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FINAL REPORT

Submitted to the Office of the Science Advisor
US. Agency for International Development

FERTILIZATION AND SALINE WATER IRRIGATION
PHASE II

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Project Number: C11-131
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AID Grant Project Officer: Dr. David Molenex
Science Attache Embassy, Tel-Aviv

Project Duration: August 1991 to January 1997

January 1997

Executive Summary

This executive summary places project accomplishments in the overall content of international cooperation. . The first part includes statistical information on the impact of the project as a seed money to attract financial support from other resources. The second part includes data on the resulting international cooperation that the project yielded. and the transfer of knowledge acquired. . The third part is a short report on the scientific skill and awareness that were developed throughout this project and will remain in Israel and the Philippines as a result of the project.

1. **Financial support for the project was given by** :

Source	Fund (USD)
AID/CDR	150,000
Israeli resources	100,000
European community	100,000
Philippines	50,000
Total	400,000

2. International Collaboration and list of participants:

Visits

The collaborating scientists visited each other several times. Prof Pacardo spent total of three month in the institute of Desert research . During the visits he wrote a major part of the research reports , and visited the research cites . Prof. Lips visited the UPLB during the month of March

1994. In this visit he gave several lectures and helped reviewing the Ph.D. thesis of Dr. F.C. Faustino. Prof. Ben-Asher visited the UPLB in October 1995. During this visit he calibrated and introduced the TDR moisture sensor to the field workers

Students:

Dr. Jose Beltrao from University of Algarve Portugal has finished his Ph.D. under the supervision of Prof J. Ben-Asher.

Dr. F.C. Faustino. from UPLB Philippines has finished her Ph.D. . under the supervision of Prof. Pacardo from UPLB and Prof. Lips from BGU Israel.

List of Participants

Name	Country
Prof. J. Ben-Asher	Israel
Prof. H.S.Lips	Israel
Dr. H.Frenkel	Israel
Dr. M. Silberbush	Israel
Mr. Y. De -Malach	Israel
Dr. J. Beltrao	Portugal
Ms. Raya Vulcan	Israel
Dr. j.E. Ephrath	Israel
Mr. M.Sagieh	Israel
Mr. U Zig	Israel
Prof. E. Pacardo	Philippines
Dr. Z.N.Sierra	Philippines
Mr. G.R.Dimasuay	Philippines
Mr. B.C.Bravo	Philippines

Dr.F.C.Faustino	Philippines
Mr. J. Rocamora	Philippines
Mr. E. Vidal	Philippines
Ms. M.C.Kahn	India
Mr. J. Palis	Philippines

Publications and Presentations

About 20 scientific papers were published and are currently in press in more than 6 reviewed journals. (See details in the previous chapter). Ten lectures concerning this project were given in the following countries: Philippines , Mexico , Portugal , Israel ,Cyprus, China and USA. (See details in previous chapter)

Agronomic Accomplishments

1. Greater appreciation of drip irrigation technology as an efficient and effective system for water application was established in the Philippines. The distribution rate of the method was enhanced and more Philippine farmers were exposed to the advantages and the drip irrigation practices.

2. Possible increase of absolute yields with fresh water (using drip irrigation) was demonstrated in the Philippines for the following crops

Crop	National Level t/ha.	Drip irrigation t/ha.	Yield Increase times
Tomato	4.7	15.5	3.3
corn (Kernel)	1.2	4.15	3.4
Peanuts	1.5	3.6	2.4
Sweet pepper	?	5.4	?

3. Possible increase of absolute yields with saline water (using drip irrigation) was demonstrated in the Philippines for peanuts (Objective 1.)

Application of KNO_3 kg/ha for 8dS/m	Shelled peanuts yield Kg/ha.	% Increase
0	677	-
300	895	25

4. Possible increase of absolute yields with supplemental fresh water (using sprinkler irrigation) was demonstrated in Israel for peanuts (Objective 1) Results indicated that with fertilizer the yield was kept high even with saline water

Application of 150 kg/ha $K+NO_3$ for 2 salinity level	Unshelled peanuts yield Kg/ha.	% change
1 0 dS/m	6260	-
25-35 % 6.3 dS/m	6000	not significant

Note: The difference between the peanuts yield in Israel and the Philippines result from difference of varieties used and addition of 40% shell weight to the total yield in Israel.

5. Possible increase of absolute yields with saline water (using drip irrigation) was unsuccessfully demonstrated in the Philippines for corn but results indicated that with fertilizer the yield was kept above national level even with saline water (Objective 2.)

Salinity dS/m	Application of KNO_3 kg/ha for 8 dS/m	Sweet corn grain yield tone/ha.
2	300	2.7
8	300	2.2

The reproductive growth stage of peanuts (See objective 4)was found to be sensitive to salinity . The penetration of gynophored into the soil and it's succeeding development into pods was found to be a function of soil salinity. Addition of $CaNo_3$ helped overcoming the sensitivity as shown in the following table.

Salinity dS/m	K uptake rate (micro mol/gynophor/hr)+ $CaNo_3$	K uptake rate (micro mol/gynophor/hr) -$CaNo_3$
0	170	20
4	189	0

Sensitive and tolerant rice varieties responded differently to salinity (See objective 4) It was found that dry bio-mass of salt sensitive variety reduced significantly with salinity increase and this was not mitigated by the addition of Nitrate fertilizer. . In tolerant variety . Nitrate increased the total dry mass significantly at high salinity level as shown in the following Table

No3 Level (mMol)	Dry matter production gr./plant Sensitive	Dry matter production gr./plant Tolerant
1	3.3	5.6
6	3.1	7.2

Skill and Awareness remaining after the project in Israel and the Philippines.

Technical aspects:

The adoption of saline water from Laguna lake in the Philippines and ground water in Israel as a supplemental source irrigation water for several crops.

The associated application of Nitrate fertilization in conjunction with saline water irrigation..

The introduction of drip/ trickle irrigation system in crop production. (Particularly in the Philippine)

Scientific aspect

Introduction of the most advanced method (TDR) to measure soil water content.

Developing of experimental techniques to conduct experiment with multivariale parameters. Including the cross triple line source (j. Irrigation sci 1990) and Double Emitter Source (Agron. j. 1996 in press)

Developing of a method to remotely evaluate roots distribution (SSSAJ 1994)with the use of IRGA (Infra-red gas Analyzer)

1. INTRODUCTION

On Phase I of this project, a conceptual model of a plant growing under saline condition was developed (Fig.1). The model linked nitrate influx into the roots with the internal circulation of potassium in the plant. The idea which was originally suggested by Ben-Zioni et al (1971) under normal conditions (Fig. 1a) NO_3 is accumulated in the root and taken up by

the shuttle K to form proteins. Under saline conditions with excessive Cl^- (Fig. 1b) and relative deficiency of NO^-_3, Cl^- is transferred by potassium from soil to the leaves but no protein is formed. Chloride accumulates in the leaves where toxicity be effected. When Na/K ratios increased in the soil, nitrate is still being taken from roots to leaves by sodium instead of potassium.

