FINAL REPORT

The Joint Study Project on Improvement of Arid Land Agriculture in the United Arab Emirates

September, 1985—March, 1989

Faculty of Agricultural Sciences／U.A.E. University

The Japan International Cooperation Agency

March, 1989

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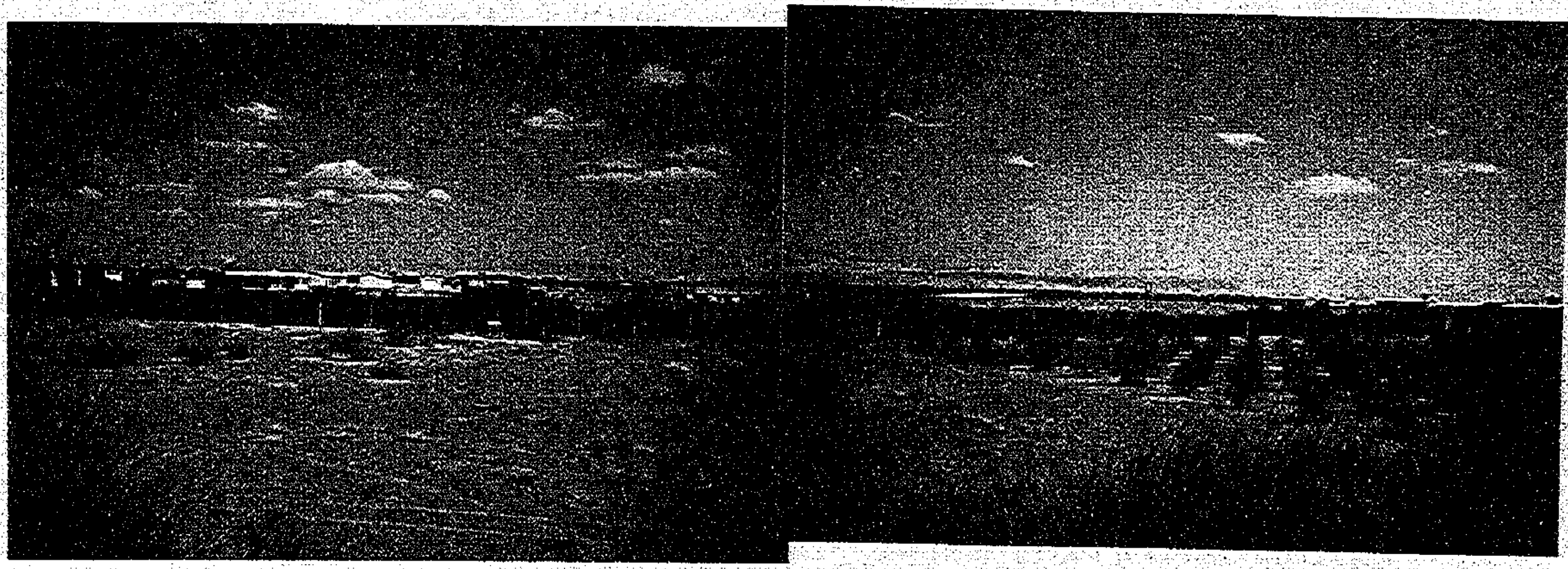
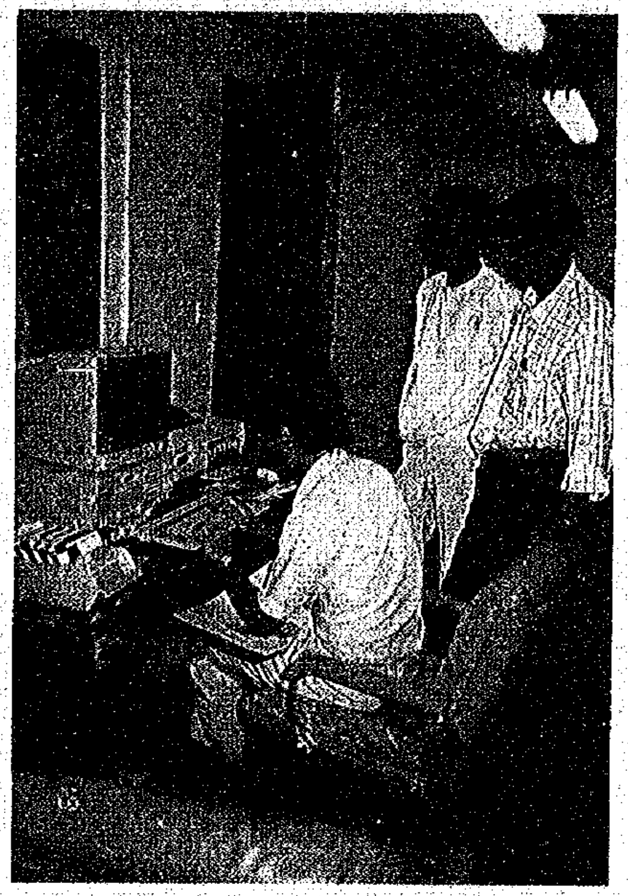


Recent aspect of the Agricultural Research and Education Center (AREC), Faculty of Agricultural Sciences, UAE Nniversity

Mr. Katakura, the Japanese Ambassador, and Prof. Kobori visiting the AREC to observe the joint study



Japanese researchers in the computer room of the ARE

I. INTRODUCTION

It is said that approximately one third of land in the world is occupied by the desertic arid area. The high temperature, drought, scarce rainfall, strong wind, drifting sand, movement of sand dune, and high salinity of the soil, of which peculiarities are common to almost all arid lands, are obstructing the agricultural production. It is essential to improve and develop the agriculture in arid lands by overcoming the aforesaid meteorological and environmental conditions through the research. Especially the greening of the arid lands in countries holding the proper areas is a very important national theme which exerts an influence upon the advance in future of countries concerned.

On the basis of the agreement signed between the United Arab Emirates (UAE) University and the Japan International Cooperation Agency(JICA), the Joint Study Project on the improvement of arid land agriculture in UAE was implemented from September 1985 to March 1989 by both Faculties of Agriculture, UAE and Shizuoka Universities. The results obtained during the first and the second years were already reported in the Annual Reports of the Joint Study Project[1, 2] by JICA.

This final report mainly describes abstracts of experimental results, which include also those obtained during the third and the fourth years, conducted by the Project teams of both Universities.

REFERENCES

1) The Japan International Cooperation Agency, 1987: The Annual Report of the Joint Study Project on Improvement of Arid land Agriculture in United Arab Emirates (September, 1985-August, 1986), pp.1-96

2) The Japan International Cooperation Agency, 1988: The Annual Report of the Joint Study Project on Improvement of Arid Land Agriculture in United Arab Emirates (September, 1986-August, 1987), pp.1-232

II. RESEARCH CONDUCTED

1. Theme A : STUDIES ON SAND DUNE FIXATION BY METHOD OF REVEGETATION WORK WITH CIVIL ENGINEERING

Introduction

Natural features in semi arid land are mainly little rainfall and high temperature. These two features correlate each other and cause a lot of phenomena. Typical phenomena are aridity, promotion of physical weathering and salt accumulation. Aridity is the result of unbalance of water economy, lots of sand produced by physical weathering become a source of sand dunes and salinity in the soil is accumulated on to the surface without being leached.

As a result, these phenomena cause much difficulties for people's activities. For example, many parts are often buried by sand along the road side where is no vegetation and many farms are always faced with dangers of burying by sand dunes, especially in Liwa Oasis.

The Government are making effort to overcome these difficulties, lots of places along the road side have been already afforestated, above all, it is very successful in Abu Dhabi and Al Ain road. Furthermore, afforestation works on the natural sand dunes are being tried to fix the movement of dunes in Slimat area in Al Ain.

When we foresee the certain future of the country, lands where should be protected by revegetation works will expand more and more. Therefore the establishment of more safety, certain, rapid and suitable afforestation technique in each land conditions will be necessary and required.

Sub-Theme of the Study

We set up the following sub-theme to establish proper and adaptable afforestation technique in The United Arab Emirates.

(1) Observation of Natural Sand Dune Movement

(2) Model Experiment of Sand Dune Fixation

(3) Effects of Dates-Fronds-Mat Fence on Erosion Control, Microclimate and Tree Growth

(4) Effects of Mulching and Water Holding Materials on Tree Growth

(1) OBSERVATION OF NATURAL SAND DUNE MOVEMENT

A typical natural sand dune was selected to observe the dune movement in the neighboring area to the Agricultural Research and Education Center (AREC) of The UAE University. The size of the dune was 190 meters in length and 4 meters in height.

Short term topographic change and amount of shifting sand were measured every 10 days from December 1986 to October 1987. Long term topographic change was measured once a year, those were December 1986, December 1987 and March 1989.

Results : Results of long term observation are shown in Fig. 1. Movement of the top of dune was recognized on NO. 1, NO. 2, NO. 7 and NO. 8 measuring lines. Their moving distances were approximately 3 to 6 meters from south to north. Their height of the top of dune showed a tendency to become lower. There was little movement in NO. 3, NO. 4 and NO. 6 lines. Although the top of dune in NO. 5 line did not move in the first year, it moved approximately 3 meters from north to south in the second year. Inclination of the slope of the dune was gentle in its windward side and steep in its leeward side in general.

Results of short term observation are shown in Table 1 and Fig. 2. Topographic change was recognized in all lines and points. The amount of topographic change showed maximum on the top and on the next point to the leeward side. The amount reduced as the distance went away from the top of dune. As a result, the figure showed nearly the normal distribution which was biassed a little to the leeward side. The actual topographic change was shown in Fig. 3.

The amount of captured sand in each site and point on the natural sand dune and the accumulative wind distance are shown in Table 2. Total amount of captured sand during the observation period was respectively 74552.5 g/100sqcm., 7452.7 g/100sqcm.1.3 g/100sqcm. at 20 cm, 50 cm, 150 cm high from the ground on the top of dune. The amount of sand captured on the top of dune was 82006.5 g/sqcm. Its value showed approximately seven times more than those of north foot of dune. Monthly maximum amount of captured sand was 28932.7 g/100sqcm. in April at 20 cm high from the ground on the top of dune. The rate was approximately 39% of the total. Southerly wind distance prevailed through the observation period.

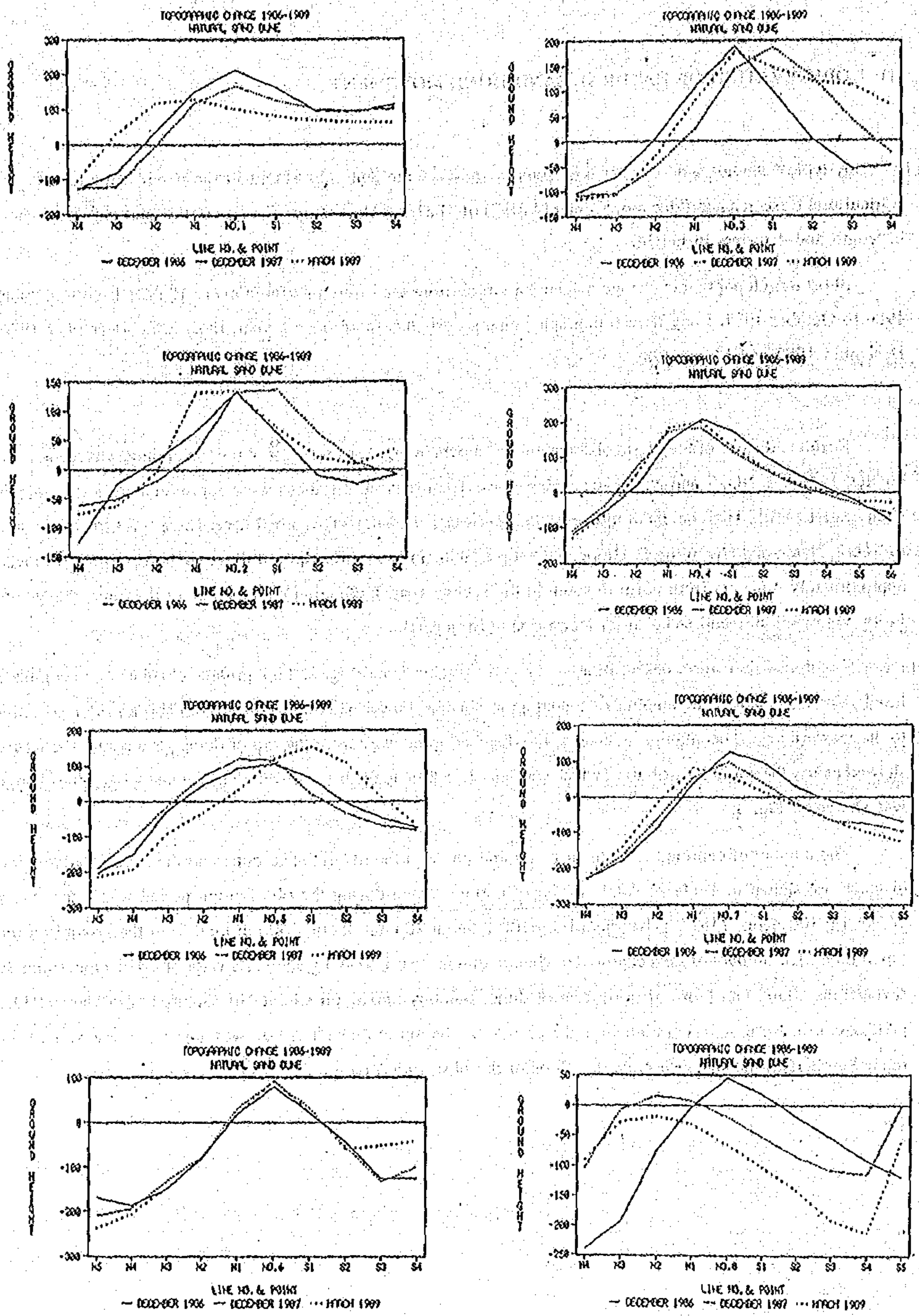


Fig. 1 Topographic change of the natural sand dune
by the long term observation

Table 1 Accumulative length of the topographic change on the natural sand dune (Dec. 1986-Oct. 1987)

DIRECTION MEASUREMENT POINT	SOUTH SIDE (WINDWARD)				TOP OF DUNE	NORTH SIDE (LEEWARD)			
	4	3	2	1	TOP	1	2	3	4
LINE NO.1	63.0	68.1	34.9	138.6	264.4	266.9	297.7	184.2	148.1
NO.2	69.3	38.0	63.4	170.4	205.1	389.5	165.6	24.8	36.5
NO.3	38.8	53.2	131.0	221.1	393.6	287.1	117.0	83.2	31.1
NO.4	57.4	48.4	63.8	168.8	363.1	454.3	168.1	60.2	30.8
NO.5	38.3	60.9	68.6	267.9	359.6	268.3	319.3	157.1	114.2
NO.6	213.4	33.4	190.0	247.4	391.9	400.8	131.9	73.1	69.1
NO.7	59.9	168.8	129.1	318.1	296.4	464.3	130.0	29.1	48.0
NO.8	38.6	57.2	60.5	73.8	76.6	71.8	243.2	191.0	32.0
TOTAL	578.6	498.0	719.2	1596.0	2439.6	2570.0	1573.7	772.7	495.4
MEAN	72.3	62.3	89.9	199.5	305.0	321.3	196.7	96.6	61.9
MEAN	106.0				305.0	189.1			

Accumulative length(cm) = ABS(A) + ABS(E)
: ABS(A) = Accumulative length of accumulation
: ABS(E) = Accumulative length of erosion

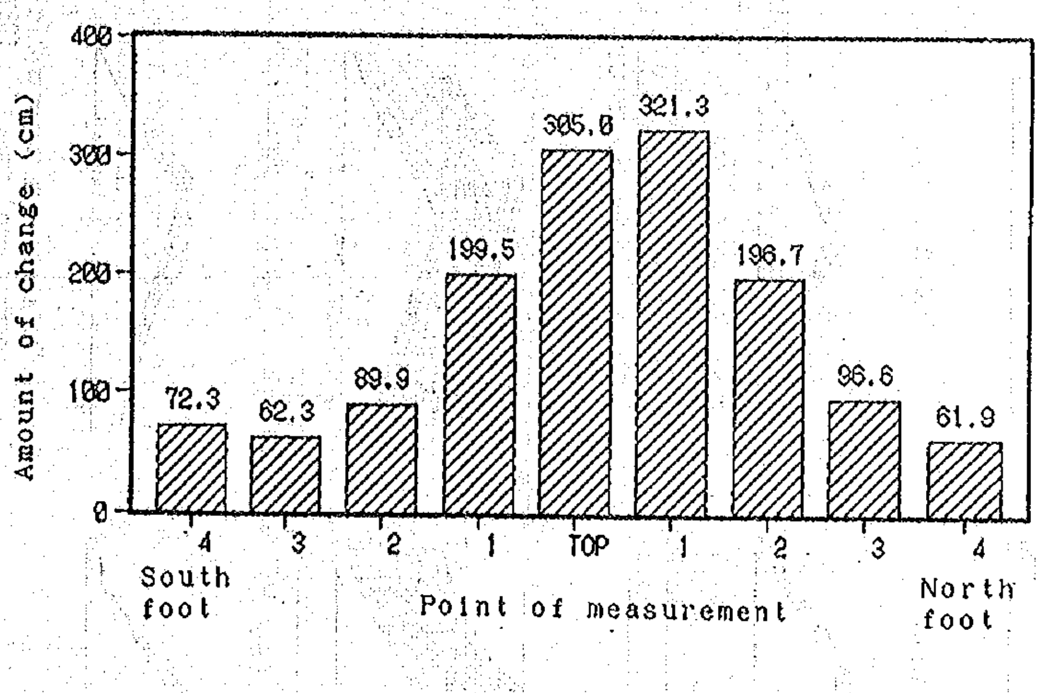


Fig. 2 Topographic change of the natural sand dune (Dec. 1986 - Oct. 1987)

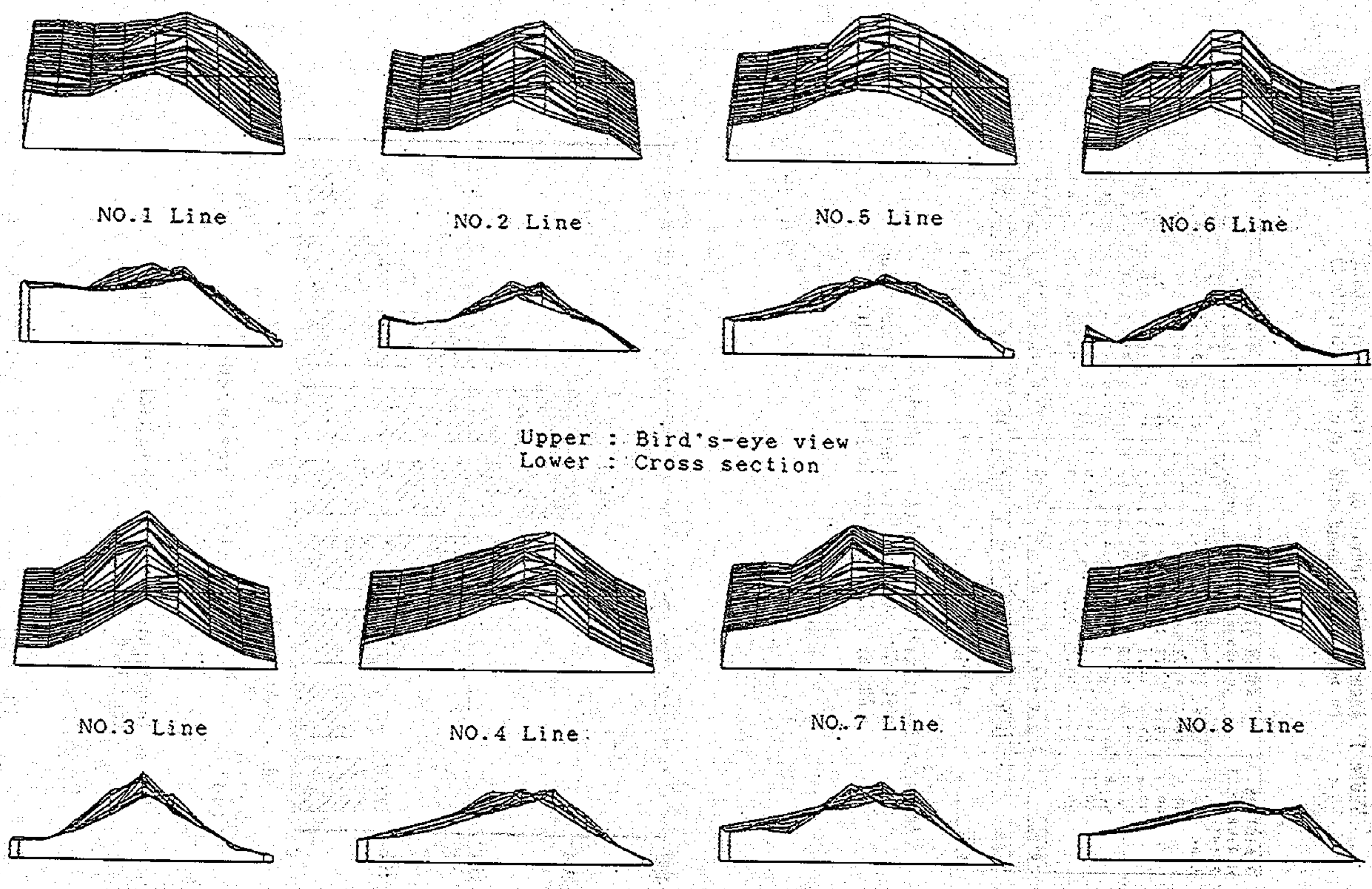


Fig. 3 The short term topographic change in every 10 days on the natural sand dune (Jan. 1987 - Oct. 1987)

Table 2 Monthly amount of captured sand in each site and point on the natural sand dune and the accumulative wind distance (January 1987 - December 1987)

SITE	HEIGHT FROM THE GROUND	(1987) CAPTURED AMOUNT OF SAND (g/100cm²) JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL	(%)
TOP OF DUNE	0.2 m	134.8	4099.7	12948.1	28932.7	16426.3	364.0	2063.8	3498.1	4268.0	1789.0	15.8	12.2	74552.5	90.9
	0.5 m	0.6	556.0	854.6	1939.6	916.0	522.3	1304.1	1067.5	79.1	212.1	0.4	0.4	7452.7	9.1
	1.5 m	0.1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.4	0.5	0.2	0.1	1.3	0.0
	TOTAL	135.5	4655.7	13802.7	30872.3	17342.3	886.3	3367.9	4565.6	4347.5	2001.6	16.4	12.7	82006.5	100.0
NORTH FOOT OF DUNE	0.2 m	0.6	1416.5	3629.1	576.7	1476.7	471.3	450.3	2221.1	188.1	56.0	3.5	22.1	10512.0	80.4
	0.5 m	0.5	422.7	928.7	129.4	43.7	47.8	70.9	887.4	20.2	3.3	0.6	1.1	2548.3	19.5
	1.5 m	0.1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	4.9	1.1	0.7	0.3	7.1	0.1
	TOTAL	1.2	1839.2	4549.8	706.1	1520.4	519.1	521.2	3108.5	213.2	60.4	4.8	23.5	13067.4	100.0

	WIND DIRECTION	(1987) ACCUMULATIVE WIND DISTANCE (km) JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL	(%)
MORE THAN 5 m / s	NORTHERLY WIND	83.34	36.72	155.00	394.20	120.06	1240.74	254.70	232.02	282.06	225.72	9.18	9.72	3041.46	14.7
	SOUTHERLY WIND	230.22	1668.60	2180.78	999.54	1681.02	469.80	2066.58	1079.46	1361.16	409.32	0.00	159.48	12225.96	59.3
	EASTERLY WIND	0.00	0.00	31.50	20.34	210.24	9.90	125.64	312.30	0.00	56.88	9.18	162.36	938.34	4.5
	WESTERLY WIND	105.84	0.00	473.84	425.88	1117.80	932.76	699.48	81.90	247.50	255.24	18.00	67.68	4425.12	21.4
	TOTAL	419.40	1705.32	2758.32	1839.96	3129.12	2653.20	3146.40	1705.68	1890.72	947.16	36.36	399.24	20630.88	99.9

(2) MODEL EXPERIMENT OF SAND DUNE FIXATION

An artificial sand dune was constructed in AREC in order to establish the technique of sand dune fixation. The dune was 180 meters in length and 4 meters in height. It was nearly the same size of natural sand dunes around there.

This experiment consists of three stages as follows.

First stage : The construction of artificial sand dune was completed in September 1986 and a bamboo fence was set up on the top of dune in October 1986. It was because the stabilization of the top of dune was the most important factor to fix sand dune.

Second stage : The bamboo fence on the top of the dune was removed in October 1987 because of the damages by heavy sand storm (approximate maximum wind speed was 40 m/s).

Third stage : Whole area of the dune was covered with synthetic resin emulsion to control wind erosion and revegetated with five local species to keep the lasting stabilization of the dune.

Short term topographic change was measured every 10 days in each stages. Long term topographic change was measured once a year, those were December 1986, December 1987 and March 1989. Shifting sand was collected and weighed every 10 days in each stages. Wind speed and the growth of revegetated species were observed in the third stage.

Results : Short term topographic change of the first and the second stage are shown in Fig. 4 and Fig. 5. The amount of topographic change at the top of dune was not always less than those of other points and the changes of north foot points were greater than those of others because of much accumulations in the first stage. In the second stage, the amount of topographic change was the greatest at the top of dune. It was considered that the reason why the bamboo fence was removed from the top of dune. We also studied on the amount of shifting sand and the wind distance as shown in Fig. 6. In spite of the longer wind distance, the amount of shifting sand was not so great in the first stage. On the contrary, the amount of shifting sand changed in proportion to the wind distance, especially at the top of dune, in the second stage.

