PN-ABC-890
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AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: 9/14/88

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. C7-143

SCI Report rec'd 9/14/88

Attachment

C7-143 PN-AAC-890

August 1988

BIMODAL EOLIAN DESERT SAND SHEET AND THEIR POTENTIAL SIGNIFICANCE FOR AGRICULTURAL DEVELOPMENT

SCIENTIFIC REPORT

Haim Tsoar
Department of Geography
Ben Gurion University of the Negev
Beer Sheva
Israel

Kofi Anane-Fenin
Department of Physics
University of Liberia
Monrovia
Liberia

The aim of this research is to enhance knowledge and understanding of spatial, dynamic, textural and chemical aspects of bimodal sand sheets, and their potential for agricultural exploitation. It will involve the use of already existing methods for studying unimodal sands and the usufruct of practical experience gained, predominantly in Israel with dune sand agriculture on bimodal sand sheets under different environmental conditions. Part of the work will be conducted in the field and part in the Laboratory. The field work is planned to be carried out in northern Senegal and the simulative laboratory work in the wind tunnel of the laboratory of geomorphology of Ben-Gurion University of the Negev.

FIELD WORK

The area chosen for the field work is located in northern Senegal, south of the Senegal River, between the villages of Dagana and Podor. This area is covered by sand of an ancient 'Erg' (sand sea) that was formed during a dryer climate of the Upper Pleistocene (more than 40,000 years ago). This dry period was succeeded by a humid phase in which the sand dunes became

stabilized, subdued in form, and underwent soil formation (Michel 1980).

The average annual rainfall of the area during the period prior to 1960 was 350 mm in a monsoonal regime between July and October (Griffiths & Soliman 1972). After 1970 there was a drastic decrease in rainfall. The average precipitation for Guede Chantier near Podor (16°27'N; 14°39'W), for the period 1970-1986, is 171 mm (data given to me by courtesy of Ms. Jane Rossing of N'Dioun). Figures 1, 2, & 3 depict the analysis of the rain data and indicate that, within the decrease of 50% in the average annual rainfall, there is an increased rainfall during the period of November to March.

This naturally produced change in the ecological conditions has left its impression on the area. An analysis of satellite images by Spot Image, taken on 24 March 1986, revealed vast fields of sand sheets that suffered from overgrazing and firewood collecting during the last 20 years, which led to the development of several low active dunes. The area has gradually deteriorated and degenerated from an ecological point of view - a process known as desertification

A previous attempt to visit the area in last May failed due to difficulties in obtaining an entry visa to Senegal. Dr. Christian S. Diatta, the Director of the Institute for Applied Nuclear Technology (ITNA), Cheikh Anta Diop University in Dakar, who is our local collaborator, has recently met with the Senegalese Ministaer of Interior who promised him solemnly that we will soon get our visas. Field work, together with three other scientists of C.A.P. University in Dakar, from the desciplines of biology, physics and geology, is planned to be carried out after the coming monsoon season. We have prepared equipment for field work such as sand traps, anemometres and recorders.

LABORATORY WORK

In the laboratory we have prepared the boundary-layer low-speed wind tunnel appropriate for studying the movement of coarse sand of which sand sheets are composed. Out of the various methods for generating the wind profile in the wind tunnel for sand movement simulation, the Cowdrey method - one of the simplest yet most effective - was chosen. By this method, velocity can be non-uniformly reduced by placing, ahead of the test section, a closely graded grid of rods near the floor and which becomes, further ahead, close to the roof.

The sand feeder built for the wind tunnel has eight outlet pipes so that the rate of sand discharged from the feeder can be easily measured and regulated. A test of poorly sorted coarse sand, created synthetically from sand components selected in the Negev desert, is shown in Figure 4. After 8 hours of wind speed of 10 m s^{-1}, the sand surface was stabilized by the formation of armoring coarse particles on the surface ("Tunnel sand" in Fig. 4).

The sand trap designed for the wind tunnel work consists of six chambers, one on top of the other, each with an aperture of 10x20 mm and a length of 350 mm (Fig. 5). The exit port at the top of the chamber is meant for decreasing the stagnation pressure and is covered by a fine mesh of 75 μm. Measurements of the amount of sand trapped by the chambers (q) in gr cm^{-1} hr^{-1} under several different wind velocities (u) show a very good correlation (r=0.994) between q and u^2 (Fig. 6). According to the regression equation: $q=(0.63u-4.5)^2$ it comes that the threshold velocity (impact threshold)

for this sand, measured at 15 cm height, is 7.15 m s^{-1}.

In another wind tunnel test, the grain-size of the sand caught by the trap was compared with the surface sand grain sizes (Fig. 7). It is obvious that the trapped sand is finer than the surface sand because of containing the saltation load whereas surface sand has a great proportion of coarse lag creeping grains. The sand used in the feeder is similar in size to sand collected in the trap.

Measurements of profiles of wind velocity were taken under several wind speeds, from the threshold velocity up to the highest possible wind tunnel speed. The results are shown in Figure 8. The threshold friction velocity is 31 cm s^{-1} and the highest friction velocity is 111 cm s^{-1}. The roughness length (z_o) is 1.766×10^{-5} m. It corresponds to an average surface grain-size of 0.53 mm ($30z_o$).

FIGURE CAPTIONS

Figure 1: The mean monthly rainfall of Guede Chantier, northern Senegal, for the period 1971-1986.

Figure 2: The distribution of northern Senegal annual rainfall (in percent) for the period 1971-1986.

Figure 3: The deviation of northern Senegal annual rainfall from the mean (1971-1986).