However, transport of Na to roots (with malate) as Na-M does not occur. As a result, Na accumulates in the leaves (Fig. 1c). This part of the model has been proven in the first stage of this study. However, the results suggested also that a certain modification of the model showed be done. It seems that the optimal ratio of Na/K and Cl/NO3 varies throughout the growth stages. For example, mature corn may tolerate high ratios while young corn may tolerate only low ratios and low total concentrations of soil solution.

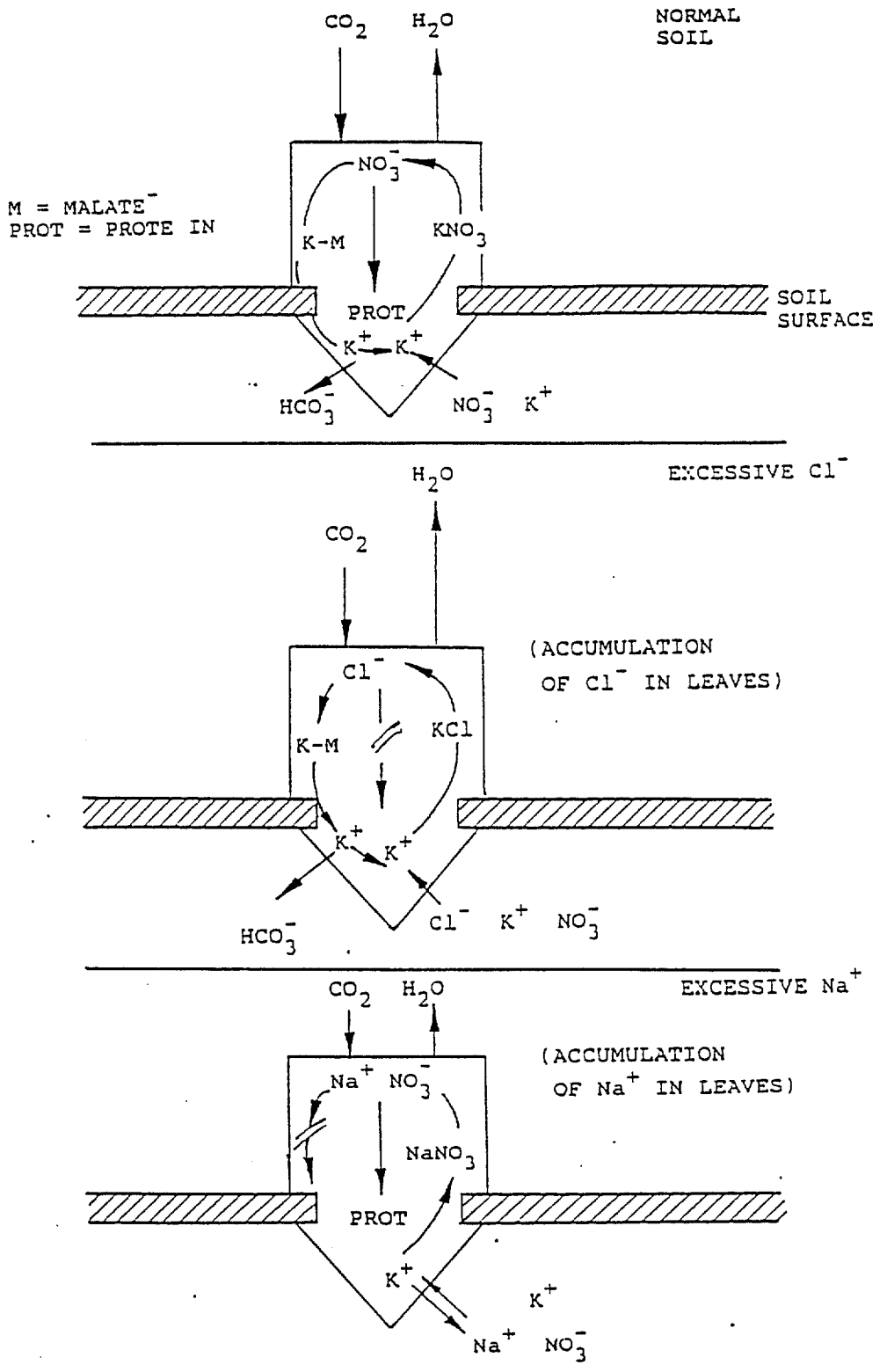
The model shows that under saline condition, plants would suffer growth reduction due to the inhibition of linked physiological processes by sodium and chloride ions. In particular, nitrate and potassium uptake is inhibited and of course all downstream metabolic processes in which nitrogen and potassium are involved.

Many of these linked metabolic processes and environmental factors which may influence the behavior of the model plant were the subject of study in Phase I and knowledge derived from them lead to the development of an agrotechnique which would allow the use of saline water for crop production. The agrotechnique requires the use of potassium nitrate fertilizer in conjunction with the trickle irrigation of saline water.

Fig.1

The effect of fertilization on crop response to saline water irrigation

Lips model



To see whether the agrotechnique would mark in the field preliminary tests were carried out in Israel and the Philippines, and the initial results were encouraging.

The overall aim of Phase II is to extend the general approach initiated in Phase I to incorporate some modifications in the agrotechnique to make it more effective using peanut, corn and other crops of interest.

2. OBJECTIVES

a. To improve peanuts and corn yield in Israel by application of supplemental fresh water during the stage of gynophore penetration for peanuts and from germination to establishment of corn.

b. To test corn and peanut under saline conditions in the Philippines. The study will include enhanced fertilization and sowing schedule before and after a rainy storm which is a natural supply of fresh water.

c. To validate in the field the greenhouse findings that salinity enhanced flowering and translocation of assimilates from leaves to filling grains of wheat.

d. To investigate under greenhouse and laboratory conditions the specific processes which are typical to salt tolerant crops during their salt sensitive stage. The understanding of the specific processes may help develop means to reduce sensitivity.

3.0 METHODS AND RESULTS

In the four Annual Reports that have been submitted already to the Office of Science Advisor, USAID, details of the Procedures and Results of the different studies conducted under this project were already fully described and analyzed. The major findings contained in these Reports as well as other accomplishments are highlighted in the Executive Summary of this Final Report. These are still however, some portions of the work carried out in the Philippines which have not been reported earlier and they reported in this section.

