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COORDINATED USE OF MARGINAL WATER RESOURCES IN ARID AND DESERT AREAS

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A. Executive Summary

The Turkana region of Kenya which was traditionally only used for very low density rangelands is typical of vast areas of Sub Saharan Africa: low and very variable precipitation (200-300 mm.) with an increasing population. Overgrazing and tree felling deprive the soil of its natural protection and lead to crust formation on the soil surface during rainfall events. Due to the presence of the crust, water does not infiltrate into the soil but runs off towards the low lying areas. The top soil is eroded and the lack of available water in the soil limits tree regrowth. Large volumes of runoff water can however be harvested, conveyed to and trapped in dike surrounded plots in which it is left to infiltrate. In these plots trees can be planted and high yields attained. Due to unexpected large gaps between rainfalls trees may absorb all the water stored in their root zone and die. Providing the trees with even a moderate amount of water during unexpected dry spells may ensure tree survival during the early growth stages, and/or a minimum biomass productivity for adult trees.

In this region, as in other similar arid zones, shallow underground brackish water sources are frequently present. These sources may be exploited with relatively simple equipment which is easy to use and does not require capital investment.

The objective of the present project is to study the response of fodder trees to the conjunctive use of runoff and brackish water and develop the necessary field techniques if trees respond positively.

During the period covered in this report the field treatments were implemented and the physiological measurements carried out. The evaluation of the response of potted saplings to irrigation with varying salt content continued. An additional pot experiment designed to evaluate photosynthesis and transpiration response to available water was conducted.

In Kenya the field plots were prepared and seedlings prepared. Dr. Nyabundi spent one month in Israel, discussing results, technical matters pertaining to the project and

B. Research Objectives

1. Assess the response of *Acacia saligna* to runoff and supplemental irrigation of different water quality by monitoring:

a)the development and productivity of the aerial parts
b) single leaf photosynthesis and photosynthate allocation(shoot /root ratio)
c)spatial distribution of thick and fine roots
d)nitrogen fixing patterns of the tree

2. Study the effect brackish water has on the physical properties of the irrigated area and on the overall infiltration rate

3. Determine the leaching efficiency of the runoff water and the distribution of both, water and salt, after flooding

In order to meet the objectives described in the previous paragraph we will carry out pot and field trials In the field we will plant *Acacia saligna* and impose the following treatments

(a) irrigated only with good quality water
(b) irrigated only with brackish water
(c) simulated runoff
(d) simulated runoff supplemented with good quality water
(e) simulated ruoff supplemented with brackish water

In the greenhouse we will study the:

(a) Primary assimilation processes and growth rate in response to salinity and nitrogen levels
(b) Effect of salinity on the nitrogen fixing bacteria of *Acacia saligna*
(c) Effect of simple treatments to alleviate salinity damage

C. Research accomplishments

I. ISRAEL

1. Experimental layout.

The soil in the experimental site is a sandy-loam/sandy clay loam. Prior to planting soil mechanical composition was determined on soil samples obtained from various locations within the experimental field. Additional samples were analyzed for N,P,K, organic matter, pH, EC and ESP. Results from soil analysis are presented in Table 1.

Table No. 1 Averages soil properties for experimental site. St. deviations in parenthesis Org. M: total organic matter on weight basis; EC: electrical conductivity in saturated paste extract; CEC: Cation exchange capacity on dry soil basis: ESP: exchangeable sodium percentage

Depth (m)	Clay (%)	Silt (%)	Sand (%)	Org. M (%).	EC (dS m^{-1})	pH	CEC (meq/100 gr soil)	ESP
0.00-0.15	18.6	21.2	60.2	0.24 (0.04)	3.52 (1.07)	8.3 (0.12)	15.6 (1.59)	25.0 (3.11)
0.15-0.3	22.6	21.2	56.2	0.25 (0.02)	3.19 (1.29)	8.6 (0.28)	15.8 (0.65)	36.5 (7.66)
0.30-0.6	26.6	21.2	48.2	—	8.03 (0.97)	8.4 (0.16)	14.0 (0.98)	59.0 (9.29)

The schematic outlay of the experimental field is presented in Fig. 1.

