PN-ACW-527

# MANAGEMENT REPORT

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## Submitted to the Office of the Science Advisor
## U.S. Agency for International Development

## COORDINATED USE OF MARGINAL WATER RESOURCES IN ARID AND DESERT AREAS , Stage II

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**1) Scientific Summary**

The present research program is a continuation to the AID/CDR Program C11-133. The results obtained during the latter showed that it is the possible, in arid areas, to supplement runoff water with brackish water irrigation in order to *Acacia saligna*, a quick growing leguminous shrub. It was also shown (in pot trials) that fertilization can improve the development of seedlings irrigated with brackish water.

In order to allow the implementation of this technique (irrigation with runoff supplemented with brackish water) further research is required, as detailed in the proposal of Phase II of the project. The specific research objectives as detailed in the approved proposal were:

I. **Fertilization** (pot and field trials)

a. To test new fertilization techniques with Mo, bicarbonate and nitrogen. To study the effect of selected mycorrhiza, which stimulate nutrient uptake by roots under saline conditions .

b. To enhance stress tolerance of $N_2$-fixing symbiotic bacteria in the roots of Acacia by screening for salt tolerant species of N2-fixing microorganisms living in symbiosis with Acacia roots in Israel and Kenya.

I. **Re-growth patterns** (field trials).

a. Assess the effect felling height above the ground or lopping have on shoot re-growth and root development when irrigated with runoff water only.

b. Monitor the effects that different levels of soil salinity, and quality and quantity of water application have on the behaviour of *Acacia saligna* shrubs after lopping at 1.5 m. height. We will monitor the following key aspects:

i. shoot re-growth,
ii. shrub water relations and biomass production characteristics,
iii. soil moisture absorption patterns of the shrubs,
iv. photosynthesis, and
v. in-situ spatial and temporal distribution of roots with the aid of a minirhizotron system

I. **Intercropping** (Kenya, field trial)

Evaluate the possibility of intercropping between the trees in the aftermath of runoff events. Sorghum, a highly versatile and popular grain crop in Turkana, will be used as an intercrop.

**2) Scientific Issues**

There are at this stage no scientific issues that require changes in the research program. A short summary of the lab experiments carried out (Specific Objectives: I. Fertilization) is appended as Annex 1

**3) Managerial Issues**

**Kenya**

As mentioned in the previous management report the fields had to be replanted. The seedlings were prepared at the University of Kisumu and planted during April 2003. To date the development of trees is extremely heterogeneous.

**Israel:**

Trees in the field plots were lopped after a flood at the experimental site in Israel (*Wadi Mashash*). The remaining set of experiments planned progressed as scheduled.

**Collaboration Travel, Training and Publication**

Following the visit of Dr. Jhonathan Ephrath in Kenya during October of 2002, Prof. J. Nyanubdi visited Israel in April- May of 2003. During his stay in Israel we visited the Israeli Experimental sites in Wadi Mashash and in Sede Boqer Campus and made several measurements of tree development, soil moisture content and carried out some preliminary biomass analysis. We discussed as well several aspects of the field experiments both in Kenya and in Israel. The irrigation set-up, equipment required and irrigation scheduling in the Kenyan experiments were the main topics. We decided as well that a Kenyan student, presently finalizing her degree at Maseno University, would enroll as a M. Sc. Student at the Albert Katz International School for Desert Studies of the Blaustein Institute, and that the topic of her thesis would be related to one of the central topics of the project. The School authorities approved her candidacy and she will commence her studies in the near future.

**5) Request for A.I.D. Actions.**

At this point we do not have any special requests from the American Embassy in Tel-Aviv or from the AID staff.

# Annex 1

## Interim Report on Fertilization Trials (Specific Objective No. 1)

### Introduction

Abiotic stresses have a variety of deleterious effects on plant growth and development. These include plant water deficit, reduced rate of photosynthesis and decreased cell expansion and division (Ort *et al.*, 1994; Bray *et al.*, 2000; Munns, 2002; Chaves *et al.*, 2002). An additional problem caused by salt stress is the accumulation of toxic ions such as $Na^+$ and $Cl^-$ in the cells, which adversely affects cell membrane integrity, enzyme activities, nutrient acquisition and the function of the photosynthetic apparatus (Zhu, 2001). Furthermore, most, if not all, abiotic stress leads to the production of reactive oxygen species (ROS) such as singlet oxygen radicals, hydrogen peroxide, superoxide anions and hydroxyl ion (Asada, 1997). These ROS are highly destructive to lipids, nucleic acids and proteins and this can be particularly severe if the abiotic stress is combined with high light intensities such as are found in arid environments.