3.1 E.P. Pacardo, E. Vidal, G. Dimasuay and J. Ben-Asher. Effect of Fertilization and Drip Irrigation of Saline Water on Peanut in the Philippines.

Effect of Fertilization and Saline Water Irrigation on Peanut

E.P. Pacardo, E. Vidal, G. Dimasuay and J. Ben-Asher.

Abstract

Peanut response to combined salinity and KNO3 application has not been studied extensively. The common practices for peanut does not include Nitrogen fertilization due to the risobium activity as Nitogen fixators.. The objective of this study was to examine peanut response to salinity under enhanced Nitrogen fixation. The hypothesis was that KNO3 fertilizer in the soil solution reduce uptake of NaCl by the roots. An experiment was conducted in the Philippines during two seasons. January - April 1994 and 1995 .It was a multivariable experiment which included two salinity levels (2 and 8 dS/m) and four KNO3 treatments (0, 75 ,150, and 300 kg/ha.) Results indicated that shoot yield responded positively to enhanced fertilization under saline conditions but shelled nuts responded normally with a limited amount yield improvement under enhanced fertilization.

INTRODUCTION

As agricultural intensification is shifting to high gear to meet the food demand of growing world population, good agricultural lands and water resources for irrigation are increasingly getting scarce. The need to explore the utility of marginal resources such as saline soils and saline water for irrigation is imperative. In many areas of the world these resources are abound but saline conditions may also

develop culturally even in good soil and in non saline areas, e.g. by continuous irrigation and salt intrusion. However, to make use of these resources the problem of salinity must be understood to overcome it.

Earlier studies (Leidi et al 1991)on salinity conducted in Phase 1 of this project in Israel and Philippines showed that the growth of peanut, cotton, wheat, sunflower, alfalfa and rice crops grown in culture solution decreased with increasing salinity of the medium. In particular, the dry weight of peanut plant grown in solution culture with varying salinity decreases significantly in 10 mM salinity level when nitrogen source in the root medium was ammonium.

When the nitrogen source was nitrate, the decrease in dry weight occurred in much higher salinity level, i.e. 30 mM, suggesting that nitrate increases the salt tolerance of peanut. Silbebush and Lips 1988 , Silberbush et al 1988 ,)

Furthermore, the decrease in plant growth in saline media was closely associated with a decrease in nitrogen and potassium uptake with increasing salinity.

Further experiments in using solution culture technique showed that the ratios Na/R and Cl/N03 in the root medium seemed to be the critical factor. Sodium and Chloride ion uptake is favored under higher ratios, but at the lower ratio, the absorption of the latter ions is favored. (Silberbush et al 1986 and Silberbush and Ben-Asher 1991)

All these results suggest the unique importance of nitrate in the physiology of the plant on top and beyond its structural and

enzymatic role. It may be involved in the competition with chloride for active site in the uptake mechanism in the root and also in some major oxidative process as electron acceptor in the shoot.

The practical implication of all these in field crop production is that with nitrate fertilizer saline water at a lower range of electrical conductivity may be used for irrigation.

This hypothesis was tested under field condition in Israel using peanut crop. The crop was drip irrigated with saline water throughout the cropping season. The result was high dry matter production but low pod yield. The high dry matter production is consistent with the hypothesis but low pod yield was a separate problem. This was found to be associated with the failure of the gynophores to penetrate the saline soil surface. It was overcome by applying fresh water prior to and during the gynophore development and confining only the application of saline water outside the critical growth stages of peanut. By doing this, pod yield of 6.lt/ha was obtained and this was hardly affected by the levels of salinity used in the experiment.

A similar field experiment on peanut but without fresh water substitution at the critical growth stage was carried out in the Philippines under different ecological conditions during the dry season of 1994 and 1995 to test this hypothesis. The objective was to determine the growth and yield of peanut crop grown in normal soil, but irrigated with saline water and fertilized with potassium

nitrate under trickle irrigation system. This paper reports on that study.

MATERIALS AND METHODS

A local commercial variety of peanut (Arachis hipogaeae L.) was used as the test plant. The experiment was conducted in a formerly grassland area with patches of trees, a slope of 0-5% and an elevation of about 50m above mean sea level. The soil is classified as Guadalupe clay of volcanic origin. The physico-chemical properties of the soil are shown in Table 1. The area was cleared of its vegetation cover plowed and harrowed a number of times before it was planted with peanut.

Experimental Design

A 2x4 factorial experiment in Split-plot RCB was designed. There were 2 salinity levels, 4 fertilizer levels and 5 replications or blocks in which the fertilizer rates were assigned in the main plot and salinity in the subplot. The details of the treatments are given below:

Salinity::

Sl - 2ds/m NaCl

S2 - 8ds/m NaCl

Fertilizer:

F0 - O Kg KNO3/ha

F1 - 75 Kg KNO3/ha

F2 - 150 Kg KNO3/ha

F3 - 300 Kg KNO3/ha

Treatments

	F0	Fl	F2	F3
Sl	SlF0	SlF1	SlF2	SlF3
S2	S2F0	S2Fl	S2F2	S2F3

Table 1: Physico-chemical characteristics of Guadalupe clay soil.

TEXTURE	DEPTH (cm)		
	0-12	12-40	40-below
Sand(%)	24.20	8.60	11.00
Silt(%)	28.20	15.80	19.40
Clay(%)	47.60	75.60	69.60
Bulk Density	1.62	1.73	1.34
Porosity	38.90	34.80	49.50
Water Holding Capacity	64.10	90.10	93.23
Field Capacity (1/3 atm)	35.03	55.84	56.25
Permanent wilting point (15 atm)	20.60	34.80	33.33
Available moisture	14.43	21.04	22.92
PH 1:1 H_2O	7.20	6.20	6.30
1:1 Kcl	6.20	5.00	5.10
CEC (meq / 100g)	35.10	39.70	40.40
Base Sat (%)	79.50	69.80	70.30
Exch Ca (meq / 100g)	18.50	18.40	18.40
Exch Mg (maq / 100g)	7.00	7.90	8.30
Exch Na (meq / 100g)	0.22	0.58	0.63
Exch K (meq /100g)	2.20	0.83	1.10
O.M (%)	-	1.01	0.94
N (%)	-	0.05	0.05
P (ppm)	T	T	T
Zn (ppm)	3.00	4.00	0.70
Cu (ppm)	9.20	5.00	8.20
Fe (ppm)	36.00	26.00	30.00
Mn (ppm)	116.00	42.00	76.00

Field Lay-out

Before peanut seeds were planted, the drip irrigation system was installed in the field. It consists of the head, filter, main line and sublines, laterals with emitters and control valves which provide accurate amount of water to apply. The field lay-out with the drip system can be seen in Fig 2. Each experimental unit measures IOm long and 9.8m Wide consisting of 7 drip lines 1.4m apart. Each drip lines contain 20 drippers spaced at 50 cm.

