2.7 Activities of Foreign Researchers

(1) Professor Uzi Kafkafi

Visiting Professor (April 1999 – September 1999)

The Hebrew University of Jerusalem, Faculty of Agriculture, Rehovot, Israel

Summary of the research:

The research on *'Response of crop plants to variable soil temperatures'* lasted 6 years and Prof. Kafkafi stayed at the ALRC for this purpose for 3 separate periods: 1/4 to 30/9 1993, 1/7-30/9 1996 and 1/4-30/9 1999. During those periods a Ph.D. work of Dr. I.E. Ali was completed. The list of publication resulted from this continuous activity is presented with the last paper attached. This work had demonstrated the importance of root temperature on plant growth and development. In combination with the type of nitrogen nutrition it was shown that at low root temperatures the nitrate nutrition hold down nitrogen translocation to the leaves while ammonium is a better nitrogen source to the plant at low root temperature. The transport of water was shown to be very sensitive to root temperature. It was demonstrated that the rate of water transport in the stem was reduced from 37 to only 17g/h within 30 minutes of the change in root temperature from 20 to 12 degrees Celsius. This result is of fundamental importance as it is contrary to the current 'Dogma' that water transport through the plant is only a result of the water potential difference. We demonstrated that the resistance to water transport through the plant is very sensitive to root temperatures. Root temperature affects the nutrient transport and cytokinin and Gibberillins transport to the leaves mainly due to the reduction in water flow at low root temperatures. Three plants were studied during that period: Tomato (publications 1, 2,4), Rapeseed (3) Sesame (4).

Research on *'Plant root temperature and salinity variability on water flux in Citrus'*, this research with Prof. Yano and the master student: Ohigashi is currently performed. Prof. C. Dirksen has joined the work and the monitoring of water uptake and water transport through a citrus tree is continuously monitored. The preliminary data obtained so far demonstrate that the transpiration during the day is not following the light pattern. In the middle of the day a sudden drop in transpiration is observed and a recovery one hour later. This up and down fluctuations in water uptake cannot be explained by meteorological data. The internal plant metabolism during the day with and without excess salts is currently being studied as well as the detailed data collected on water uptake and meteorological data.

Publications:

1) Ali, I., Kafkafi, U., Sugimoto, Y. and Inanaga, S. (1994): Response of sand-grown tomato supplied with varying ratios of NO_3/NH_4 at constant and variable root temperatures. J. Plant Nutr. 17(11) 2001-2024.
2) Ali, I., Kafkafi, U., Yamaguchi, I., Sugimoto, Y. and Inanaga, S. (1996): Effect of low root temperature on sap flow rate, soluble carbohydrates, nitrate contents and on cytokinins and gibberellin levels in root xylem exudate of sand grown tomato. J. Plant Nutr. 19:619-634.
3) Ali, I.A., Kafkafi, U., Yamaguchi, I, Sugimoto, Y. and Inanaga, S. (1998): Response of oilseed rape plant to low root temperature and nitrate: ammonium ratios: J. Plant Nutr.21(7): 1463-1481.
4) Ali, I., Kafkafi, U., Yamaguchi, I., Sugimoto, Y. and Inanaga, S. (1996): Transpiration, drop after a sudden decrease in root temperature. In: Evapotranspiration and irrigation scheduling, Proc. Intern. Conference ASAE. pp. 442-448., CA, Camp, EJ, Sadler and RE Yoder (Eds). ASAE.
5) Paper submitted to the Journal of Plant Nutrition on July 1, 1999: Imad-eldin A. Ali, Uzi Kafkafi, Yamaguchi, I., Sugimoto, Y. and Inanaga, S. Growth, Transpiration, Root-Born Cytokinins and Gibberellins, and Nutrient compositional Changes in Sesame Exposed to Low Root-Zone Temperature under Different Ratios of Nitrate: Ammonium Supply.

(2) Professor Nafisa E. Ahmed

Visiting Professor (Oct.1999-Sep.2000)

Agricultural Research Corporation, Crop protection Center, Sudan**.**

Title: *Basic Studies on control of root parasitic weeds in semiarid regions*

My activities have been performed in the Ecophysiology subdivision, headed by Prof. Inanaga, S. in collaboration with Dr Sugimoto, Y., Associate Professor.