One low-input method that can alleviate the effects of abiotic stress on plants is better fertilzation. For instance, nitrogen fertilization not only affects plant growth, it may also alleviate salinity effects depending on its ionic forms (Flores *et al.*, 2001). Nitrogen is required in large quantities for plant growth and is taken up in the form of ammonium ($NH_4^+$) and nitrate ($NO_3^-$) ions. Some plant species show enhanced growth when provided with both nitrate and ammonium, as compared to growth on sole nitrate or ammonium (Kant and Kafkafi, 2003) although there are substantial differences among plant species in the extent to which the $NH_4^+$ level in the $NO_3^-/NH_4^+$ mixture is beneficial.

### Objective

To determine whether different nitrogen forms can alleviate the effects of salt stress on *Acacia saligna*.

### Materials and Methods

### Plant growth

*Acacia saligna* seeds were scarified by immersion in concentrated (98%) $H_2SO_4$ for one hour followed by rinsing in deionized water until neutral pH. Seeds were germinated in the greenhouse by sowing onto moist vermiculite No. 3 and covering them with a thin layer of vermiculite No. 2. Under these conditions, germination commenced 2 days after sowing. Ten days after sowing, seedlings were transplanted to 3 liter pots containing soil comprising 2/3 loess and 1/3 washed dune sand. Plants were irrigated with Hoagland's solution (Hoagland and Arnon, 1950) containing 6mM nitrogen as $NaNO_3$. After 3 months, plants were irrigated with Hoagland's solution plus 6mM nitrogen as $NaNO_3$, $NH_4Cl$ or $NH_4NO_3$. Salt stress was applied to half the plants in each nitrogen treatment by adding NaCl to the fertilizer solution in 50mM steps every 3 days until a concentration of 200mM NaCl was reached. The conductivity of effluent from each pot was measured after every irrigation in order to monitor any accumulation of salts. Each treatment comprised six replicate plants. However, *Acacia saligna* plant

growth is not uniform and this can lead to problems in analyzing results. In order to overcome this problem therefore, plants were divided into large-, medium- and small-size plants, and each treatment was assigned two plants of each size category. Moreover, six plants had very narrow leaves and each treatment included one of these plants. Pots were randomized over the growing area within the greenhouse in order to remove position effects. Plants were harvested two months after commencement of experimental treatments.

## Photosynthesis, stomatal conductance, transpiration and biomass measurements

Photosynthesis, stomatal conductance and transpiration rate were measured with a portable infrared gas analyzer, CIRAS-I, PP systems, UK. Measurement of photosynthesis was performed on the first fully expanded leaf between 10:00a.m and 12:00 noon. Plants were then removed from pots, washed of soil, split into roots and shoots and fresh weights determined. Plant tissue was then dried at 65°C in a drying oven for 72 hours and dry weights determined.

### Results and discussion

### Plant Growth

The effect of salinity on the growth of *Acacia saligna* was most dramatically observed in the reduction of root fresh and dry weights in all nitrogen treatments (Figs. 1B and 2B). Root fresh weight was reduced by 64% to 79%, while dry weight was reduced by 50% to 85%. The only exception was the $NH_4Cl$ treatment where there was no significant difference in dry weight between non-saline and saline conditions due to a large amount of variation between replicate plants. Saline treatment had less of an effect on average shoot fresh and dry weights compared to the roots (except for the shoot FW in the $NH_4Cl$ treatment). However, the large amount of variation between replicate plants meant that there was no significant difference in shoot fresh and dry weights between non-saline and saline conditions (Figs. 1A and 2A).