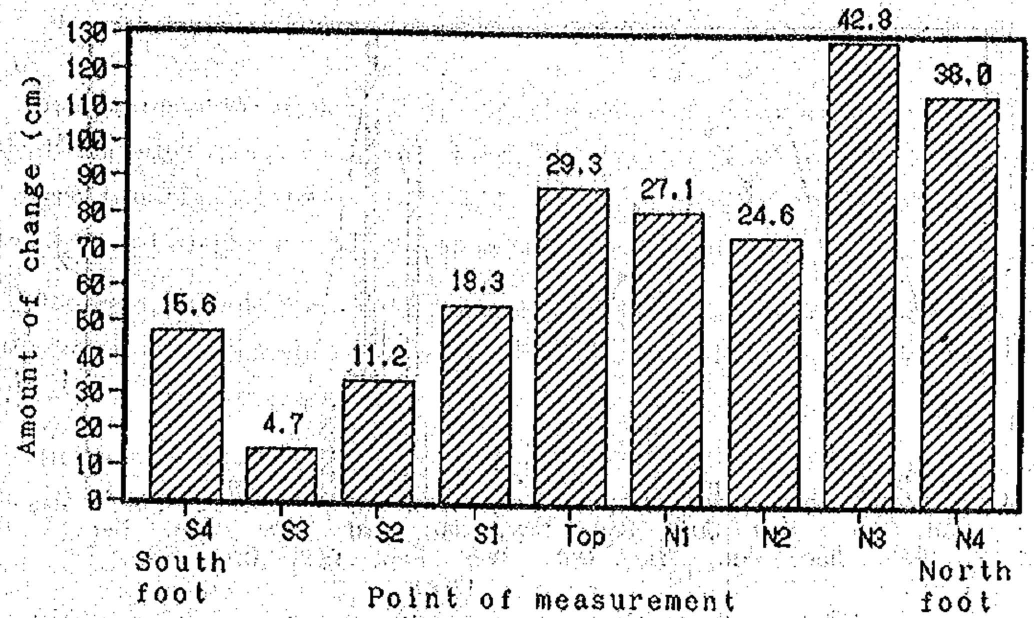


Fig. 4 Topographic change of the artificial sand dune with bamboo fence (Dec. 1986 - Jun. 1987)

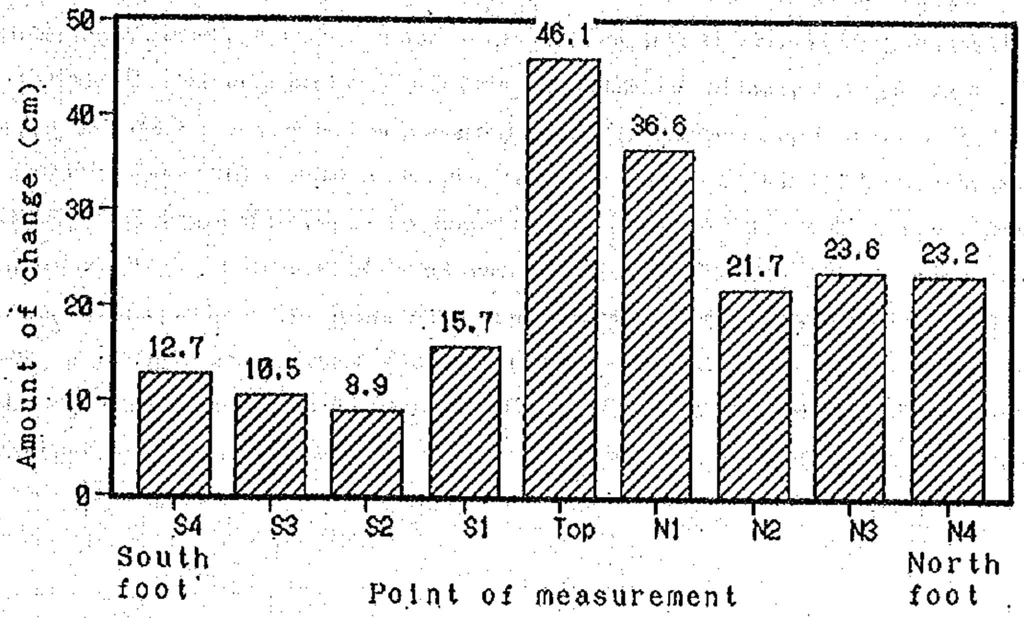


Fig. 5 Topographic change of the artificial sand dune without bamboo fence (Oct. 1987 - Mar. 1988)

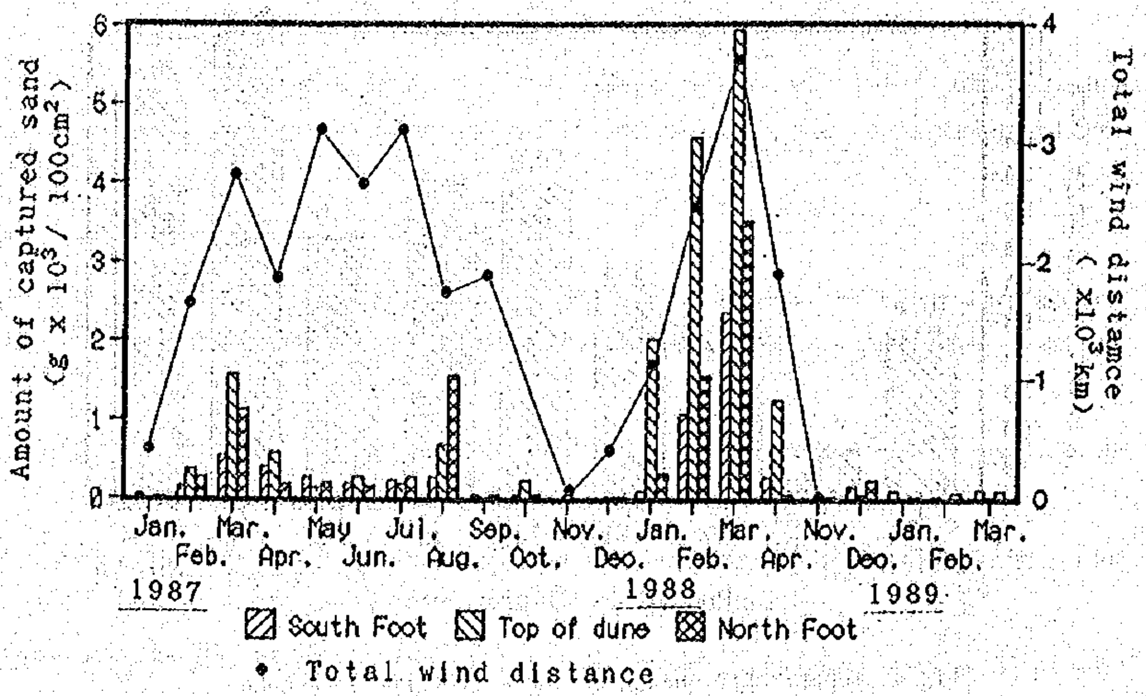


Fig. 6 Total wind distance and the amount of caotured sand on the artificial sand dune (Jan. 1987 - Mar. 1989)

(3) EFFECTS OF DATES-FRONDS-MAT FENCE ON EROSION CONTROL, MICROCLIMATE AND TREE GROWTH

The experiment was set up at the west side of AREC. Three densities of Dates-Fronds-Mat fence were established in 60x60 square meters plots. All plots were surrounded with the fence. The control plot(D-0) was left without further fencing. Treated plots were devided further into 10x10 square meters(D-10), 20x20 square meters(D-20) and 30x30 square meters(D-30) by fencing within each plot.

The fence was made of Dates (*Phoenix*, spp)-Fronds-Mat with woody stakes and bars at one meter high from the ground surface. Seventy two seedlings of one year-old of each Samar (*Acacia tortilis*) and Ghaff (*Prosopis spicigera*) were planted in each plot.

Tree growth, amount of shifting sand at 20 centimeter high from the ground, amount of evaporation and wind speed were measured to estimate the effects of Dates-Fronds-Mat fence.

Results : (1) The growth in height of the planted trees are shown in Fig. 7. Both trees showed better growth in D-10, D-20, D-30 and D-0 plot in order. Especially the growth of Ghaff tree was approximately 1.7 times in D-10, 1.4 times in D-20 and 1.3 times in D-30 better than that of D-0 plot. The growth was significant among each plots in Ghaff tree according to the test for equality between two means. The change of the height growth was shown in Fig. 8. The height growth was more rapid from June to October in the first year and from March to October in the second year. On the contrary, it was very slow from October to March. But the change of height growth was not so clear in Samar tree. (2) Covering ratio (The ratio of the sum of each crown occupation area in the plot) of Samar tree was always higher than that of Ghaff tree in every plots as shown in Fig. 9.Total covering ratio after two years of afforestation in each plot was 19.5% in D-0, 28.8% in D-30, 31.8% in D-20 and 37.9% in D-10 plot. The change of covering ratio showed nearly the same tendency to the change of height growth as shown in Fig. 10. (3) As the result of the measurement described above, following results can be considered. There was an effect of Dates-Fronds-Mat fence on tree growth. Higher density of the fence was more effective on their growth. Ghaff tree was superior to Samar tree in the upward growth, on the contrary, Samar tree was superior to Ghaff tree in the horizontal expansion. (4) There was an effect of Dates-Fronds-Mat fence on microclimate and erosion control as the same as height growth and covering ratio as shown in Fig. 11 and Fig. 12.

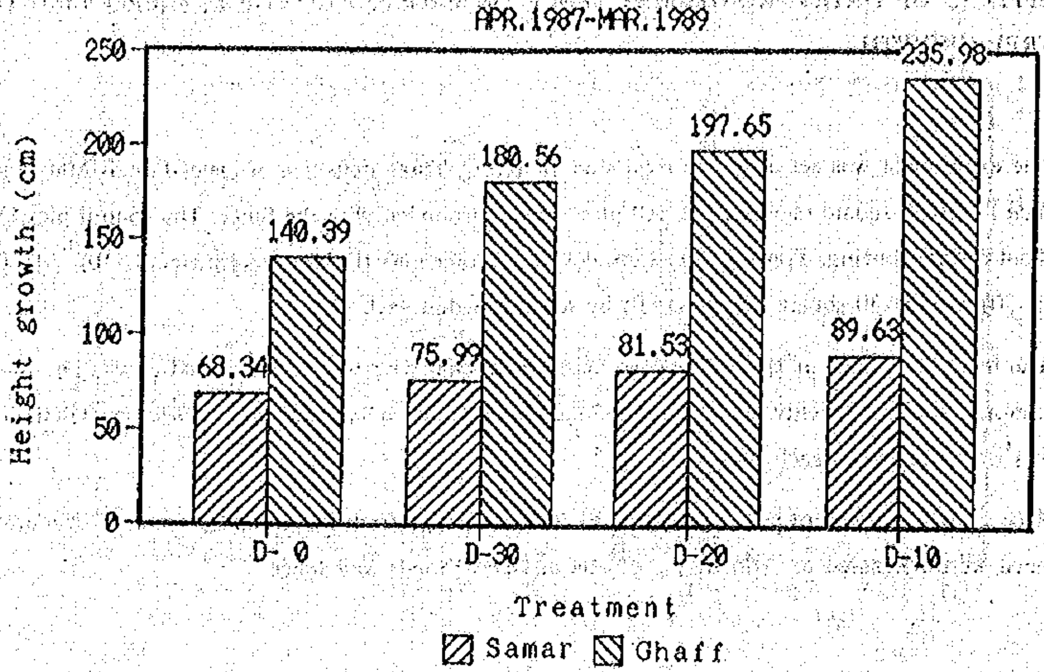


Fig. 7 The effect of the fence on height growth

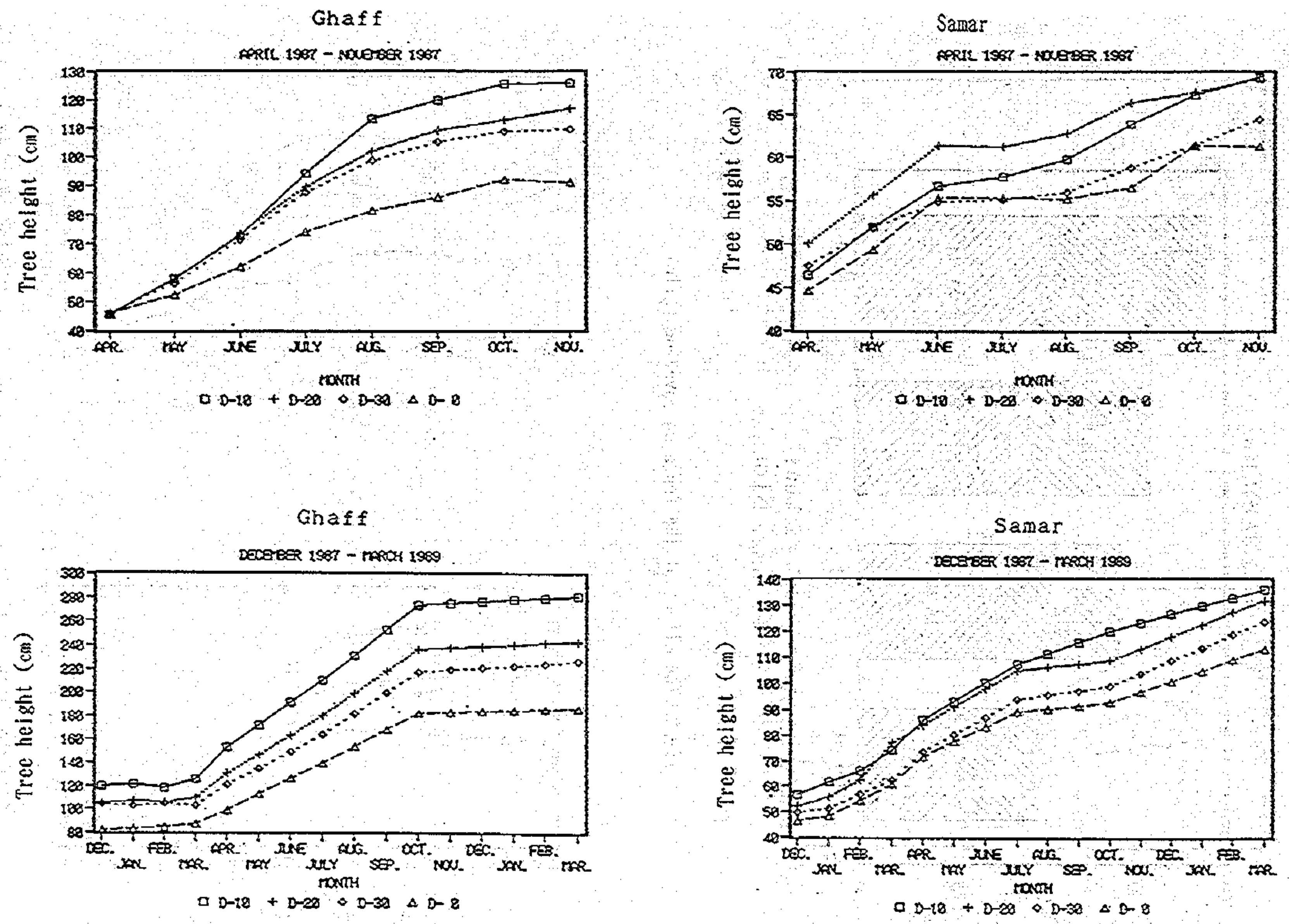


Fig.8 The change of tree height in each plot

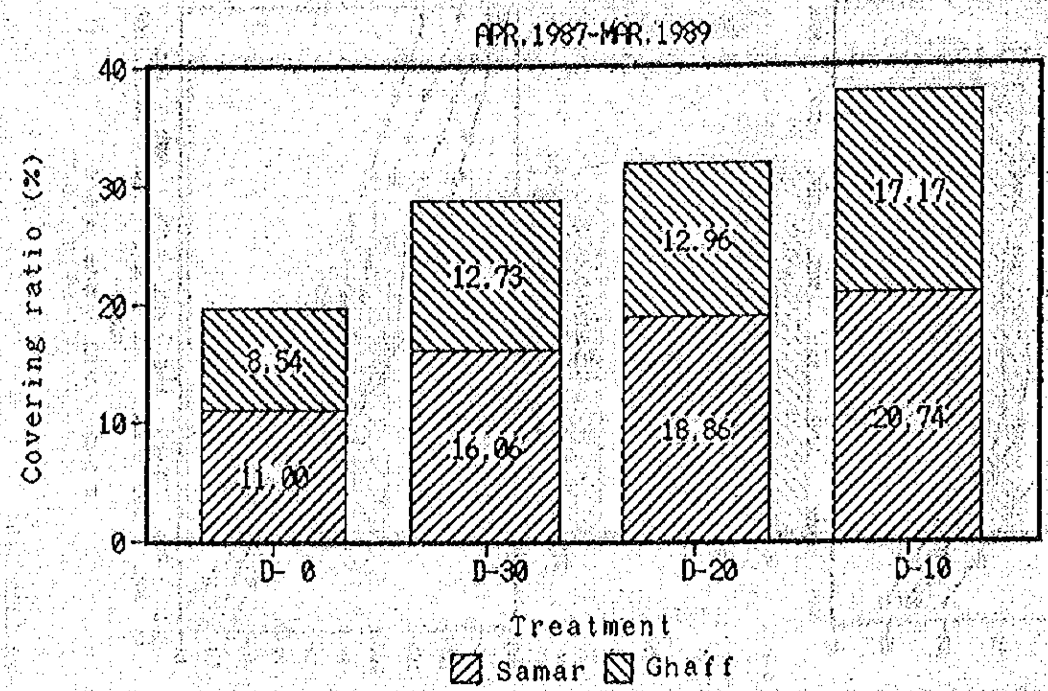


Fig. 9 The effect of the fence on covering ratio

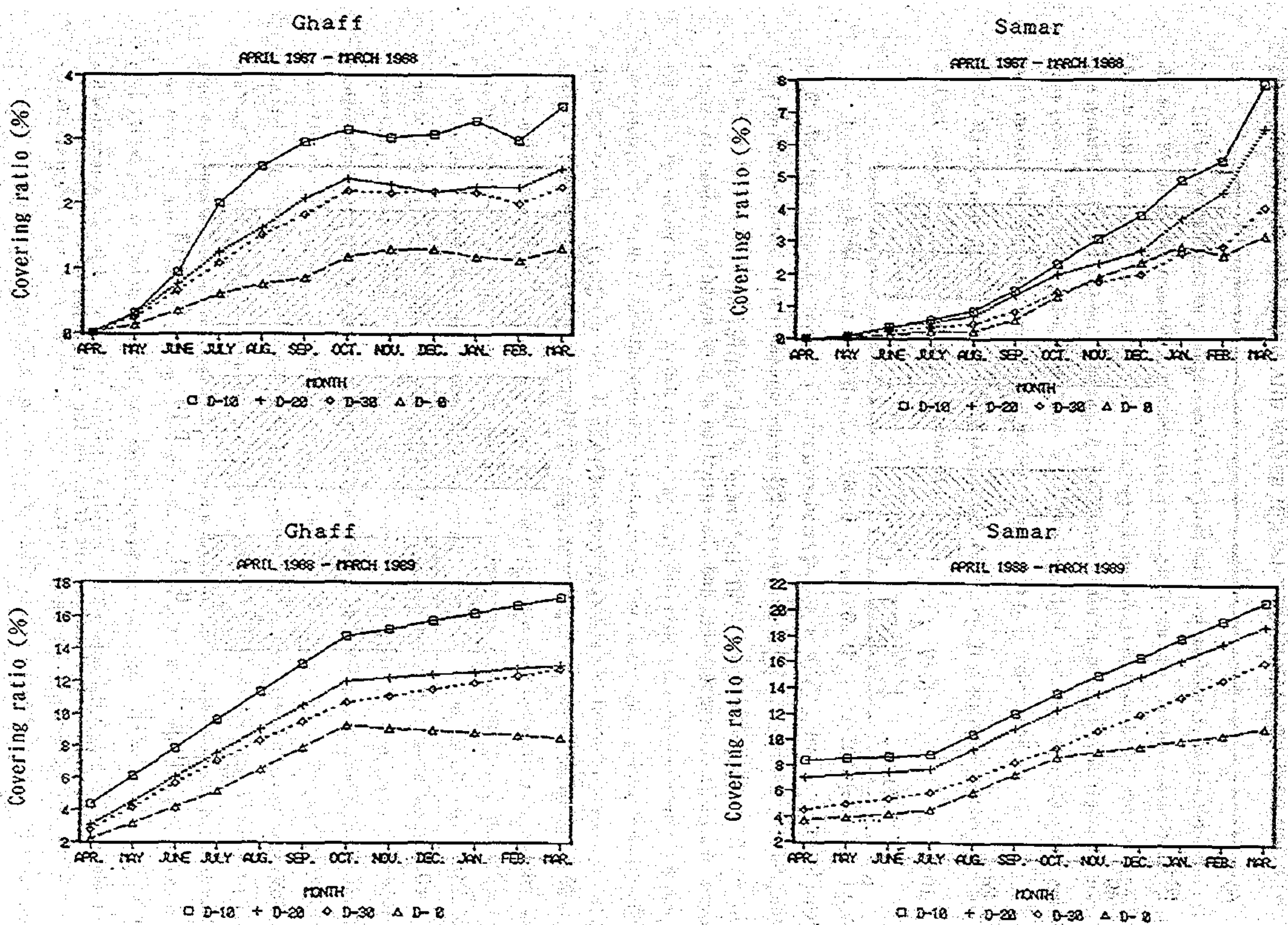


Fig. 10 The change of covering ratio in each plot

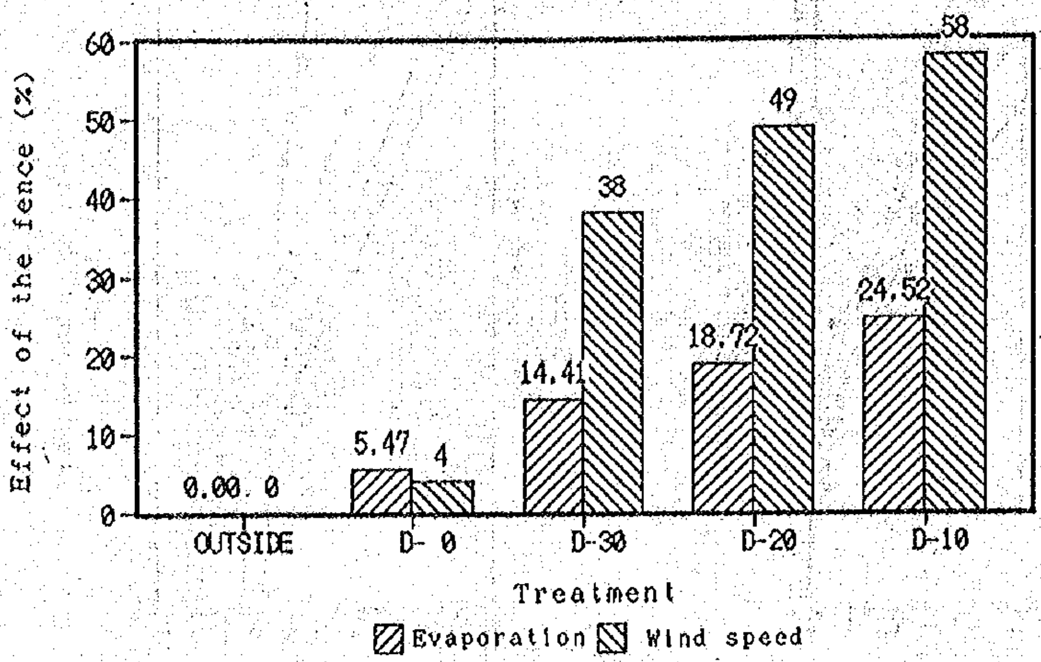


Fig. 11 The effects of the fence on the control of evaporation and the reduction of wind speed

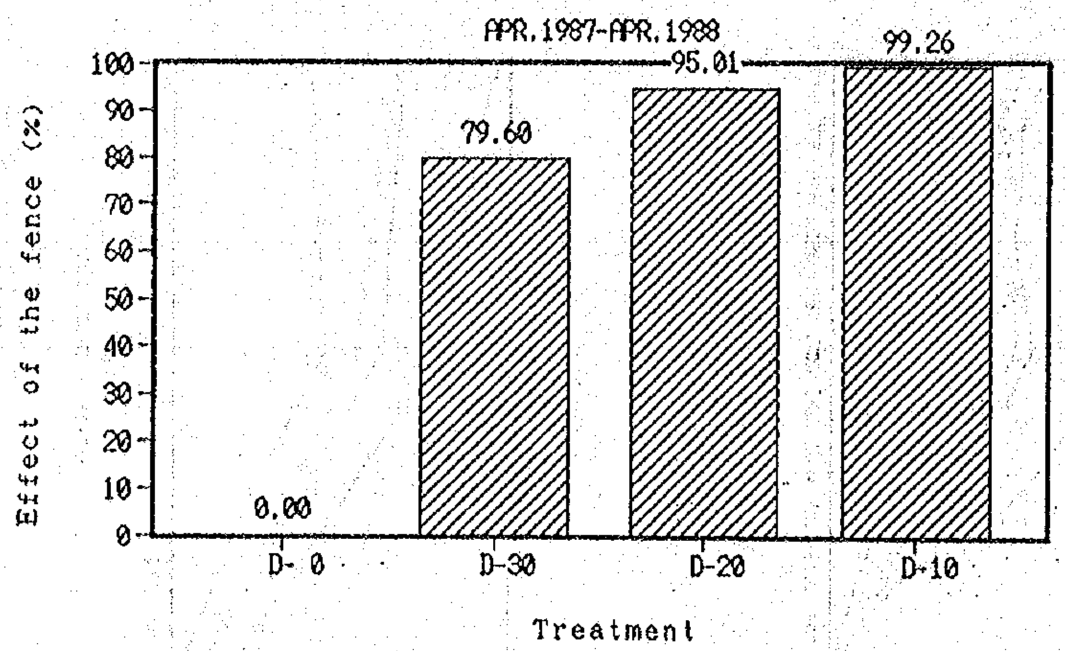


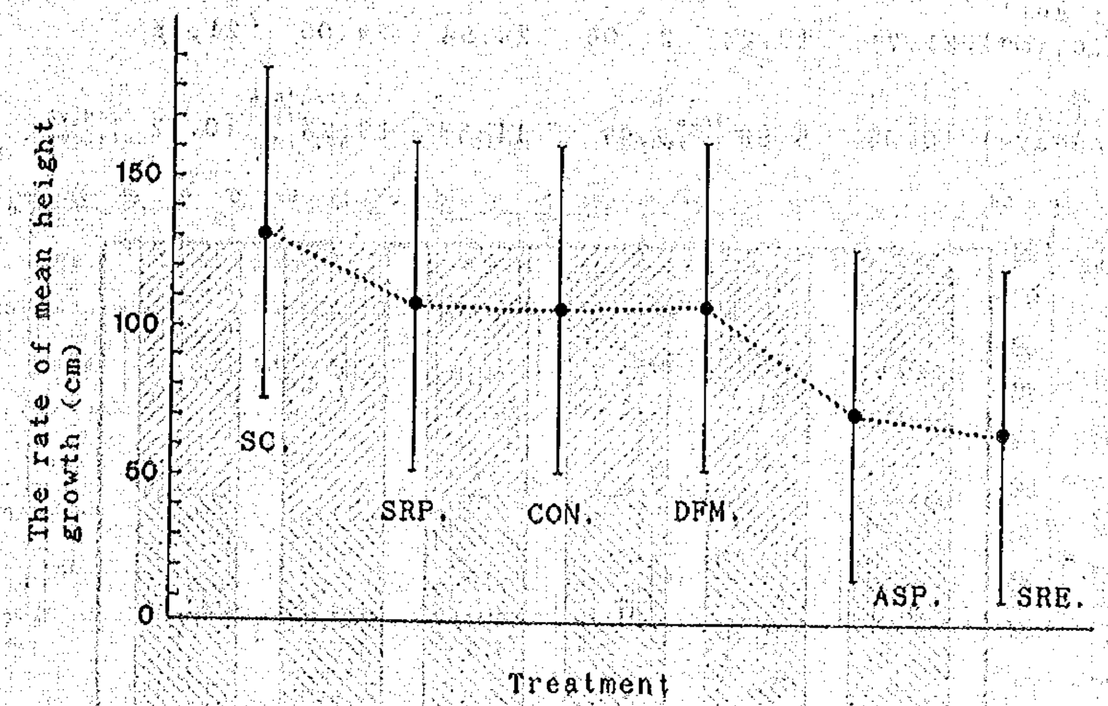
Fig. 12 The effect of the fence on the prevention of shifting sand

(4) EFFECTS OF MULCHING AND WATER HOLDING MATERIALS ON TREE GROWTH

It is very important for planted trees that irrigated water will be lastingly kept without downward loss in the soil. We chose five materials to control water loss. Asphalt emulsion, synthetic resin emulsion and Dates-fronds-mat were chosen as the materials which save the evaporation loss from the soil surface. Asphalt emulsion and synthetic resin emulsion were sprayed on the soil surface. Dates-fronds-mat was put around the trees. Synthetic resin powder and soft ceramics were chosen as the materials which save water loss into deeper ground. Those were mixed with sand and buried around the root zones when trees were planted.

