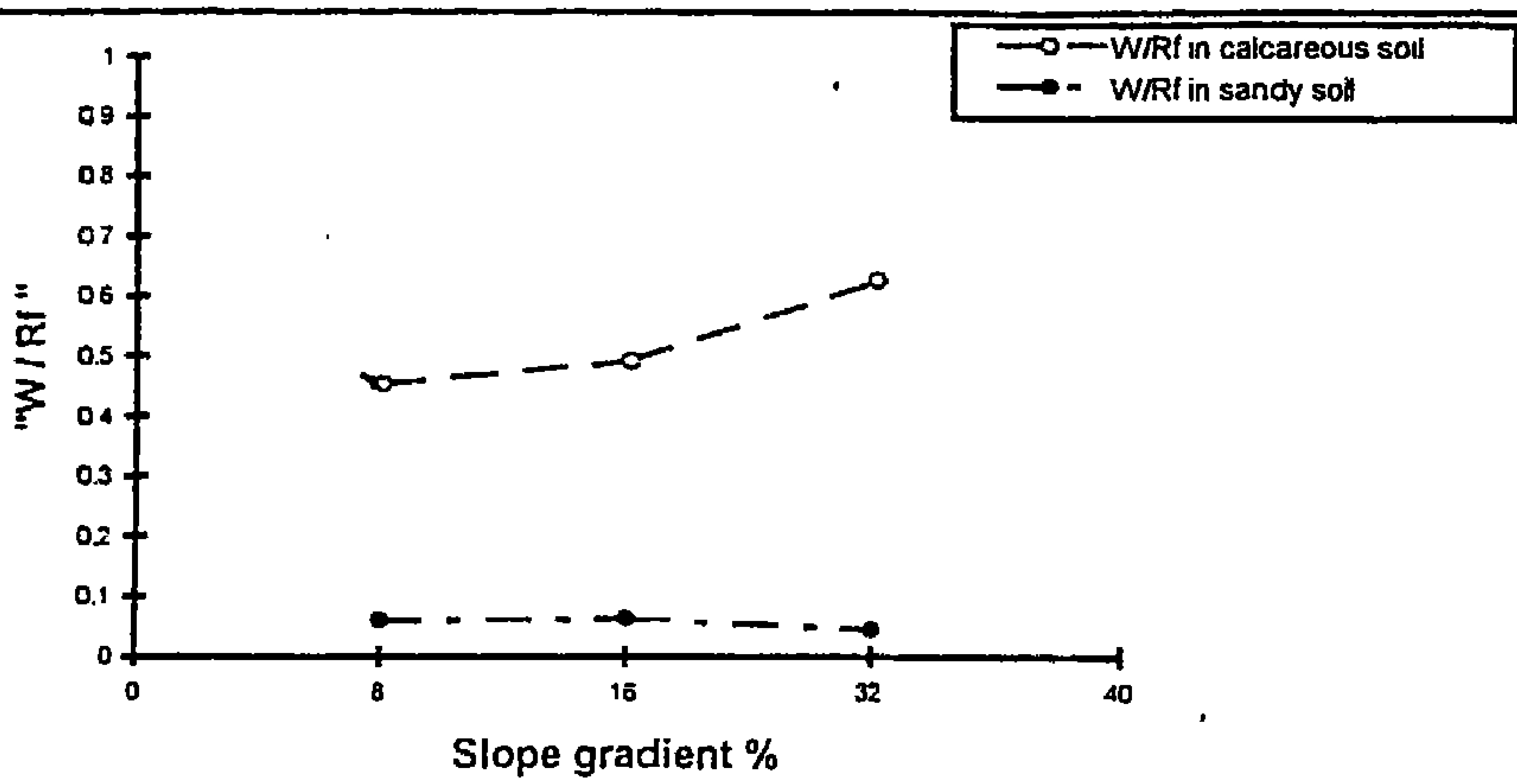

Fig.15: The relation between "W/Rf" and slope gradient in calcareous and sandy soils at I15.

At I_{30}, the trend of "W/RF" in calcareous and sandy soils was the same trend of the water used in runoff process at the same conditions, (Fig. 16).