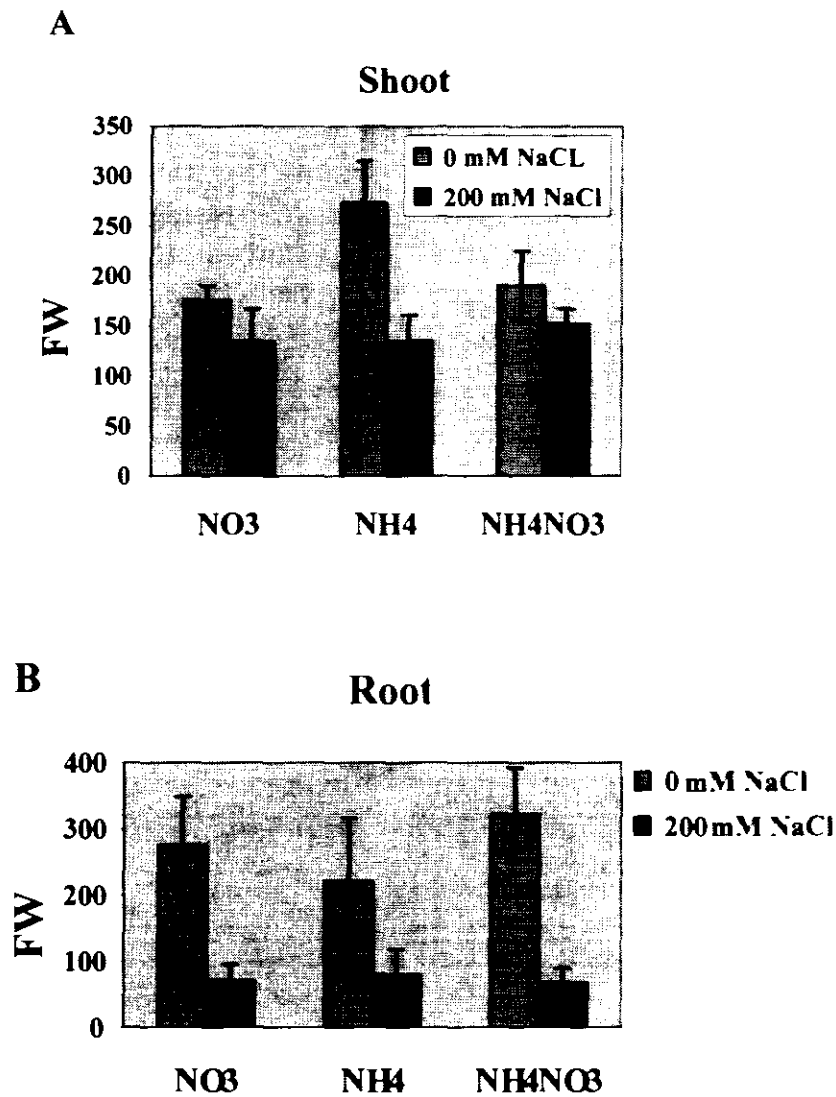


**Figure 1. Effect of nitrogen form on fresh weight of *Acacia saligna* grown under saline conditions.** *Acacia* plants were washed of soil and split into shoots (A) and roots (B). $NO_3$, $NaNO_3$; NH4, $NH_4Cl$. Bars represent S.D.

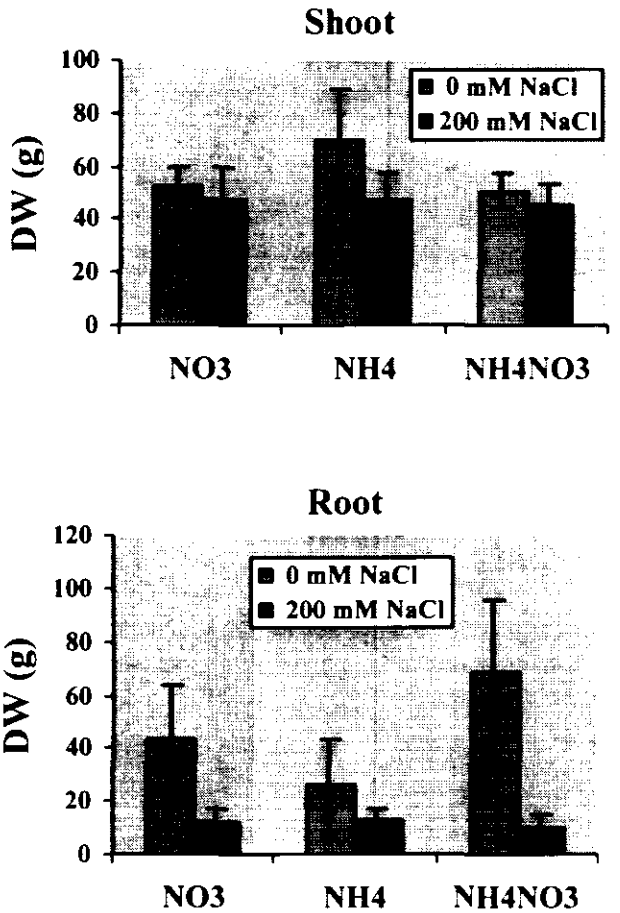


**Figure 2. Effect of nitrogen form on dry weight of *Acacia saligna* grown under saline conditions.** *Acacia* plants were washed of soil and split into shoots (A) and roots (B). $NO_3$, $NaNO_3$; $NH_4$, $NH_4Cl$. Tissue was dried at 65°C in a drying oven for 72 hours. Bars represent S.D.

Under non-saline and saline conditions no significant difference was observed in growth parameters between nitrogen treatments. Furthermore, no consistent significant effect of each nitrogen form on the relative decrease in each growth parameter under saline compared to non-saline conditions was observed.

**Photosynthesis**

A similar pattern of results as those obtained with growth parameters, was observed when rates of photosynthesis were examined (Fig. 3A). No significant differences in rates of photosynthesis were observed between nitrogen treatments in either non-saline or saline conditions. Only within the $NaNO_3$ treatment was a significant drop in photosynthesis observed under saline conditions. A significant reduction in stomatal conductance and transpiration rate was only observed under saline conditions in the $NH_4Cl$ treatment (Figs. 3B and 3C) but this was not correlated with increased fresh weight (Fig. 1): in fact there was a larger decrease in shoot fresh weight with $NH_4Cl$ under saline conditions than with other nitrogen treatments (Fig. 1A).