Therefore, there are 140 drippers in each experimental unit. The set-up was protested to see that the whole system works by pumping fresh water from the reservoir until the soil became saturated.

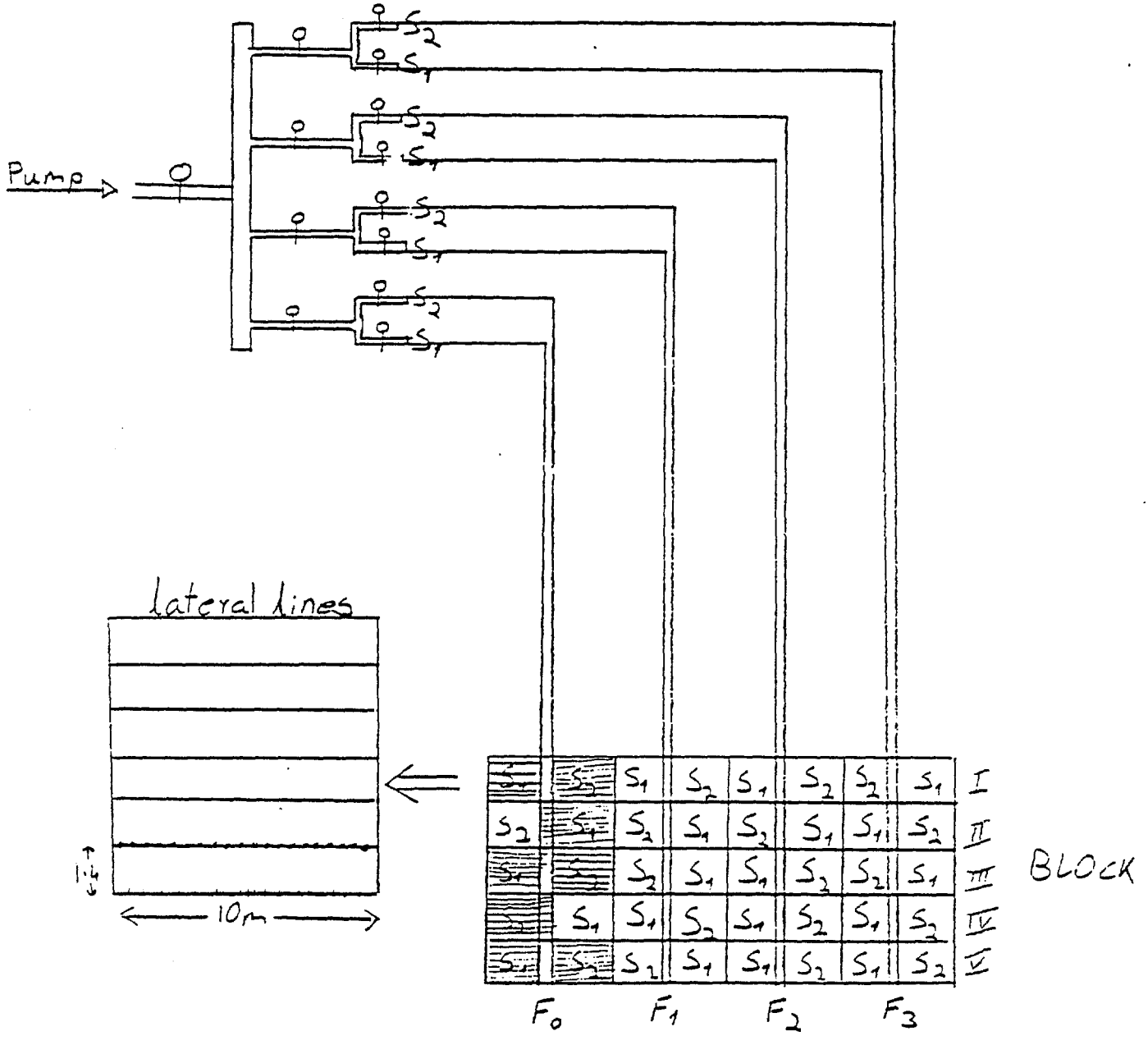
Planting

Peanut seeds were planted at the beginning of dry season on 15 January 1994 and 1995 at the rate of 2 seeds per hill, Seeds were drilled 25cm away to the left and right sides of the drip lines forming a double hedge rows with the drip lines in the middle. Since the distance between hills in a row was 25cm, the number of hills per hectare would be 57,000.

Irrigation And Treatment

The amount of water applied was estimated from the USDA class A pan evaporation during the previous days after the last irrigation

Fig. 2 Experimental lay-out



Salinity (S):

S_1 2 ds/m
S_2 8 ds/m

Fertilizer (F):

F_0	0	kg	KNO_3/ha
F_1	75	"	"
F_2	150	"	"
F_3	300	"	"

multiplied by a factor of 0.7. This figure was actually obtained from the yield response curve for corn in another CDR project.
Irrigation was given twice a week by pumping fresh water from the rain water collecting pond. Saline water solution was applied every irrigation event by introducing dissolved sodium chloride into the main line through the venturi. Potassium nitrate fertilizer was applied in the same manner in two split applications - 15 and 40 days after planting.

Crop Management

Throughout the cropping season, weeding by hand was done 2 times. No pesticide was applied as there was not much insect pest and disease occurrence during dry season.

Growth And Yield Measurement

Growth was measured on representative sample plants. Three plants were identified and tagged at random in the 3 center rows in each experimental unit. Height was measured weekly until 8 weeks old. At 105 days after planting the peanut crop was harvested. Only the 3 center rows of 7 rows in each experimental unit were considered. The peanut pods were separated from the plant, sun dried, shelled by mechanical sheller and the seeds weighed. The shoots were likewise sun dried and weighed.

Plant Tissue and Soil Analysis

A couple of plant shoots were picked up at random row each treatment and block for chemical analysis of potassium, sodium and chloride content. Samples were thoroughly mashed off of dusts, dried and grounded into fine mesh. The analysis represents the composition of the whole shoot.
Like wise the same elements were analyzed in soil samples taken from each treatment.