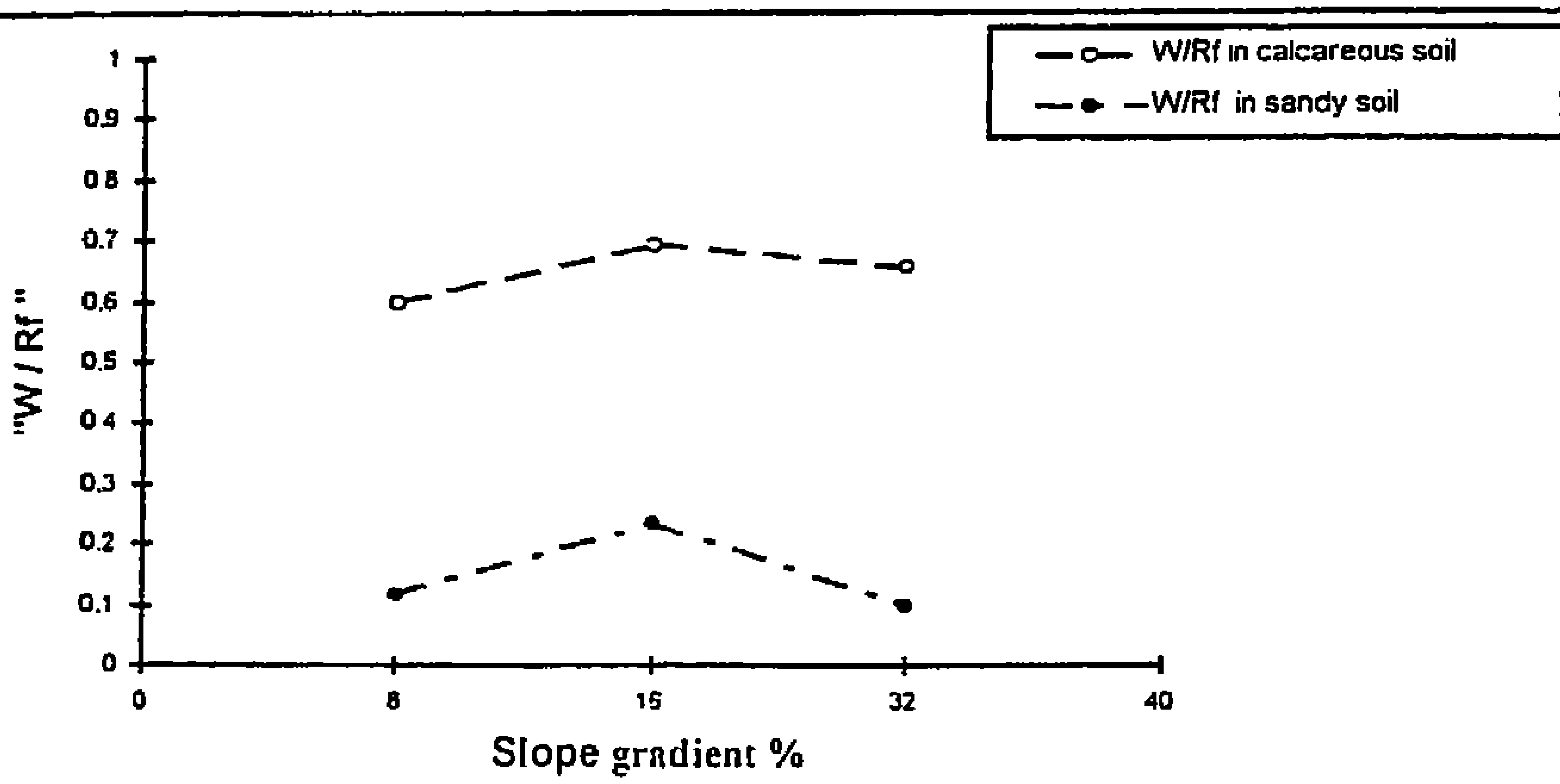

Fig.16: The relation between " W/Rf " and slope gradient in calcareous and sandy soils at I30.

3.6.2. Out let soil

Infiltrated water through the soil surface played an important role during its movement by moving some soil particles through the breeches of the experimental plot. These downward soil particles have been called out let soil . It is a laboratory state that does not occur in nature. Out let soil did not appear in the calcareous soi under all conditions of short time rain (90 and 120 mm/hr rainfall intensities) and als at long time rain (Iis and 1_{30}) Generally, the out let soil is not only depending on the infiltrated water and its ratio but also on the type of the soil, physical and chemical soil properties and slope gradients. So, the disappearance of outletparticles in calcareous soil under all conditions of laboratory experiments is attributed to its higher wet stable aggregates (about 69%), (Table 6). On the other hand, the total calcium carbonate, which was about 19.6%, worked as a cementing agent and cased this higher value of wet stable aggregates. Although, the maximum value of "IA /Rf" was 1.0 in sandy veil at short time rain (90 and 120 mm/hr rainfall intensities), the out let of sandy soil did not appear under the experimental plot. This is due to the amounts of water, which were used at these rainfall intensities (1.5 &1.250 liters). And, this reflects the effect ofthe water amount during the rain and the raining period. At I_{15} and I30 the out let of sandy soil appeared under the experimental plot and it increased when the slope gradient increased (Fig.17). That was due to the "IA / Rf " , which increased at these experimental conditions as the slope gradient increased. Only one exception was at I30 and 16% slope gradient, where the out let soil decreased when the slope gradient increased, because "IA/ Rf " at this slope gradient was the smallest value (0.761).