Research activities

My research activities have been focused on development of biological control strategies to *Striga hermonthica* being devastating to cereal cultivation in Africa and responsible for most of the losses encountered in these crops and a shift towards desertification and hunger. During my stay, I was able to identify fungal toxins that can inhibit *Striga* seed germination and deplete the seed reserves in the soil. In addition these toxins could be utilized to synthesise new herbicides for *Striga* OR otherwise their mode of action could be efficiently used to invent new herbicide molecules. My research activities opened new avenues for research in *Striga* program on going in the ecophysiology subdivision at ALRC.

Editorial activities

I edited quite a number of English manuscripts of Staff and students as well as conferences and symposia presentations and reports. I am happy to be able to help in this essential part of research.

Publications submitted during the sabbatical period at ALRC

1. Ahmed, N. E., Sugimoto , Y., Babiker, A. G. T., Mohamed, O. E., Ma, Y. Inanaga, S. and Nakajima, H. (2000): Effects of some isolates of *Fusarium solani* on germination of *Striga hermonthica* (Del.) Benth. (submitted to Weed Science).
2. Ahmed, N. E., Kanan, H. O., Sugimoto, Y., Ma, Y. Q. and Inanaga, S. (2000): Effect of Imidacloprid on Incidence of Tomato Yellow Leaf Curl Virus. (Accepted for publication in Plant Disease)
3. Ahmed, N. E., Kanan, H.O., Inanaga, S., Ma Y.Q. and Sugimoto Y. (2000): Effects of Pesticide Seed Treatment on Aphids Control and Wheat Yield Improvement (Accepted for publication in Crop Protection)
4. Sugimoto, Y., Ahmed, N. E., Yasuda, N. and Inanaga, S. (2000): *Striga hermonthica* seed germination inhibitors produced by *Fusarium* solani (To be submitted to Phytochemistry)
5. Gamiel, S. A., Ahmed, N. E., Ma, Y., Inanaga, S. and Sugimoto, Y. (2000): More important weed species as host plants of powdery mildew. Accepted for publication in Journal of Agric. Sciences, Sudan.
6. Sugimoto, Y., Miyamoto, M., Inanaga, S. and Ahmed, N. E. (2000): Non-host tissue cultures produce haustorium inducing substance for root prasitic weed Striga hermonthica. Invited chapter in Recent Research Development in Phytochemistry, Publisher Research Signpost, India.
7. Mohamed, O. E., Ahmed, N.E., Eneji, E., Ma, Y., Ali, E., Inanaga, S. and Sugimoto, Y. (2000): Effect of sowing dates on incidence of bacterial blight and yield of of cotton. Submitted to J. Field Crops Research.

International Symposium

- Ahmed, N. E., Sugimoto, Y., Yasuda, N. and Inanaga, S. (2000): Effect of *Fusarium solani* on germination of *Striga hermonthica*. 27th Annual Meeting of the Plant Growth Regulating Society of America, Hawaii July 30 – August 3.
- Ahmed, N. E., Sugimoto, Y., Ma, Y. and Inanaga, S. (2000): Toxins of Fusarium solani and their effects on *Striga hermonthica* seed germination. Seventh Arab Congress of Plant Protection, Amman, Jordan, 22-26 October.

- Ma, Y., Inanaga, S., Sugimoto, Y., Han, Q., Feng, X., Tian, k., Li, H., Liu, G., Babiker, AGT. And Ahmed, N. E. (2001): Inducing of *Striga hemonthica* (Del.) Benth seeds germination by Chinese traditional medical herbs. Weed Science Society of America, Greensboro, North Carolina, Feb. 11-14.

National symposium

Sugimoto, Y., Ahmed, N.E., Yasuda, F. and Inanaga, S. (2000): Germination inhibitors against the root parasitic weed *Striga hermonthica* produced by *Fusarium solani*. Annual Meeting of Japanese Growth Regulation Society, Tokyo, October 2000.

Students Assistance

1. Supervising the MSc. Study of Norifumi Yasuda, Arid Land Research Center, Tottori University.

Seminars and Lectures

1. Crop Protection in Sudan, an Overview of the state of research and development work on Integrated Pest Management (IPM). Utsunomiya University, Center for Research on Wild Plants May 31, 2000.
2. The above mentioned seminar was given with some modifications, Arid Land Research Center Tottori University, Tottori, June, 19,2000
3. Farmers Field School Approach, Arid Land Research Center Tottori University, Tottori, June 26, 2000.