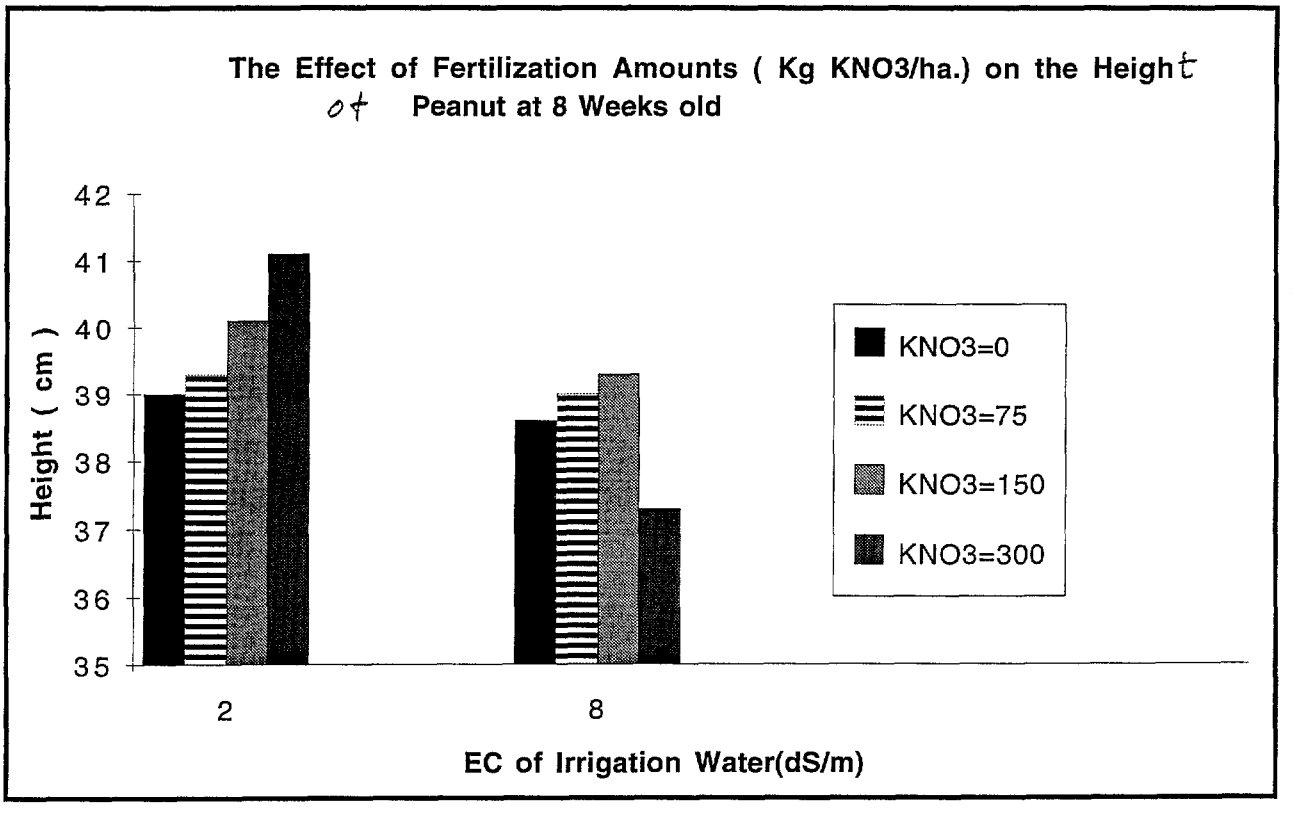
Statistical Analysis

Growth and yield data were processed and statistically analyzed. They are presented in tables and graphs.

RESULTS AND DISCUSSION

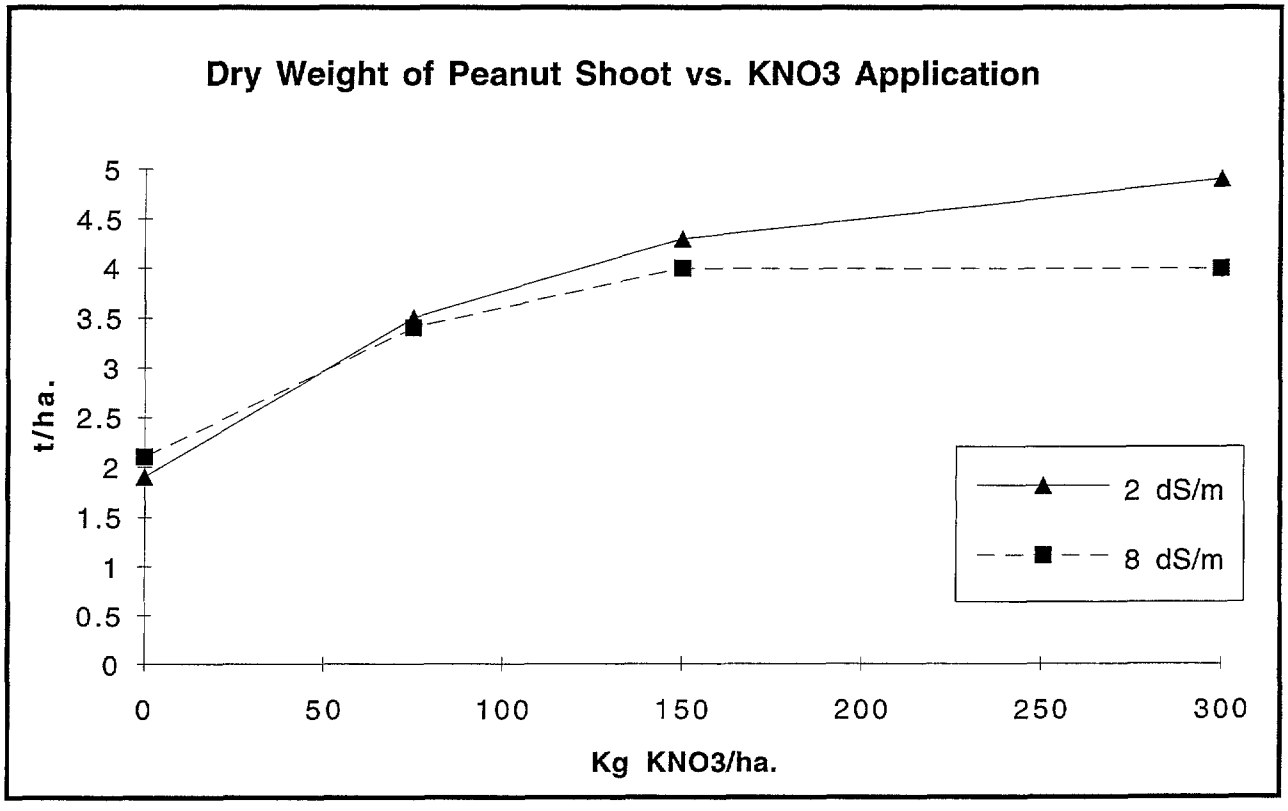
Peanut is a short stature crop which grows at most around 40 cm under favorable condition. Hence, the change in its height by few cm. plus or minus, would mean very much physiologically. The growth of peanut in saline conditions as shown in Fig.3 reflects this concept. Comparing plants without fertilizer in 2 and 8 ds/m indicates that growth generally decreased with increase in salinity. This effect, however, was reversed by nitrate fertilization The growth enhancement by nitrate fertilizer was more pronounced at 2 ds/m, but still present at 8 ds/m to a lesser extent.