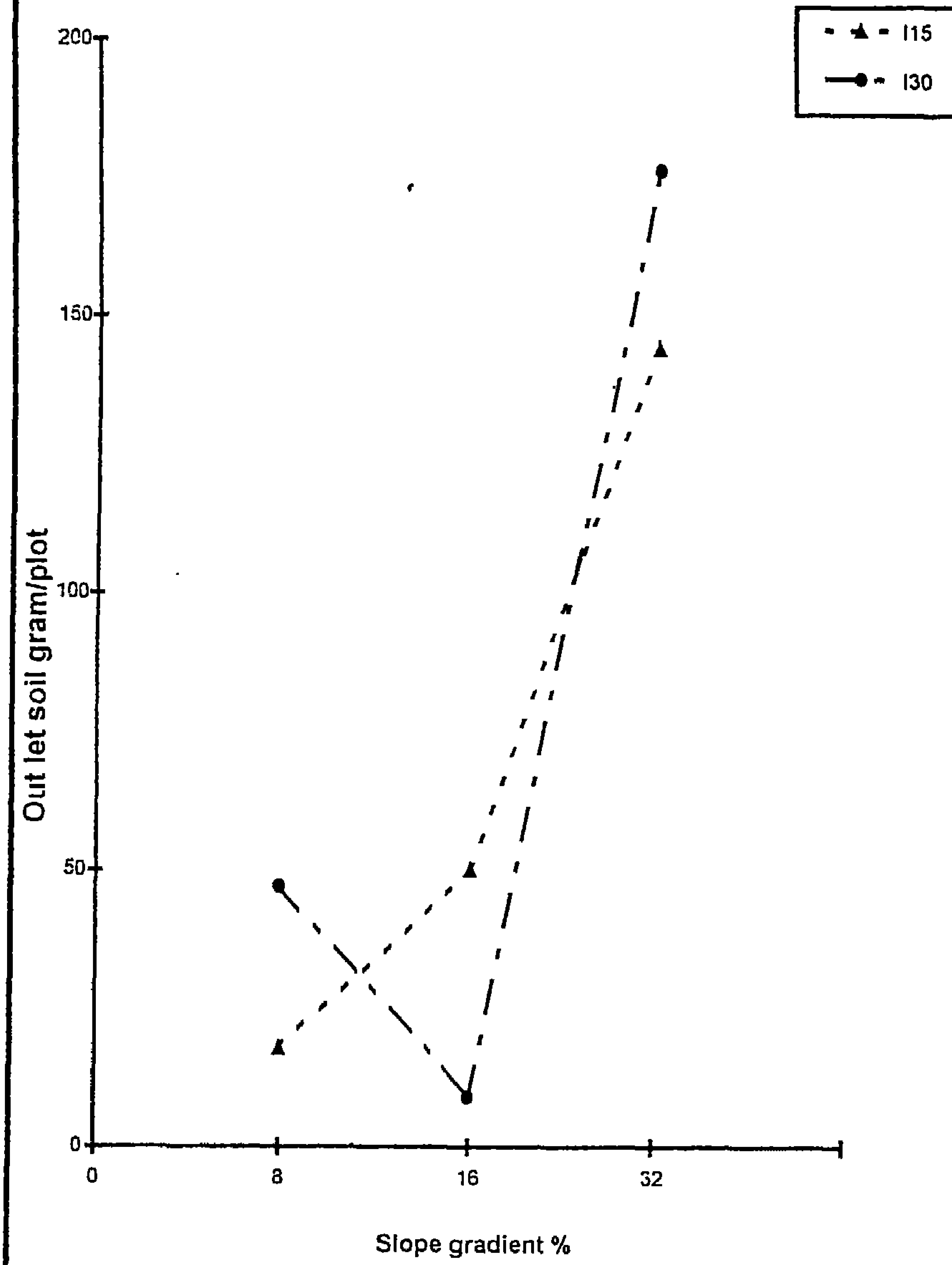

Fig.17: The relation between out let soil in sandy soil and slope gradient at I15 and I30

3.7. Soil loss

3.7.1 The relation between soil loss empirical estimation and slope gradient

3.7.1.1 Calcareous soil loss at short time rain (90 and 120 mm/ hr rainfall intensities)

Soil loss depends on many factors such as rainfall erosivity, slope gradient, slope length, erodibility of the soil, plant cover, human practice and soil conservation practices. The effect of slope gradient on the loss of calcareous soil is depicted in Fig. (18).

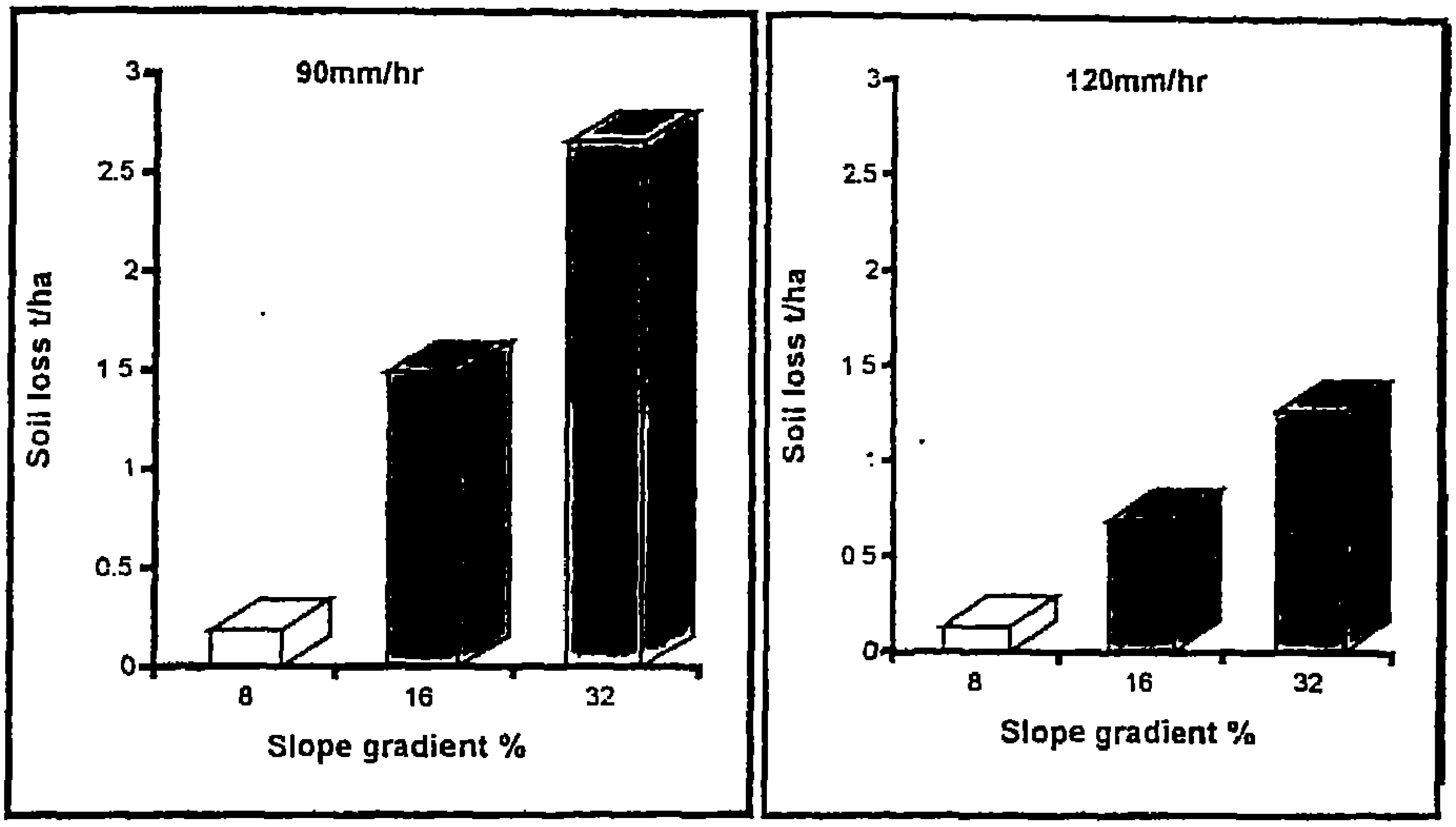

Fig.18: The relation between calcareous soil loss and slope gradient at 90 and 120 mm/hr rainfall intensities.