Summary of the Seminars

1. *Crop Protection in Sudan, an Overview of the state of research and development work on Integrated Pest Management (IPM).*

In Sudan, there is a wide range of basic knowledge gained in the different aspects of crop protection. Implementation of this knowledge has up to now succeed in very few cases. Integrated pest management had become an acceptable strategy to control pests and diseases. The deficit in IPM relates to biological pest control and establishment of the bases for process development such as mass breeding and culturing of natural enemies. The current requirement to complement the existing chemical control system is to design IPM strategy suitable for the existing cultivation system. Biological crop protection strategy created by adoption of IPM in field crops should be extended to vegetable crops. It became very clear that promotion of naturally occurring benificials could be introduced very quickly and at no cost. However, economic relations between these natural enemies and the ecosystem should be evaluated and accurately determined to attract farmers to adopt IPM.

2. *Farmer Field school:*

The farmer field school (FFS) approach requires a change of attitude of both farmers and extension staff involved. In contrast to the traditional top –down approach, in which the extensionists or researchers (top) introduce a new technology to the farmers (base) to be implemented according to their instructions. FFS approach is based on participatory approach in which extensionists and farmers are considered equal partners. This approach aims at changing farmer skills of crop management for a safe environment and human health. It focuses on the agro-ecosystem of the crop, relation and interactions of the crop with the environment. This is achieved by non-formal system of adult education using long season group meetings in the field. Learning is based on learning by doing and to make use of farmer traditional knowledge. New technologies are introduced and adapted to farmer local conditions and farmers existing ideas are transferred to research topics. Group meetings and participatory approach, stimulate discussion and create farmer- to- farmer extension service. It also increases self-reliance of the farmers and reduces their dependence on outside services. Simple problems may be easily solved through knowledge and experience from a fellow farmer, and more complicated problems can be well formulated and addressed to specialized services.

Research

Basic studies on control of root parasitic weeds in semi-arid regions

Striga hermonthica is a root parasitic weed, which seriously affects sorghum cultivation in Africa. The damage inflicted by this parasite on cereals may account to > 70%. The parasite is characterized by their high efficiency to produce seeds, which will remain viable for up to 20 years in the soil. The seeds remain dormant in the soil until triggered by adequate rains and an external germination stimulant naturally produced by host plants. Once germinated, the parasite is attached to the host plant within 3-5 days or the seedling dies. Several methods of stimulating *Striga* germination had been identified and suggested for control of the parasite in agricultural system. However, the instability and high cost of synthetic stimulants precluded their usefulness and use of stimulant producing non-host plants in a crop rotation with host plant cereals appear to be unacceptable to traditional farmers in the region. The method needs a long time to deplete the seed reservoir in the soil and become economically and socially acceptable. Several methods of control have been recommended, but because of high cost and other logistic reasons, none of them has been adopted to any appreciable extent in farmers' fields.

Recently, interests in exploiting microbes and their toxins to control weeds, including *Striga* have been developed. Many fungi including *Fusarium* spp. were reported to have a potential as bioherbicides for *Striga* and a number of other weeds.

Fusarium solani isolated from infected *Striga* plant growing parasitically on sorghum was found very effective in inhibiting *Striga* seed germination. Our study was directed to investigate the production of toxins by this isolate as inhibitors to *Striga* seed germination and their impact on *Striga* control within the existing agricultural system. Suitable culture medium for the fungus growth and production of inhibitory toxins was elected. Effective application time of these toxins was studied to verify the mechanism of action, which remains a question. Our results indicated the presence of at least four toxins with the potential to inhibit *Striga* seed germination. Identification of these toxins was performed using NMR, Mass spectra, UV detector, and other analytical methods. Effective concentration of each toxin on *Striga* seed germination was detected and their effects on growth parameters of some important cultivated crops in sub-Saharan region were reported.