Saplings of *Acacia saligna* raised in a greenhouse were planted on March 1, 1995. Sixteen shrubs were planted per plot with a distance between rows of 4 m. and 1 m. distance between trees in the row. Each treatment was replicated three times with a completely random distribution within each block. The treatments were implemented as from the 5 of August:

Access tubes for soil moisture determinations using the neutron probe were inserted to a depth which varied according to soil conditions. An almost impassable impeding chalk layer was found at depths that varied between 2.5 and 3 m. To insert the tubes a special percussion auger with an hydraulic extractor was designed and built. A diagram of the instrument is presented in Fig. 2. One access tube per plot was installed, located within the row midway between trees.

T8	T4	T3 o	T9	T6	T11 o	T5	T10	T1 o	T7	T2
T1 o	T11	T5 n	T2 o,n	T10 n	T3 p	T7 o,n	T4 n	T8 n	T6 o	T9
T10	T7 o	T6	T4	T8 o	T1	T9	T2 o	T3	T5	T11 o

Fig. No.1: Schematic outlay of field. Plot size: 5 x 14 m. The subscripts n,o and p denote the sites on which nutrient, organic matter and particle size distribution were sampled The following descriptors of treatments were used:

T1 runoff (equivalent depth of 400 mm)
T2 runoff+ irrigation when midday LWP reached -1.8 MPa
T3 runoff+ irrigation when midday LWP reached -2.4 MPa
T4 runoff+ irrigation with brackish when midday LWP reached -1.8 MPa
T5 runoff+ irrigation with brackish when midday LWP reached -2.4 MPa
T6 irrigation when midday LWP reached -1.8 MPa
T7 irrigation when midday LWP reached -2.4 MPa
T8 irrigation with brackish water when midday LWP reached -1.8 MPa
T9 irrigation with brackish water when midday LWP reached -2.4 MPa
T10 well watered
T11 well watered with brackish water

2. Results

The EC of the water for plots irrigated with good quality water was 0.4 dS m^{-1} while that of the plots irrigated with brackish water was 6.0 dS m^{-1}. Total amounts of water applied to the treatments during the first growing season are presented in Table No. 3.

Table No. 3 Water application to the various treatments throughout the first growing season (liters)

Date	Irri. Nr.	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
1/3-27/6	1	3909	3909	3909	3909	3909	3909	3909	3909	3909	3909	3909
* July	2	22442	22175	15509	20709	20409	4548	4548	4548	4548	4548	4548
5/8	3	22442	22175	15509	20709	20409	5373	4548	5308	4548	5416	5217
14/8	4	22442	22548	15509	21070	20409	5967	5194	5861	5150	6028	5672
22/8	5	22442	22855	15705	21381	20409	6095	5260	5987	5150	6268	5910
27/8	6	22442	22921	15705	21507	20409	6638	5456	6421	5563	6811	6344
31/8	7	22442	23263	15705	21941	20547	7006	5456	6834	5563	7179	6757
4/9	8	22442	23263	15871	22159	20547	7348	5622	7052	5701	7649	7154
10/9	9	22442	23595	15871	22437	20547	7680	5769	7330	5854	8156	7647
18/9	10	22442	23914	15871	22742	20547	7999	5769	7635	5854	8623	8067
23/9	11	22442	24347	16018	23192	20700	8432	6202	8085	6304	9056	8517
28/9	12	22442	24780	16018	23642	20700	8865	6635	8535	6754	9489	8967
1/10	13	22442	24780	16018	23642	20700	8865	6635	8535	6754	9721	9285
5/10	14	22442	25273	16018	24179	20700	9358	6635	9072	6754	10214	9822
19/10	15	22442	26509	17043	25457	21701	10594	7452	10350	7613	11450	11100

