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Crop Production in the 21st Century: Global Climate Change, Environmental Risks and Water Scarcity

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Abstracts

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Session 1: Global Climate Change and Water Issues

Chaired by David Broday

OVERVIEW OF GLOBAL CLIMATE CHANGE WITH FOCUS OVER THE MEDITERRANEAN

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Based on RegCM3 regional climate model applied over the east Mediterranean, the IPCC's A2 and B2 scenarios indicate that the temperature increase over Northern Israel during the years 2071-2100 is expected to be about 4-6 ºC higher than the rise in temperatures during the control period of 1961-1990. Whereas a negative rainfall trend is found for the A2 scenario over Northern Israel, the B2 scenario shows no significant trend. In general, there is an increasing tendency toward extreme events, i.e., there is a significant increase in the number of days with extreme precipitation over Northern Israel in both the A2 and B2 scenarios in comparison with present climate. Similarly, the standard deviation of the average annual precipitation is higher in the A2 and B2 scenarios with respect to present climate, suggesting an increasing trend towards both drier and wetter years in the 21st century. These changes in extreme events are analyzed along with expected changes in synoptic systems. For instance, the number of days with a

dry "Red-Sea trough" synoptic system has doubled over the last 50 years, which can be directly related to the recently observed and projected climate changes.

A new super-high-resolution (20 km) global climate model was validated to reproduce with a high degree of accuracy the precipitation and the present-day streamflow in the Fertile Crescent. Previously, this was not possible due to lack of observations and of atmospheric models with sufficient resolution. It is projected that by the end of the 21st century, the Fertile Crescent will lose its current shape, or virtually disappear. The annual discharge for the Euphrates River will decrease significantly (29-73%), and the stream flow in the Jordan River will almost disappear.

P. Alpert, S.O. Krichak, H. Shafir , D. Haim, and I. Osetinsky, "Climatic trends to extremes employing regional modeling and statistical interpretation over the E. Mediterranean", Global and Planetary Change, 63, 163-170, 2008.

A. Kitoh, A. Yatagai and P. Alpert, "First super-high-resolution modeling study that the ancient "Fertile Crescent" will disappear in this century", Hydrological Research Letters,p. 1-4, 2008.

GLOBAL WARMING AND ITS IMPACTS ON WATER AVAILABILITY FOR AGRICULTURE

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Climate change in the western US is predicted to produce significant changes in temperature, precipitation amount and their spatial/temporal distributions. These changes will have profound affects on California's water resources and on both natural and agricultural ecosystems.

California, with its limited water supply and the reliance of the State's economy on agriculture, faces enormous challenges in the near future, to analyze and to forecast climate change impacts. A recent series of white papers (California Climate Center, 2005) laid out the impacts of possible climate change scenarios in California resulting from increasing atmospheric concentration of green house gases (GHGs) on coastal sea level, precipitation, water resources, agriculture, public health, forestry, and electricity production and demand. Results were based on three GHG

scenarios: lower emission, medium-high emission, and higher emission scenarios, using 3 different Global Climate Models (GCM's). California's farmers are expected to respond to reducing surface water supplies and/or increasing irrigation water requirements by supplementing available irrigation waters by increased groundwater pumping. However, increased pumping will increase energy costs as hydraulic heads in the aquifers drop, whereas the lesser quality of groundwater will generally increase soil salinity.

The results of a recently developed hydrosalinity model will be presented, summarizing impacts of climate change on irrigation water availability, crop water requirement (ET) and soil salinity for a 1,400 km2 irrigated area in the San Joaquin Valley that includes a large part of Westlands Water District (WWD), Broadview Water District (BWD) and 11 additional water districts. This model couples subsurface hydrology with climate change and will provide for an integrated approach towards understanding the impact of climate change on CA's irrigated agriculture, including the forecasting of the effect of various climate change scenarios on potential crop ET for typical crops in the SJV; and the

impact of climate change on irrigation water availability, crop water requirement and soil salinity in the 21st century.

SATELLITE-DERIVED DROUGHT ASSESSMENT: MERITS AND LIMITATIONS

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A large number of water- and climate-related applications, such as drought monitoring, are based on spaceborne-derived relationships between land surface temperature (LST) and the Normalized Difference Vegetation Index (NDVI). The majority of these applications rely on the existence of a negative slope between the two variables found from site- and time-specific studies. The current paper investigates the generality of the LST-NDVI relationship over a wide range of moisture and climatic/radiation regimes encountered over the North American continent (up to 60° N) during the summer growing season (April – September). Information on LST and NDVI comes from long-term (21-year) datasets obtained by the Advanced Very High Resolution Radiometer (AVHRR).