(3) Professor H. S. Ibrahim

Visiting Professor (Apr.1999-Mar.2000)

Land and Water Research Center, Agricultural Research Corporation, Sudan**.**

Research work:

1 - *Effect of low soil moisture level on the root growth of two-grain sorghum cultivars of varying drought tolerance.*

Scientists in identifying the basis of sorghum drought tolerance have followed several approaches. The pattern of root growth in the drought tolerant cultivars has been one of these approaches. This was a glass house experiment conducted on Tottori sand dune soil in large root boxes (50 x 50 x 50 cm). Two sorghum cultivars, Gadambalia (drought tolerant) and Tabat (drought susceptible) were grown under two soil moisture levels. These levels were 0.01 (control) and 0.5 MPa (drought-stressed). The experiment continued for 8 weeks.

Drought stressed Gadambalia had the highest root length density (RLD), at the top 45cm of the soil; whereas control Gadambalia had the least RLD at that depth. Drought stressed Tabat had the least RLD below 45cm, but the control Tabat had the highest RLD at that depth. It was found that the elongation angle (θ) of the nodal roots had increased with drought in both cultivars. The increase in the elongation angle of the nodal roots was more and significant in case of Gadambalia. This indicates that cultivar Gadambalia root system can grow deeper under drought conditions.

2 - *Effects of low soil moisture on some morphological and physiological parameters of two-grain sorghum cultivars.*

The treatments in this experiment are similar to those in the first experiment except that the experiment is a field experiment. The soil was a loam soil. The experiment was sown in mid August 1999 and harvested on 26 November 2000. Gadambalia had more growth than Tabat from seedling to almost the flowering stage. After flowering up to maturity the rate of growth was more in Tabat than Gadambalia. Drought reduced photosynthesis, stomatal conductance, transpiration rate and leaf water potential in both cultivars, but the reduction was more significant in Tabat. Drought stressed Gadambalia had relatively higher water potential than the drought stressed Tabat and it maintained this high water potential throughout its growth period. Stressed Tabat exhibited leaf rolling and leaf firing, but Gadambalia did not. Drought reduced the fresh-dry biomass, but the reduction in Gadambalia was insignificant and minimum. Drought did not reduce the grain yield of Gadambalia significantly. It was found that the drought stressed Gadambalia had the highest number of nodal roots, even than the control.

Gadambalia probably achieved drought tolerance through the following mechanisms:

a. High rate of growth from seedling to the start of the flowering stage, and thus accumulating more assimilates for post- flowering stages.
b. Reduced leaf area from flowering to maturity and hence reduced transpiration during post flowering stages.
c. Stressed Gadambalia maintained relatively high leaf water potential.
d. It did not have leaf rolling nor leaf firing, and hence bigger leaf area was available for photosynthesis.
e. Higher number of nodal roots in drought stressed Gadambalia and thus Gadambalia could have extracted more water.

Seminar:

The author gave the following presentation:

Effects of farm yard manure and urea application on crop yield, quality and soil properties in a semi-arid region, Sudan. 1999. The Annual Meeting of Joint Research. Arid Land Research Center, Tottori University, Tottori. 8 December 1999.

Abstract

The soil of the Gezira is heavy cracking clay belonging to the Vertisols. It has low organic matter content with total N of 350-mg kg^{-1} and organic C of 3.4-g kg^{-1}, slow hydraulic conductivity and high bulk density. These unsuitable soil characteristics have contributed in the low cotton and wheat yields attained on this soil in the Sudan. A field experiment investigating the effects of FYM and urea application on cotton and wheat yields and soil properties was conducted for three consecutive seasons (1995-1998) at the experimental farm of the Gezira Research Station, Wad Medani, Sudan. The field trial was a factorial experiment in which FYM was applied at 3 rates 0, 10 and 20 t ha^{-1} and urea at 5 levels 0, 21.5, 43.0, 64.5 and 86 kg N ha^{-1}. Application of FYM or urea significantly increased the cotton and wheat yields. The combined application of 20 t FYM + 64.5 kg N urea to cotton and of 10 t FYM + 64.5 kg N or 20 t FYM + 43.0 kg N ha^{-1} to wheat attained the highest crop yields. This represents cotton fiber yield increase of 15.3 % and wheat grain yield increases of 37 and 30% over the standard practice (86 kg N ha^{-1}) respectively. FYM and urea increased total -N uptake by wheat. FYM increased soil total- N, organic - C and hydraulic conductivity and decreased the bulk density of the top 30cm of the soil. Urea increased only the soil total- N.