It is conspicuous that soil loss at 90 and 120 mm / hr rainfall intensities increased when the slope gradient increased. The soil loss at 90mm/hr rainfall intensity was higher than that at 120 mm / hr at all slope gradients.

3.7.1.2.Calcareous soil loss at lon~ time r ain " I_{1s} and I_{30} "

At I_{15} and I_{30} the soil loss increased by increasing the slope gradient. The effect of I_{15} on soil loss at 8 and 39 !O slope gradient was more than the effect of I_{30} at the same slope gradients. But, this effect at 16% slope gradient was less than the effect of I_{30} at the same slope gradient (Fig. 19).

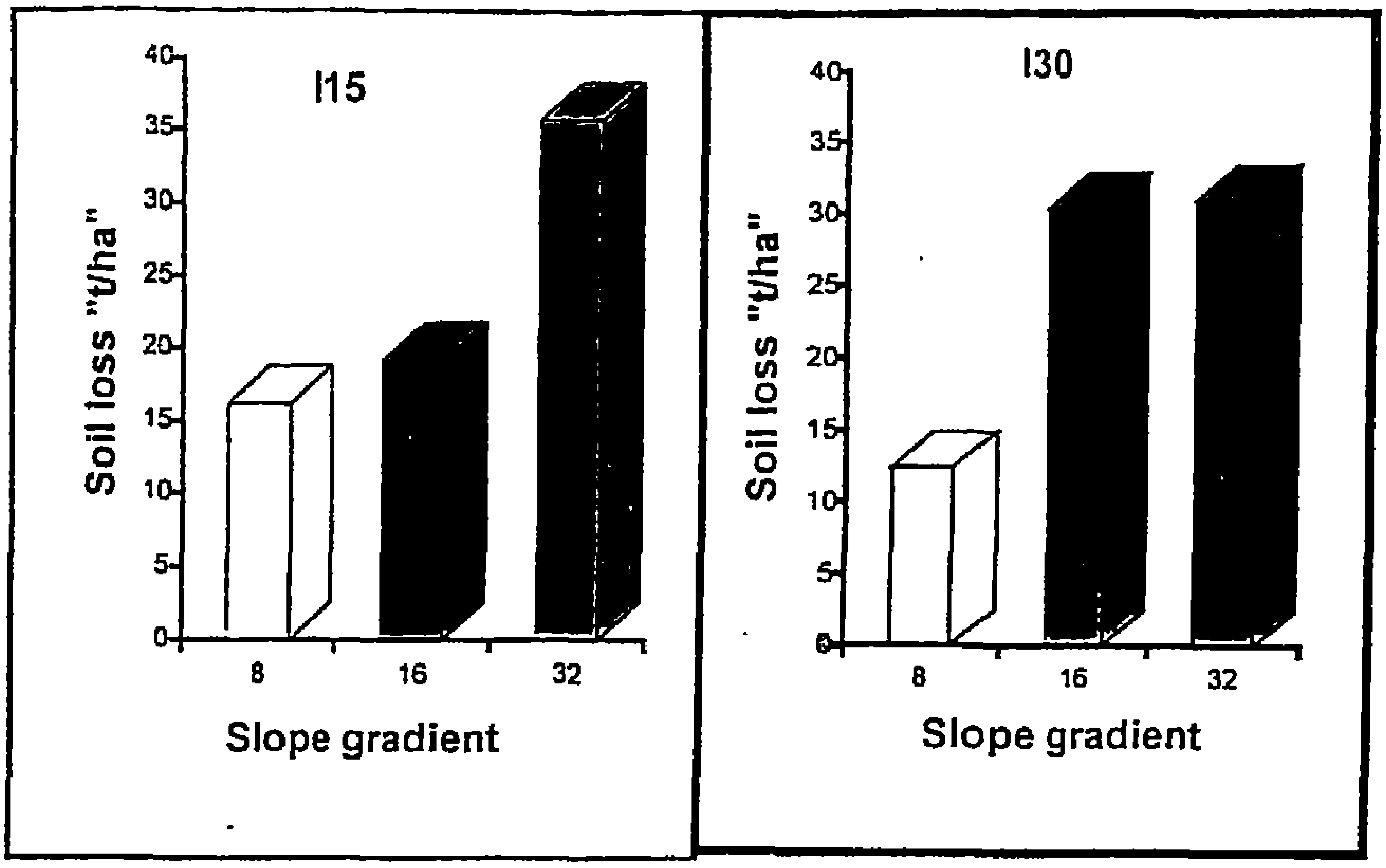

Fig.19: The relation between calcareous soil loss and slope gradient at I15 and I30.

The relation between soil loss and rainfall amount "A/Rf" ,which is defined as the soil loss volume divided by the rainfall amount, is an another parameter that must be onsidered to assist in identifying the general trend of soil loss at different slope gradient, (Table 10).

The relation between "A/Rf" and slope gradient in the calcareous soil is represented in Fig. (20). It increased when the slope gradient increased at short time rain (90 and 120 mm/hr rainfall intensities) and at long time rain (I_{15} and I_{30}).

There is another relation between soil loss and water used in runoff process (A/W) which reflects the ability of water used in runoff process to carry the disintegrated soil aggregates that have been broken down by falling raindrops. It was calculated by dividing the dry sediments volume on water used in runoff process. The relation between "A/W" and the slope gradient in calcareous soil is presented in Fig. (21).