fig 3


The Effect of Fertilization Amounts (Kg KNO3/ha.) on the Height of Peanut at 8 Weeks old
Height (cm)
42
41
40
39
38
37
36
35
2
8
EC of Irrigation Water(dS/m)
KNO3=0
KNO3=75
KNO3=150
KNO3=300

24

Fig 4


Dry Weight of Peanut Shoot vs. KNO3 Application
t/ha.
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
200
250
300
Kg KNO3/ha.
2 dS/m
8 dS/m

25

In term of shoot dry weight, Fig. 4 demonstrates the same effect of nitrate fertilizer. At a given salinity level, nitrate significantly increases shoot dry weight which levels off at 150 Kg. KNO^3 per hectare. The effect of fertilizer on peanut shoot is clearly demonstrated . In both salinities (2 and 8 dS/m) the weight of shoot of heavily fertilized plants (150 and 300 kg/ha.) was significantly larger than the weight of the two other salinities . Table 2 indicates also that there is no significant difference between the weights that were measured in the two salnities.

Table 2. Interactive effect of salt and fertilizer on shoot dry weight

Potassium Nitrate Kg/ha.	Yield t/ha. EC= 2 dS/m	Yieldt/ha. EC=8 dS/m	Mean
0	1.9c	2.2c	2.1c
75	3.6b	3.5b	3.5b
150	4.4a	4.1a	4.3a
300	4.8a	4.2a	4.5a
Mean	3.7	3.5	3.6

Therefor the difference between the two dry weight curves in Fig. 4 is not significant.

The yield data as shelled nut are shown in Fig. 5 for the years 1994 and 1995 and in Table 3 .

Table 3 Yield of peanut as shelled nut in the second cropping season (1995). Average of 5 replications.

POTASSIUM NITRATE	(Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
1995	0	801.3	639.68 d	720.5
1994	0	743.4 cd	677.6 d	710.5
1995	75	836.7	687.12c d	761.9
1994	75	841.3 bc	792.3 bc	816.8
1995	150	901.25	650.26 d	775.7
1994	150	883.4 b	867.9 b	875.6
1995	300	937.7	712.37 c	825.0
-1994	300	1117.0 a	895.3 b	

Table 3 indicates that the differences in yield are significant on both directions salinity and enhanced fertilization. A dramatic increase in yield due to nitrate fertilizer occurred at 2 ds/m salinity. The yield response at 8 ds/m was generally lower than those in lower salinity condition. In fig 5. the correlation equation was :

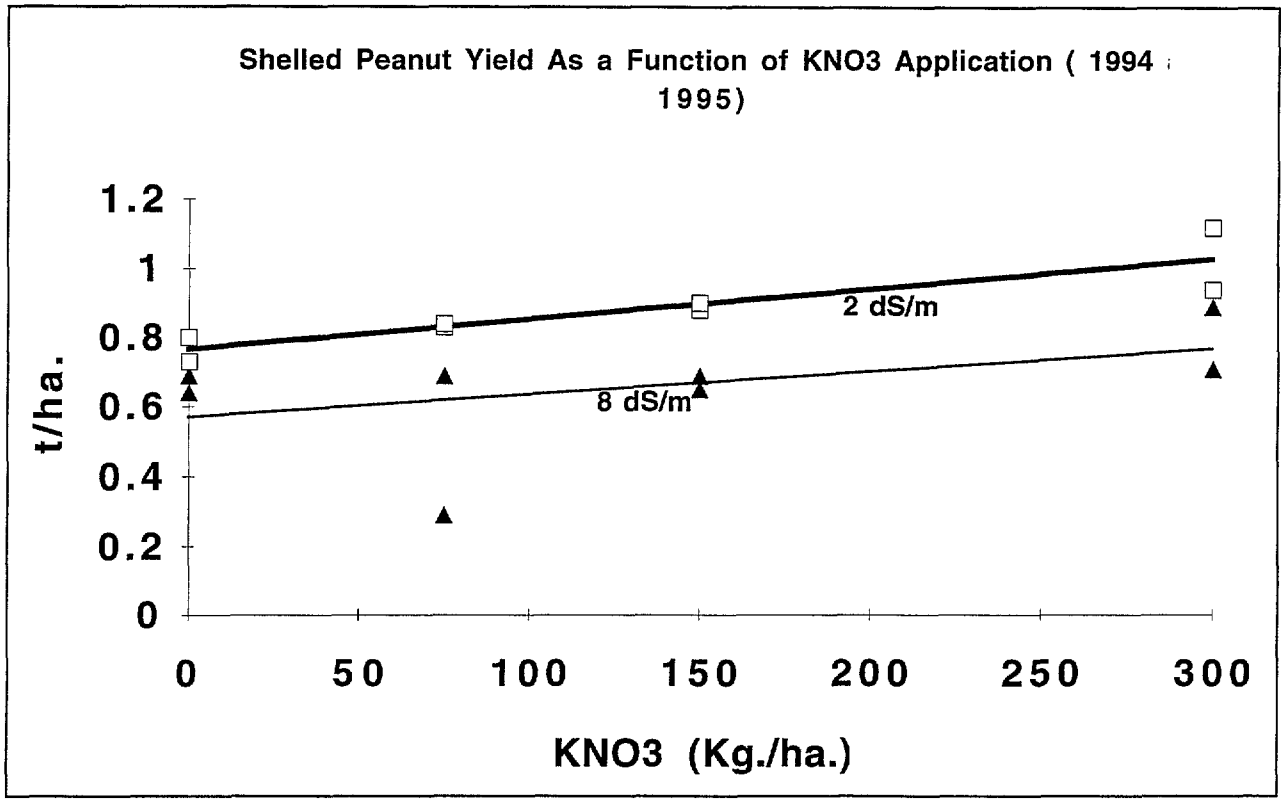
Yield=0.0009*KNO3 +0.8 ; r^2=0.8 for 2 dS/m treatment

and

Yield=0.0007*KNO3 +0.6 ; r^2=0.2 for 8 dS/m treatment

Thus, Initial fresh water yield (NO KNO3 application) started at 800 kg/ha. while saline water yield started only at 600 kg/ha..

fig 5


Shelled Peanut Yield As a Function of KNO3 Application (1994 - 1995)
1.2
1
0.8
0.6
0.4
0.2
0
t/ha.
2 dS/m
8 dS/m
0
50
100
150
200
250
300
KNO3 (Kg./ha.)