Pre-dawn and mid-day xylem leaf water potential (LWP), trunk diameter and height, photosynthesis and transpiration were monitored at regular intervals throughout the season.. Leaf fluorescence was measured a few times. Results of mid-day LWP for selected treatments are presented in Figs. 2,3,4 and 5 . No clear differences in LWP's for treatments were apparent even though they received different amounts of water (Table No. 3) . The reason for this lack of response becomes evident once the soil moisture profiles are analyzed. The profiles for treatments 1,4 and 10 are presented in Figs. 6,7 and 8. Water uptake patterns for treatments 1 and 4 are very similar. Both treatments were flooded but treatment 4 was irrigated thereafter. It appears that the water applied did not reach the root zone probably due to a very high evaporation rate and low emitter discharge. This hypothesis is confirmed when the soil moisture profile for treatment 10 is analyzed. Frequent water applications did not increase the amount of water available in the soil profile.

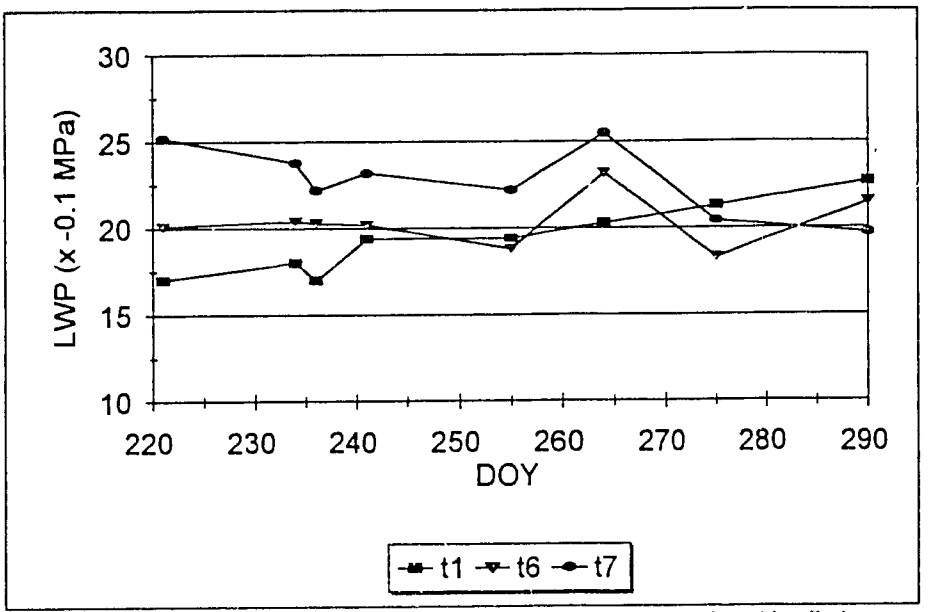

Fig. No. 2: Evolution of midday LWP for treatments 1,6 and 7 (detailed treatment description in text)