Figure 4: Grain-size distribution of poorly sorted sand. In black the grain-size distribution given by the feeder. In grey the tunnel surface grain-size distribution after 8 hours of wind velocity of 10 m s^{-1}.

Figure 5: A chamber for trapping saltating sand.

Figure 6: Regression line for the correlation between sand transport (q) and wind velocity (u).

Figure 7: Comparison between grain-size distribution of tunnel surface sand and sand collected in the trap.

Figure 8: Wind velocity profiles, on a logarithmic scale of heights, for the wind tunnel and the surface sand.

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Griffiths, J. F. and Soliman, K.H. 1972, The northern desert (Sahara), Chapter 3. In H.E. Lansberg (ed.), World Survey of Climatology, Climates if Africa. 10: 75-132.

Michel, P. 1980, The southwestern Sahara margin: Sediments and climatic changes during the recent Quaternary. In M. Sarnthein, E. Seibold and P. Rognon (eds.), Sahara and Surrounding Seas. 12: 297-306.

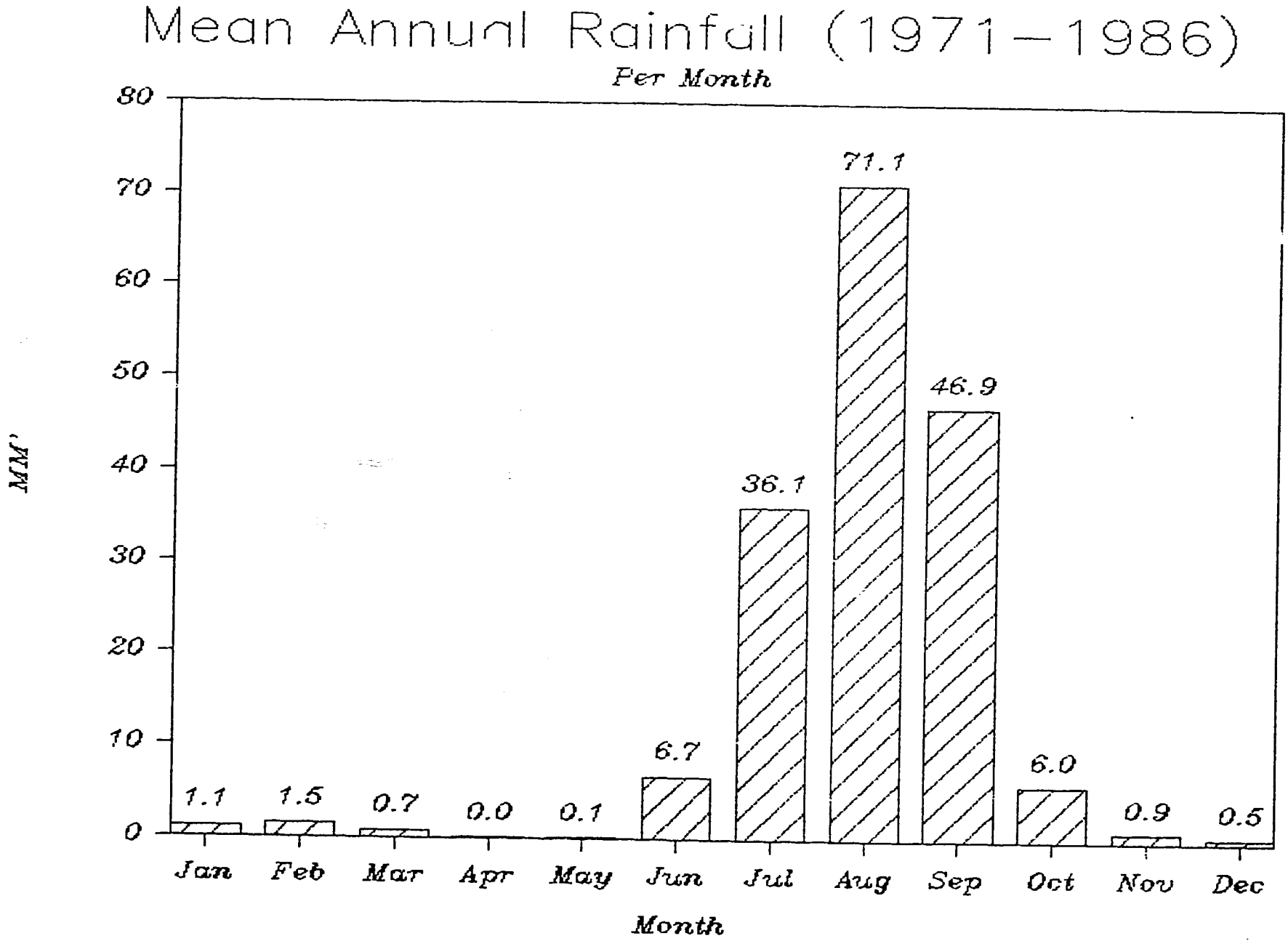

Mean Annual Rainfall (1971–1986)
Per Month
MM
80
70
60
50
40
30
20
10
0
1.1
1.5
0.7
0.0
0.1
6.7
36.1
71.1
46.9
6.0
0.9
0.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Fig. 1