Randomized block design with three replications was set up. Tree growth, consumption of soil moisture and soil temperature were measured and estimated.

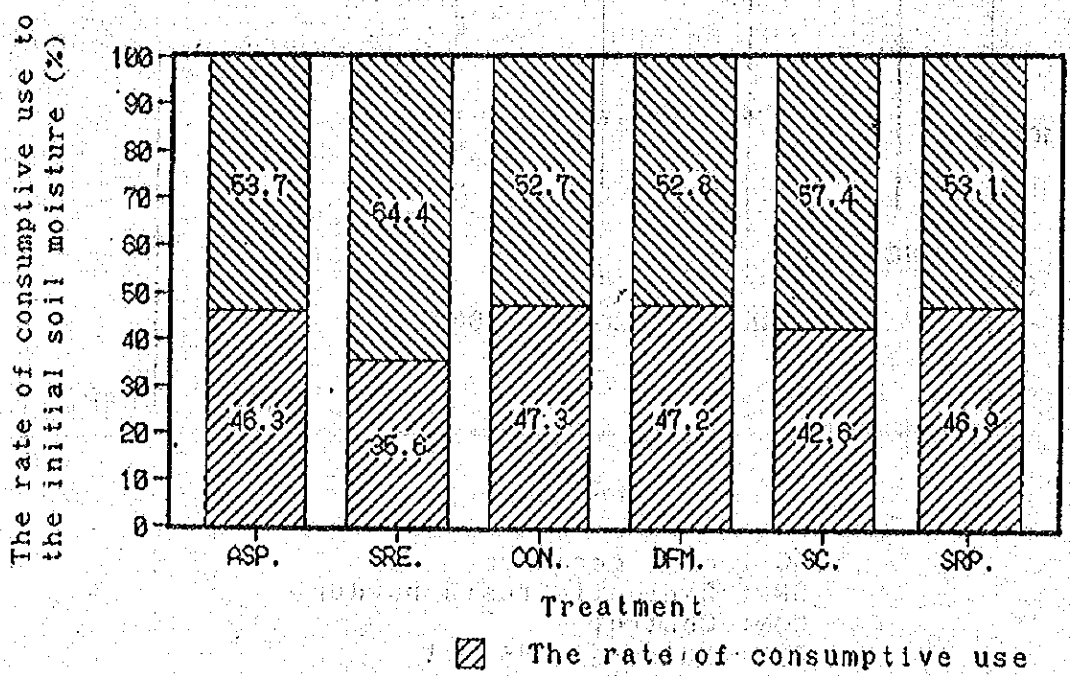
Results : (1) We studied firstly the effect of each treatment on tree growth as shown in Fig. 13. We picked up the final tree height, the amount of height growth and the rate of height growth to the initial height during the experimental period as the statistics to estimate the effect on tree growth. There was little correlations between these statistics and the initial tree height. Normal analysis of variance was studied. The height growth was the best in soft ceramics and those of synthetic resin powder, control and Dates-fronds-mat plots were approximately the same. The height growth of asphalt emulsion and synthetic resin emulsion plots were lower than those of other plots, as the results of the estimation of population means. But there was no significance statistically between these statistics and tree height growth. (2) We studied next the effect of each treatment on soil moisture as shown in Fig. 14. The initial amount of soil moisture, the amount of water consumption and the rate of water consumption to the initial amount of soil moisture were chosen as the statistics to estimate the effect on soil moisture. Initial amount of soil moisture showed maximum value in Dates-fronds mat plot and minimum value in synthetic resin emulsion plot. Besides there was statistically significance between them. Amount of water consumption had a same tendency to the initial amount of soil moisture. The rate of water consumption showed maximum value in control plot and minimum value in synthetic resin emulsion plot. But the significance was not statistically recognized among each treatment. Mean initial amount of soil moisture of all treatments after two hours of irrigation was 22.03 mm and means amount of water consumption of all treatments after five days of irrigation was 9.81 mm and the mean rate of water consumption of all treatments after five days of irrigation was 44.3%. We also studies the pattern of water consumption in each depth from the soil surface as shown in Fig. 15. The rate of water consumption showed maximum in the 20-40 cm depth. Its means value was 40.1%. It was realized that three-fourth of initial amount of soil moisture were consumed in the 0-40 cm depth from the ground during five days. (3) We also studied the effect of each treatment on soil temperature as shown in Table 3 and 4. The mean soil temperature was higher in asphalt, synthetic resin emulsion, control and dates-fronds mat plot in order. It was always higher than those of other treatments in asphalt plot. But there was no significant difference between asphalt and control plot in the diurnal range. The temperature in synthetic resin emulsion plot was higher than that of control plot in summer, but its degree was lower than that of asphalt plot. There was no difference between them in winter. The diurnal range was narrower than that of control plot in summer, but the difference between them was not recognized in winter. The diurnal range was also no difference comparing with it of control plot in dates-fronds mat plot, but the diurnal range had a tendency to be narrower than those of other treatments. Typical changes of soil temperature in 20 and 40 cm depth from the ground surface were shown in Fig. 16 and Fig. 17.



SC : Soft ceramics
SRP: Synthetic resin powder
CON: Control
DFM: Dates-fronds mat
ASP: Asphalt emulsion
SRE: Synthetic resin emulsion

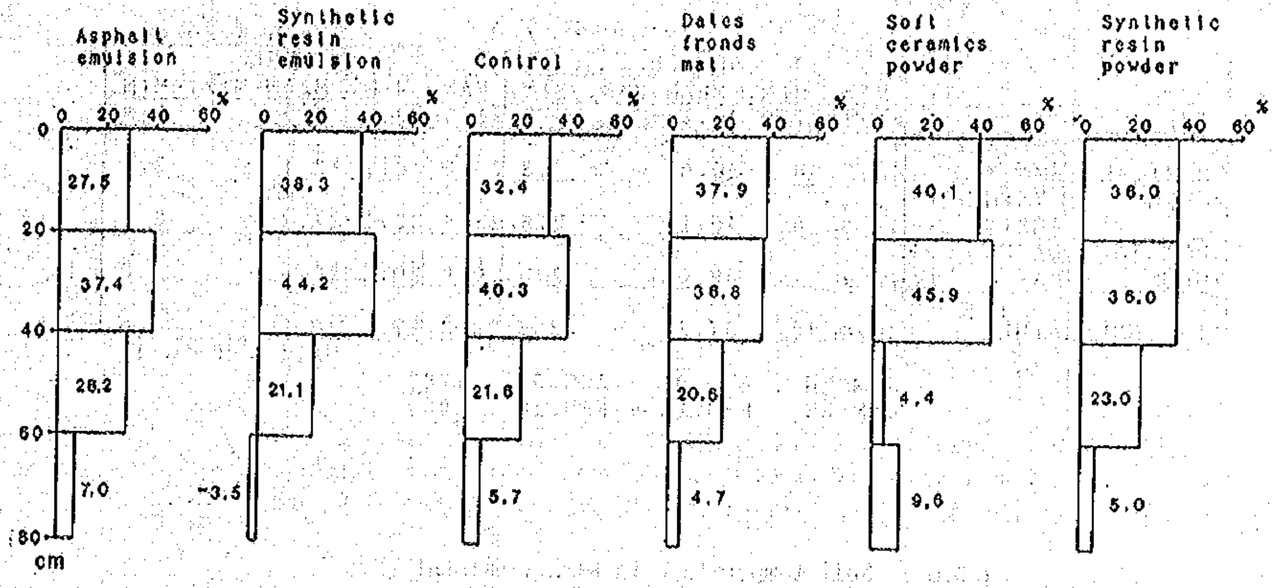
Fig. 13 The rate of tree height growth in each treatment
(April 1988 - March 1989)

Initial soil moisture (mm)	21.71	19.24	21.06	24.54	24.05	21.55
Consumptive use(mm/5days)	10.06	6.85	9.97	11.58	10.25	10.12



ASP : Asphalt plot
SRE : Synthetic resin emulsion plot
CON : Control plot
DFM : Dates-fronds mat plot
SC : Soft ceramics plot
SRP : Synthetic resin powder plot

Fig. 14 The rate of consumptive use to the initial soil moisture in five days



Horizontal axis : Rate of consumptive use (%)
Vertical axis : Depth from the soil surface (cm)
Value : Rate of consumptive use(%) in each soil layer

Fig. 15 Distribution of the rate of consumptive use in each soil layer

Table 3 Soil temperature in each treatment (1)

Depth = 20 cm

		SUMMER				WINTER			
		MAX.	MIN.	MEAN	MAX.-MIN.	MAX.	MIN.	MEAN	MAX.-MIN.
CONTROL		41.2	37.0	39.1	4.2	21.5	19.7	20.6	1.8
CHEMICAL MULCH	ASPHALT EMULSION	43.3	38.6	40.9	4.8	23.6	20.7	22.1	2.8
	SYNTHETIC RESIN	41.8	38.2	40.1	3.6	22.4	20.1	21.2	2.3
ORGANIC MULCH	DATES MAT	40.7	37.2	39.0	3.5	20.9	20.0	20.5	1.0
AIR TEMPERATURE		46.9	28.5	37.2	18.5	24.2	17.6	20.5	6.6

Unit : (°C)

SUMMER : AUG.01 - AUG.05 , 1988
WINTER : FEB.15 - FEB.20 , 1988

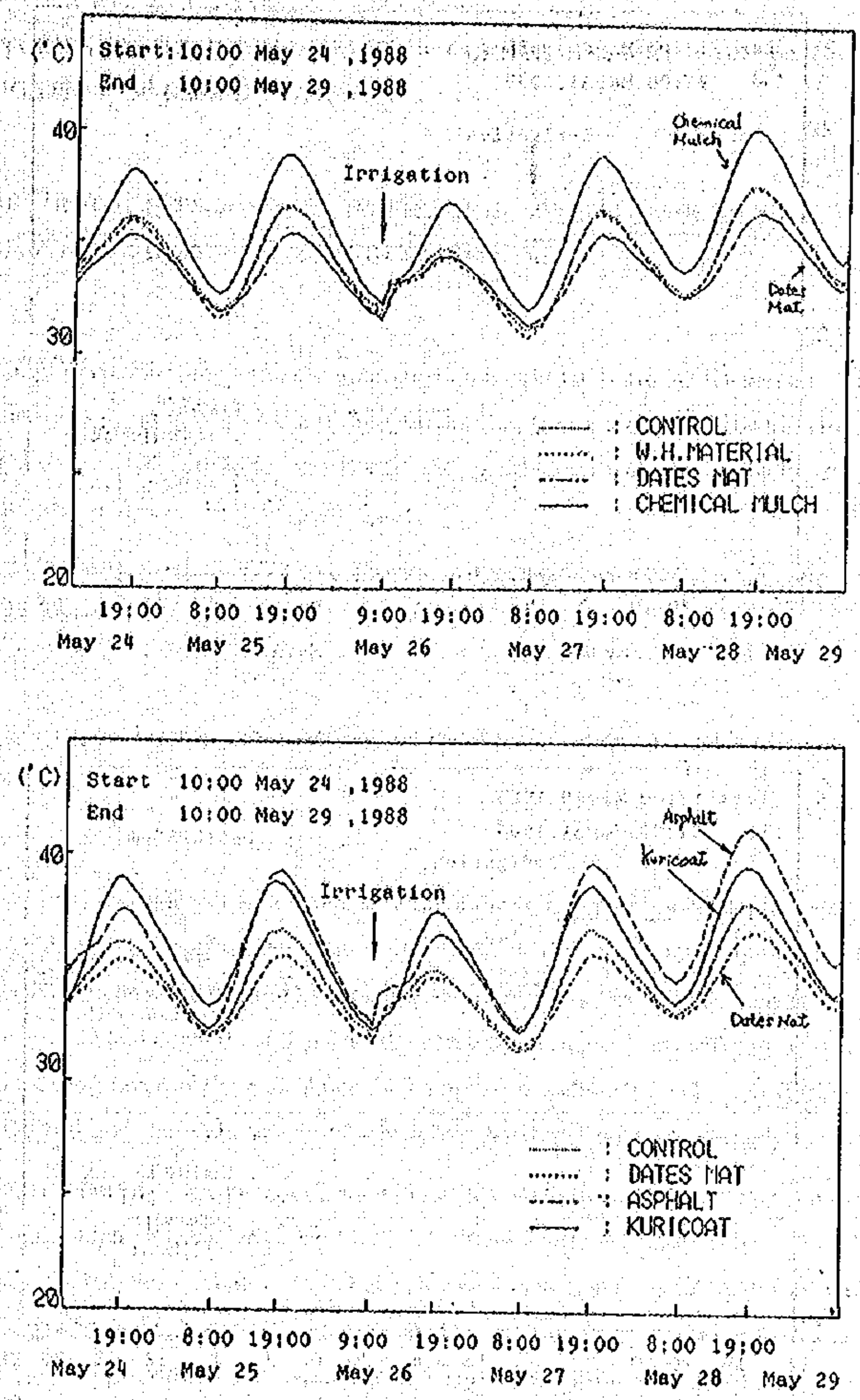
Table 4 Soil temperature in each treatment (2)

Depth = 40 cm

		SUMMER				WINTER			
		MAX.	MIN.	MEAN	MAX.-MIN.	MAX.	MIN.	MEAN	MAX.-MIN.
CONTROL		37.4	36.8	37.0	0.6	20.7	19.7	20.3	1.0
CHEMICAL MULCH	ASPHALT EMULSION	39.5	38.7	39.0	0.8	22.5	21.6	22.0	0.9
	SYNTHETIC RESIN	37.8	37.3	37.5	0.5	21.7	20.9	21.3	0.8
ORGANIC MULCH	DATES MAT	37.6	37.0	37.2	0.6	22.1	21.4	21.8	0.7
AIR TEMPERATURE		43.9	28.4	35.5	15.5	23.8	7.0	15.2	16.8

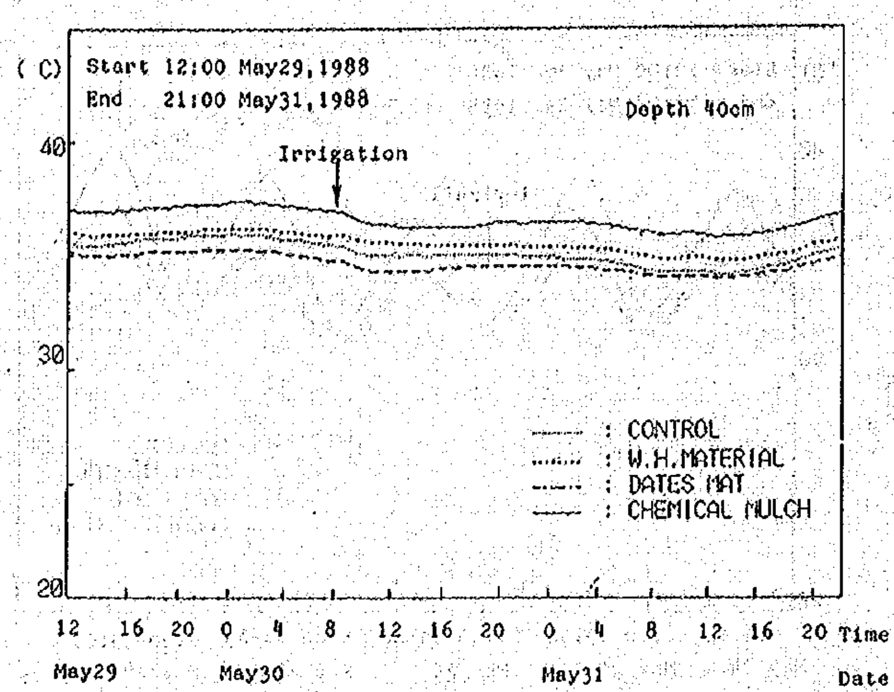
Unit : (°C)

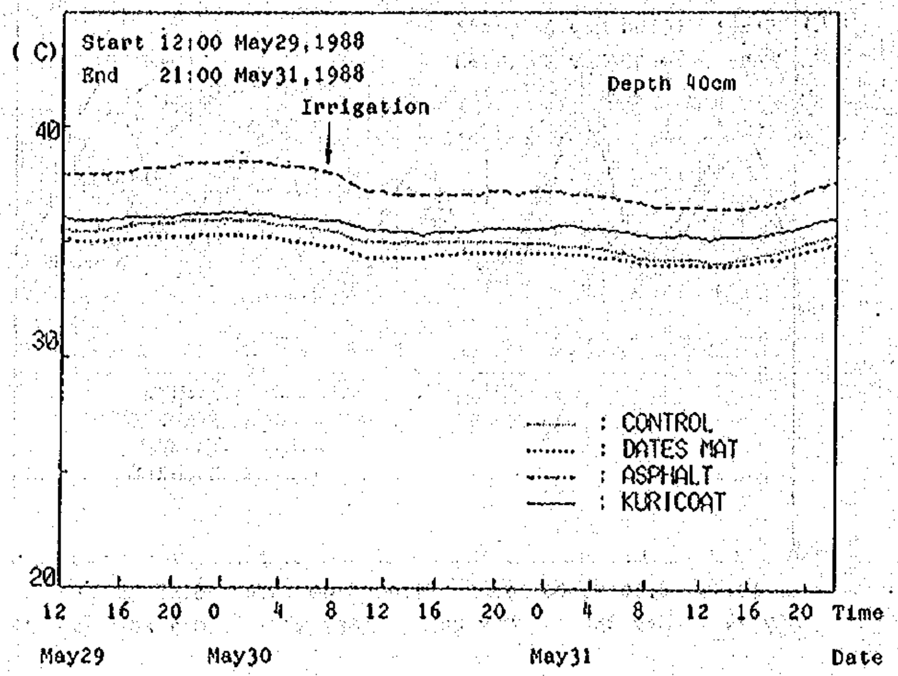
SUMMER : JUN.30 - JUL.04 , 1988
WINTER : JAN.19 - JAN.24 , 1989



※ KURICOAT : Synthetic resin emulsion

Fig.16 The change of soil temperature (depth:20cm) in each treatment





※ KURICOAT : Synthetic resin emulsion

Fig. 17 The change of soil temperature (depth:40cm) in each treatment

2. Theme B : STUDIES ON THE IMPROVEMENT OF CULTIVATION METHODS FOR CROP PRODUCTION UNDER IRRIGATION OF SALINE WATER

(1) STUDIES ON THE EFFECT OF A SUBSURFACE COMPOST LAYER ON WATER PRESERVATION, SALINITY AND YIELDS OF CROPS IN SANDY SOIL

The main problems limiting agricultural production in arid lands are the unavailability of irrigation water and accumulation of salt on the soil surface. Soil salinity imposes a stress on growing crops and may lead to a low crop yield or a complete crop failure. Hence, saving irrigation water and reducing salt accumulation are of prime importance in arid or dry land agriculture.

The objectives of present studies are to investigate the effect of a subsurface compost layer on crop yields under conditions of UAE.

(i) Effects of compost layer in subsurface soil on water preservation and yields of crops under sweet water irrigation

The experiment was laid out in a completely randmized design with three replications (20 m^2/plot). The treatments were : thick layer application in the subsurface soil (T), whole layer application (W), and without application of the bark compost (20 tons/ha). Thick and whole layers are forms of the compost applied. The compost layer in T-treatment was laid down the soil to a depth of 15 cm in form of sheets while the compost in W-treatment was mixed with the top layer of the soil. After the treatment of different levels of irrigation, the fresh weight of alfalfa (cv. Omani) and the grain weight of wheat (cv. Mexipak) were respectively measured.

From results obtained, T-treatment increased the yields of alfalfa and wheat compared to those of the other two treatments under high and low irrigation levels for alfalfa and high irrigation level for wheat. Alfalfa tops in T-treatment absorbed higher amounts of N, P, K, Ca, Mg and Na than in the other treatments under both irrigation levels. Such increase in yields results from the remarkably high moisture retention in the subsurface compost layer which supplies crops with enough water and prevents water infiltration down the sandy soil (Fig. 1 and 2).

(ii) Effects of two kinds of compost and their application method on water conservation and the yield of cabbage under sweet water irrigation

The main objective of this study is to determine the role of the compost layer and to compare the effects of the Al-Ain compost and the bark compost on the growth and yield of cabbage (*Brassica oleracea*, capitata group).

There was no significant difference in the average head weight between two kinds of compost. However, significant difference in average head diameter between two kinds of compost was observed. Significant difference in head weight, head diameter, and head hight were also observed between the control plot and compost applied plots in both compost treatments.

Regarding the soil analysis, the third layer (15-30cm from the soil surface) in T-treatment which was containing the compost layer showed the higher soil moisture content than the other layers. The second layer (1-15cm from the soil surface) in T-treatment also showed rather high moisture content than the equivalent layers in the other treatments. The EC value of the surface layer was higher than those of lower layers and was increased during the growing period.

According to results of the soil moisture measured by the tensionmeter, the pF value at 20cm depth in T-treatment generally showed lower value than those of W-treatment and control. It was considered that the thick layer of the compost was effective to retain the irrigated water in its upper soil layer.

The root system in T-treatment was well developed in the compost layer to form the carpet-like root mat. Such formation of active root mat was also considered as one of the reason for the better plant growth in T-treatment.

It was supposed that the main roles of the compost layer are to retain the irrigated water in the compost layer and also in its upper soil layer and to develop active root system in its layer (Table 1, Fig. 3 and 4).

(iii) Effects of compost layer in subsurface soil on the yield of spinach irrigated with saline water

The main objective of this study is to investigate the effect of compost layer on the yield of spinach (*Spinacia oleracea*, Orient, Sakata) in relation to salinity hazard under saline water irrigation.

The estimated yields (ton/ha) were generally higher in low salinity plots than in high salinity plots. The comparative yield in high salinity against low salinity was highest in T-treatment. Similar trends were observed in the leaf length, the root length, and the dry weight of the plant.

There were significant differences in the fresh weight and the root length between low and high salinity levels. The fresh weight, the leaf length, and the root length in T-treatment were significantly higher than those in the other two treatments (control and W-treatment).

The soil moisture in the third layer of T-treatment was higher than those of the other layers. The soil pH was generally higher in high salinity plots than in low salinity plots. The soil pH of the third layer in T-treatment was lower than the other two treatments. The EC value of saturation extract (ECe) in the surface layer was always higher than those in the other layers. The ECe of the surface layer increased at the 2nd sampling and decreased at the 3rd sampling. This was because of the heavy rain fall between these samplings. On the contrary, the ECe of 2nd and 3rd layers increased during the cultivation period. The 3rd layer of T-treatment showed extremely high ECe specially in high salinity plots. This would be explained that the salt accumulated in the surface layer was leached down to the lower layer with rain water and held by the compost layer in T-treatment.

The composition of cations in the irrigation water and in plant leaves were studied. Although concentration of divalent cations such as Ca and Mg in the high salinity water were 4-5 times more than those in the low salinity water, their contents in plant leaves were almost similar in both high and low salinity plots. In the irrigation water Na concentration was higher than those of Ca and Mg, but its content in plant leaves was lower than those of Ca and Mg. Na content in plant leaves was 2-3 times higher in high salinity plots than in low salinity plots. Also Na content in W-treatment was lower than those in control and T-treatment at both low and high salinity plots. As for potassium, in spite of very low concentration in the irrigation water, its content in plant leaves was higher than all the other cations. And K contents in plant leaves were higher in low salinity plots than those in high salinity plots. Consequently, K/Na and K/Ca+Mg balances were generally higher in low salinity plots than in high salinity plots and also they were higher in W-treatment than in the other treatments at both low and high salinity plots. According to the cation balance in plant leaves mentioned above, W-treatment may be more effective than T-treatment against the absorption of excess salt by the plant.