28

More over, the slopes of the lines were very moderate and indicated that the contribution of the fertilizer was only 0.7-0.9 kg. nuts /kg KNOP3 . The absolute magnitude of yield in this experiment (0.6-1.1 t/ha) is lower than those which were reported in the 1990 Annual Report (2.0-2.7 t/ha) due to difference in peanut varieties used and probably to the scale of the experiment. On both experiments, saline water was applied throughout the cropping season.

Comparing the yield of peanut grown in the Philippines with those in Israel (e.g. see Ben-Asher and Zig in 1993-94 Annual Report) the yield in Israel is very much higher by about 300 per cent (3.7 t/ha shelled peanut) at the lowest salinity level. This may be explained by the fact that the amount of saline water applied was only 30% of the total water applied to peanut. The rest was fresh water. Also, the varieties used were not the same as well as the micro climate in both places.

According to Table 3 there is an increase in yield as KNO3 application is increased. The yield increase is more pronounced in fresh water than in saline water . For example KNO3 fertilization of peanut in 1994 added about 50% to the yield of fresh water and only 32% to the yield of peanut on saline water.

In all fertilizer treatments the yield of peanut grown on fresh water was larger than the yield on saline water. However, only the treatment in which we used 300 Kg/ha of KNO3 we could detect a unique significant difference between the treatments. In 1995 the results were similar but for a lower yield.

It is interesting to note that in these salinity levels, peanut crop was able to accumulate potassium in the shoot at a much higher concentration (Table 4)

Table 4. Potassium content of peanut shoot (ppm). Average of 5 replications.

POTASSIUM NITRATE (Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
0	3,836.36	3,698.10	3,767.23
15	4,178.13	4,738.62	4,458.37
150	3,186.30	3,772.50	3,479.40
300	3,277,81	3,717.27	3,497,54
MEAN	3,619.65	3,981.62	3,800.63

Note also that this amount of Potassium in the leaves was extracted from a lower potassium concentration in the soil (Table 5).

Table 5. Extractable potassium (ppm) in various designated plots before the first peanut crop was planted. The data are average of 5 replications.

POTASSIUM NITRATE (Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
0	171.51	179.08	175.29
15	279.64	283.15	281.39
150	334.87	320.79	327.83
300	269.98	320.55	295.25
MEAN	264.80	275.89	269.95

The various accumulation of potassium by peanut may have dumped the salinity effect. Unfortunately, there was no analysis of nitrogen in the tissue, but it is expected to follow that of potassium.

In contrast, chloride and sodium accumulation in the shoot remained low (Table 6 and 7).

Table 6. Chloride content of peanut (ppm). Average of 5 replications.

POTASSIUM NITRATE (Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
0	92.4	80.0	86.2
15	77.0	95.0	86.0
150	87.0	98.0	92.5
300	100.0	91.0	95.5
MEAN	89.1	91.0	90.0

Table 7. Sodium content of peanut shoot (ppm). Average of 5 replications.

POTASSIUM NITRATE (Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
0	109.55	96.88	103.21
15	90.47	114.39	102.43
150	52.98	150.53	101.75
300	71.49	150.72	111.10
MEAN	81.12	128.13	104.62

Much of the applied sodium chloride remained in the soil. (Tables 8 and 9).

Table 8. Chloride content of the soil after harvest of peanut crop (ppm). The initial chloride before planting was not detectable.

POTASSIUM NITRATE (Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
0	30.11	140.18	85.14
15	34.94	115.38	75.16
150	48.67	117.14	82.90
300	31.23	108.33	69.76
MEAN	36.23	120.26	78.2

Table 9. Sodium content of the soil after harvest (ppm). Average of 5 replication. The initial sodium content of the soil before planting was 52.80 ppm.

POTASSIUM NITRATE (Kg/ha)	SALINITY LEVEL 2 ds/m	8 ds/m	MEAN
0	309.73	213.58	261.65
15	326.16	255.42	290.80
150	357.01	122.70	239.85
300	320.70	442.96	264.10
MEAN	328.40	258.66	293.53

In the second cropping that followed the following year which also received the same inputs of fertilizer and saline irrigation, the yield trend remained basically similar, but the absolute value was generally lower. (Table 10). The overall average yield for all treatments was 770.8 Kg. shelled peanut per hectare as compared to

852.3 Kg/ha on proceeding year. The difference in yield might be due to the cumulative effect of salinity.

Peanut plant is reported to be susceptible to salinity as mentioned in the Phase I Report of this project. However, it appears that peanut grown in the soil can tolerate a much higher salinity than when grown in culture solution. The physiological functions of potassium and nitrate elements may have helped in conferring salt tolerance mechanism to otherwise susceptible crop.

Summary

The combination between salinity and fertilization did not mask the general effect of yield decline as salinity increase. . The major finding of this study is that for the specific case of N deficiency a given yield can be maintained constant or even increase with the increase of salinity provided that the higher salinity level is associated by an increase KNO3 application.. The improved yield of peanut was also associated by an increase in Potassium level in the leaves and decline of Sodium and Chloride level. We interpreted this result as a support to the K-shuttle hypothesis.

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3. Silberbush, M. and J. Ben-Asher. 1990. Peanut yield and spatial distribution of ions under trickling with saline water. Plant and Soil. In Press.

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5. Silberbush, M., A. Golan-Goldhirsch, Y. Heimer and S. H. Lips. 1988. Response of peanuts (Arachis hypogaea L.) grown in saline nutrient solutions to potassium nitrate. J. Plant Physiol. 132: 229-233.

6. Silberbush, M. and S. H. Lips. 1988. Nitrogen concentration, ammonium/nitrate ratio and NaCl interaction in the vegetative and reproductive growth of peanut plants. Physiol. Plantarum, 74: 493-498.

7. Lips, S. H., J. Ben-Asher and E. P. Pacardo. 1990. Final Report . Fertilization and Saline Water Irrigation. Phase I. J. Blaustein Inst. Desert Research, Ben-Gurion University of the Negev, Sde Boqer, Israel.