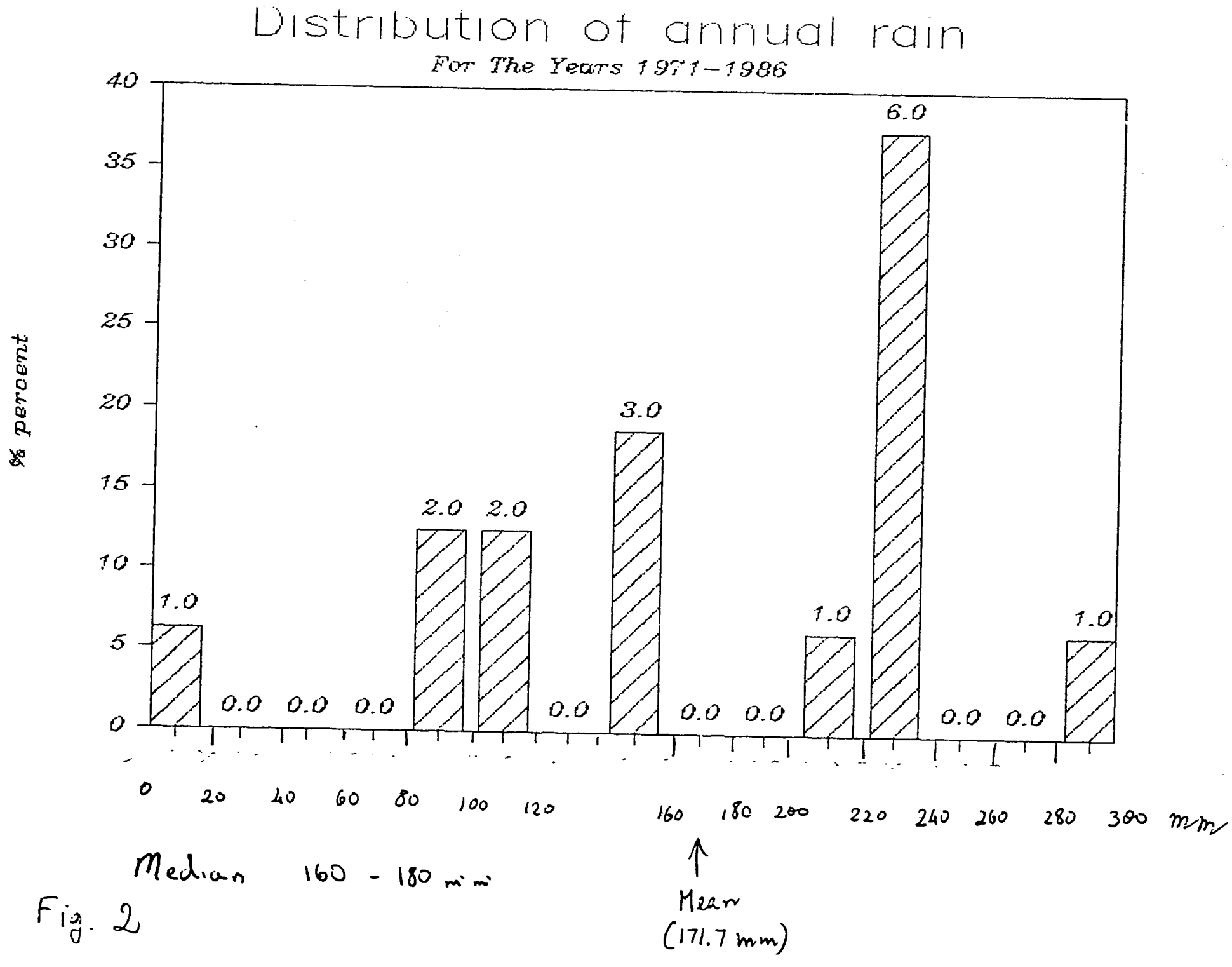

Distribution of annual rain
For The Years 1971–1986
% percent
40
35
30
25
20
15
10
5
0
1.0
0.0
0.0
0.0
2.0
2.0
0.0
3.0
0.0
0.0
1.0
6.0
0.0
0.0
1.0
0
20
40
60
80
100
120
160
180
200
220
240
260
280
300
mm
Median 160 - 180 mm
Mean
(171.7 mm)