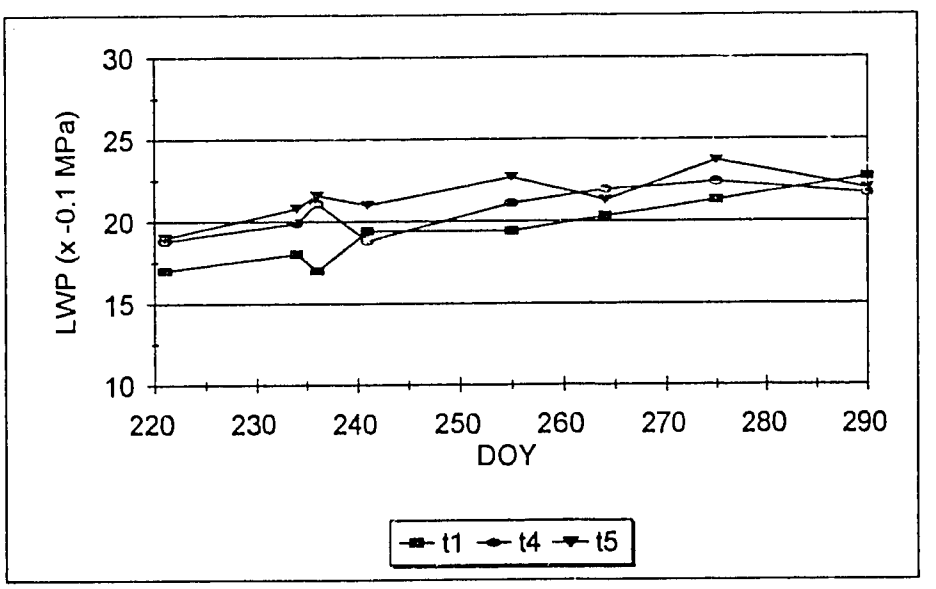

Fig. No. 3: Evolution of midday LWP for treatments 1,4 and 5 (detailed treatment description in text)

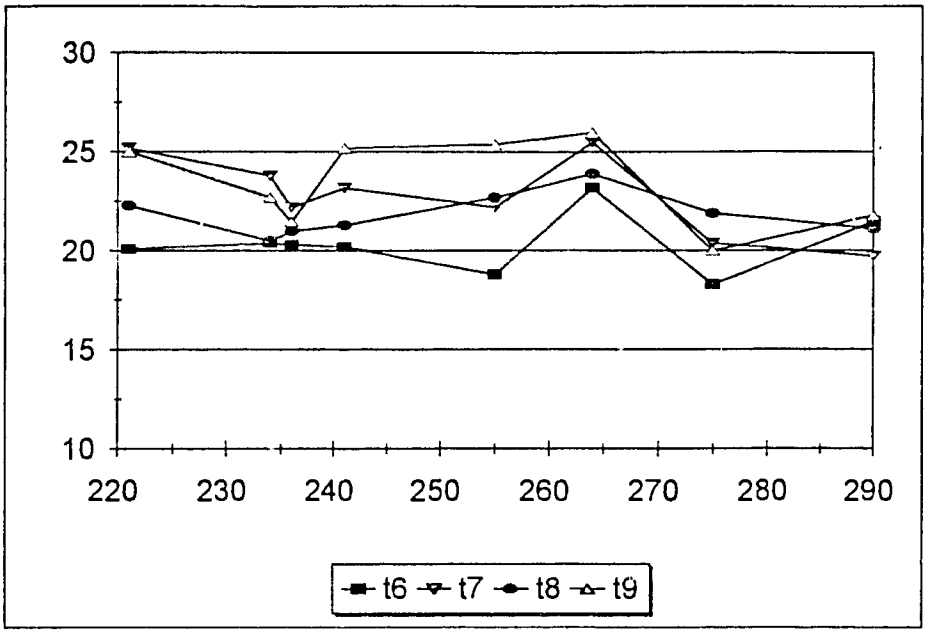

Fig. No. 4: Evolution of midday LWP for treatments 6,7,8 and 9 (detailed treatment description in text)