The function of the compost layer can be summarized as follows. The compost layer is effective to retain the irrigation water in its layer and in its upper soil layer. At the same time, the compost layer can hold some of the inorganic salts leached down from the upper layer. The compost layer was also effective to develop the longer root system than the other treatments. Consequently, although W-treatment seems more effective than T-treatment against the absorption of excess salt by the plant, the yield in T-treatment was higher than those in the other two treatments. Furthermore, the reduction rate of the yield due to salinity was lower in T-treatment than in the other two treatments. These results suggest that T-treatment would be useful not only for saving water but also for reducing salt hazard (Table 2, Fig. 5 and 6).

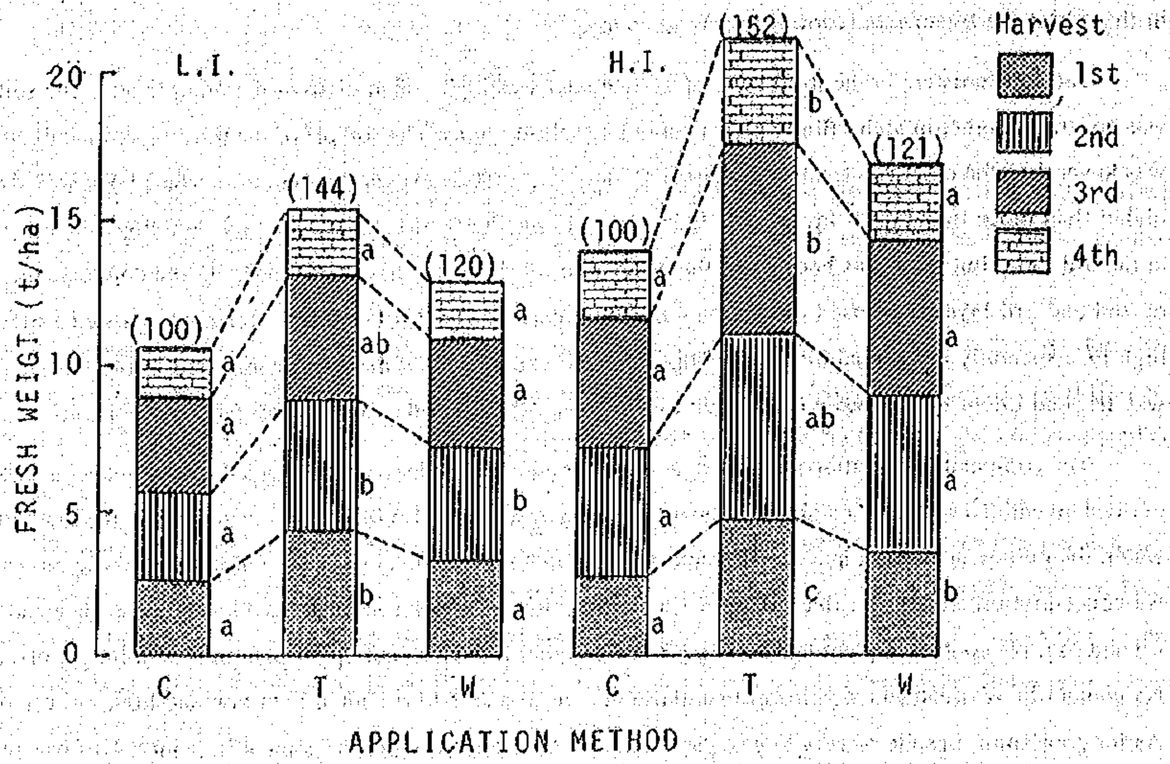


Fig.1 Relationships between fresh weights of alfalfa and application methods of bark compost under irrigation of sweet water. Figures in parentheses are indexes for 100 of control. C:Control;T:Thick layer application;W:Whole layer application. L.I.Low irrigation;H.I.:High irrigation. Columns shown by the same letter are not significantly different by LSD at 5 % level.

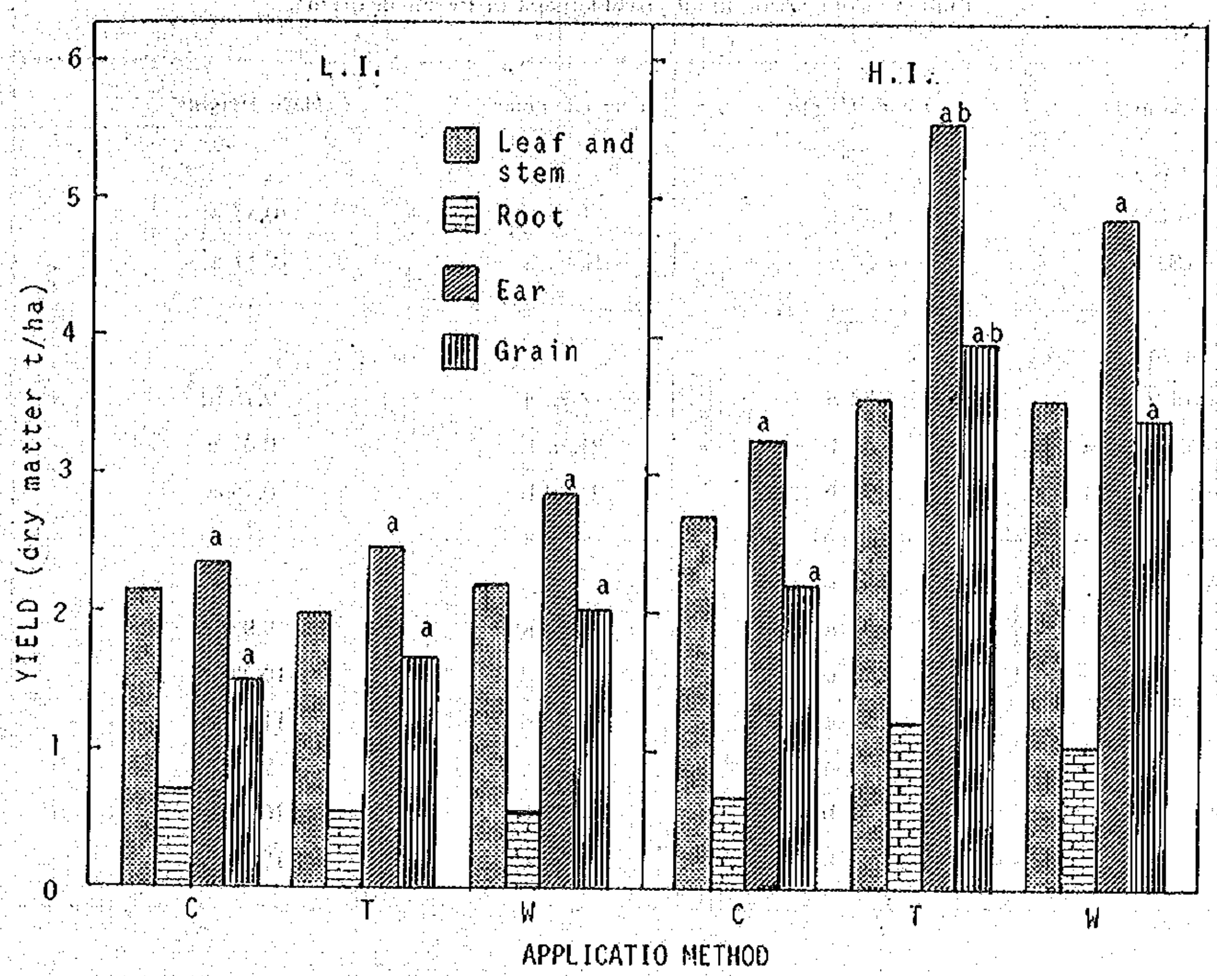


Fig. 2 Relationships between yields of wheat and application methods of bark compost under irrigation of sweet water. Columns shown by the same letter are not significantly different by LSD at 5 % level.

Table 1 Comparison in all possible pairs of treatment means

Treatment	Head Weight	Head Diameter	Head Height
Compost (C)			
Al Ain (A)	1.88 a	21.56 a	10.57 a
Bark (B)	1.54 a	19.71 b	10.11 a
Application (A)			
Control (C)	1.33 a	18.78 a	9.78 a
Whole layer (W)	1.83 b	21.14 b	10.49 b
Thick layer (T)	1.97 b	21.99 b	10.75 b
C x A			
AC	1.34 a	19.06 ab	9.93 ab
AW	2.04 c	22.29 d	10.77 d
AT	2.27 c	23.33 d	11.02 d
BC	1.32 a	18.50 a	9.63 a
BW	1.62 b	19.98 bc	10.22 bc
BT	1.67 b	20.64 c	10.49 cd

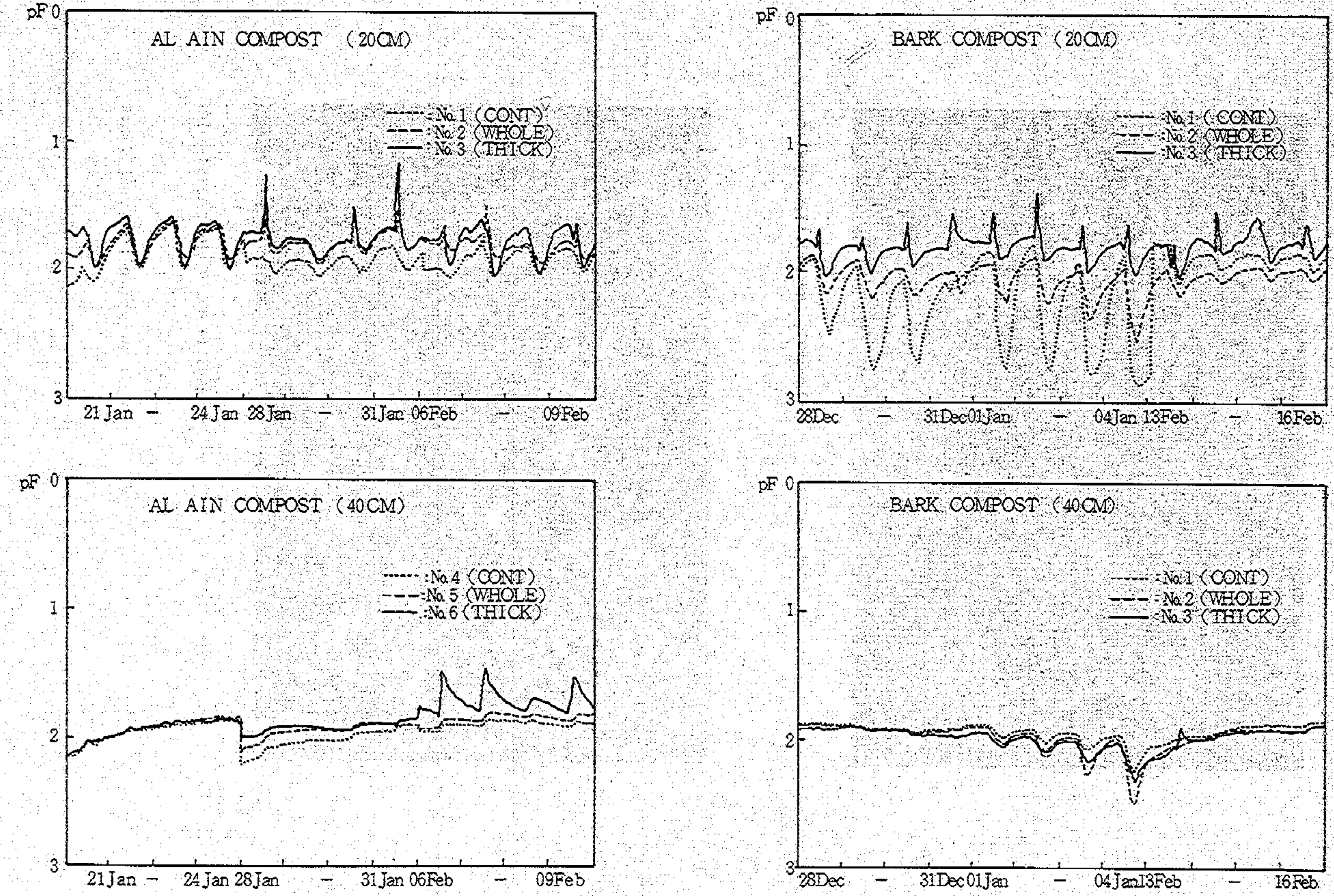
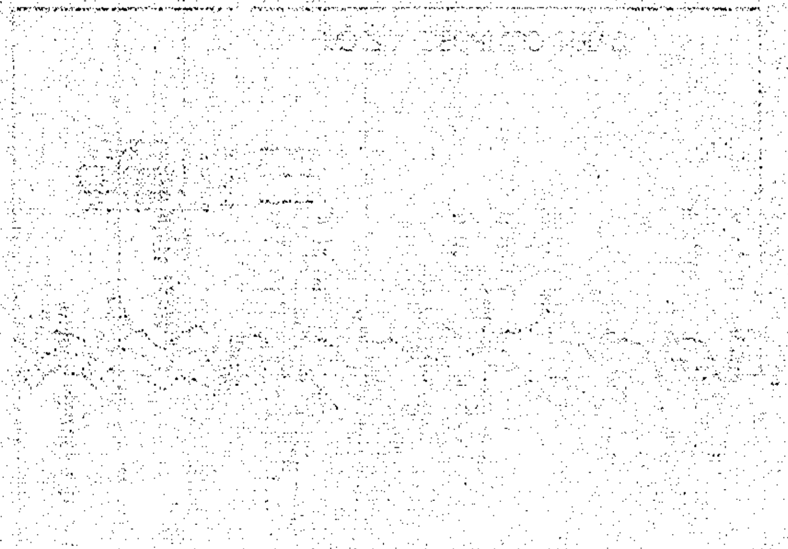
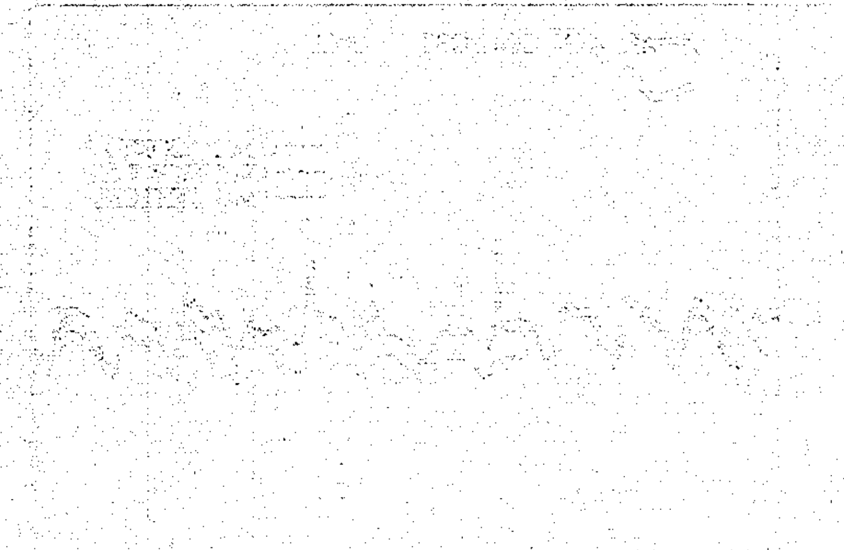
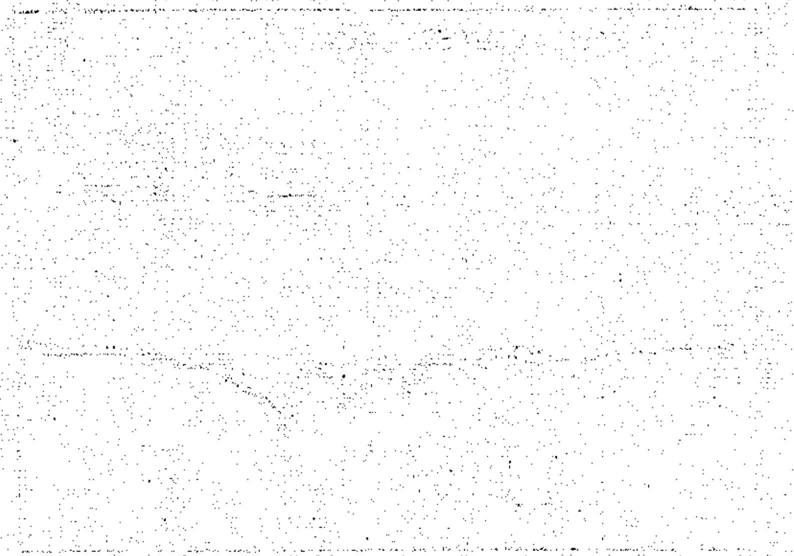
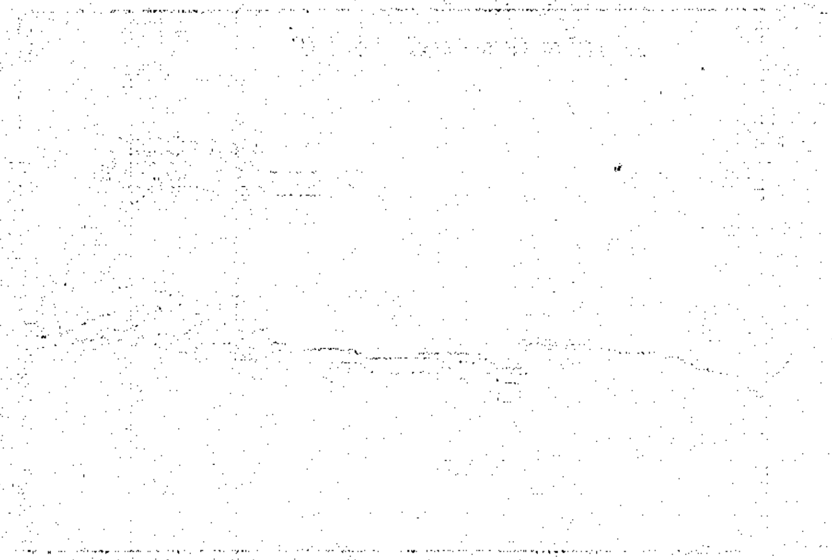


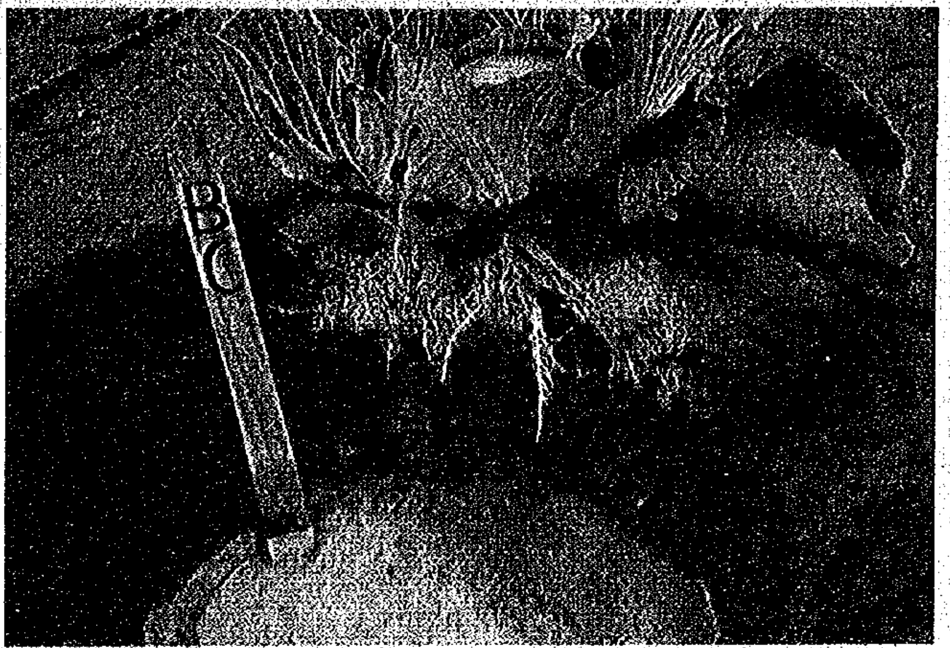
Fig. 3 Soil moisture measured by the tensiometer at the different periods



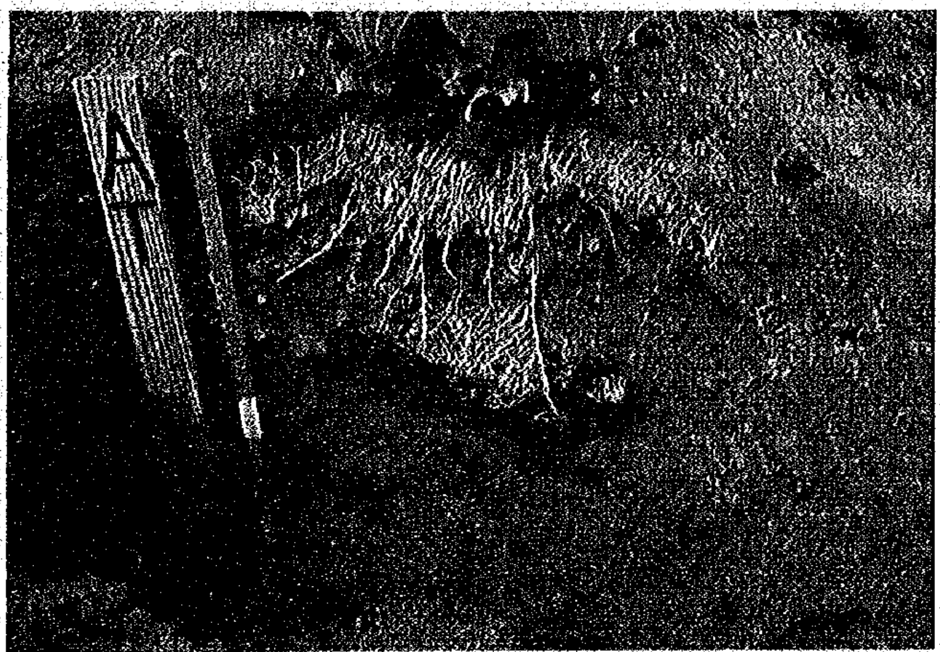








Without applicationof compost



Thick Layer Application of compost

Fig.4 Observation of root system

Table 2 Comparison in all possible pairs of treatment means

Treatment	Fresh Weight	Leaf Length	Root Length
Salinity (S)			
Low (L)	77.70 a	29.69 a	17.12 a
High (H)	62.32 b	25.58 a	15.39 b
Application (A)			
Control (C)	52.94 a	24.28 a	14.51 a
Whole layer (W)	71.78 b	27.44 b	15.28 a
Thick layer (T)	85.32 c	31.33 c	18.97 b
S x A			
LC	59.31 a	26.29 bc	15.78 bc
LW	81.20 c	29.79 cd	16.23 c
LT	92.60 c	33.29 d	19.34 d
HC	46.58 a	22.27 a	13.23 a
HW	62.35 ab	25.10 ab	14.33 ab
HT	78.04 bc	29.37 c	18.61 d