4.0 IMPACT, RELEVANCE AND TECHNOLOGY TRANSFER

The agrotechnology which came out of this project addresses one of he major constraints in crop production not only in the two collaborating countries of Israel and the Philippines, but other developing countries as well. This constraint is salinity of the water and soils.

5. PROJECT ACTIVITIES / OUTPUTS

The output of the project is summarized by the following list of publications, meetings and presentations in meetings. Most of them were cited in the previous annual reports.

A. List of Published Papers

Silberbush, M., J. Ben-Asher, and H.S. Lips, 1989. Nutrients-salt interaction and peanut growth. In: Bishay a. and H. Dregue Eds. Desert Development Part I. § Desert Agriculture, Ecology and Biology. Advances in desert and arid lands, technology and development, Vol.5, Harwood Academic Publishers,l N.Y, pp. 631-645.

. Ben-Asher, Jiftah. 1995. Soil and water contamination in arid coastal zones. Water Resources Management under Drought or Water Shortage Conditions, Tsiourtis (ed). pp. 235-242.

. Alekperov, C., Barukhin, F., Ephrath , J. and J. Ben-Asher. 1995. A system of microirrigation for optimum fertilizing study in Hippeastrum spp.Microirrigation for a changing world . Fifth Int. Microirrigation Congress. (April 2-6, 1995. Hyatt Regency Orlando, , Florida, USA. pp.566-570.

* Ben-Asher, J., G.E. Cardon, D. Peter, D.E. Rolston , C.J. Phene, J.W. Biggar, and R.B. Hutmacher. 1994. Determining almond root zone under three irrigation treatments by measuring surface CO_2 fluces. SSSAJ. 58:926-930.

Ben-Asher, J., G.E. Cardon, D. Peters, D.E. Rolston, J.W. Biggar, and C.J. Phene. 1992. Determining root activity distribution by measuring surface CO_2 fluxes. SSSAJ. 58:930-934.

Siberbush M , S. Sorek and A . Yakirevitch 1993 Uptake by Root systems Grown in Soil Under Salinity: I A Mathematical Model Transp. Prous media 11: 101-116

Yakirevitch A . , S. Sorek and M . Siberbush 1994 Uptake by Root systems Grown in Soil Under Salinity: II Sensitivity Ananalysis . Transp. Prous Media 14: 123-141

Ben-Asher and J. Beltrao, 1996. Sweet corn response to combined effects of saline water and nitrogen fertilization. Irrig. drain. systems (in press)

. Ben-Asher, J., 1993. A simplified model of integrated water and solute uptake by salts and selenium accumulating plants. SSSJA 58:1012-1017.

Ben-Asher, J. and J. Beltrao, 1995. The effect of salinity on corn yield using ceres maize model. European J. Irrig. Drainage (accepted).

Beltrao, J. and J. Ben-Asher, 1996. The effect of capillary water rise on corn yield using ceres maize model. Irrig. Drain. Systems 10: 179-189

Ben-Asher, J., D.A. Magnusson, B.E. Mackey, Y. De Malach, and H. Lips. 1995. Nitrogen deficiency and corn reponse to salinity. Agron. J. (submitted).

De Malach,Y. Jben-Asher, M Sagih and A. Alret 1996 Double emmiter Source (DES) for Irrigation Experiments in Salinity and Fertiliztion Agron.J. (In press)

Nitrate and Ammonium Nitrate Uptake By Wheat Seedlings As Affected by Salinity and Light. A Reprint.
M.A. Botella, A. Cerda and S.H. Lips.

Kinetics of $NO3^-$ and $NH4^+$ Uptake by Wheat Seedlings. Effect of Salinity and Nitrogen source. A Reprint.M.A. Botella, A. Cerda and S.H. Lips.

. Dry Matter Production, Yield and Allocation of Carbon-14 Assimilates by Wheat as Affected By Nitrogen Source and Salinity. A Reprint.M.A. Botella, A. Cerda and S.H. Lips.

B. LIST OF WRITTEN PAPERS FOR PUBLICATIONS

Pacardo, E.P., Z.N. Sierra, G.R. Dimasuay, H. Lips and J. Ben-Asher.
Preliminary Study on the Response of Common Crops to Drip Irrigation of Saline Water and Fertilization in the Philippines.

Pacardo, E.P., E. Vidal, G. Dimasuay and J. Ben-Asher.

Effect of Drip Irrigation of Saline Water and Fertilization on Peanut.

C. LIST OF MEETINGS, CONFERENCES AND SEMINARS.

. Nov. 10-15, 1990. Pacardo visited Israel.

. Oct.-Nov. 1994. Prof. Pacardo stayed in Ben-Gurion University, to write reports and gave lecture to University students and seminar to staff of Desert Agrobiology Center.

. May 1-30, 1996. Prof. Pacardo visited Desert Agrobiology Center to prepare the final report of the Project.

Prof Pacardo spent total of three month in the institute of Desert research . During the visits he wrote a major part of the research reports , and visited the research cites . Prof. Lips visited the UPLB during the month of March 1994. In this visit he gave several lectures and helped reviewing the Ph.D. thesis of Dr. F.C. Faustino. Prof. Ben-Asher visited the UPLB in October 1995. During this visit he calibrated and introduced the TDR moisture sensor to the field workers

Invited lectures and Presentations in Cnferences.

*Cardon, G.E., J. Ben-Asher, D. Peters, D.E. Rolston, R.B. Hutmacher, and C.J. Phene, 1992.

Soil surface carbon dioxide flux determination of roots area lenght and number. Annual meeting of ASA. Minneapolis. Book of Abstract, p. 226.

Beltrao, J. and J. ben-Asher, 1992. Simulation of corn yield to combined fertilization and salinity. Fertilization Conference. VIII Internatinal coloquium of Plant Nutrition. 1-8 Sept., Lisbon, Portugal.

Ben-Asher, J. and J. Beltrao, 1992. Sweet corn response to combination. Spain. ISHS: I International Symposium on Irigation of Horticultural Crop. Nov. Almeria, Spain.

Ben-Asher, Jiftah. 1995. Soil and water contamination in arid coastal zones. Water Resources Management under Drought or Water Shortage Conditions, Nicosia, Cyprus.14-18 March 1995.

Alekperov, C., Barukhin, F., Ephrath , J. and J. Ben-Asher. 1995. A system of microirrigation for optimum fertilizing study in Hippeastrum spp. Microirrigation for a Changing World: Conserving Resources/Preserving the Environment. Proceedings of the Fifth Int. Microirrigation Congress. April 2-6, 1995. Orlando, Florida, USA.

J. Beltaro and J. Ben-Asher 1996 Simulating the effect of salinity on the wilting point of corn and it's yield. ICID conference Cairo Egypt.