Table10: "A/Rf" in calcareous soil at different rainfall intensities and slope "~radients

Slope grndient	8%				16%				32%			
Type of rainfall	Int. 90 Mm/hr	Int. 120 mm/hr	I_{15}	I_{30}	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}	Int. 90 mm/hr	Int. 120 mm/hr	I_{15}	I_{30}
Rainfall amount liter	1.500	1.250	12.500	12.500	1.500	1.250	12.500	12.500	1.500	1.250	12.500	12.500
soil loss volume liter	1.003	0.002	0.233	0.179	0.021	0.010	0.276	0.436	0.038	0.018	0.514	0.445
"A/Rf"	0.002	0.002	0.019	0.014	0.014	0.008	0.022	0.035	0.025	0.014	0.041	0.036

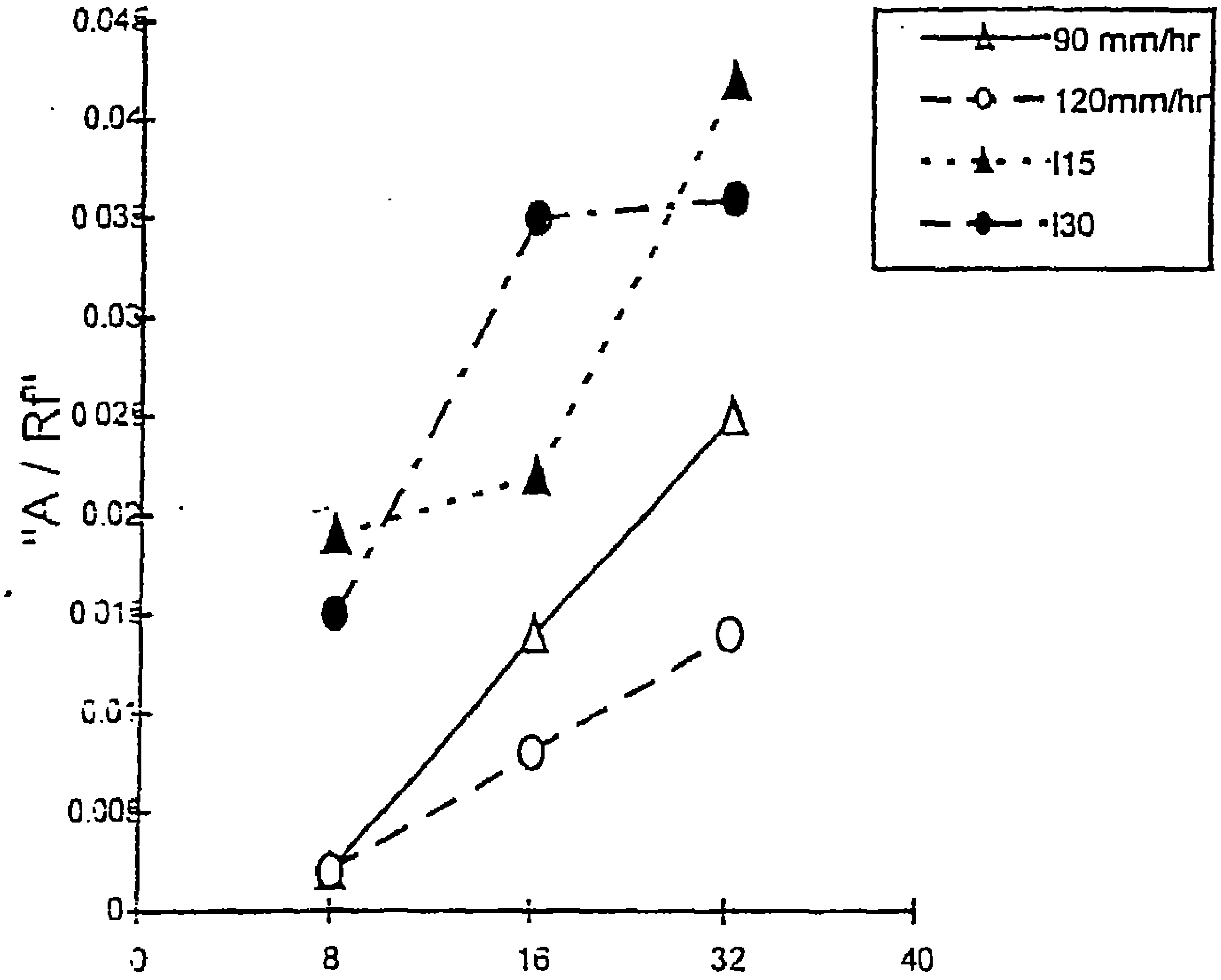

Fig. 20: The relation between "A/ Rf" and slope gradient in calcareous soil at different intensities.