It is concluded that the combined application of FYM and inorganic N fertilizer is recommended, as it is beneficial for both the crop and the soil. It is worth- mentioning that the total animal population of the Sudan is 120 million head out of which two millions are found in the Gezira Scheme where this experiment

was conducted.

Publications:

The following papers have been written jointly with some of the staff of the Ecophysiology Department of the ALRC and the staff of the Agricultural Research Corporation, ARC, Sudan: -

1- lbrahim, H. S., Ali, I.A., Eid, T. M. and Inanaga, S. (l999): Wheat response to farm yard manure and urea application in the semi- arid environment of Gezira, Sudan. Submitted for publication to Journal of Plant Nutrition, USA

2- Ibrahim, H. S., Ali, I.A., Eid, T. M. and Inanaga, S. (1999): Wheat irrigation water management under the arid environment of northern Sudan. Submitted for Publication to the Journal of Arid Environments, UK.

3- Ibrahim, H. S., Mohamed, G. S., Adlan, M. A., Ma, Y. and Inanaga, S. (2000): Response of wheat to nitrogen and phosphorus application on major soil types of the northern region of Sudan. Plant Nutrition for the Next Millennium. Xth International Colloquium for the Optimization of Plant Nutrition. 8-13 (April 2000) Cairo- Arab Republic of Egypt.

(4) Professor Christiaan Dirksen

COE Visiting Professor (June.1999-Mar.2000)

Wageningen Agricultural University, The Netherlands

Title: *Measurement and prediction of water flow, solute transport and root water uptake in the vadose zone*

My activities have been performed mainly in the Subdivision of Land Conservation, headed by Prof. T. Yamamoto, in close cooperation with Dr. M. Inoue, Associate Professor. I have also been involved in experiments of Dr. H. Fujimaki (COE Researcher) and a number of graduate students. A few activities involved other subdivisions.

Research activities

My two major research activities have been focused on the development of soil physical measurements and on irrigation management for salinity control, in particular the relative effect of matric and osmotic soil water potentials on the root water uptake distribution. These past experiences fit very well in the ongoing research program at ALRC.

The numerical model HYSWASOR for simulating hysteretic water and solute transport in the root zone is particularly well suited for simulating the lysimeter experiments.

Lysimeter experiments

1. *Scheduling of salt leaching for improving fertilizer use efficiency.*

For agricultural production in arid and semi-arid regions to be sustainable, salts must be leached regularly out of the root zone by excess irrigation. With the harmful salts, however, fertilizers are also flushed out of the root zone. This study investigated how leaching might be optimized for maximum fertilizer use efficiency. Two lysimeters were planted with sorghum; one was irrigated daily with excess water for leaching, the other was irrigated intermittently and excess irrigation was applied only after the solute concentration reached a critical value. Fertilizer was mixed with the irrigation water. Both lysimeters received the same total amount of water. The ground water table was maintained at 120 cm depth. Soil water content, pressure head, salt concentration (EC), and root density distribution were measured in detail. The results have been reported in a MSc thesis (A. Inoue).

2. *Irrigation with different water qualities.*

Three lysimeters planted with sorghum were irrigated 11 times over a 70-day period with water of 0, 1500, and 5000 ppm, respectively. The ground water table was maintained at 30 cm depth without

drainage. Soil water contents, pressure heads, and salt concentrations were measured. The data are being used to tailor HYSWASOR to the lysimeter experimental conditions.

3. *Semi-automatic TDR measurements in a citrus lysimeter experiment (Prof. T. Yano).*

These soil water content and electrical conductivity measurements are aimed at detecting differences in root water uptake between root zone quadrants due to temperature differences.

Soil physics measurements

1. *Soil water flux meter*

Dr. Inoue and I designed an apparatus for automatic *in-situ* measurements of soil water fluxes in unsaturated soil. This apparatus and the needed accessories have been constructed commercially and are being tested. There is much need for such an apparatus; several Japanese researchers have been working on similar projects.

2. *Soil hydraulic properties*

Dr. Inoue and Dr. Fujimaki have been developing new direct and inverse methods to determine the soil hydraulic properties. I have had a modest input in these activities.