Fig. 2

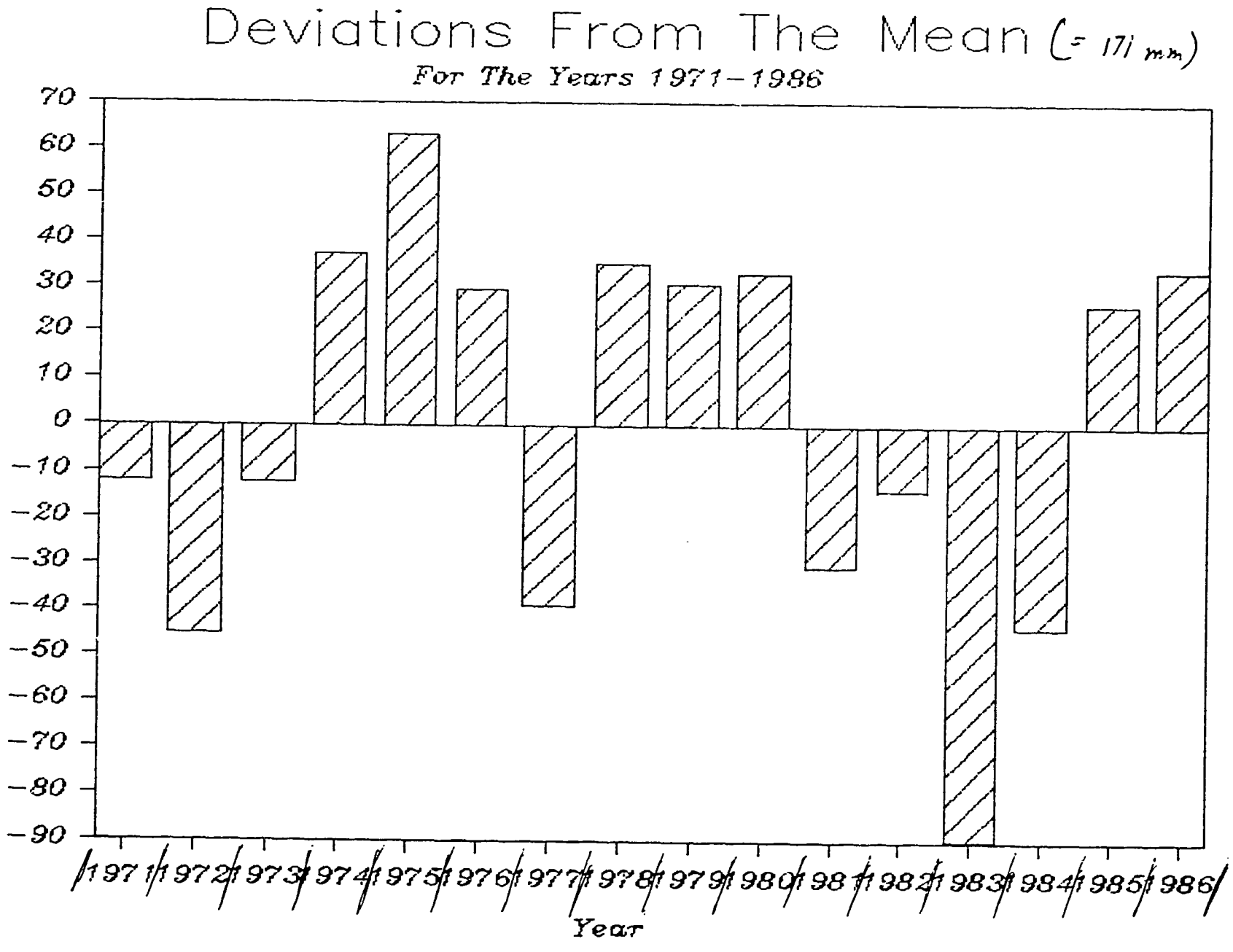

Deviations From The Mean (= 171 mm)
For The Years 1971–1986
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
Year

Fig. 3

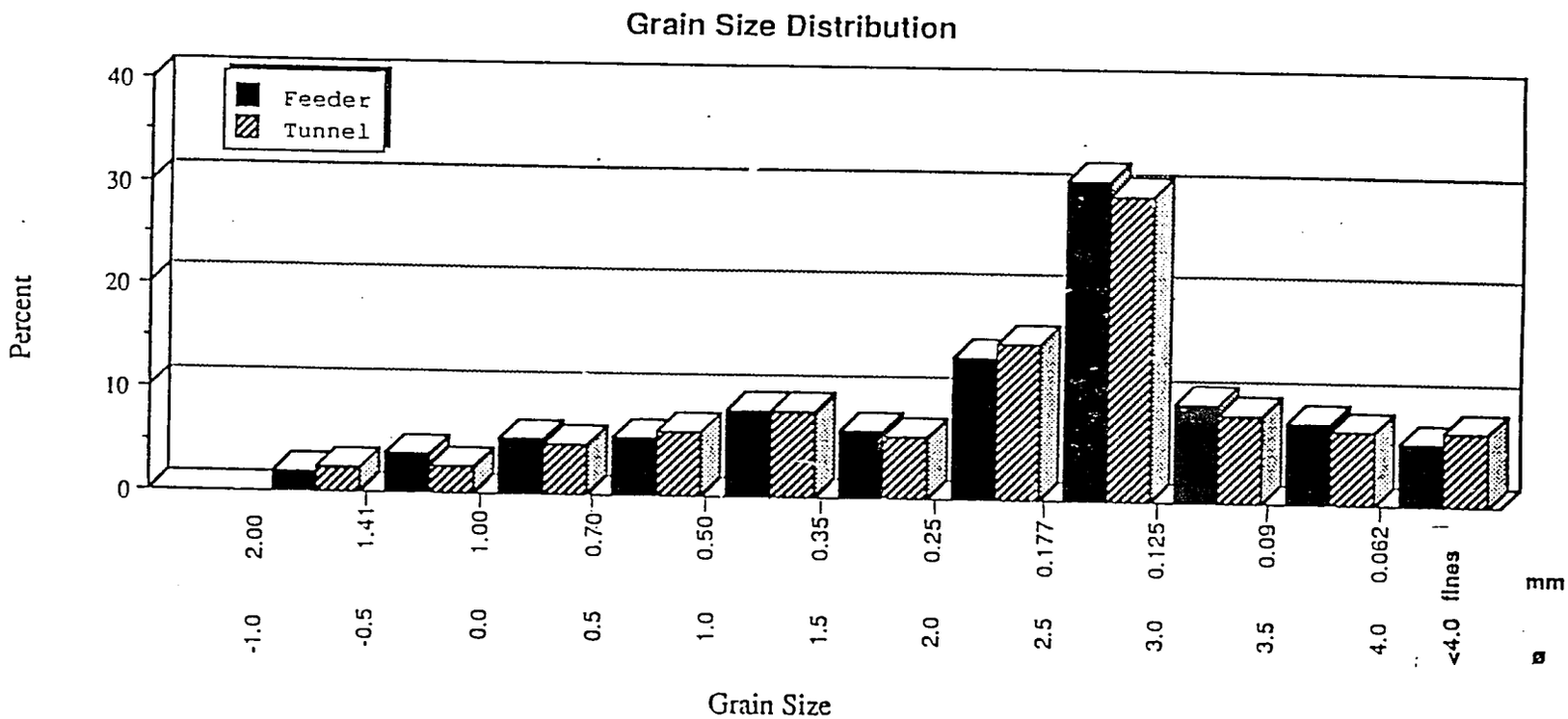

Grain Size Distribution
Feeder
Tunnel
Percent
40
30
20
10
0
2.00
1.41
1.00
0.70
0.50
0.35
0.25
0.177
0.125
0.09
0.062
<4.0 fines
mm
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
ø
Grain Size