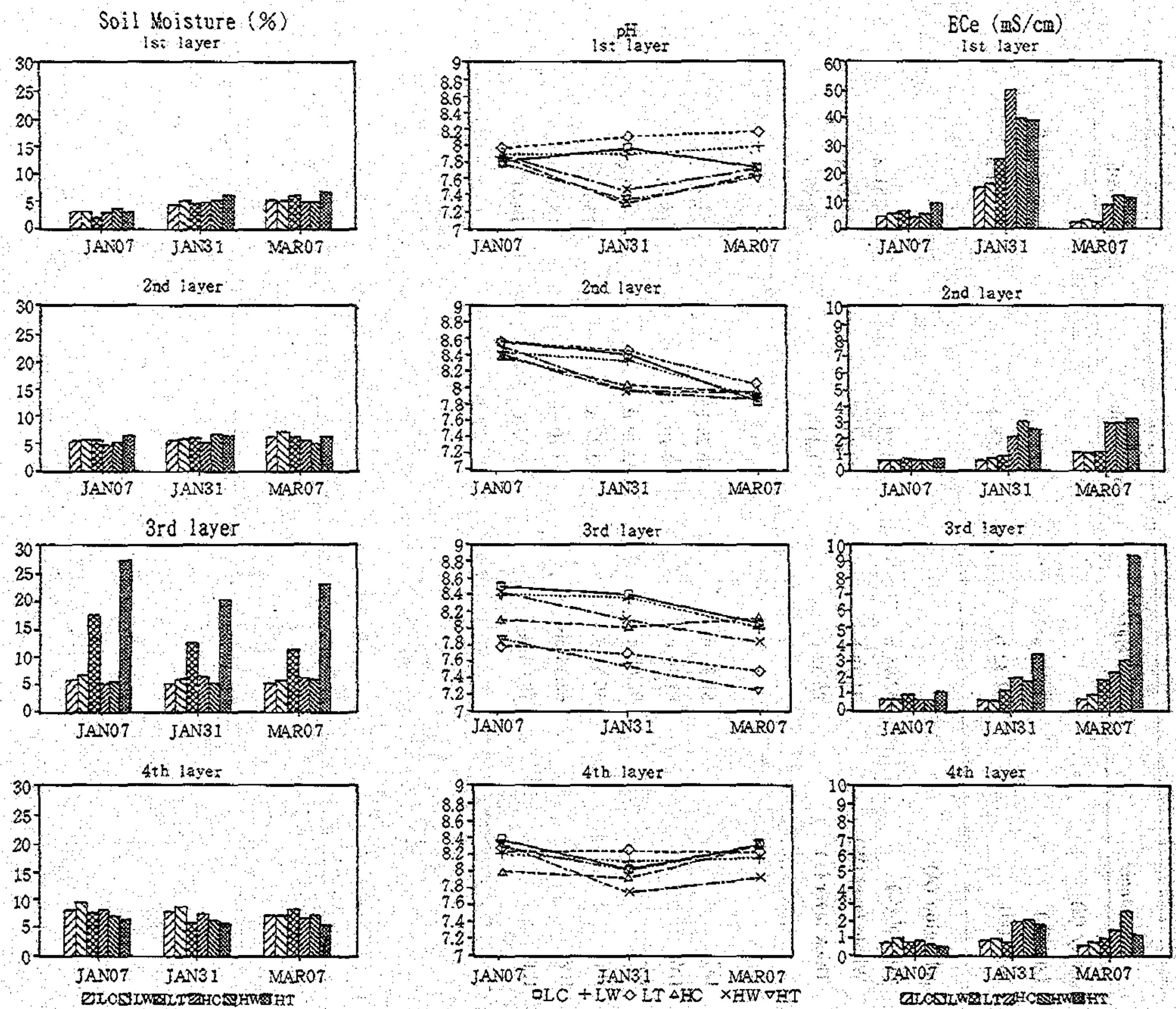


Fig.5 moisture, pH, and EC of sample soils

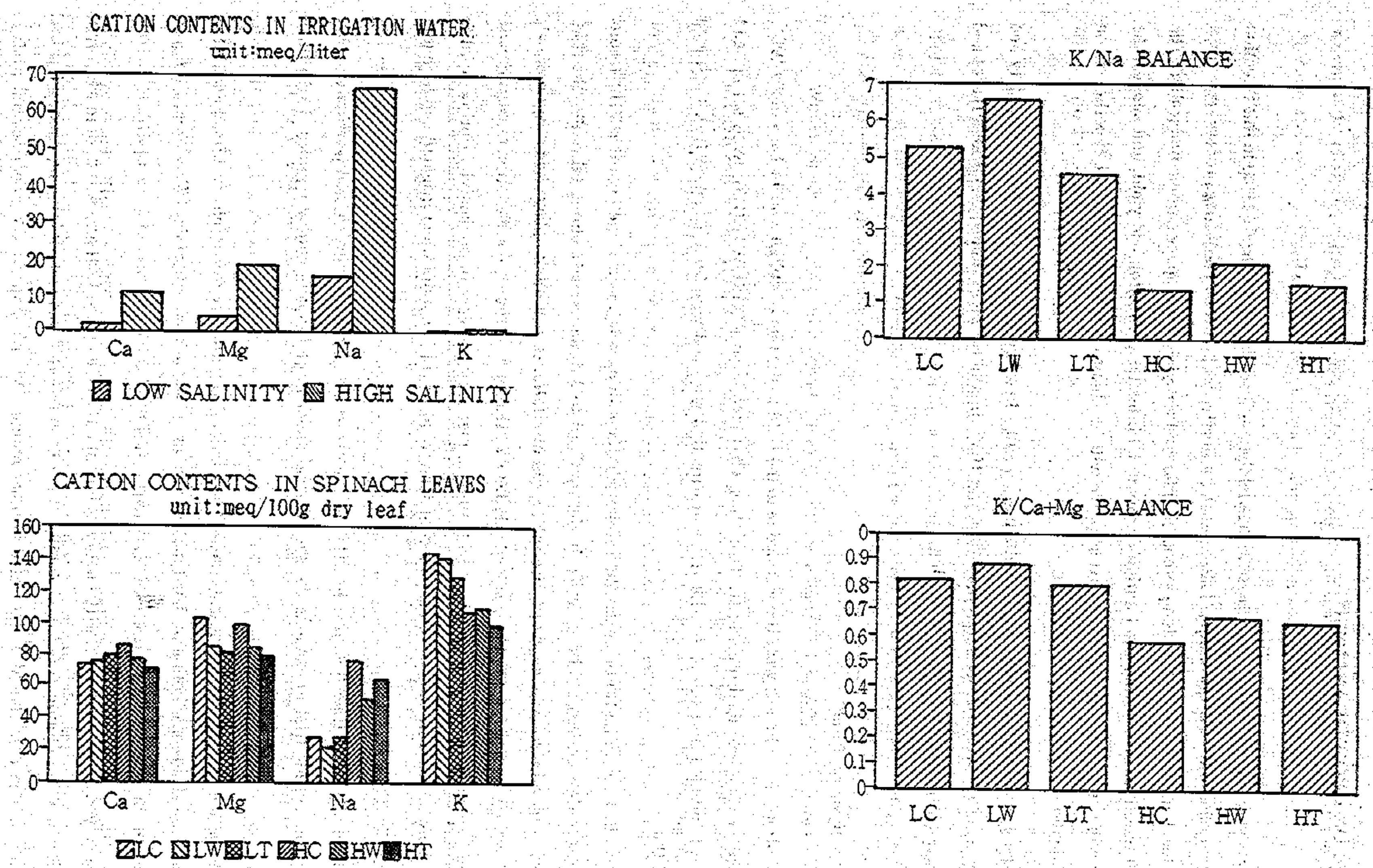


Fig. 6 Composition of cations in irrigation water and in plant leaves with some cation balance

(2) STUDIES ON GROWTH ANALYSIS

There may be some possibilities to increase in the yield per unit area in UAE. The first step in this direction is to answer exactly the following questions: (1) how much productivities and what productive processes do crops have under the local and standard cultivation method?, (2) how do the yields of crops determine under that? The answers to both questions will clarify the limiting factors to both matter production and yield, and suggest the ways to improve the cultivation methods. In next step, we will be able to conduct the factorial experiments on the cultivation methods using these suggestions.

In this study, we conducted wheat and alfalfa experiments. In wheat, we examined the productivity and productive process of the winter cropping in both 1986 and 1987. In alfalfa, we examined the productivities and productive process for two years after the seeding.

(i) Growth analysis of Alfalfa

Seeds of alfalfa (cv. Omani) were broadcasted onto the field at the rate of 40kg/ha on 14 December 1986. Sward management was described previously. Two plots, CUTTING and REGROWTH(B5), were set up, and CUTING plot was divided into sub-plots with standard irrigation (B6) and with high irrigation(B4). Each area was 24.7 x 33.0m.

There may be two methods to increase the yield of alfalfa: cutting schedule and cutting times. The results of CUTTING plots showed that alfalfa grew fastly during April to July but slowly during other months (Fig. 1). Fastly growing months corresponded to flowering season of alfalfa, so that alfalfa plants had long internode and developed well layers of leaves. The result of REGROWTH plot also shows that the amount of regrowth was low during September to November. These facts suggest that more increase in productivity during April to July results in more increase in annual yield. We recommend frequent cutting, more water irrigated and high top-dressing during this period.

We had cut alfalfa 12 times per year in CUTTING plots to obtain the data on seasonal productivity. We recommend to conduct the trial to examine the annual yield under more frequent cutting regimes, 14-15 times per year.

The results of micro-meteorogical trial showed that twice irrigation per day results in higher yield than once irrigation on condition that both plots had the same amount of water irrigated per day. We recommend more frequent irrigation throughout the year, especially in April to July.

The annual yield was 2800-3000kg/10a in dry weight in CUTTING plots. Leaf area was high in May, June and July, but low in other months (Fig. 2). Generally, it has been reported that well-developing canopy has LAI of 4-8 in alfalfa, so leaf area should be increased in other months. We recommend to conduct several trials to examine the characters affecting leaf area index, leaf weight and stem number per unit area, the number of nodes on stem and vertical distribution of leaves, under the irrigation and fertilizer treatments.

We observed many small-sized bare grounds in alfalfa fields. We recommend that irrigation and fertilizer are applied more regularly in space, and large amount of compost are applied as possible to obtain sufficient number of alfalfa plants and vigorus seedlings with large and deep root system.

(ii) Growth analysis of Wheat

In 1987/1988 winter cropping, two levels of fertilizer treatment, CONTROL and FREQUENT, were set up with three replications. CONTROL plot was applied at 100kg/ha urea in levelling but FREQUENT plot was applied at each 50kg/ha urea in both levelling and 9 February. Seeds of wheat (cv. MEXIPAK) were row-seeded at the rate of 150kg/ha on 18 November 1987, with the interrow space of 42kg N/ha, 110kg P_2O_5/ha, 96kg K_2O/ha and 20tons/ha of Al Ain compost.

Wheat plants were sampled at seven times from 8 December to 5 March. Morphological variables were measured.

In analyzing the yield components, while grain number per ear and 100 grainb weight were high, ear number was considerably low, 215.2-219.6 ears per m^2 (Table 1). Therefore, it is important for the improvement of yield to increase the ear number per unit area. It may be accompanied with the increase in plant number. Plant density, however, was low and a large spatial variation in that was also observed in the study field. We recommend that both irrigation and fertilizer are applied more regularly in space, and a large amount of compost is applied as possible to obtain the sufficient number of wheat plants. Especially, irrigation should be payed more attention in early phase of wheat plant for the development of root system more deeply and strongly.

Although the period between heading and grain-filling was long enough to mature, that between the seeding and heading was short. We suggest that there is some possibility to increase the yield by extending the vegetative growth period. We recommend to conduct some experiments on the effects of the seeding date on productive process and yield components.

Grain yield in this study, 4475kg/ha, was much higher than that in the 1986/1987 crop, 2766kg/ha. In comparing the yield components of both experiments, large differences were found in ear number, kernel number per ear and 100 kernel weight. 1987/1988 experiment had more kernel number per ear and heavier 100 kernel weight than 1986/1987 experiment, although it had fewer ear number. These differences seemed to be partially due to the difference in the seeding date, 1987/1988 experiment started on 27 November. The differences in the seeding date may affect the yield components. The growth data also suggest that the difference in LAI (leaf area index) of the late phase (mid-January to late-February) was partially responsible for the difference in grain yield (Table 2). LAI was high, 3.15-3.26, in this study but low, 2.18, in 1986-1987 experiment. It should be maintained to be high in the late phase of growth. The irrigation and top-dressing in this phase should be payed attention.

Table 1. Yield components of wheat.

	No. ears (no./m²)	No. grains per ear	100 grain weight(g)	Yield (g/m²)	Culm length	Ear length
1986 Control	277.3	30.6	3.26	276.6	50.4cm	8.6m
1987 Control	219.6	54.7	3.71	445.7	60.2cm	10.2cm
1987 Treatment	215.2	60.1	3.90	504.4	60.6cm	10.7cm

Table 2. Leaf area index and dry matter weight (g/m²)

Cont-1986/1987			Cont-1987/1988			Treat.-1987/1988		
Date	LAI	DW	Date	LAI	DW	Date	LAI	DW
			8 Dec.	0.27	39.8	8 Dec.	0.20	32.7
24 Dec.	2.56	154.3	24 Dec.	1.98	250.4	24 Dec.	1.78	245.5
16 Jan.	5.19	784.7	10 Jan.	4.00	800.4	10 Jan.	3.90	770.2
30 Jan.	3.00	994.7	21 Jan.	4.68	932.3	21 Jan.	5.05	1063.9
13 Feb.	1.52	1491.7	6 Feb.	2.00	1062.7	6 Feb.	1.96	1091.3
27 Feb.	0.94	1338.8	22 Feb.	1.47	1394.7	22 Feb.	1.69	1498.5
13 Mar.	0.03	1211.3	5 Mar.	–	1759.2	5 Mar.	–	1530.1

(3) STUDIES ON MICROMETEOROLOGY

(i) Effect of irrigation frequency and irrigation amount on soil temperature

This study was conducted in September and December 1986. Diurnal changes in soil temperature and some micrometeorological variables were measured in the desert near Al Ain city.

September, an extremely hot and dry month, had a high daily maximum temperature of 41.9°C, and exhibited large diurnal changes in air temperature. Evaporation was high during the day (10.59mm/12 hours), and diurnal pattern of evaporation corresponded well with diurnal changes in air temperature. Maximum temperature at 5cm depth in bare soil with no irrigatioln was 49.7°C. High irrigation frequency and plant cover reduced soil temperature at 5 cm depth, while irrigation amount had no effect.

December had a low daily maximum temperature of 23.0°C. Evaporation was low during the day (2.34mm/11 hours) and exhibited large diurnal changes in soil temperature at 5cm depth, which corresponded with changes in air temperature, but little changes were found at 30cm depth. Both irrigation frequency and irrigation amount had no effect on soil temperature. On the other hand, plant cover reduced soil temperature at 5cm depth (Fig. 1 and 2).

(ii) Effects of different kinds of mulches on soil temperature, soil moisture and plant growth

Plastic mulches are frequently used to conserve soil moisture, increase soil temperature, and control weeds. Increasing soil temperature is especially beneficial when warm-season crops are grown in winter. On the other hand, conserving soil moisture is very important in UAE, specially in summer, because evaporation is considerably high.

Three field experiments were conducted under drip irrigation system to evaluate the effects of mulches on soil temperature, soil moisture and plant growth.

(a) 1st experiment : Okra seeds were sown on 27 December 1987. The following mulch treatments were tested: 1) bare soil (control) ; 2)paper mulch; 3)clear plastic mulch; 4) black plastic mulch. Soil temperatures were increased by plastic mulches, which resulted in faster germination and better plant growth in the plastic mulch plots. The experiment was terminated in the middle of February 1988 due to heavy damage to the plant by strong wind. This result suggested the necessity of proper windbreak around the experimental plot (Fig. 3).

(b) 2nd experiment : Treatments included bare ground, white plastic mulch, and black plastic mulch, each with two levels of irrigation amount (3 litres/plant/day and 6 litres/plant/day). Soil temperatures and soil moistures were increased by plastic mulches. Irrigation amounts did not influence both soil temperatures and soil moistures. It is suggested that a very durable mulch is required under the severe weather condition in UAE, because the tested plastic mulches were destroyed within two months after the experiment started (Fig. 4 and 5).

(c) 3rd experiment : Cauliflower was seeded in the middle of October 1988, and transplanted to the field on 10 December 1988. The treatments were as follows: 1) bare soil (control); 2) clear plastic mulch; 3) black plastic mulch; 4) chemical mulch (KURI-COAT). Soil temperatures were increased by plastic mulches. Chemical mulch, however, had little effect on soil temperature. Soil moistures were not influenced by mulches. Clear plastic mulch increased curd yield by 5%, however, the difference was not significant (Fig. 6 and 7).

(iii) Effect of irrigation frequency on transpiration rate, leaf temperature and yield of alfalfa

UAE belongs to extremely arid area and its annual rainfall is approximately 100mm, which fluctuates from 0mm to more than 200mm. Consequently agriculture in UAE mainly depends on ground water supply. Since recharging the ground water by rainfall is very limited in UAE, too much water use may result in shortage or exhaustion of water resource. It is very important to clarify water movement for appropriate agricultural management. Several basic studies on water economy were conducted in alfalfa field.

(a) The amount evaporation from water surface and soil surface

The evaporation amount from water surface (Ew), soil surface with everyday irrigation (Ee), and soil surface with every two days irrigation (Et) were measured in August 1988. Ew was 12-14mm/day and Ee was 11-13mm/day. Et of irrigated day was similar to Ee, but that of no-irrigated day was much less than Ee (i.e. 2-3mm/day). It was obvious that once soil surface was dried, evaporation from soil surface was reduced remarkably (Fig. 8).

(b) Diurnal change in transpiration rate and leaf temperature of alfalfa

Diurnal change in transpiration rate and leaf temperature of alfalfa was measured by porometer (LI-1600: LI-COR Co.) with two levels of irrigation frequency. The measurements were done in April, June, August, November 1988 and January 1989. Leaf temperature was lower than air temperature in April, June and August. Leaf temperature was, however, almost same as air temperature in November, and was higher than air temperature in January. Frequent irrigation was effective to keep higher transpiration rate during midday, which resulted lowered leaf temperature especially in hot season (Fig. 9).

(c) Effect of irrigation frequency on the yield of alfalfa

Fresh weight, dry weight and plant height of alfalfa were measured monthly from March 1988 to February 1989 with two levels of irrigation frequency. Fresh weight of alfalfa was significantly increased by frequent irrigation (Fig. 10). In general, the yield of alfalfa was high in winter and spring, but low in summer. The ratio of dry weight to fresh weight was the largest in May, followed by gradual decrease up to January.

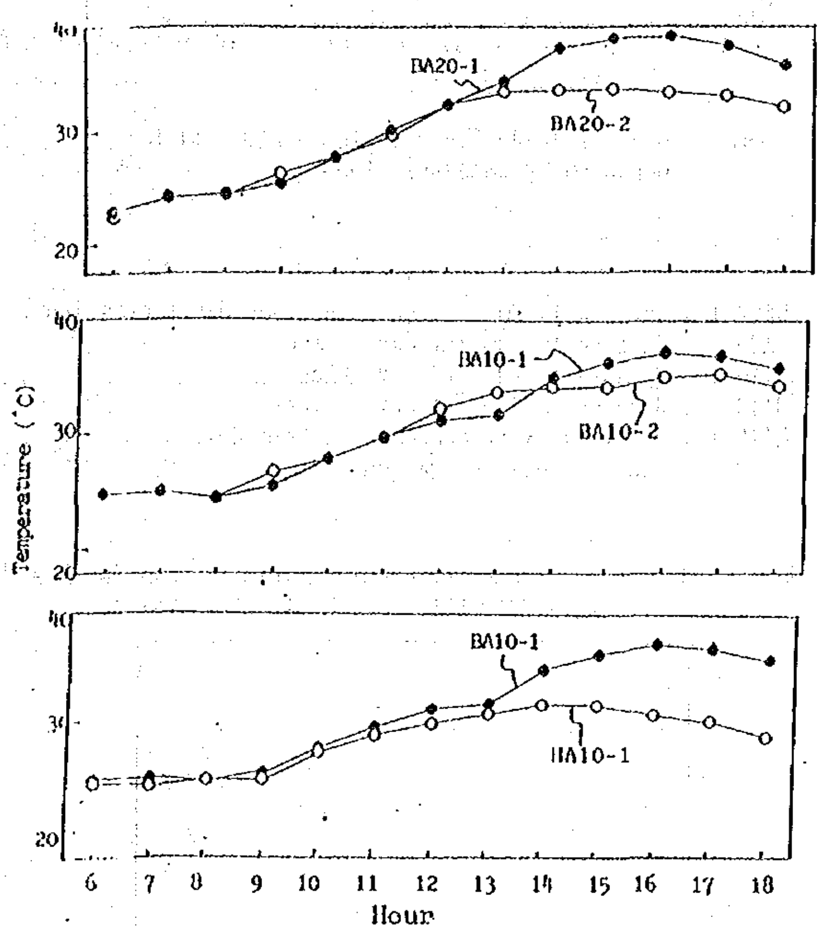


Fig. 1 Diurnal change in soil temperature at 5 cm depth on 14 September, 1986

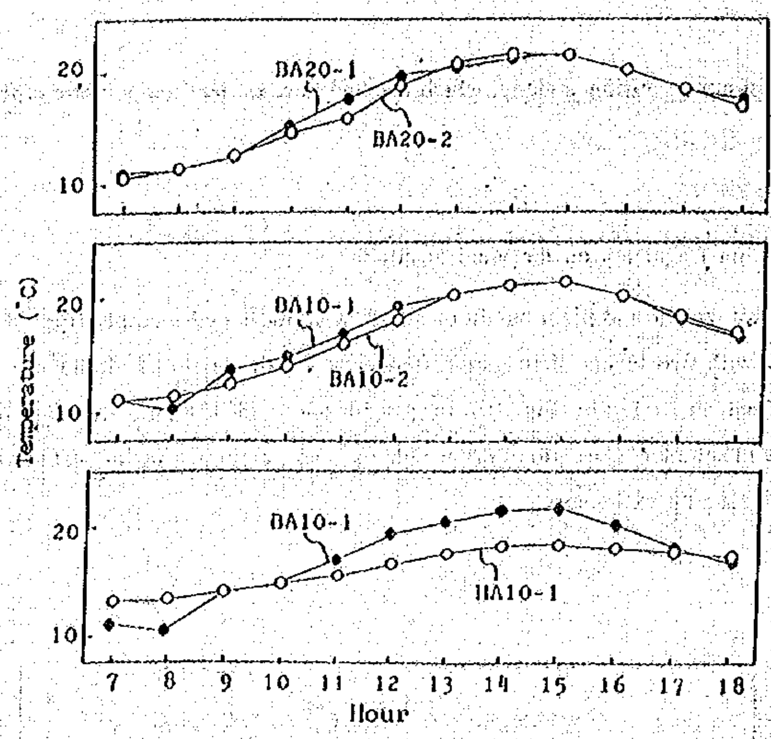


Fig. 2 Diurnal change in soil temperature at 5 cm depth on 22 December, 1986

NOTE; BA20-1 : Bare soil, 20 ℓ/m²/day, once per day irrigation
BA20-2 : Bare soil, 20 ℓ/m²/day, twice 〃
BA10-1 : Bare soil, 10 ℓ/m²/day, once 〃
BA10-2 : Bare soil, 10 ℓ/m²/day, twice 〃
HA10-1 : *Haloxylon salicornicum* 10 ℓ/m²/day, once per day irrigation

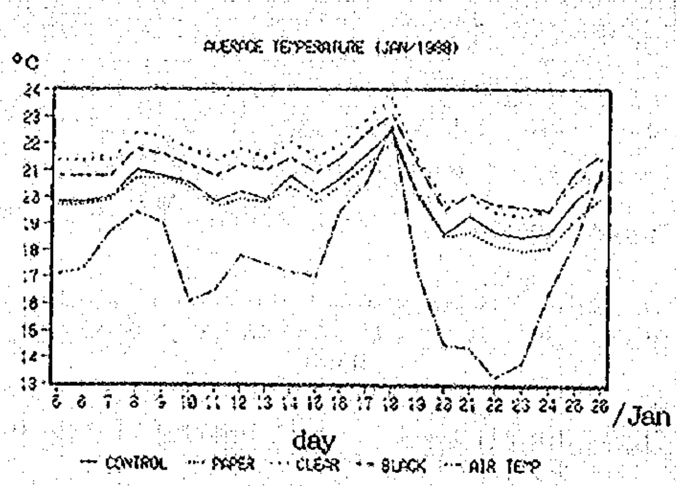


Fig. 3 Change in average soil temperature at 10cm depth and average air temperature (Okra 1/ winter)

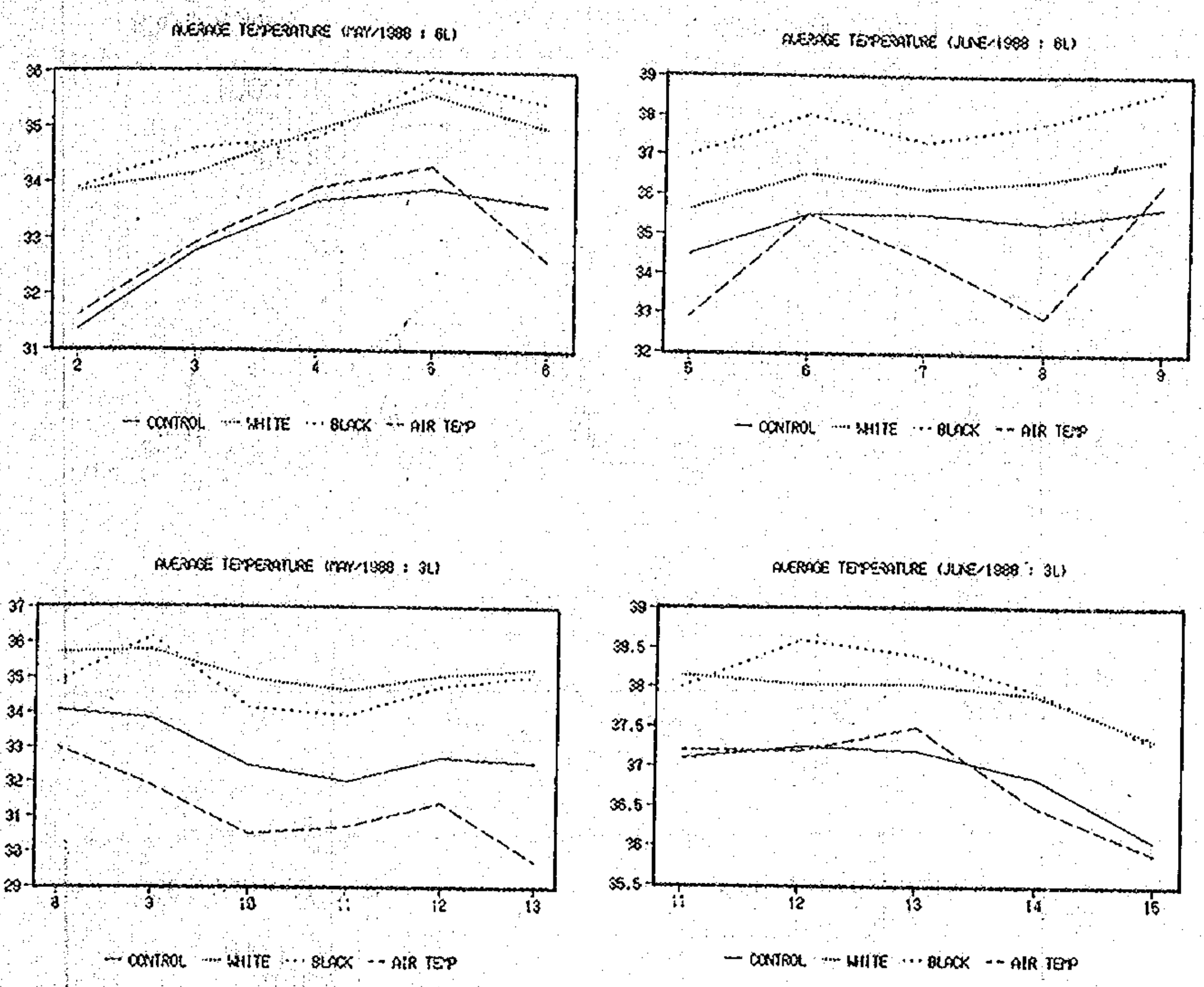
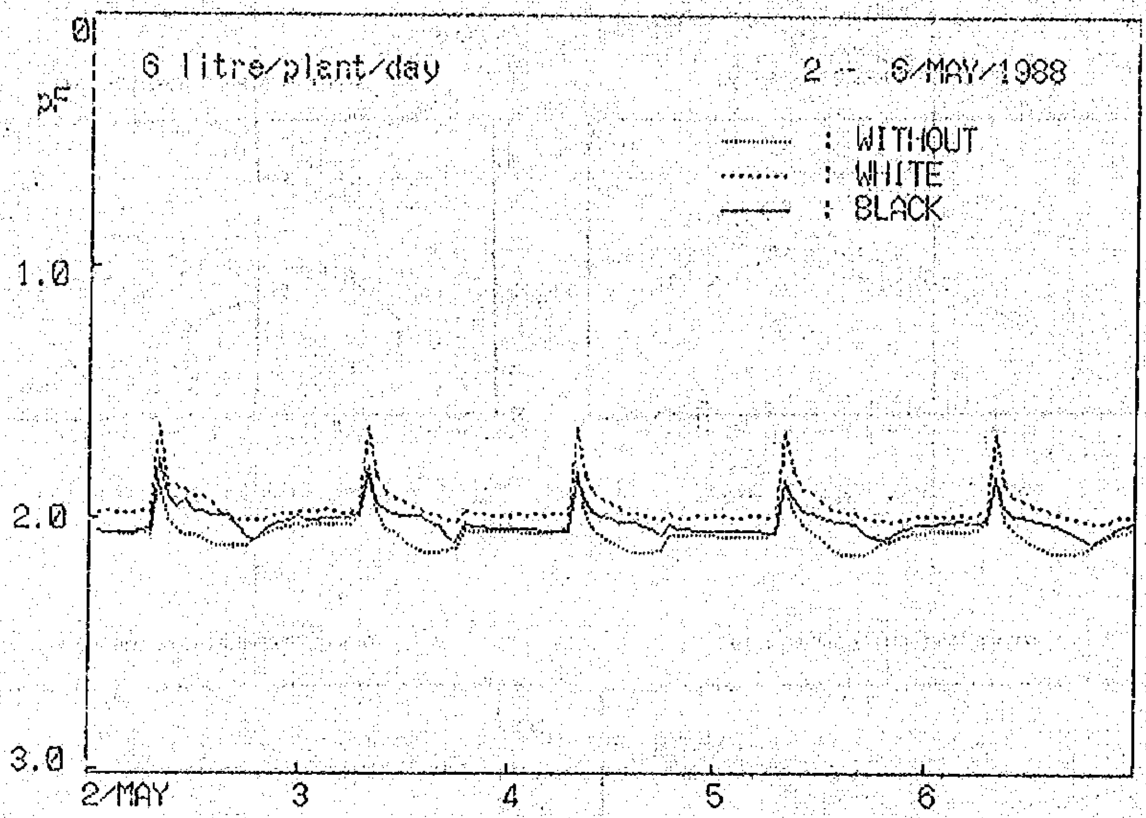