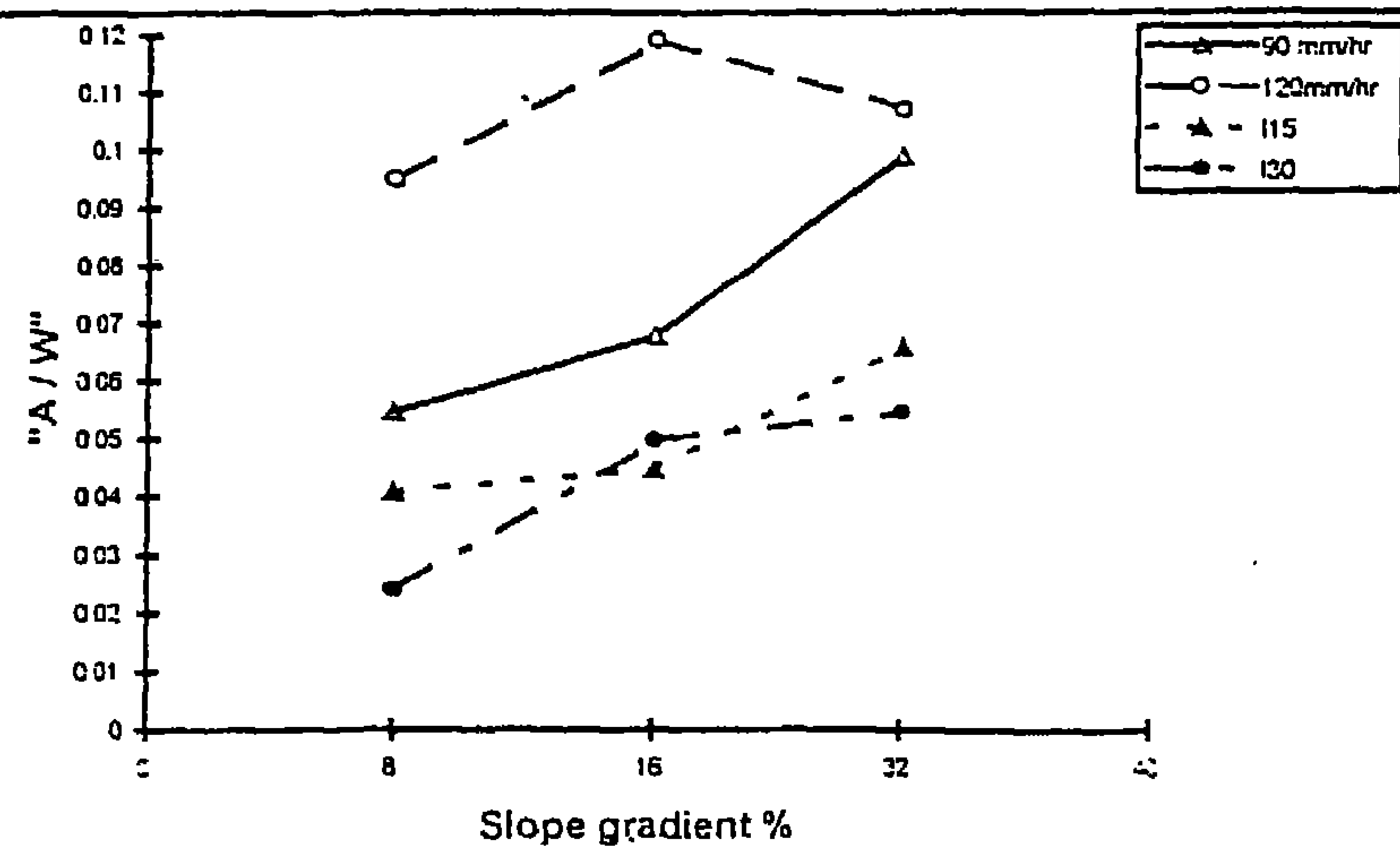

Fig21:The Relation between A / W " and Slope gradient in Calcareous differnt rainhall intensities.

It is evident that the "A/W" values in calcareous soil increased as the slope gradient increased. It emphasizes that the calcareous soil loss by water erosion increased as the slope gradient increased at different rainfall intensities.

3.7.1.3. Sandy soil loss at short time rain (90 and 120 mm / hr rainfall intensities)

No soil loss was detected in 9 replications of simulated rainfall at 90 mm/hr rainfall intensity (1.5 liter of water during a rain period of 4 minutes) and slope gradients of 8, 16 and 32%. The same results were also obtained in 9 replications at 120 mm / hr rainfall intensity (1.250 liter of water during a rain period of 2.5 minutes) and the same slope gradients (8, 16 and 32%).

3.7.1.4 Sandv soil loss at lone time rain (I~5 and 130)

I_{03} was more effective on the sandy soil in causing the loss of soil particles than I_{15}, at 8 and 16% slope gradient. But, at 32% slope gradient, the I_{15} was more effective in causing soil loss than 130. Generally, sandy soil loss increased as the slope gradient increased, (Fig. 22).