Fig. 4

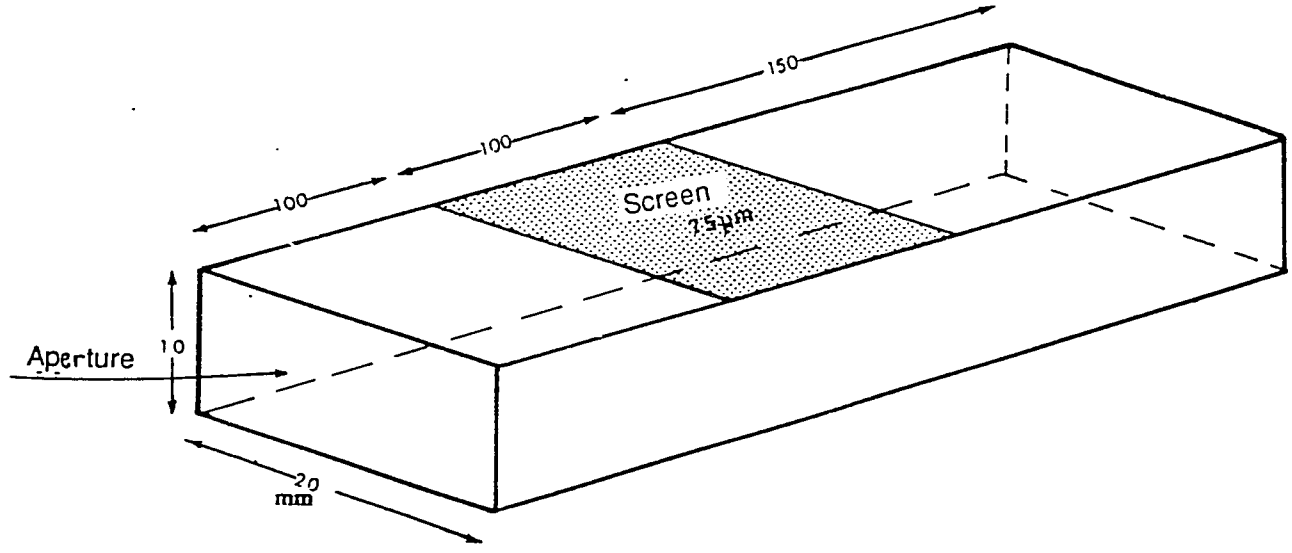


Fig. 5

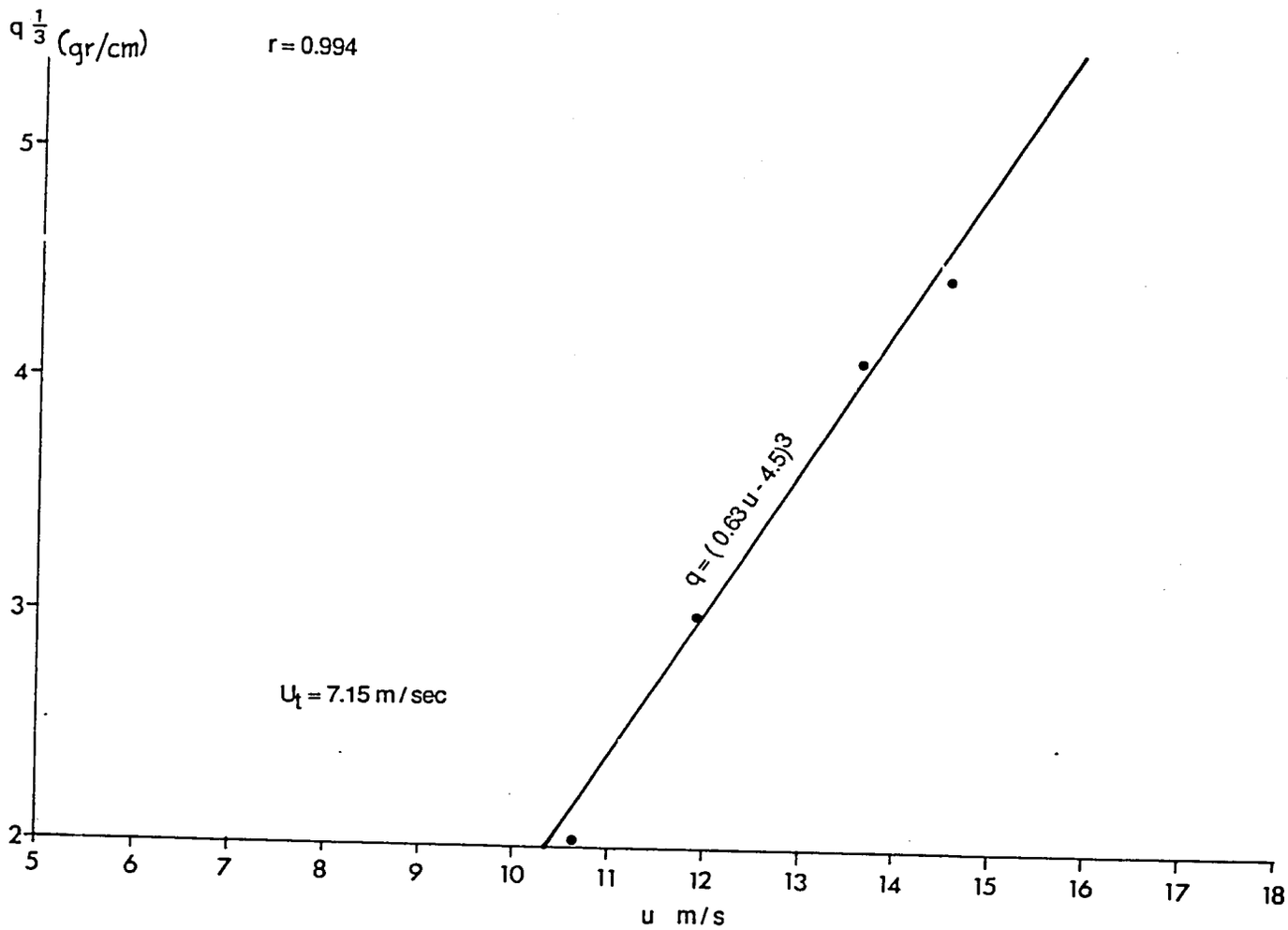

q 1/3 (gr/cm)
r = 0.994
5
4
3
2
q = (0.63 u - 4.5)3
Ut = 7.15 m/sec
5
6
7
8
9
10
11
12
13
14
15
16
17
18
u m/s

Fig. 6