Fig.4 Change in average soil temperature at 10cm depth and average air temperature (Okra 2/ summer)



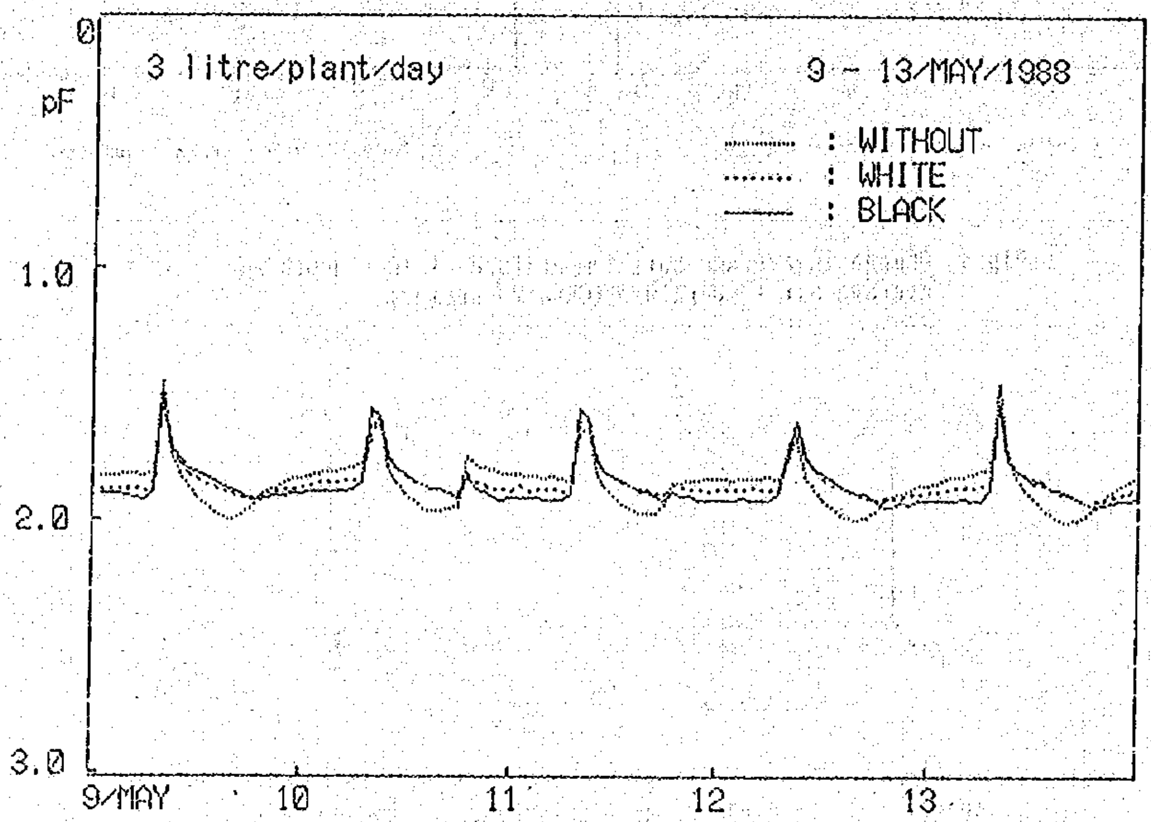
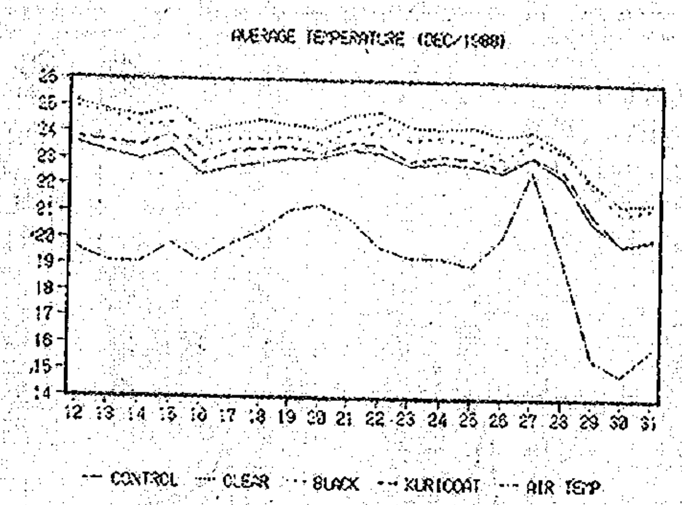


Fig.5 Diurnal change in soil moisture at 10cm depth (Okra 2/ summer)



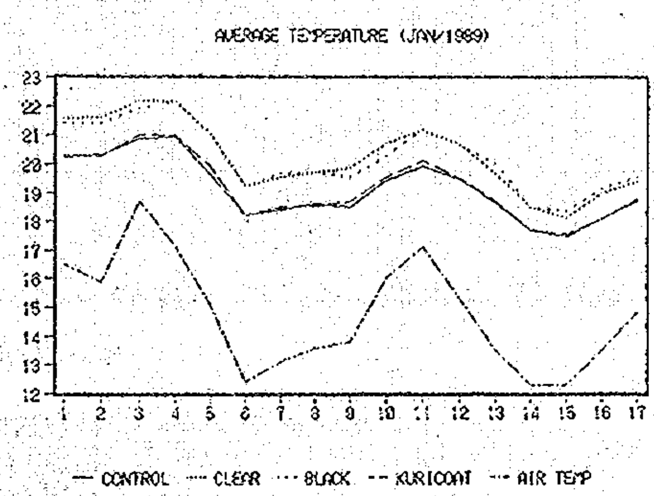


Fig. 6 Change in soil temperarure at 10cm depth and average air temperature (Cauliflower)

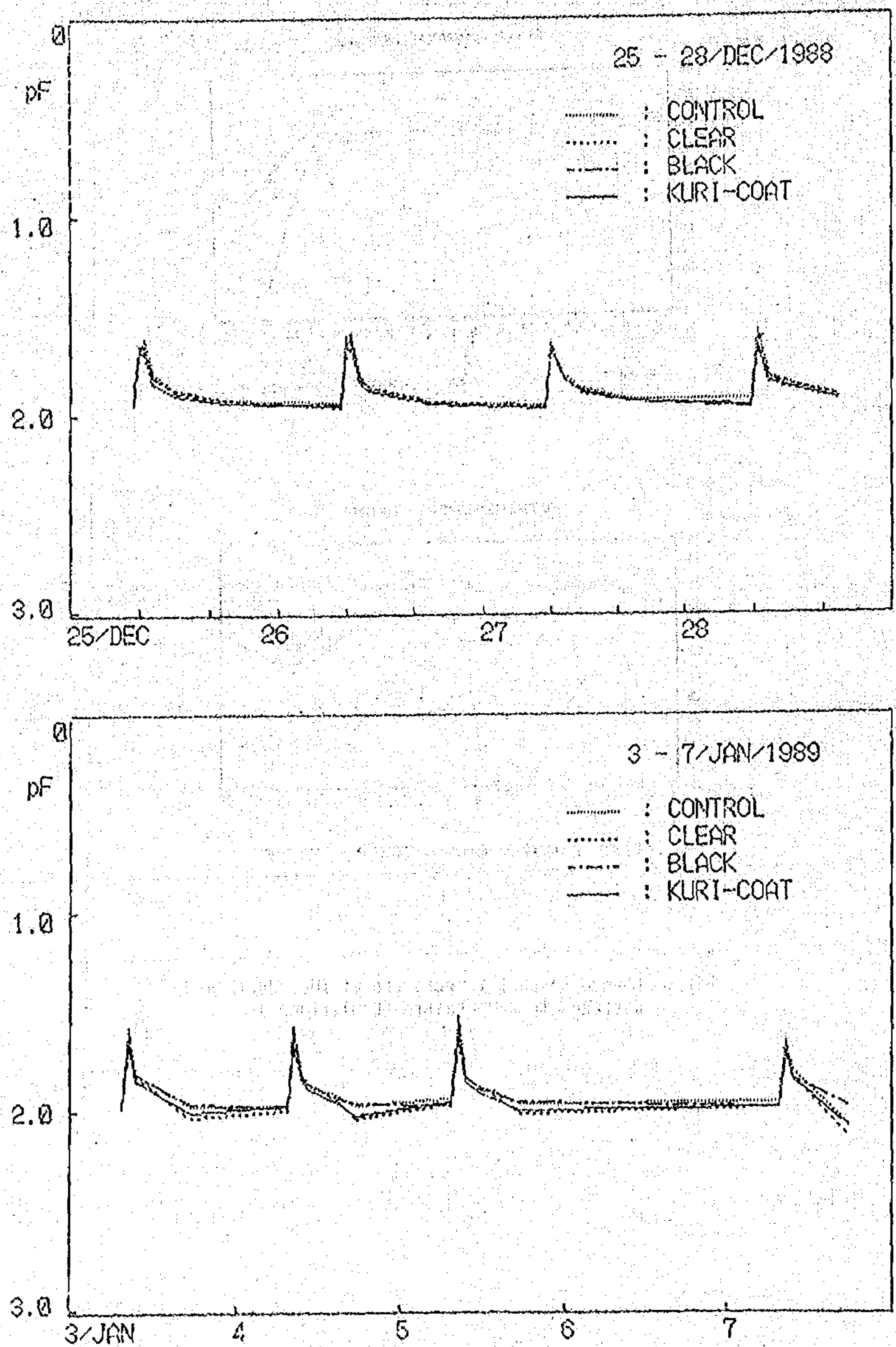


Fig.7 Diurnal change in soil moisture at 10cm depth (Cauliflower)

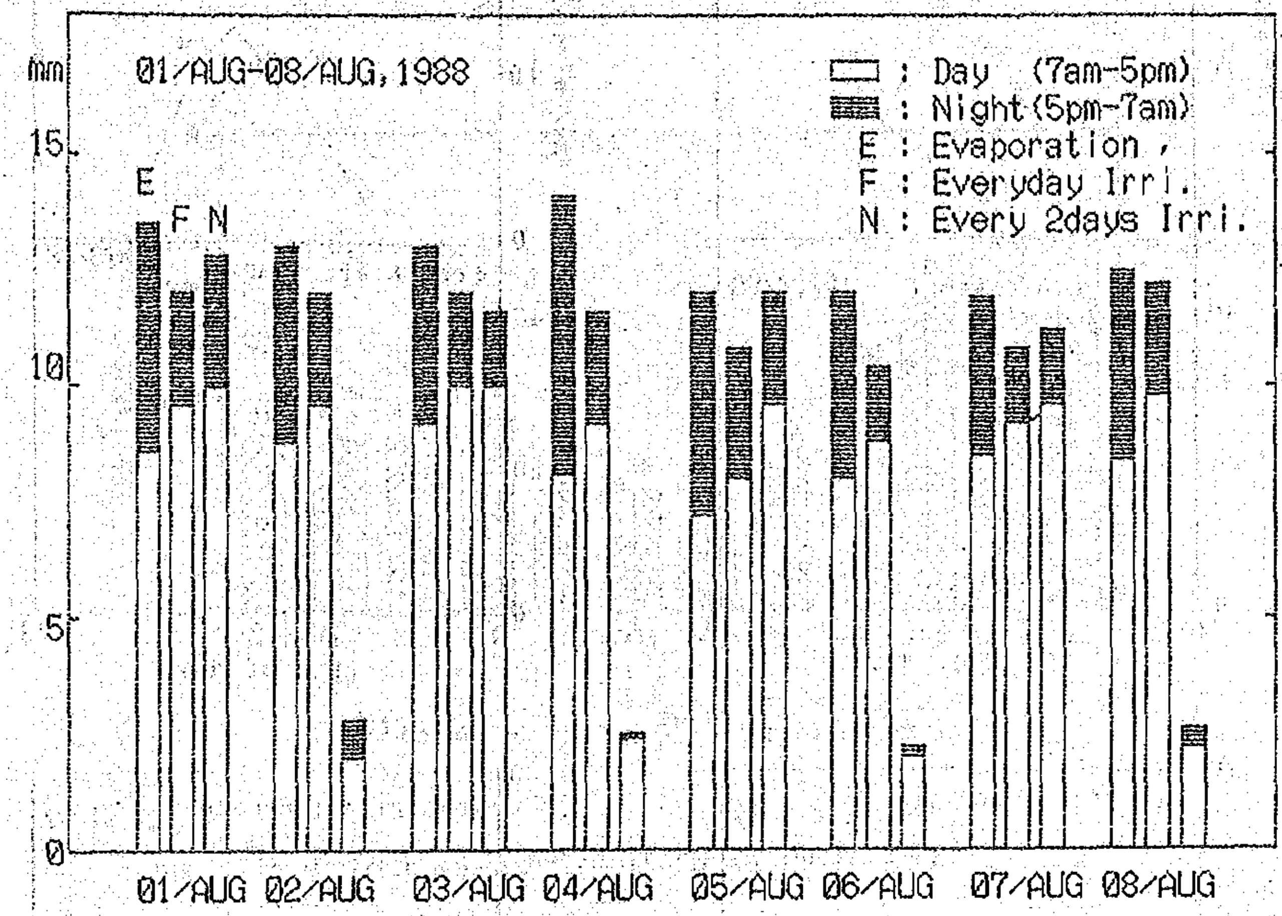


Fig. 8 The evaporation amount from water surface, soil surface with everyday irrigation and soil surface with every two days irrigation

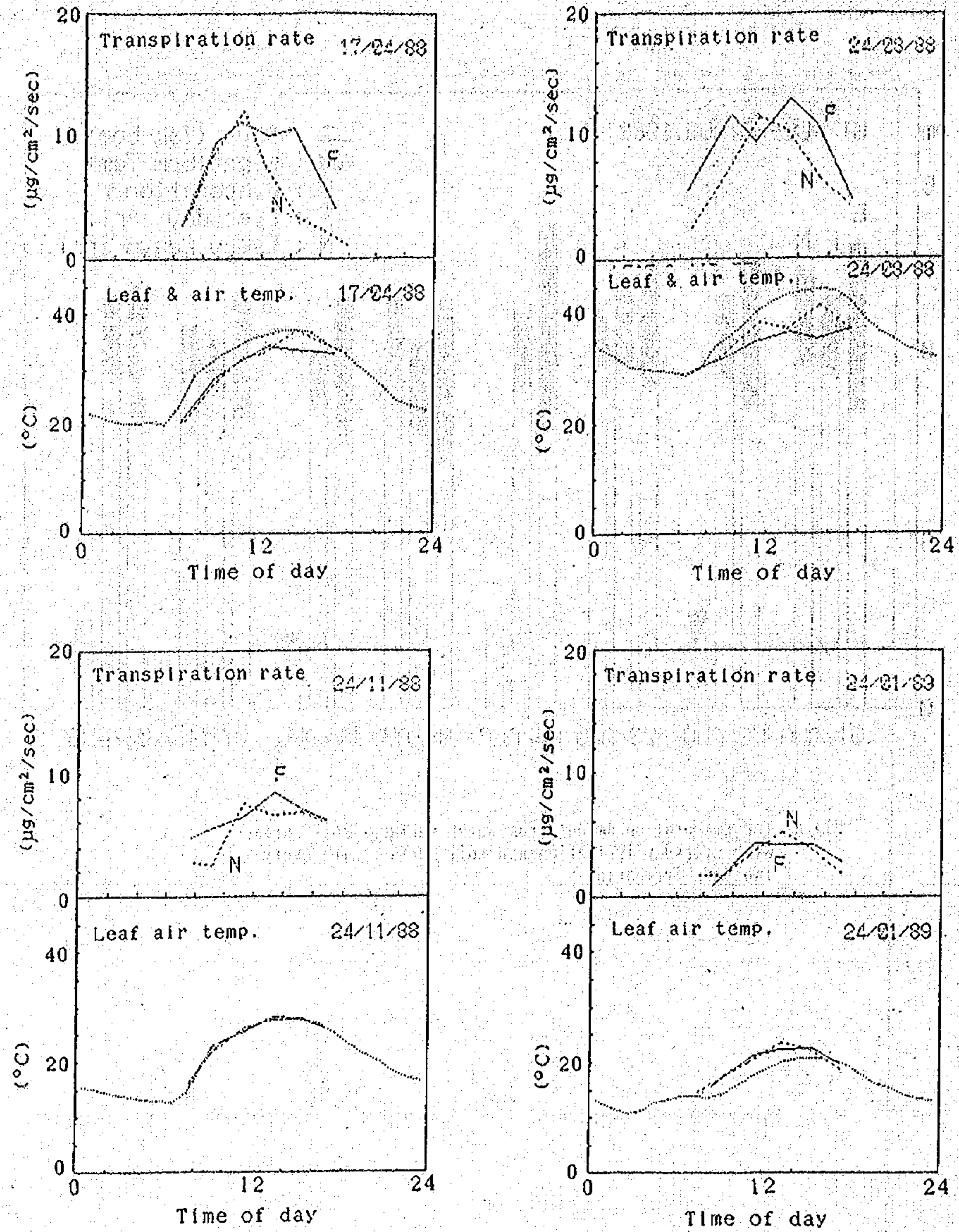


Fig. 9 Diurnal and seasonal trends of transpiration rate, leaf temperature and air temperature.

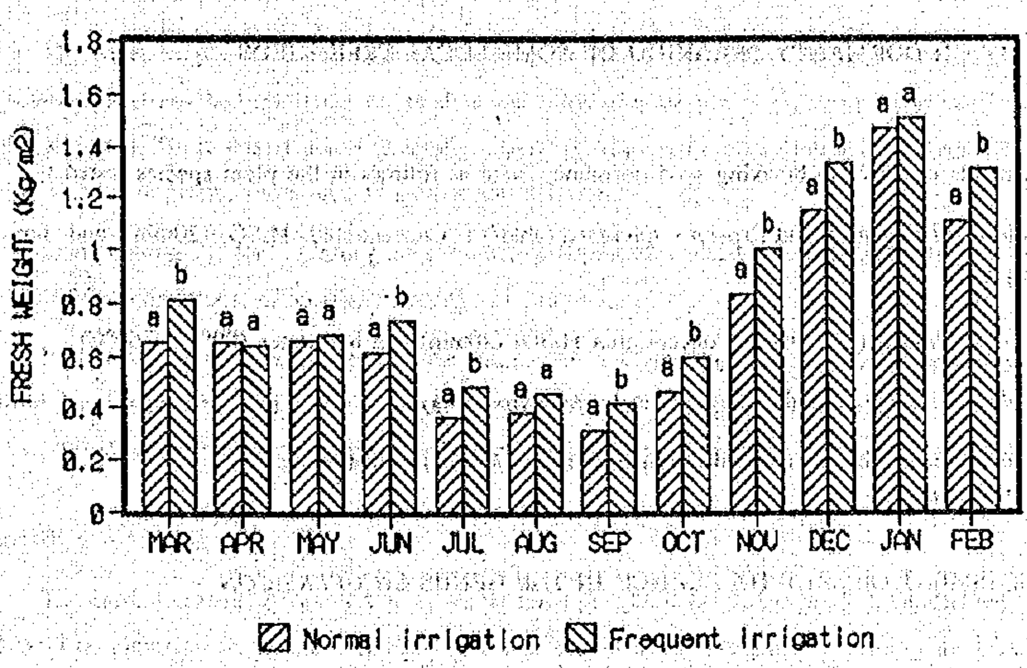


Fig. 10 Forage fresh weight for the normal and the frequent alfalfa.

3. Theme C : STUDIES ON INTRODUCTION AND BREEDING OF WELL-KNOWN DROUGHT-TOLERANT AND SALT-TOLERANT CROPS IN UAE

(1) STUDY ON DORMANCY BREAKING OF SOME LOCAL TREE SEEDS

Treatments effective in breaking seed dormancy were as follows in the plant species tested :

Acacia tortilis (Samar) and *Prosopis spicigera* (ghaff) : Concentrated H_2SO_4 (20min) and hot water (80°C, 10min)

Prospois juliflora (Ghwaif) : Concentrated H_2SO_4 (20min) and hot water (80°C or 60°C)

Zizyphus spina-christ (Sidar) : Soaking in water for 3 days

Acacia arabica (Garaat) : No difference were found among treatments.

(2) ASSESSMENT OF SALT TOLERANCE IN THE GENUS *LYCOPERSICON*

Salinity problem is one of the main obstruction to arid land agriculture. There are two major strategies for this problem. One is improvement of cultural practice including soil reclamation or establishment of drainage system. And another is introducing salt tolerant crops. Since engineering and management costs are high, to develop higher salt tolerant crops has increased tremendously. This study was conducted to establish the procedure of assessment of salt tolerance in the genus *Lycopersicon* and to select the salt tolerant accessions according to the procedure.

1. Preliminary experiment was conducted to establish the procedure of screening test. The procedures are as follows:

   (a) Use 15mS/cm of saline water for 4 weeks after 2 weeks of sweet water irrigation in artificial weather chamber (BIOTRON LH-200-RDCD).

   (b) Transfer survived seedlings of selected accessions to nursery and irrigate with saline water (15mS/cm) for 15 days more, then irrigate with sweet water for 2 or 3 weeks.

   (c) Transplant all surviced plants in the field to extract seeds from the remaining accessions for further studies.

2. Three screening tests were conducted according to the procedure using both commercial and wild accessions. The wild accessions were kindly provided by United States Department of Agriculture (USDA) and University of California. 10 accessions were survived, and transplanted in the field.

(3) INVESTIGATION OF PROPAGATING METHODS OF ADAPTIVE WOODY PLANTS IN ARID LAND

The water supply is one of the most important factors for covering arid land with rich-green. However, we should also stress the importance of breeding and cultivating the plants which are adaptive to the environment of the arid land. These desert plants generally depend on the seed propagation although some of them depend on the vegetative propagation such as cutting and division.

Leafy cutting and leafy grafting are extremely difficult to succeed in rooting and uniting because of severe environmental conditions, especially humidity conditions.

In this experiment, we tried to root the cuttings by covering them with polyethylene film so that we used as little water as possible and investigated the possibility of the rooting by leafy cutting of adaptive woody plants in UAE. We also investigated the application for acclimating process of plantlets after proliferation by tissue culture.

Materials and Method.

The current season shoots of Samar(*Acacia tortilis*), Siddir (*Zizyphus jujuba*), Ghaff(*Prosopis spicigera*) and Wild jasmine(*Clerodendron inerme*) which were grown in the experimental farm of the U.A.E. University were collected for use. The subterminal cuttings which was cut back weakish shoot tip (about 5cm) was inmediately adjusted to 10cm long. The cuttings of Wild jasmine had four leaves and other species were adjusted to cuttings with same amount of leaves in same species because it was difficult to adjust the numbers of leaves and attaching of branches.

The cuttings were immersed in the water for about 3 hours to protect from wilting.

Before inserting the cuttings to the rooting media, the base of cuttings was dipped in Oxyberon (IBA 4000ppm) for 5 seconds or covered with Oxyberon powder (containing 0.4% IBA). Sand and Sand + peatmoss (1:1 v/v) were used as the rooting media. These treatment sections were respectively set up with and without polyethylene film cover. Those sections were given the short name of PC and CONT respectively.

Irrigation was carried out every day to CONT and once a month to PC. The percentage of rooted cuttings, number of root per cutting and total dry weight per section were counted after three months of planting. The light intensity, temperature and relative humidity during planting period were recorded in CONT and PC.

1. Experiment of leafy cutting in March

Twenty five to 41 sub-terminal cuttings were inserted to the rooting media on 21 March and the aspects of rooting were compared with CONT and PC on 20 July.

2. Experiment of leafy cutting in October

On 15 October 1988, 20 sub-terminal cuttings were used for experiment and were counted on 17 January 1989. The aspects of rooting were contrasted to polyethylene film covered cutting (PC) and polyethylene film sealed cutting (PS) except for CONT.

Results

1. Experiment of leafy cutting in March

Changes of the light intensity, temperature and relative humidity in planting period were shown in Fig. 1.