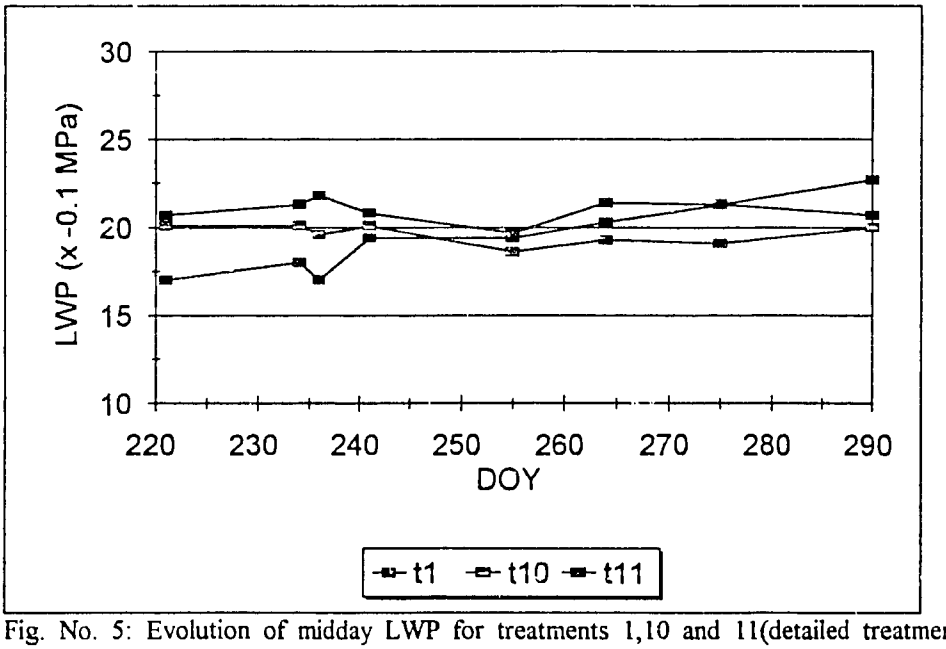

Fig. No. 5: Evolution of midday LWP for treatments 1,10 and 11(detailed treatment description in text)