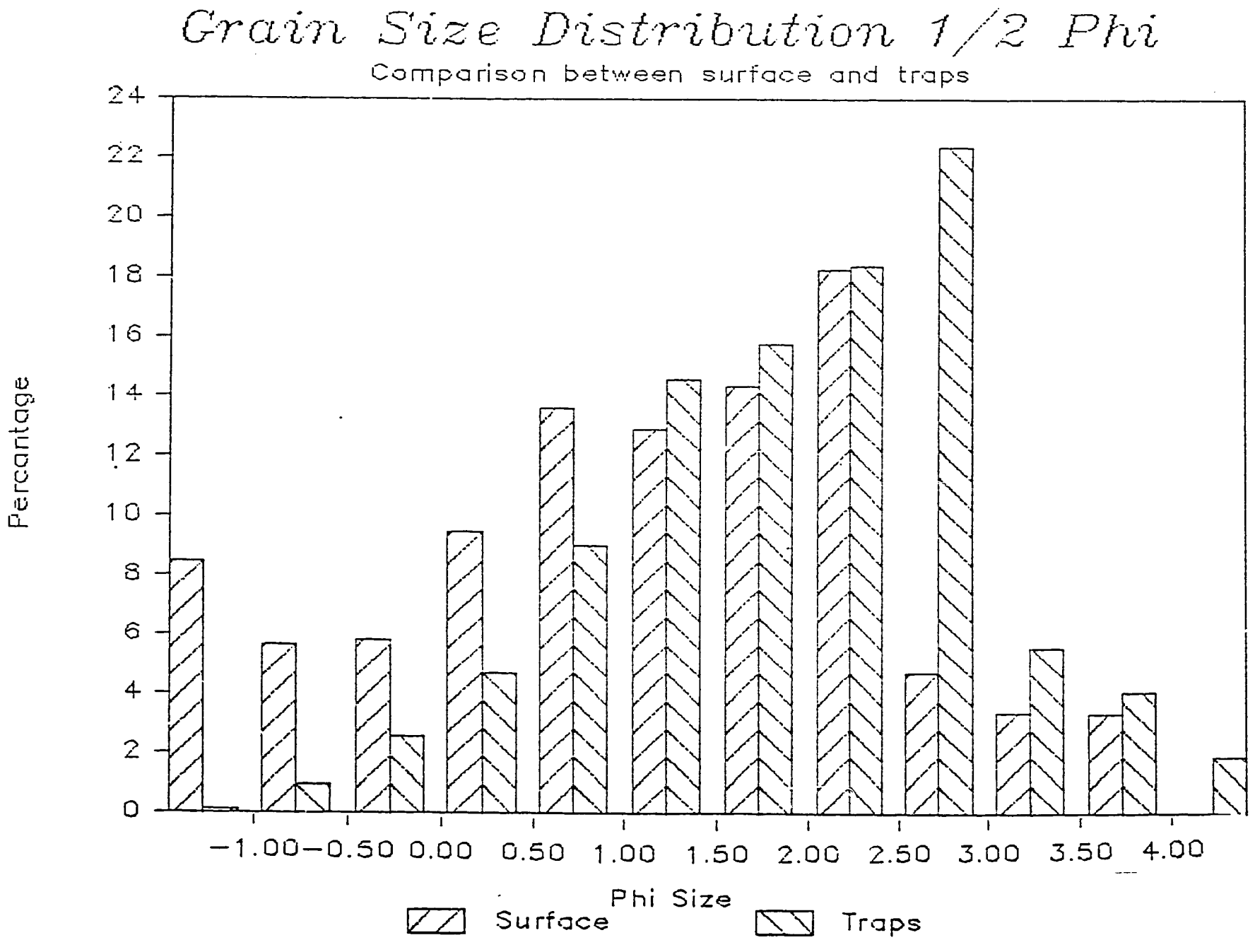

Grain Size Distribution 1/2 Phi
Comparison between surface and traps
Percentage
24
22
20
18
16
14
12
10
8
6
4
2
0
−1.00
−0.50
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Phi Size
Surface
Traps