The ratio of light intensity under cheese cloth in contrast to direct sunlight stayed at 6-8% in CONT. In PC, the ratio of light intensity in PC was 0.5-1.0% less than that in CONT as shown in Fig. 1 (upper).

The air temperature at 1.0m high from the ground at noon ranged from 35-47°C except for rainy day. On the other hand, the temperature (on the soil surface) under cheese cloth maintained 25-31°C and the temperature in PC was 6-7°C higher than that in CONT as shown in Fig. 1 (middle).

The relative humidity in PC was kept at a uniform rate about 100% through planting periods but the relative humidity in CONT showed a great differentials between 4:00 AM and 14:00 PM. The differentials came to about 70%/day in the widest range as shown in Fig. 1 (lower).

In CONT, all cuttings of Samar, Siddir and Ghaff died after 30th to 40th day from inserting but a few cuttings of Wild jasmine survived up to 3 months. In PC, both of the survival and root formation of Samar, Siddir and Ghaff were very difficult but the cuttings of Siddir and Ghaff formed a small amount of roots. On the other hand, Wild jasmine obtained rooting percentage of over 90% at all sections.

The effects of rooting media and treatment of Oxyberon on root formation were not significant but yet the highest total dry weight of root was obtained in the cuttings that treated with Oxyberon powder in the sand as shown in Table 1.

2. Experiment of leafy cutting in October

Root formation of four species in PS showed as same tendency as in PC. Percentage of survival of cuttings was higher than those of Siddir, Ghaff and Wild jasmine in March and this cuttings also failed to root in October as shown in table 2.

Conclusion

Leafy cuttings of Samar, Siddir, Ghaff and Wild jasmine were unable to endure the severe changes of humidity between day and night in Al Ain. However, the cuttings in PC and PS could be put a high survival percentage with two times of irrigations during three months.

These apparatus are considered to be useful as a brief system in relation to the propagation of leafy cutting, easy to root, and the acclimation of plantlet by tissue culture in arid land.

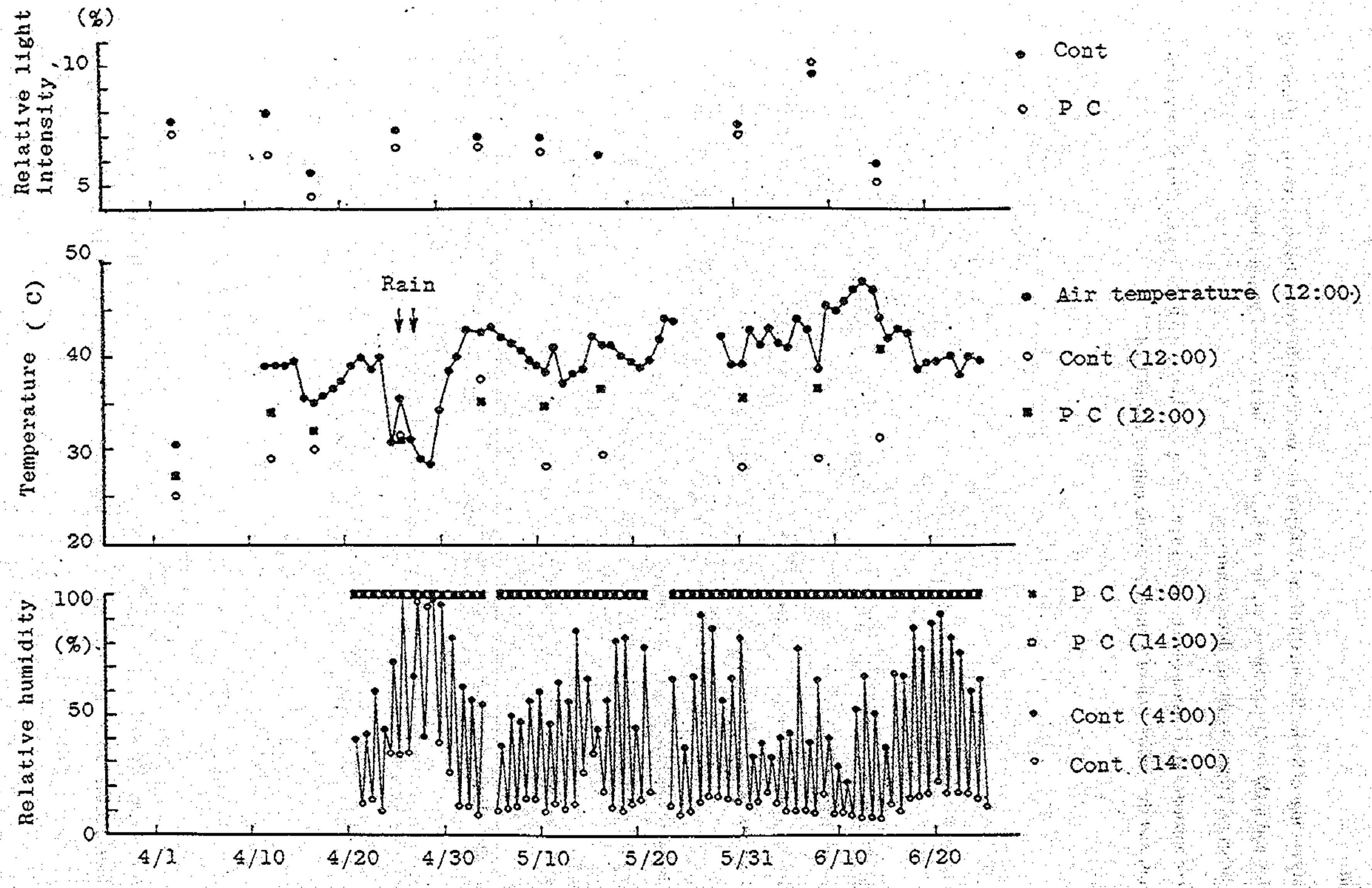


Fig. 1 The seasonal changes of relative light intensity, temperature and relative humidity in polyethylene film covered(P C) or Uncovered(Cont) cutting in March 1988

Table 1 Effeets of the polyetlylene film covered cutting on root formation of the four plants in U.A.E.

	Rooting media	IBA treatmant	species	NO, of cuttings	NO, of survival (%)	% of rooted cutting	NO, of roots per cutting	D.W, of roots per cutting
Control (Cont)	sand	powder	Samar	29	0	0	0	0
			Siddir	25	0	0	0	0
			Ghaff	40	0	0	0	0
			Wild jasmine	27	1 (3.7%)	7.4	12.5	0.01
		4000ppm 5sec. dipping	Samar	31	0	0	0	0
			Siddir	25	0	0	0	0
			Ghaff	41	0	0	0	0
			Wild jasmine	30	0	0	0	0
	sand + peat moss	powder	Samar	30	0	0	0	0
			Siddir	25	0	0	0	0
			Ghaff	34	0	0	0	0
			Wild jasmine	28	0	10.7	4.3	——
		4000ppm 5sec. dipping	Samar	31	0	0	0	0
			Siddir	25	0	0	0	0
			Ghaff	41	0	0	0	0
			Wild jasmine	28	1 (3.6%)	14.3	13.3	0.01
Polyethylene film coverd cutting (PC)	sand	powder	Samar	31	0	0	0	0
			Siddir	27	0	0	0	0
			Ghaff	35	0	0	0	0
			Wild jasmine	35	29 (82.9%)	100	48.1	5.58
		4000ppm 5sec. dipping	Samar	31	0	0	0	0
			Siddir	28	0	0	0	0
			Ghaff	36	0	0	0	0
			Wild jasmine	35	28 (80.0%)	94.3	35.2	3.28
	sand + peat moss	powder	Samar	31	0	0	0	0
			Siddir	27	2 (7.4%)	7.4	14	——
			Ghaff	35	0	22.9	3.6	——
			Wild jasmine	35	35 (100%)	97.1	40.2	2.28
		4000ppm 5sec. dipping	Samar	31	0	0	0	0
			Siddir	28	1 (3.6%)	3.6	4	——
			Ghaff	31	0	0	0	0
			Wild jasmine	35	25 (71.4%)	91.4	40.8	2.05

The Period of propagation was from March 21 to June20, 1988

Table 2 Effeets of the polyetlylene film covered or seald cutting on root formation of the four plants in U.A.E.

	Rooting media	IBA treatmant	species	NO, of cuttings	NO, of survival (%)	% of rooted cutting	NO, of roots per cutting	D,W, of roots per cutting
Polyethylene film coverd cutting (PC)	sand	powder	Samar	20	0	0	0	0
			Siddir	20	9 (45%)	5	15	0.26
			Ghaff	20	1 (5%)	0	0	0
			Wild jasmine	20	20 (100%)	100	49	3.95
		4000ppm 5sec. dipping	Samar	20	0	0	0	0
			Siddir	20	5 (25%)	15	2	0.08
			Ghaff	20	10 (50%)	0	0	0
			Wild jasmine	20	20 (100%)	95	34	2.03
	sand + peat moss	powder	Samar	20	0	0	0	0
			Siddir	20	1 (5%)	0	0	0
			Ghaff	20	2 (10%)	0	0	0
			Wild jasmine	21	19 (100%)	95	14	0.63
		4000ppm 5sec. dipping	Samar	20	0	0	0	0
			Siddir	20	3 (15%)	0	0	0
			Ghaff	20	1 (5%)	0	0	0
			Wild jasmine	20	19 (95%)	85	16	0.51
Polyethylene film seald cutting (PS)	sand	powder	Samar	20	0	0	0	0
			Siddir	20	5 (25%)	25	7	0.16
			Ghaff	20	6 (30%)	0	0	0
			Wild jasmine	20	20 (100%)	100	47	1.36
		4000ppm 5sec. dipping	Samar	20	0	0	0	0
			Siddir	20	0	0	0	0
			Ghaff	20	2 (10%)	0	0	0
			Wild jasmine	20	20 (100%)	100	34	0.61
	sand + peat moss	powder	Samar	20	0	0	0	0
			Siddir	20	3 (15%)	10	4	0.02
			Ghaff	20	1 (5%)	0	0	0
			Wild jasmine	20	19 (95%)	100	21	0.55
		4000ppm 5sec. dipping	Samar	20	0	0	0	0
			Siddir	20	2 (10%)	0	0	0
			Ghaff	20	3 (15%)	0	0	0
			Wild jasmine	20	19 (95%)	95	13	0.34

The Period of propagation was from October 15, 1988 to January 17, 1989

III. METEOROLOGICAL DATA

Monthly meteorological data (1986 to 1988) are summarized as follows (Fig. 1 ~ 5).

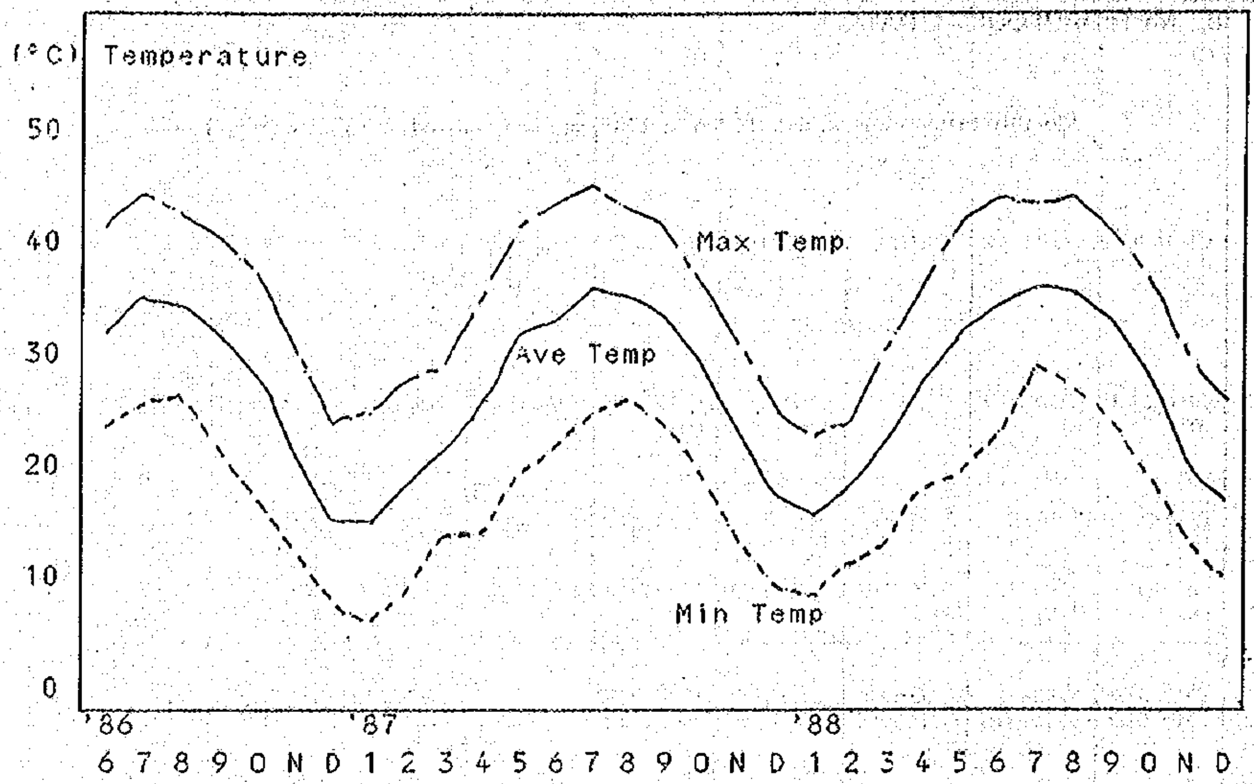


Fig. 1 Change in maximum, average and minimum air temperature.

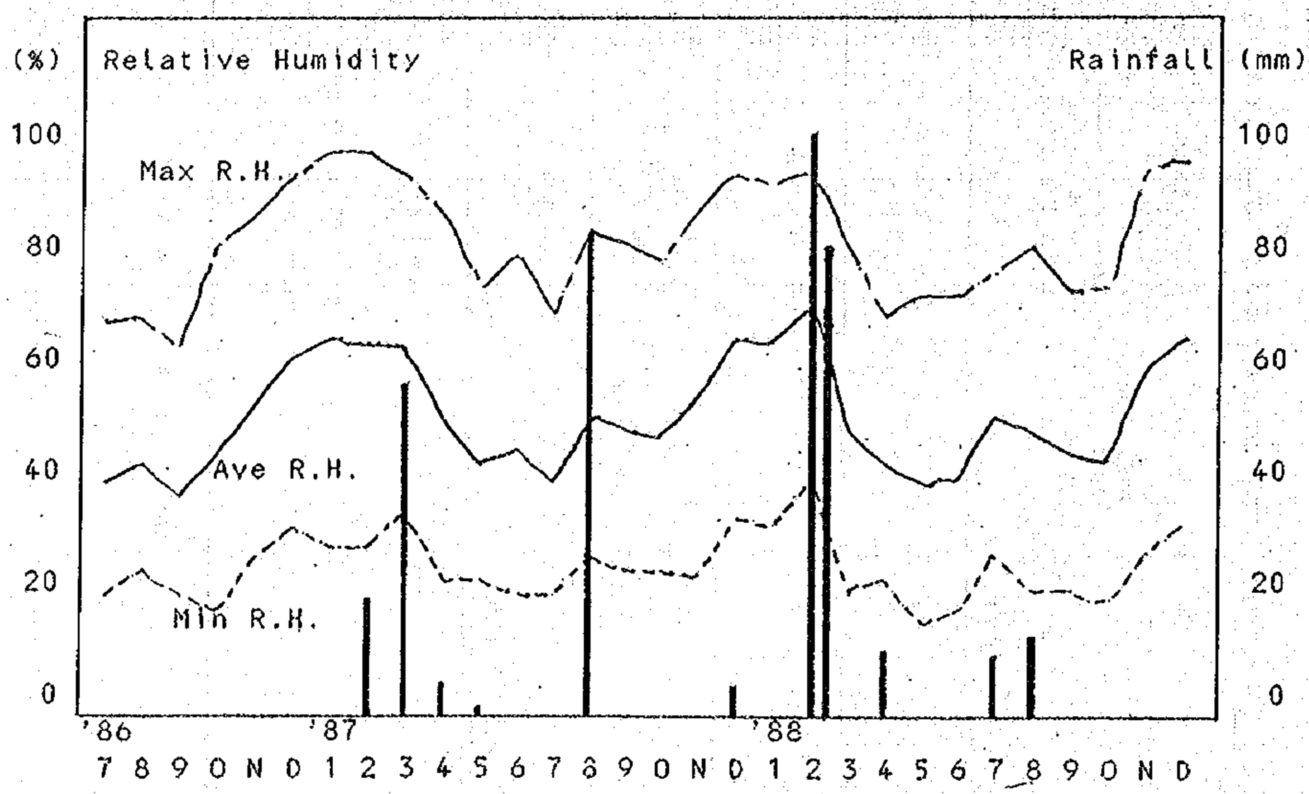


Fig. 2 Change in maximum, average and minimum relative humidity with monthly rainfall data.

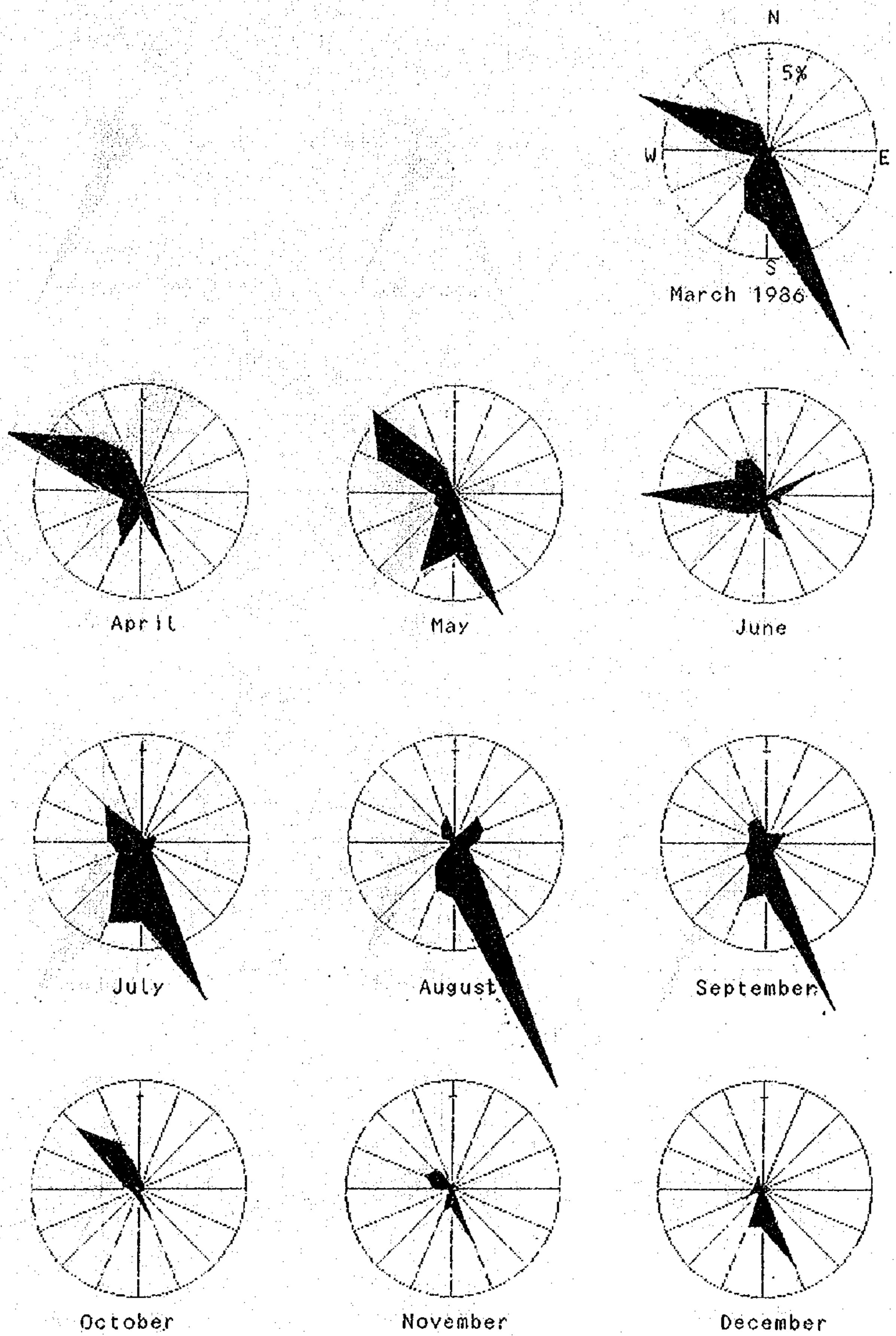


Fig. 3 Wind rose in 1986.

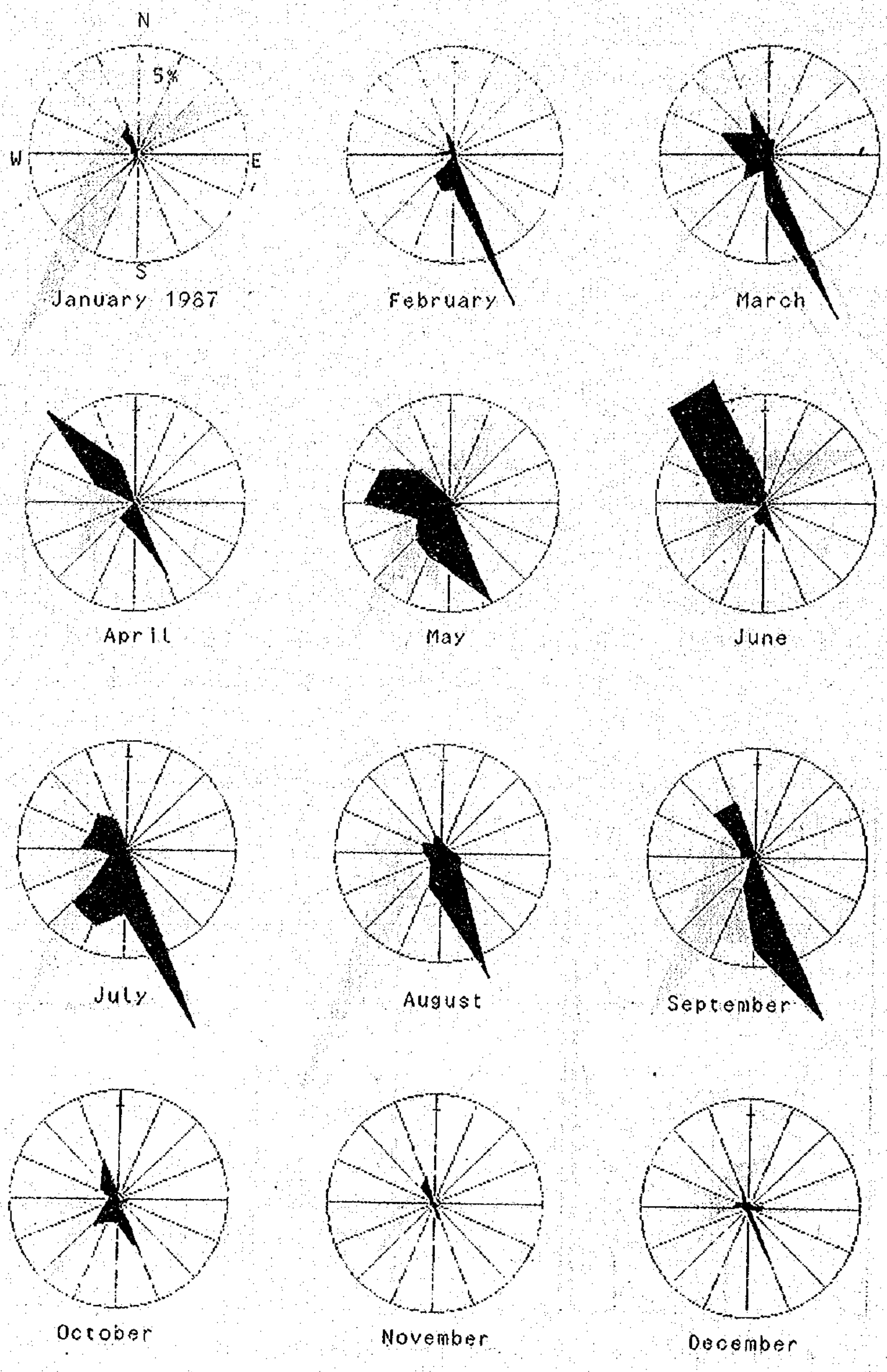


Fig. 4 Wind rose in 1987.