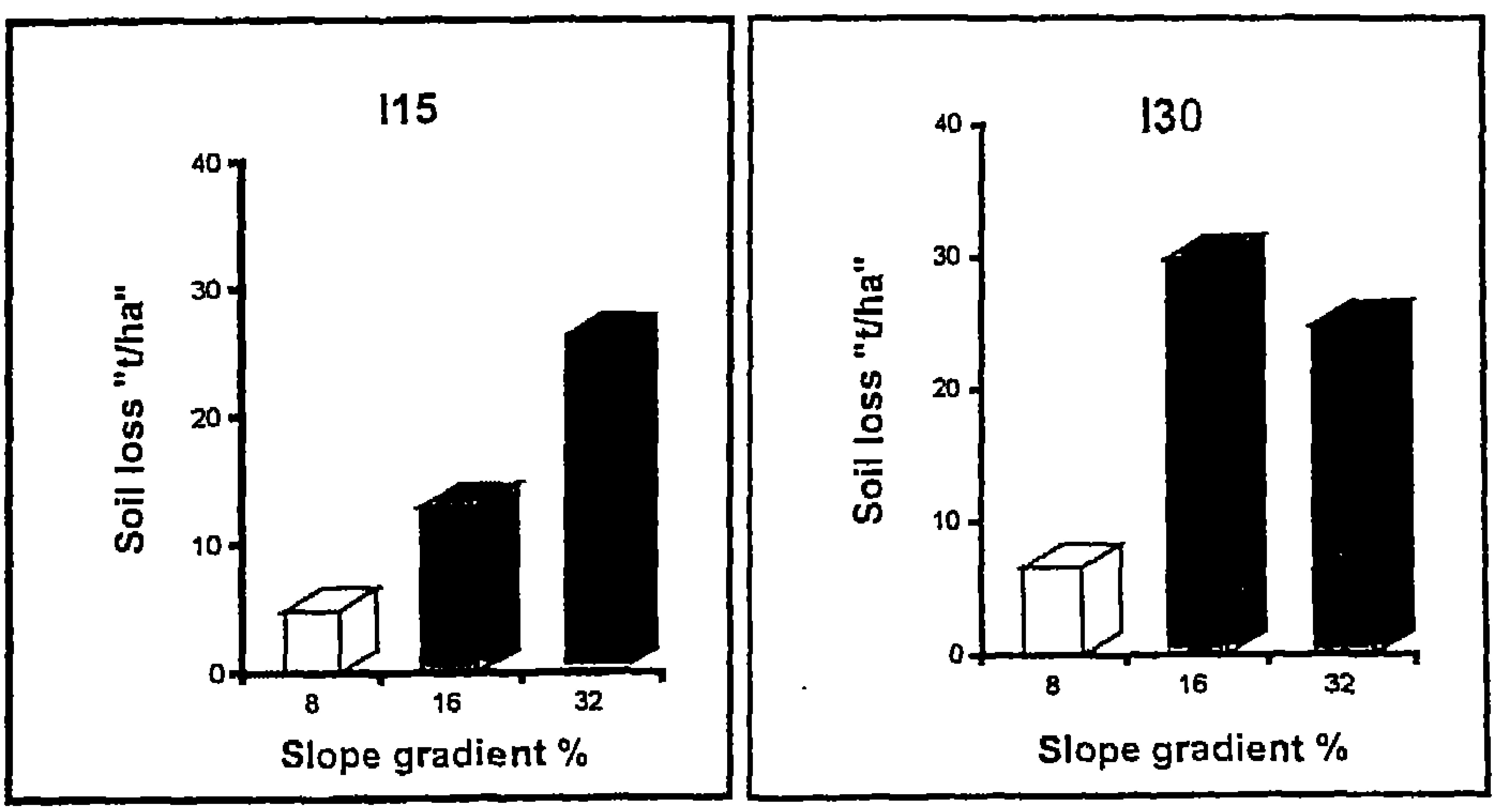

Fig.22: The relation between sandy soil loss and slope gradient at I15 and I30.

·In this context, "A/Rf3' (soil loss volume divided by rainfall amount), can also be utilized in order to know if there is a difference in the trend of sandy soil loss or not. "A/Rf" values in sandy soil at 90 and 120 mm/hr rainfall intensities at different slope gradients up to 32 % havé not shown a specific trend because their values equal zero. "A/Rf" values at I_{30} were more than those at I_{15} with 8 and 16% slope gradients. But, at 32% slope gradient, `(A/Rf) at I_{15} was more than I_{30} (Table 11).

Slope gradient	8%		16%		32%	
Type of rainfall / Criteria	I_{15}	I_{30}	I_{15}	I_{30}	I_{15}	I_{30}
Rainfall amount (liter)	12.500	12.500	12.500	12.500	12.500	12.500
Soil loss volume (liter)	00.072	00.099	00.195	00.449	00.395	00.373
"A/Rf"	00.006	00.008	00.016	00.036	00.032	00.030

Generally, "A/Rf" values empllasized the general trend of sandy soil loss at I_{15} and I_{30},which was influenced by the increase in slope gradient, (Fig.23)

A/W (It is defined as the soil loss volume divided by water used in runoff process) can also be used to know the ability of water used in runoff process to carry the broken soil aggregates "A/W" values in sandy soil also increased as the slope gradient increased up to 32 % at both of I_{15} and I_{30} Although, the sandy soil loss at 1_{30} was higher than that at I_{15} at 8 and 16% slope gradients, "A/W" values at I_{15} were higher than those at I30 at the same slope gradients, (Fig.24).

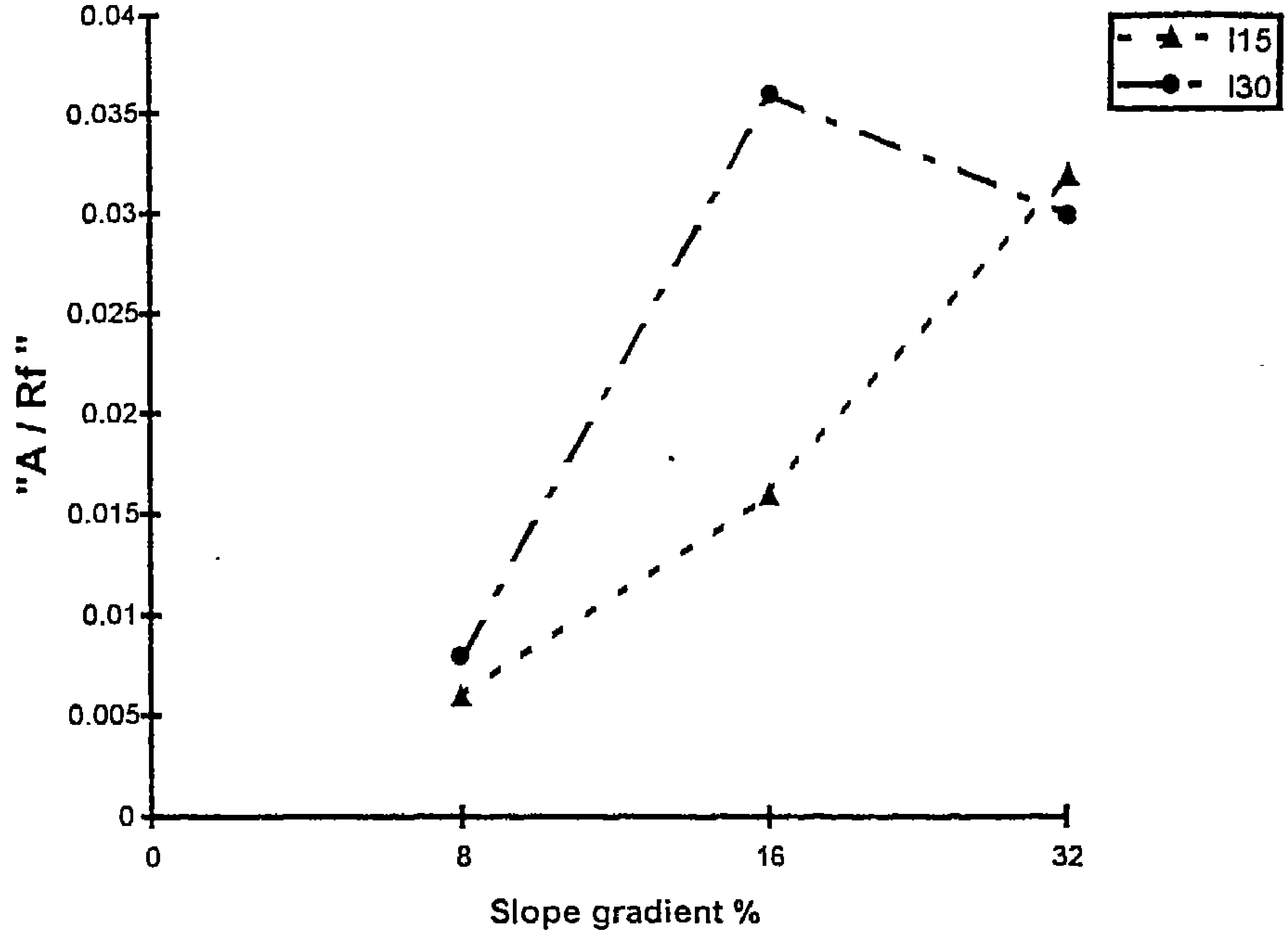

Fig.23: The relation between "A / Rf " and slope gradient in sandy soil at I15 and I30