Fig. 7

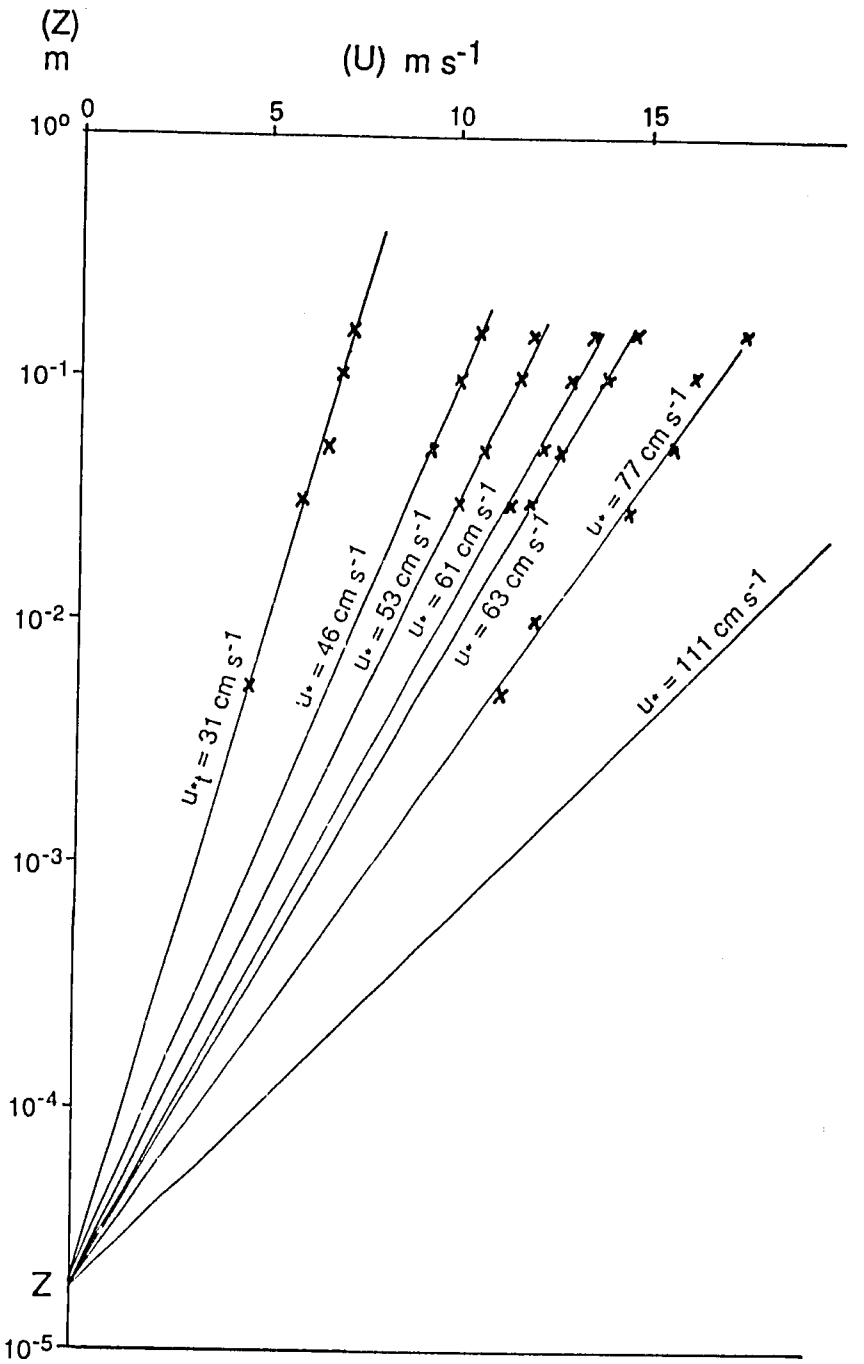

(Z)
m
(U) m s-1
0
5
10
15
10⁰
10-1
10-2
10-3
10-4
Z
10-5
u* = 31 cm s-1
u* = 46 cm s-1
u* = 53 cm s-1
u* = 61 cm s-1
u* = 63 cm s-1
u* = 77 cm s-1
u* = 111 cm s-1

Fig. 8

April 1988

BIMODAL EOLIAN DESERT SAND SHEET AND THEIR POTENTIAL SIGNIFICANCE FOR AGRICULTURAL DEVELOPMENT

C7-143

PROGRESS REPORT

Haim Tsoar
Department of Geography
Ben Gurion University of the Negev
Beer Sheva
Israel