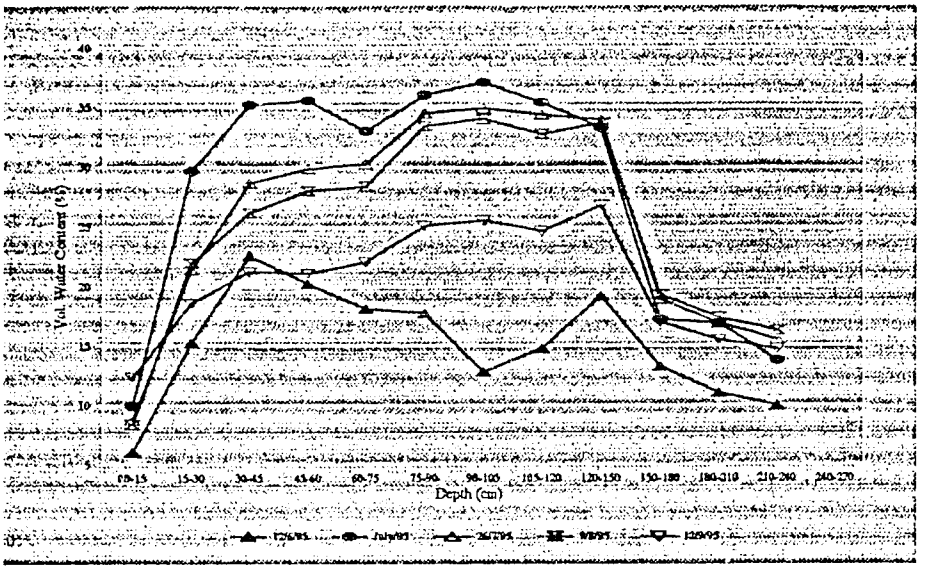

Fig No. 6: Volumetric water content distribution for treatment No. 1

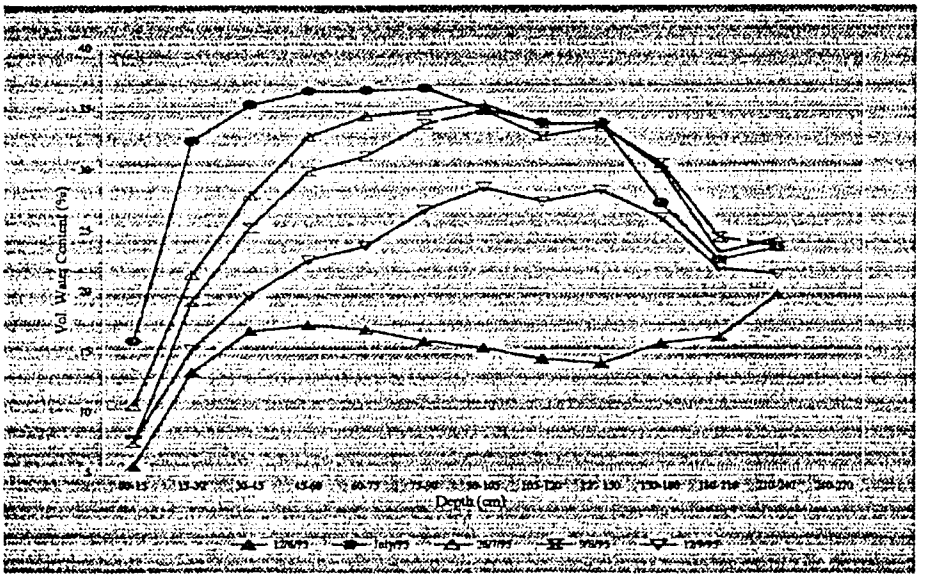

Fig No. 7: Volumetric water content distribution for treatment No. 4

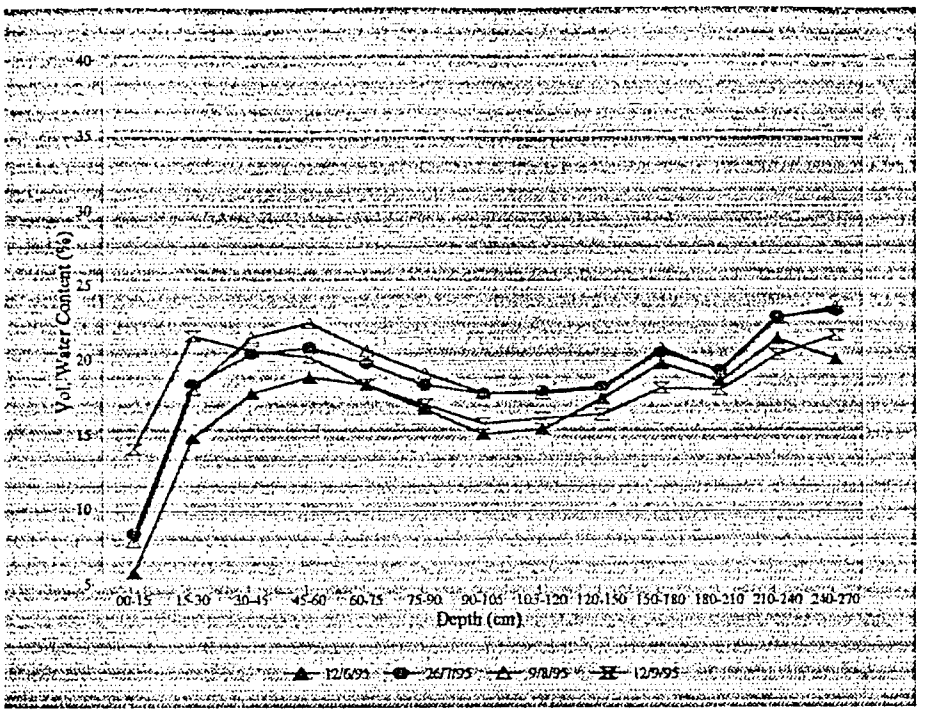

Fig No. 8: Volumetric water content distribution for treatment No. 11

Analysis of variance of trunk diameter measurements showed that both runoff and irrigation had a statistically significant effect on biomass production. This would appear to contradict the results of LWP and soil moisture distribution presented previously. The explanation to this contradiction may be resolved if the timing of the measurements is taken into account. LWP and soil moisture were measured 48-72 hours after irrigation. Water did not penetrate deep into the soil and the shallow root system could only absorb water from that layer for a very short period (probably one day only). Thereafter the shrub behaved as a non irrigated shrub. These short one day spells of water absorption, and hence photosynthesis, could only be measured during their occurrence or by integrating them over a certain growth period. Trunk diameter is directly related to biomass production and therefore a suitable "integral" index.

2. KENYA

The plots with their retaining structures were built according to plan (Plate 1). During the first flood water was collected. Minor changes have to be introduced in the structures as some walls did not withstand the pressure of water.