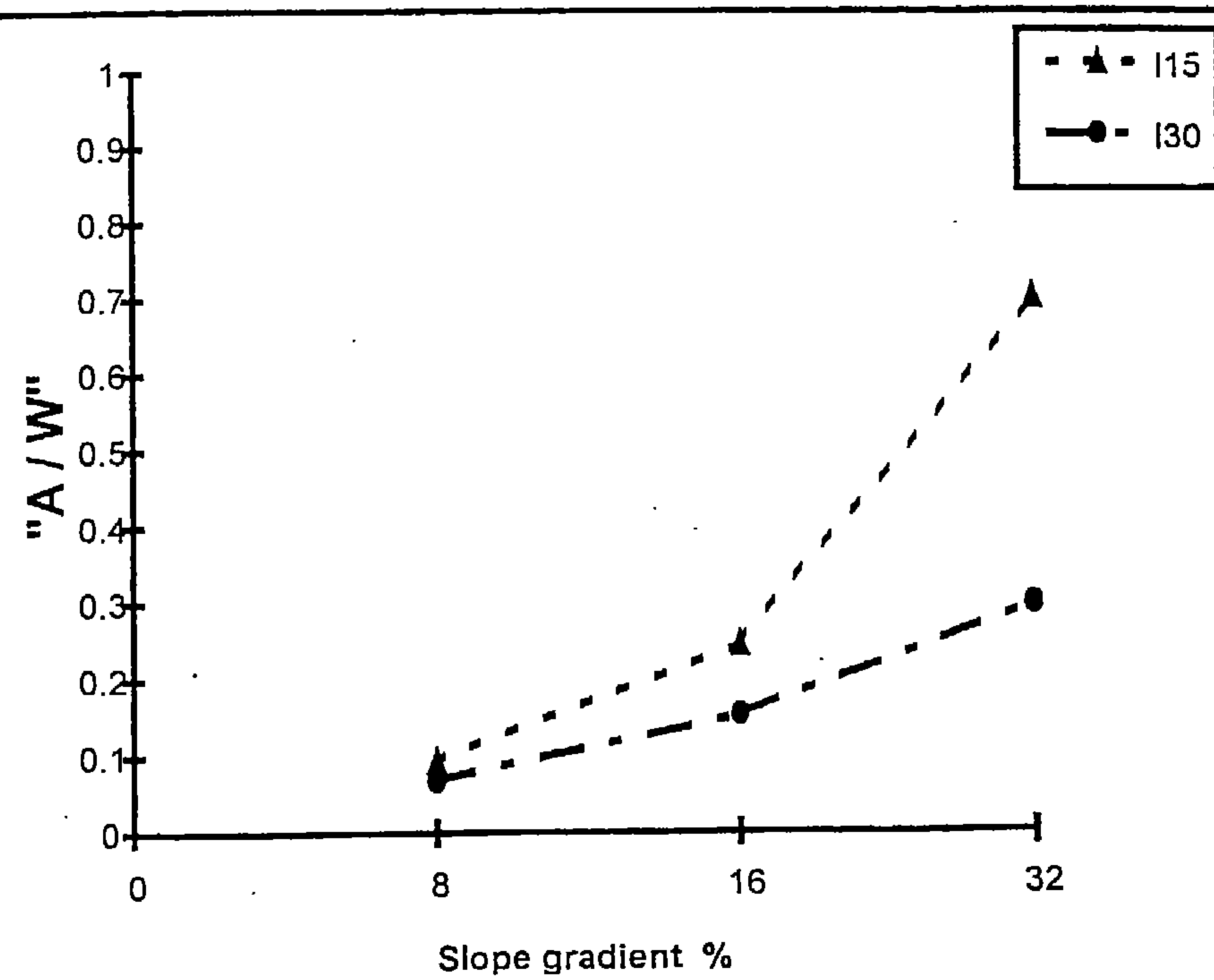

Fig.24: The relation between "A/w" and slope gradient in sandy soil at I15 and I30.

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MISE AU POINT SUR LA VIE ENTOMOLOGIQUE DANS LES DESERTS AFRICAINS, PARTICULIEREMENT SUR LES INSECTES COLLEMBOLES

Par

Jean-Marc THIBAUD*

Cette mise au point est divisée en trois parties inégales: la première sur l'entomofaune du désert mauritanien, la deuxième sur les Insectes Collemboles et la troisième sur quelques données sur les Collemboles des déserts africains.

1- PRELIMINAIRE SUR LA BIODIVERSITE DES INSECTES DES SABLES LITTORAUX DE MAURITANIE

Deux missions franco-mauritaniennes se sont déroulées en avril et en novembre 1995. Elles ont permis d'établir un premier inventaire de sept stations du littoral dunaire depuis le sud du Banc d'Arguin (230 km au nord de Nouakchott) jusqu'au Pare de Dwaling près de la frontière avec le Sénégal (200 km au sud de Nouakchott).

Matériels et méthodes

Observations et récoltes ont été menées de jour comme de nuit par des chasses à vue, par la technique des pièges-trappes et par lavage de sable pour la microfaune. Le rendement du travail a été souvent contrarié par des vents assez forts. Les prospections en avril, mois assez chaud et sec, n'ont permis que des prises relativement faibles; celles de novembre, période plus fraîche après les pluies, se sont

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