Kofi Anane-Fenin
Department of Physics
University of Liberia
Monrovia
Liberia

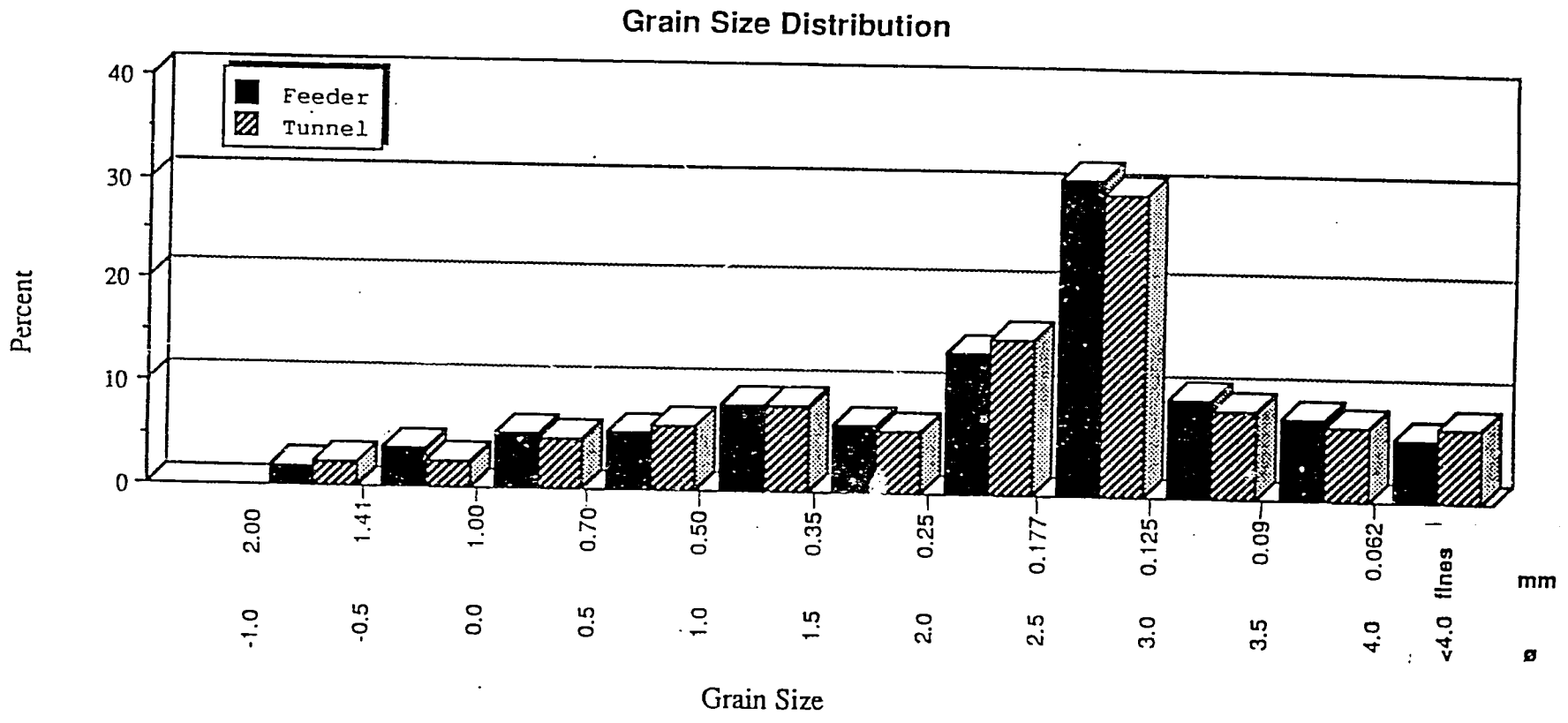
The aim of this research is to achieve a better understanding of eolian sand sheets for all the aspects related to the development of modern desert agriculture. The field work is planned to be carried out in northern Senegal. The laboratory work of simulation is performed in the wind tunnel of the laboratory of geomorphology of Ben Gurion University of the Negev.

The work has been carried out up to now in accordance with the time schedule estimated for the total research objective. We have purchased satellite images of Spot Image taken on 24 March 1986 which have a resolution of 10 meters. Analysis of these images revealed a vast sand sheet field in northern Senegal, south and east of the village of Dagana, in an area with an average annual rainfall of about 300 mm. The area is known as composed of "subdued ancient erg dunes" that suffered from overgrazing and firewood collecting during the last 20 years. Several low subdued dunes have developed in this area. The area has gradually deteriorated and degenerated from an ecological point of view, but it can nevertheless serve as a good field site for sand sheet studies.

Dr. Christian S. Diatta, the Director of the Institute of Applied Nuclear Technology (ITNA), Cheikh Anta Diop University in Dakar, has expressed his wish to participate in the project, together with three other scientists of the same institute, from the desciplines of biology, physics and geology. We have prepared equipment for field work such as sand traps, anemometres and recorders. Field work is planned to be carried out after the coming monsoon season.

In the laboratory we have prepared the boundary-layer low-speed wind tunnel appropriate for studying the movement of coarse sand of which sand sheets are composed. Out of the various methods for generating the profile of specific velocities in the wind tunnel for sand movement simulation, the Cowdrey method - one of the simplest yet most effective - was chosen. The Cowdrey method was used to design the number and spacing of screen of horizontal 700 mm x 18 mm diameter brass rods which were inserted in the main flow section upstream of the sand feeder.

The sand feeder built for the wind tunnel has eight outlet pipes so that the rate of sand discharged from the feeder can be easily measured and regulated. A test of bimodal coarse sand used in the tunnel indicated a stabilization by armoring coarse particles on the surface after 8 hours of wind speed of 10 m s^{-1}. Results of this test are shown in the enclosed figure which shows bar diagrams of bimodal sand grain sizes, as also the change in grain size resulting from the formation of the armored coarse cover. Some other tests with different grain size distributions will be made this coming summer. After collecting samples in the field we will simulate the field type of sand movement and formation in the tunnel.


Grain Size Distribution
Feeder
Tunnel
Percent
40
30
20
10
0
2.00
1.41
1.00
0.70
0.50
0.35
0.25
0.177
0.125
0.09
0.062
<4.0 fines
mm
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
ø
Grain Size