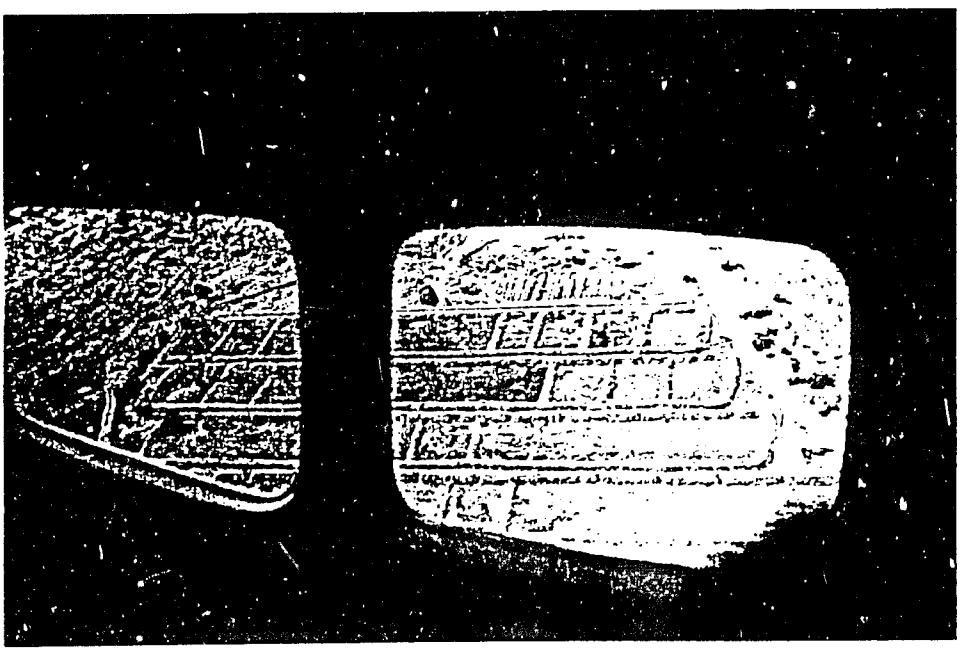

Plate 1: Aerial view of plots with retaining walls in Kakuma, Turkana, Kenya.

Preparation of seedlings was difficult due to the extreme conditions prevailing in the area. It appears however that they will be ready for planting after the next floods (November-January). Soil and water samples were collected and are presently being analyzed.

D. Scientific impact of collaboration.
The scientific effect of collaboration will be felt after the next season when the field results will be analyzed. The visit of Dr. Nyabundi to Israel proved to be very fruitful and led to a better understanding of the techniques implemented in Turkana, Kenya.

E. Description of Project Impact
The runoff plots built in Turkana had a very big local impact. The local population came from far away to participate in the building process. The final assessment of the impact of the project will have to be made once fodder and firewood will be collected after the second growth year.

F. Strengthening of Developing Country Institutions
The visit of Dr. Nyabundi to Israel coupled to the new instrumentation that will arrive within a short period will undoubtedly strengthen the Crop Production Dpt. of the University of Nairobi

G. Future Work

1. Israel.
Monitoring of all soil and plant parameters that were carried out hitherto will continue throughout the winter and next summer. Water application will be modified in order to decrease the effect of evaporation, but no change will be made in the treatments.
The relevant soil parameters will be measured within the next few weeks in order to assess the potential negative impact of the use of brackish water. The same parameters and salt distribution will be measured after the simulated flood in spring.
Pot experiments will continue and the response of *Acacia saligna* to alternating cycles of brackish and good water evaluated

2. Kenya
The saplings will be planted after the next flood. After establishment access tubes for moisture measurement will be introduced. Once the shrubs reach a height of one meter the differential treatments will be implemented and the physiological measurements carried out.

SECTION II

A. Managerial issues
No new managerial issues arose since the last Management Report

B. Budget
There is presently no need for major changes

C. Special concerns
There are no special concerns

D. Collaboration, Travel, Training and Publications

A Kenyan co-worker (Mr. S. Kututu) is being trained by Dr. Nyabundi since March 1995. Travel proceeded according to plan. There are no publications yet.

E. Request for A.I.D. or BOSTID actions

No requests.