Teaching activities

While at ALRC, my book Soil Physics Measurements was published. I taught and demonstrated the chapter on dielectric methods for measuring soil water content and electrical conductivity to ALRC staff and students and also to the JICA participants.

The book Elements of Soil Physics, which I co-authored, is the major text used for teaching Soil Physics in Wageningen. It has received international acclaim as a teaching tool. I reviewed this book for JICA participants.

The numerical simulation model HYSWASOR has been explained and demonstrated to the graduate class of Dr. Inoue. All basic transport processes in unsaturated soil can be simulated with this model. Its run-time display of water content, matric and osmotic soil water potentials, and root water uptake distributions are very helpful to understand these processes.

Editorial activities

I edited quite a number of English manuscripts of staff and students of various subdivisions and often also substantially improved the presentation of the subject matter. I am happy to be able to help in this essential part of research.

Presentations and visits

Presentations on Soil Physics Measurements: Water and Solute Transport in Unsaturated Soil, or Root Water Uptake, Salinity and Irrigation Management were given at:

- Tottori University. Arid Land Research Center,
- Tsukuba Bioscience Hall,
- Hiroshima University, Department of Civil and Environmental Engineering
- Kyoto University. Department of Forestry,
- Kyushu University. Biotron Institute,
- Saga University. Department of Agricultural Sciences,
- Tokyo University. Department of Biological and Environmental Engineering,

I discussed various research subjects of mutual interest with many researchers and teachers at these institutions, as well as at the following institutions:

- National Research Institute of Agricultural Engineering (NRIAE), Tsukuba,
- National Institute of Agro-Environmental Sciences (NIAES), Tsukuba,
- National Research Institute for Earth Science and Disaster Prevention (NIED), Tsukuba
-Tokyo National Research Institute of Cultural Properties (TNRICP).

Seminars and Lectures

Root Water Uptake, Salinity and lrrigation Management (Dec. 8, 1999)

The actual amount of water supplied by flood irrigation depends on the spatial distribution of the infiltration rate. In order to recharge the root zone everywhere, areas with high infiltration rate necessarily receive too much water, resulting in large leaching fractions (LF). Flood irrigation is also impractical and wasteful in sandy soils because of their small water retention properties.

In contrast, water application by high-frequency irrigation with closed systems (e.g., trickle irrigation) is not controlled by the soil hydraulic properties, but by the irrigation system and its management. This flux-controlled system can easily be automated to tailor the water gifts at all times to plant needs, thus allowing very small LF without large labor costs. The root water uptake distribution becomes shallower with increasing irrigation frequency, causing the soil solution salinity to increase rapidly with depth. Most plant salt tolerance studies have been carried out under quite uniform water (matric potential) and salinity (osmotic potential) conditions in the root zone, such as occur under flood irrigation at large leaching fractions.

To manage high-frequency irrigation at small LF most efficiently, a number of questions need to be answered, such as:

a) How do plants take up water under non-uniform matric and osmotic potential distributions?
b) What is the transpiration under these conditions that differ from conventional flood irrigation?
c) What is the minimum LF without unacceptable yield and quality reductions?
d) Which type of sensors can be used at what depths for optimal automation of the irrigation?
e) How can a small target LF be attained and verified, considering the large effect of small errors in estimated evapotranspiration?

Against this background, principles of water and salt transport, root water uptake, irrigation frequency, leaching fraction, crop salt tolerance, water quality, and high-frequency irrigation at small LF have been discussed, illustrated by methods and results of laboratory and field experiments with citrus and alfalfa. The need for direct measurements of the water flux out of the bottom of the root zone to determine actual LF has also been stressed. Special attention has been given to root water uptake models under non-uniform matric and osmotic soil water potential distributions. Because high-frequency irrigation continually imposes wetting and drying cycles on the root zone, hysteresis must be taken into account. The numerical model HYSWASOR for simulating hysteretic water and solute transport in the root zone is particularly well suited for analyzing and evaluating complex results of lysimeter experiments and testing root water uptake models.

Publications:

- Inoue, M. and Dirksen, C. (2000): An automatically operated soil water flux meter of improved design, Submitted for publication to JSIDRE.