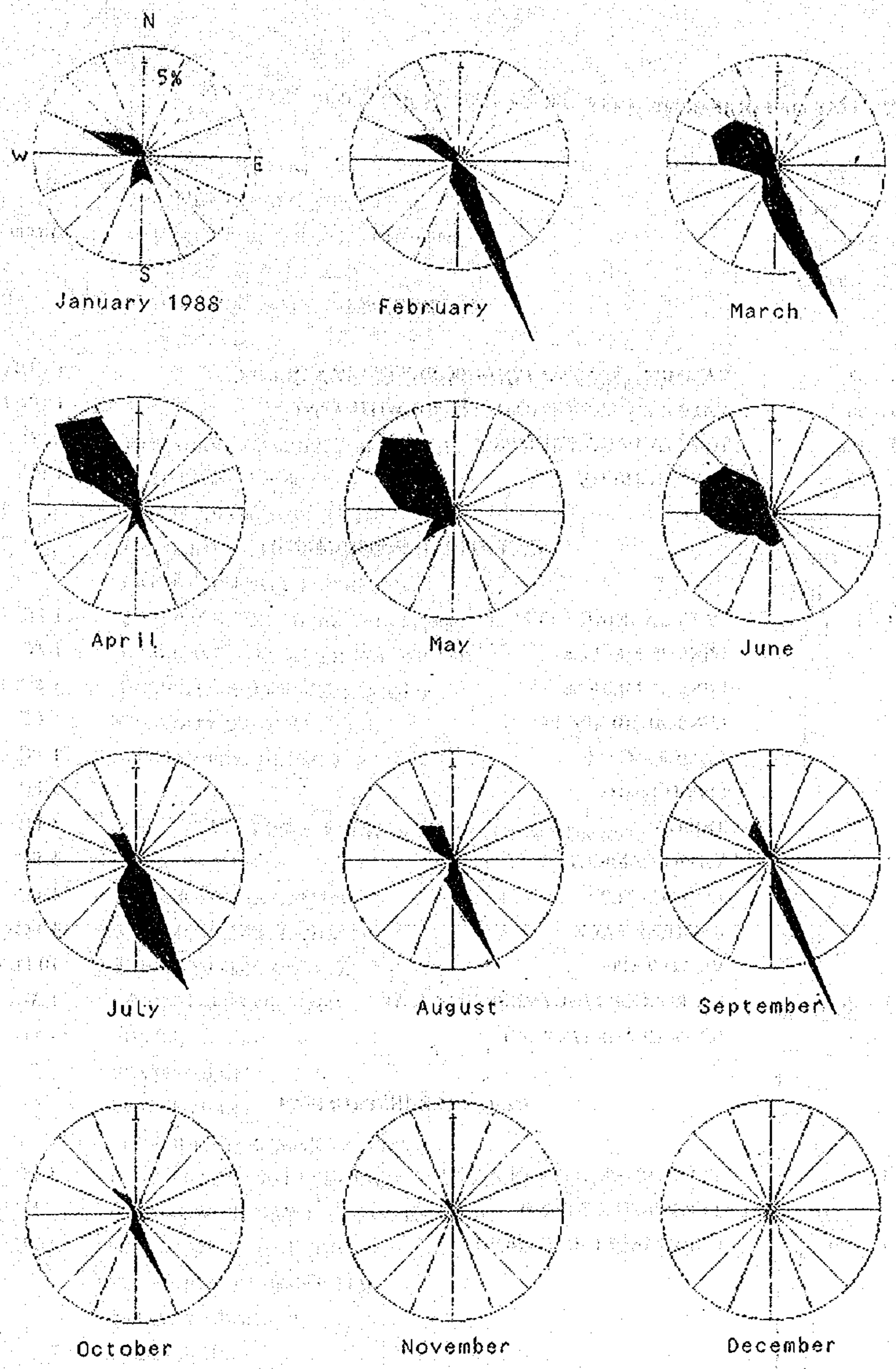


Fig. 5 Wind rose in 1988.

IV. LIST OF EQUIPMENT

No.	Equipment	Amount
	I. VEHICLES	
J - 52	YAMMER TRACTOR (YKA 400 S) WITH PARTS	1 UNIT
J - 56	YAMMER CARRIGE (CAD 120 SH) WITH TENT	1 UNIT
J - 128	TOYOTA LAND CRUISER	1 PC
J - 29	TOYOTA HILUX	1 PC
	II. OPTICAL INSTRUMENT	
J - 1	CAMERA (NIKON FE2)	1 PC
	LENS 35 MM F2.8	1 PC
	LENS 55 MM F2.8	1 PC
	LENS 70-210 MM F4	1 PC
	CAMERA CASE	1 PC
	SPEED LIGHT	1 PC
	TRIPOD	1 PC
J - 2	VIDEO CAMERA	1 PC
	AC ADAPTER	1 PC
	BATTERY PACK	5 PCS
	VIDEO TAPE	10 PCS
J - 40	MICROSCOPE (OLYMPUS VMZ-4SA)	1 SET
J - 76	BINOCULARS (7X50 IF)	1 PC
	III. OFFICE INSTRUMENT	
J - 9	TYPEWRITER (CANON AP200)	1 PC
	TYPEWRITER STAND	1 PC
J - 130	COPY MACHINE (CANON)	1 PC

IV. FIELD EQUIPMENT I (SPRAYER)

J - 28	SPRAYER (HOTTA)	1 SET
J - 61	SPRAYER (SMALL TYPE)	1 PC
J - 85	NOZZLES FOR SPRAYER	3 PCS
J - 88	SPRAYER (MARUYAMA)	1 SET
J - 102	NOZZLE FOR MARUYAMA SPRAYER	5 PCS

V. FIELD EQUIPMENT II (PLANT PHYSIOLOGY)

J - 43	PRESSURE CHAMBER (DIK - 7000)	1 SET
J - 44	COMPRESSOR FOR J - 43	1 SET
J - 97	SUPER POLOMETER (LI-1600)	1 SET
J - 117	LIGHT INTENSITY METER (NS-2)	2 SET
J - 122	LIGHT INTENSITY METER (NS-2)	1 SET
J -146	RAM PACK FOR SUPER PLOMETER	1 PC
	RAM CARD FOR SUPER POLOMETER	5 PCS
J -162	HUMIDITY RECORDER (SS-100P)	1 SET
	HUMIDITY SENSER	3 PCS
J - 10	ASSMAN PSYCHROMETER	1 PC

VI. FIELD EQUIPMENT III (THERMOMETER)

J - 12	THERMOMETER (L-TUBE)	2 SET
J -24	THERMOMETER (L- TUBE)	2 SET
J -26	THERMOMETER (ER-186)	2 SET
	CHART PAPER (ER-186)	12 ROLLS
	SENSER 10 CM	16 PCS
	SENSER 30 CM	6 PCS
	SENSER 50 CM	2 PCS
J - 63	THERMOMETER (MAX AND MIN)	2 PCS
J - 112	DATA COMPUTING RECORDER FOR SOIL TEMPERATURE	1 SET
	IPC 1112 WITH HAND HELD COMPUTER	1 SET
	SENSER WITH 30 M CORD	8 PCS
	STEP DOWN TRANSFORMER	1 PC
	BATTERY CHARGER	1 PC
	SOLAR PANEL	1 PC

VII. FIELD EQUIPMENT IV (SOIL MOISTURE)

J - 106	MEMORY SENSER (MES 801)	1 SET
	BATTERY PACK	1 SET
	AC ADAPTER	1 SET
	SOLAR BATTERY	1 SET
	FITTING BASE	1 SET
	CASE FOR OUT DOOR	1 SET
	CABLE (MES 892)	1 PC
	PROGRAM (FLOPPY DISK)	1 PC
J - 107	SOIL MOISTURE SENSER	8 PCS
J - 108	HAND HELD COMPUTER (HC-20)	1 SET
J - 109	TRANSFORMER (YSA-500)	1 PC
J - 182	MEMORY SENSER (MES 801)	1 SET
	BATTERY PACK (MES 823)	1 SET
	PLUG IN ADAPTER (MES 822)	1 SET
	SOLAR BATTERY (MES 826)	1 SET
	FITTING PLATE (MES 826)	1 SET
	OUTDOOR CASE	1 SET
	SOIL MOISTURE SENSER	6 PCS
	SOIL TEMPERATURE SENSER	2 SET
	MICRO CASSETE TAPE	30 PCS
	ROLL PAPER FOR HC-20	10 PCS
	CASSETTE RIBON FOR HC-20	5 PCS
	CABLE	1 PC

VII. FIELD EQUIPMENT IV (SOIL MOISTURE)

J - 14	TENSIOMETER (DIK-3006)		1 SET
J - 34	TENSIOMETER (DIK-3006)		3 SET
J - 35	TENSIOMETER (DIK-3100)		20 PCS
J - 77	TENSIOMETER SENSOR		3 PCS
J - 123	TENSIOMETER (DIK-3120)		12 PCS
J - 133	TENSIOMETER (DIK-3100)	50 CM	8 PCS
J - 134	TENSIOMETER (DIK-3100)	100 CM	8 PSC
J-174	TENSIOMETER (DIK-3100)	10CM	20 PCS
		30 CM	50 PCS
		50 CM	20 PCS
		100 CM	10 PCS
J - 175	CABLE FOR TENSIOMETER (DIK-3006)		10 PCS
J -187	SENSER FOR TENSIOMETER (DIK-3006)	10CM	8 PCS
J - 188		30CM	8 PCS
		50CM	8 PCS
J - 189	ARRESTER (MA-200) FOR TENSIOMETER (DIK-3006)		5 PCS

VIII. FIELD EQUIPMENT V (GEOGRAPHICAL SURVEY)

J - 4	PLASTIC PILE	100 PCS
J - 5	AUTO LEVEL (TOPCON AT-F2) WITH TRIPOD	1 SET
J - 6	ALIMINUM STAFF	3 PCS
J - 7	ESLON PLE	10 PCS
J - 8	MEASURING TAPE	1 PC
J - 11	COMPASS (S-27)	1 PC
J - 19	STEEL MEASURE	150 PCS
J - 60	LARGE MALLET	2 PCS
J - 64	INCREMENT BORES	1 PC
J - 65	MEASURING TAPE	2 PCS
J - 75	STAINLESS SCALE (1M LENGTH)	100 PCS
J - 152	MEASURING POLE	1 PC

IX. FIELD EQUIPMENT VI (SOIL SURVEY)

J - 16	BORING SHOVEL (DIK-1670)	1 SET)
J - 17	SOIL SAMPLING BOTTLE	10 SET
J - 18	SOIL SAMPLER (DIK-1800)	1 SET
J - 46	BORING STICK (DIK-1640)	1 SET
J - 47	POST HOLE AUGER (DIK-1700)	1 SET
J - 67	CYLINDRICAL SAMPLER	1 PC
J - 68	CYLINDER FOR GATERING SOIL	12 PCS
J - 69	CARRIAGE FOR J-68	2 PCS
J - 70	DRILL LOD FOR HAND AUGER	2 PCS
J - 137	SOIL PENETRATION TESTER (H-100)	1 SET

X. FIELD EQUIPMENT VII (WIND SURVEY)

J - 3	ANEMOMETER	2 SET
J - 21	ANEMOETER	6 SET
J - 104	ANEMOMETER (KC101)	2 SET
J - 111	ANEMOMETER (MX865)	1 PC
	WIND VANE SENSER	1 PC
	CAB LE (L7S-100)	1 SET
	CABLE (L4S-100)	5 PCS
	STAND	5 PAIRS
	ANEMOGRAPH SENSER	5 PCS
J - 150	AMPLIFER FOR MX865	2 PCS
	CABLE FOR MX865	2 PCS
J - 173	ANEMOMETER (MX865)	1 PC
	WIND SENSER (VF216)	1 PC
	WIND SENSER (AF860)	5 PCS
	EXTENSION CABLE	1 PC
	EXTENSION CABLE	5 PCS
	POLE FOR SENSER	5 PCS

XI. FIELD EQUIPMENT VIII (SAND CATCH SYSTEM)

J - 23	SAND CATCH SYSTEM	1 SET
J - 62	METAL BOX FOR SHIFTING SAND	50 PCS
J - 90	STOPPER FOR SAND CATCH SYSTEM	75 PCS
J - 92	SAND CATCH APPARATUS	24 SET
J - 93	SPARE BAG FOR SAND CATCH SYSTEM	100 PCS
J - 127	SAND CATCH SYSTEM	10 SET
J - 131	SAND CATCH SYSTEM WITH MESH	32 SET
J - 151	SAND CATCH SYSTEM WITH POLE AND BAG	20 SET

XII. FIELD EQUIPMENT IX (UNDER GROUND WATER SURVEY)

J - 25	AUTOMATIC WATER LEVEL METER (NR-110)	1 SET
J - 115	EARTH RESISTANCE TESTER (3244 00)	1 SET
J - 145	PORTABLE WATER LEVEL METER	1 PC
J - 149	WIRE FOR WATER LEVEL METER	1 PC
	PULLY FOR WATER LEVEL METER	1 PC
J - 159	WATER LEVEL METER 50 M	1 PC
J - 160	WATER LEVEL METER 100 M	1 PC
J -197	SENSER FOR WATER LEVEL METER (NR-110) WITH 45 M CORD	1 SET

XIII. LABORATORY EQUIPMENT I (SOIL PHYSICS)

J - 20	THREE PHASE METER (DIK-1100)		1 SET
J - 41	CENTRIFUGE (H-65S)		1 SET
J - 45	pF METER (DIK-3320)		1 SET
J - 48	SOIL SHAKER (DIK-2100)		1 SET
J - 51	DRYING OVEN (DS-44)		1 SET
J - 59	PERMABILITY METER (DIK-40000		1 SET
J - 91	EVAPORATION BOTTLE		50 PCS
J - 202	SHAKER FOR SIEVE WITH 150mm ADAPTER AND TRANSFORMER		1 SET
J - 203	SIEVE	45 MICRON	1 PC
		63 MICRON	1 PC
		75 MICRON	1 PC
		150 MICRON	1 PC
		300 MICRON	1 PC
		500 MICRON	1 PC
	CUP AND PLATE FOR SIEVE		1 SET

XIV. LABORATORY EQUIPMENT II (METEOROLOGY)

J - 36	IPC SYSTEM	1 SET
	COMPUTER SYSTEM (PC-8801)	1 SET
	ANEMOETER (S-SA1)	1 SET
	AIR TEMPERATURE (S-PT)	1 SET
	SOIL TEMPERATURE (S-PT)	3 SET
	DEW POINT (S-DW-1)	1 SET
	SOLAR RADIATION (S-SR-1)	1 SET
	LEAF WETNESS (S-DW-C)	1 SET
	EVAPORATION (S-EV)	1 SET
	CORD (100M0	1 SET
	POLE (PM-6)	1 SET
	INSTRUMENT SHELTER (IUS-2)	1 SET
	BATTERY POWER SUPPLY	1 SET
	OBSERVATION HOUSE	1 SET
J - 183	IPC COLOR DISPLAY (PC-KD854)	1 SET
J - 125	RAIN GAUGE	1 PC

J - 126	RECORDER FOR J - 125'	1 SET
J - 153	CARTRIDGE PEN FOR RAIN GAUGE	10 PCS
J - 189	ARRESTER FOR IPC SYSTEM	1 SET
	SK- 1 FOR POWER SOURCE	1PC
	SK- 2 FOR SENSER	1PC
	POLE 3 M	3PCS

XV. LABORATORY EQUIPMENT III (COMPUTER SYSTEM)

J - 37	PERSONAL COMPUTER SYSTEM (PC8001)	1 SET
	COLOR DISPLAY	1 SET
	PRINTER	1 SET
	REGURATOR	1 SET
	MANUAL	1 SET
J - 144	PERSONAL COMPUTER SYSTEM (PC9801 VM)	1 SET
	COLOR DISPLAY (KD-853)	1 SET
	PRINTER (PC-PR201 H2)	1 SET
	REGURATOR (SVC-1010-A)	1 SET
	MANUAL	1 SET
J - 196	BACK-UP POWER SUPPLY (BU502)	1 SET
J - 147	SOFTWARE LIBRARY (MS-DOS)	1 SET
J - 158	SOFTWARE STATISTICS	1 SET
J - 164	SOFTWARE FORTRAN 77	1 SET
	SOFTWARE PLINK 86	1 SET
	SOFTWARE COREGRAPH	1 SET
J - 165	RAN BOARD FOR PC 9801VM	1PC
J - 184	DATA PROCESSOR	1PC

XVI. LABORATORY EQUIPMENT IV (LAND SAT DATA)

J - 142	NEGATIVE FILM FOR LAND SAT NO. 1, 2, 3	4 PCS
	POSITIVE FILM FOR LAND SAT NO. 1, 2, 3	1 PC
	MAGNETIC TAPE FOR LAND SAT NO. 1, 2, 3	1 PC
	NEGATIVE FILM FOR LAND SAT NO. 4, 5	4 PCS
	POSITIVE FILM FOR LAND SAT NO. 4, 5	1 PC
	MAGNETIC TAPE FOR LAND SAT NO. 4, 5	1 PC

XVII. LABORATORY EQUIPMENT V (TISSUE CULTURE)

J - 38	CLEAN BENCH (HITACHI)	1 SET
J -3 9	AUTO CLAVE (RKI KT-23)	1 SET
J - 42	REFRIGERATOR (HITACHI)	1 SET
J - 120	CLEAN BENCH (HITACHI)	1 SET
J - 121	NK SYSTEM BIOTRON	1 SET

XVIII. LABORATORY EQUIPMENT VI (CHEMICAL ANALYSIS)

J - 27	SPECTROPHOTOMETER (UV-120)	1 SET
	GLASS CELL	4 PCS
	TUNGSTEN LAMP	4 PCS
	FUSE	5 PCS
J - 50	HANDY ASPIRATER (WP-25)	2 SET
J - 49	AUTO STILL (WS-22)	1 SET
J - 71	FUNNEL FOR ABSORPTION	10 PCS
	GLASS BOTTLE FOR ABSORPTION	10 PCS
J - 96	MUFFLE FURNACE (OPM-40)	1 SET
J - 101	CRASHER (SK-M-10)	1 SET
J - 113	ATOMIC ABSORPTION AND SPECTROPHOTOMETER (HITACHI 170-30)	1 SET
	COMPRESSOR (SC-72)	1 SET
	HOLLOW CATHODE LAMP	3 PCS
	REGULATOR (ATC 1.5 K)	1 PC
	RECORDER (561-1004)	1 PC
J - 114	KIJELDHAL DIJESTORS	1 SET
J - 124	FLAME PHOTOMETER (FP-33D)	1 SET

J - 135	KIJELDHAL DIJESTORS	2 SET
J - 116	OVEN (WFO 1000D)	1 PC
J - 13	CONDUCTIVITY METER (CM-117)	1 PC
J - 57	pH METER (HORIBA M-8)	1 SET
J - 138	pH METER (NPH-30)	2 SET
J - 139	EC METER (U-7 COND.)	2 SET

XIX. LABORATORY EQUIPMENT V (BALANCE)

J - 58	BALANCE (METTLER PE3600)	1 PC
J - 78	BALANCE (EK-1200 A)	1 SET
J - 95	BALANCE (AE 166)	1 SET
J - 98	BALANCE (FA2000)	1 SET
J - 99	SHIELD FOR J-98	1 PC
J - 100	WEIGHT (AD-1600-2K) FOR J-90	1 PC
J - 136	BALANCE (DP-6000) WITH TRANSFORMER	1 SET

XX. LABORATORY EQUIPMENT VI (AREA METER)

J - 15	LEAF PUNCHER (NO. 162)	1 PC
J - 94	LEAF PUNCHER	1 PC
J - 110	AREA METER (AAM-8) BROKEN	1 SET
J - 186	AREA METER (AAM-8)	1 SET

XXI. NURSERY MATERIALS

J - 83	SEEDLING REAR POT	30 PCS
J - 118	JIFFY POT (NO. 517)	5 BOXES
J - 119	PLASTIC TRAY	100 PCS
J - 166	PLASTIC TRAY	50 PCS
J - 168	LABEL 15X1.9 CM	1000 PCS
	LABEL 10X5.4 CM	1000 PCS
J - 169	POLY POT	2000 PCS
	PAPER POT	1 BOX
J - 176	WAGNER POT	50 PCS
J - 140	CHAIN SAW (E-346-14)	1 SET
J - 141	BIRD NET	12 PCS

XXII. CHEMICAL EMULSION AND POWDER

J - 53	ASPHALT EMULSION	5 PACKS
J - 73	ASPHALT EMULSION	25 DRUMS
J - 179	ASPHALT EMULSION	2000 LITTER
J - 54	SYNTHETIC RESIN EMULSION (KURICOAT)	6 PACSK
J - 74	SYNTHETIC RESIN EMULSION (KURICOAT)	78 CANS
J - 180	SYNTHETIC RESIN EMULSION (KURICOAT)	1008 KG
J - 87	SYNTHETIC RESIN POWDER (G-20)	30 KG
J - 180	SYNTHETIC RESIN POWDER (G-20)	50 KG
J - 87	SOFT CERAMICS (FG-3)	60 KG
J - 178	SOFT CERAMICS (FG-3)15KG/PC	14 PCS

XXIII. OTHERS

J - 29	INSECTICIDE AND PESTICIDE	120 PCS
J - 84	INSECTICIDE (ORTHORAN)	50 BAGS
J - 30	FERTILIZER (14:14:14)	30 PCS
J - 31	COMPOST (BARK 20KG/BAG)	10 BAGS
J - 55	COMPOST (BARK 20KG/PACK)	500 PACKS
J - 181	COMPOST (BARK 20KG/BAG)	200 BAGS
J - 33	IRRIGATION TUBE (EVAFLOW)	10 PCS
J - 172	IRRIGATION TUBE (EVAFLOW)	2 PCS
J - 163	INDOLE BUTYLIC ACID EMULSION (OXYBELON)	10 PCS
	INDOLE BUTYLIC ACID POWDER (OXYBELON)	2 BOXES
	HYPONEX	10 PCS

XXIV. BOOKS

J - 72	BOOKS	10 VOLS
J - 89	BOOKS	1 LOT
J - 105	BOOKS	2 VOLS
J - 143	BOOKS	1 LOT
J 158	BOOK	1 PC
J - 161	BOOKS	5 VOLS
J - 171	BOOKS	25 VOLS

V. DISPATCH OF EXPERTS

Experts mentioned below were dispatched by JICA to conduct the Joint Study Project in the period of 1985 to 1988.

Short-term Experts

Name	Speciality	Duration of Dispatch
Dr.Keiichiro Matsuda	Team Leader	(1) 12-29 Sep. 1985
	Soil Science and	(2) 15-28 Dec. 1985
	Plant Nutrition	(3) 2-20 Sep. 1986
		(4) 17-30 Nov. 1986
		(5) 3-16 Apr. 1987
		(6) 17-31 Dec. 1987
		(7) 16-30 Sep. 1988
		(8) 16-31 Dec. 1988
Dr.Hiroshi Murai	Forest Hydrology	(1) 12-29 Sep. 1985
		(2) 15-26 Jun. 1986
		(3) 2-20 Sep. 1986
		(4) 18-31 Dec. 1986
		(5) 3-16 Apr. 1987
		(6) 17-31 Dec. 1987
		(7) 16-26 Sep. 1988
Dr.Mamoru Nagai	Crop Science	(1) 12-29 Sep. 1985
		(2) 15-28 Dec. 1985
Mr.Yasuo Yuasa	Silviculture	(1) 15-28 Sep. 1985

Dr.Hitoshi Sawada	Crop Science	(1) 2-20 Sep. 1986
		(2) 22 Jun.-5 Jul. 1987
		(3) 15-26 Mar. 1988
Dr.Atsushi Ooishi	Horticultural Plant Propagation	(1) 15-26 Mar. 1988
Dr.Yoshitaka Kakubari	Silviculture	(1) 10-21 Apr. 1988
Mr.Satoru Tsuchiya	Forest Hydrology	(1) 10-21 Apr. 1988

Long-term Experts

Mr.Hiromi Yokota	Plant Nutrition	20 Aug. 1985-19 Aug. 1987
Mr.Akira Koto	Soil Science and Soil Conservation	20 Aug. 1985-7 Apr. 1989
Mr.Shinji Yoshizaki	Silviculture	11 Apr. 1987-9 Apr. 1989
Mr.Hiroyasu Onuma	Plant Nutrition	1 Aug. 1987-5 Apr. 1989

VI. OBSERVATION AND RESEARCH WORKS BY COUNTERPARTS

Counterparts mentioned below were invited to Japan for observation and research works on the arid land agriculture in the period of 1986 to 1989.

Name	Period of visit/Institutions visited
Dr.Abdur-Rhaman Saghir	14 Jan.1987-27 Jun. 1987
	JICA Headquarters (TOKYO)
	Shizuoka University (SHIZUOKA)
	Kyoto University (KYOTO)
	Tokyo University (TOKYO)
	Ministry of Agriculture (TSUKUBA)
	-Tropical Agriculture Research Center
	-National Institute of Agro-Environmental Sciences
	-National Institute of Agrobiological Resources
Dr.Mahmoud A. Al Afifi	28 Oct. 1986-8 Nov. 1986
	JICA Headquarters (TOKYO)
	Shizuoka University (SHIZUOKA)
	Tottori University (TOTTORI)
	Tsukuba University (TSUKUBA)
	Ministry of Agriculture (TSUKUBA)
	-Tropical Agriculture Research Center
	-National Institute of Agro-Environmental Sciences
	-National Institute of Agrobiological

Resources

Mr.Suhayl A. Itani	24 May 1987-21 Aug. 1987 JICA Headquarters (TOKYO) Shizuoka University (SHIZUOKA) Kyoto University (KYOTO) Tokyo University (TOKYO) Tottori University (TOTTORI) Ministry of Agriculture (TSUKUBA) -Tropical Agriculture Research Center -National Institute of Agro-Environmental Sciences -National Institute of Agrobiological Resources -Forestry and Forest Products Research Institute
Dr.A. Almasoum	1 Jul. 1988-28 Jul. 1988 JICA Headquarters (TOKYO) International Meeting on Remote Sensing (KYOTO) Shizuoka University (SHIZUOKA) Tottori University (TOTTORI) Tsukuba University (TSUKUBA) Ministry of Agriculture (TSUKUBA) -Tropical Agriculture Research Center -National Institute of Agrobiological Resouces -Forestry and Forest Products Research Institute

Dr.A.S. Ibrahim

JICA Headquarters (TOKYO)

Shizuoka University (SHIZUOKA)

Tottori University (TOTTORI)

Ministry of Agriculture (TSUKUBA)

-Tropical Agriculture Research Center

-National Institute of Agrobiological Resouces

-Forestry and Forest Products Research Institute

Dr.I. Haffar

JICA Headquarters (TOKYO)

Shizuoka University (SHIZUOKA)

Tottori University (TOTTORI)

Ministry of Agriculture (TSUKUBA)

-Tropical Agriculture Research Center

-National Institute of Agrobiological Resouces

-Forestry and Forest Products Research Institute

VII. ACKNOWLEDGEMENT

The Joint Study Project Team between UAE University and Shizuoka University is indebted to His Hiness Shaikh Nahyan bin Mubarak Al Nahyan, President of UAE University and Dr. Abdul-Hafez M. Elkordy, Acting Vice Chancellor of UAE University, and staff members of the Faculty of Agricultural Sciences, UAE University during implementation of the Project.

We wish to express our appreciation to staff members of Al Ain Agriculture Department, Al Ain Forestry Department, and Central Laboratory of Ministry of Agriculture and Fisheries for their kind arrangements during our studies.

We also would like to appreciate staff members of the Embassy of Japan in Abu Dhabi, Japan International Cooperation Agency (JICA) and the Faculty of Agriculture, Shizuoka University for their counsel and advice during the implementation of the Project.

JICA