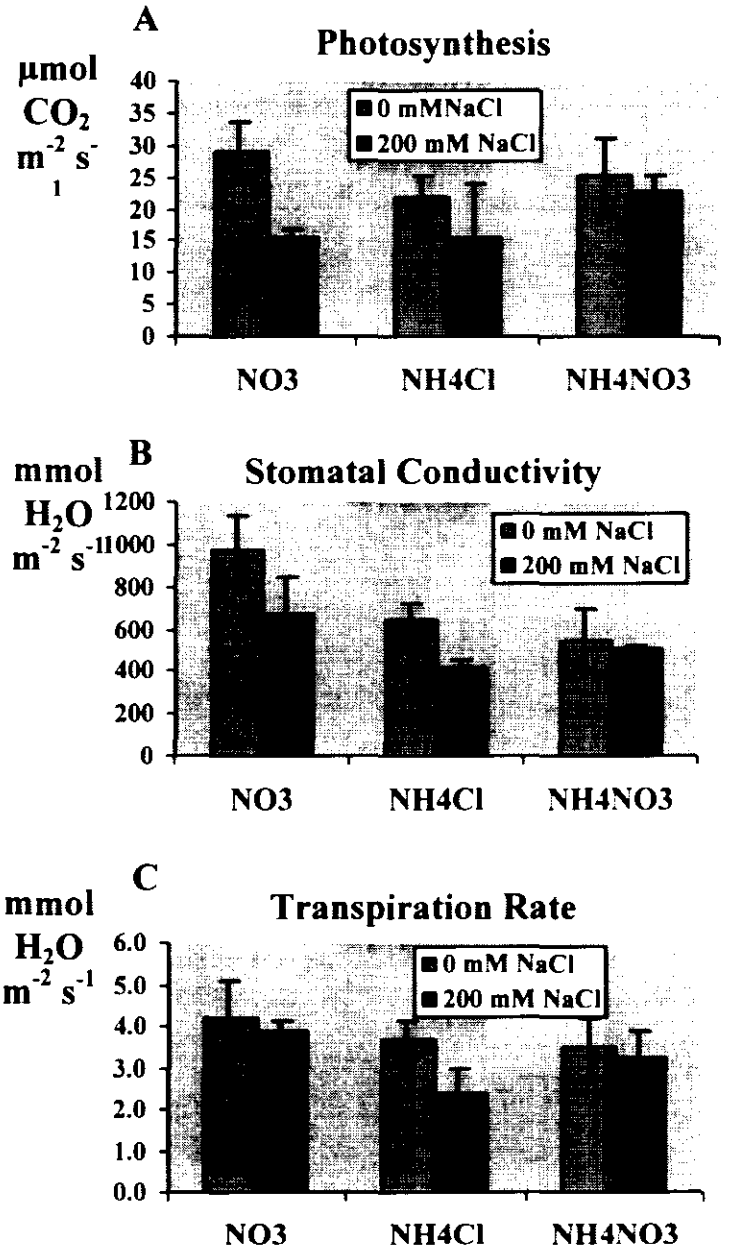


**Figure 3. Effect of nitrogen form on photosynthesis (A), stomatal conductance (B) and transpiration rate (C) of *Acacia saligna* grown under saline conditions.** All measurements were performed with a portable infrared gas analyzer, CIRAS-I, PP systems, UK on the first fully explanded leaf. $NO_3$, $NaNO_3$; $NH_4$, $NH_4Cl$. Bars represent S.D.

**Discussion**

The major problem encountered in this experiment was the large amount of variation between replicate plants even with the precautions taken to minimize this (see Materials and Methods). This variation was due to non-uniformity between individual plants both in plant size and in growth habit. We will attempt to further minimize this non-uniformity in future experiments by germinating larger numbers of plants in order to increase the number of uniform plants that can be selected. Furthermore,

treatments will begin at an earlier stage of plant development than two months after sowing used in this present experiment. One other problem encountered was the accumulation of salts in the soil as determined by conductivity measurements of effluent from each pot during irrigation. Even flushing of soil with large quantities of irrigation solution could not overcome this. Thus, plants were in fact exposed to twice the amount of salt than in the irrigation solution showing that *Acacia* plants are very tolerant to saline conditions. In future experiments, perlite will be used as the growing medium, which should prevent accumulation of salts.

The above problems notwithstanding, one conclusion that may be drawn from the results is that no particular nitrogen treatment conferred a dramatic alleviation of salt stress. This is possibly due to the high intrinsic tolerance of *Acacia* to saline conditions making it unlikely that changing fertilization regimes (at least with respect to nitrogen) will lead to a significant increase in stress tolerance.

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