It was found that when water is the limiting factor for vegetation growth (typical situation for low latitudes of the study area and during the mid-season), the LST-NDVI correlation is negative. However, when energy is the limiting factor for vegetation growth, (in higher latitudes and elevations, especially at the beginning of the growing season) a positive correlation exists between LST and NDVI. Forward multiple regression analysis revealed that during the beginning and the end of the growing season, solar radiation is the predominant factor driving the correlation between LST and NDVI, while other

biophysical variables play a lesser role. Air temperature is the primary factor in mid summer.

It is concluded that there is a need to use the LST-NDVI relationship with caution and to restrict its applications as a drought index to areas and periods where negative correlations are observed.

WATER AND ENERGY: NEED FOR PLANNING COORDINATION

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Water and energy are inextricably connected, so approaches to sustainably managing these two essential resources must be carefully aligned as well. Optimization strategies that look at the technologies, policies, laws and so forth related to only one of these resources inevitably over exploit the other. For example, in much of rural India, policies aimed at keeping electric energy costs low for farmers, which in itself fosters energy inefficiencies, often result in excessive pumping of groundwater, leading to severe water shortages. This paper will focus specifically on the groundwater and energy connections but will touch on other water-energy nexuses as well.

In most all contemporary societies, energy is needed to access and use water, just as water is needed to access and use energy. The word *hydropower* suggests that water is in fact sometimes the source of energy, but water is required for many other aspects of energy production, such as power plant cooling processes, transporting and treating raw energy sources, and production of biomass for biofuels. When water is used in the production of energy, determination of whether it is a consumptive or non consumptive use is important, because non consumptive uses, such as most hydropower plants, allow the potential for the water to be used for other purposes, such as irrigation. Some water uses for energy production can also result in degrading the water quality if it is not consumed. Similarly, use of water requires energy to be transported, lifted, and treated.

Key to optimizing the use of water and energy at their nexus is to strategically coordinate the planning for use of water and energy. Historically, however, we have often thought of access to water and energy very differently. Some societies view water as an inalienable, or even God given right of all people. Energy, on the other hand, is rarely ever viewed

that way. We sometimes think of water as being free while we almost always expect that energy must be paid for. Obviously, use of water is almost never free because access, transport, and processing have real costs, including those of energy. Still in most societies water is a public good, often provided by public or other not for-profit entities. Energy, however, is typically seen as a major for-profit industry. These differing perceptions make optimization of the so called water-energy nexus difficult to rationalize, if the objective function for energy is cost-benefit optimization and for water --equality or equity of access to all.

This paper explores through some case studies the concerns or creating unsustainable systems of water and energy use, especially with regard to sustainable groundwater.

Session 2: Agriculture and Global Changes

Chaired by Ahmed Nasser

THE ACTUAL AND POTENTIAL EFFECTS OF SOIL

THE ACTUAL AND POTENTIAL EFFECTS OF SOIL MANAGEMENT ON THE EXACERBATION OR MITIGATION OF THE GREENHOUSE EFFECT

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The world's soils contain some 1500 Gt of organic carbon to a depth of 1 meter, and some 2400 Gt to a depth of 2 meters. Terrestrial biota contains an additional amount estimated at 560 Gt. These quantities total 3 to 4 times the amount of gaseous carbon in the atmosphere (~ 730 Gt). In addition to organic carbon, some soils contain large amounts of inorganic carbon, mainly in the forms of Ca and Mg carbonates (estimated to total some 700-750 Gt). The soil's store of carbon is labile rather than permanent: it can be augmented by net absorption from the atmosphere (via photosynthesis and accumulation of plant residues) or diminished by net emission to the atmosphere due to decomposition. The balance of soil carbon is greatly influenced by anthropogenic factors, including the clearing or restoration of natural vegetation and the patterns of land use. Cultivation spurs microbial respiration and organic matter decomposition. In well aerated soils, organic matter oxidizes and releases CO2; in poorly aerated soils, it undergoes reduction and tends to release CH4, as well as N2O, both of which are powerful greenhouse gases. Under prolonged and intensive cultivation, some soils may lose over half of their original organic matter content. Especially vulnerable are soils of marshy areas (such as histosols), which -- when warmed and drained -- may emit very large quantities of those greenhouse gases. Though agricultural soils acted in the past as significant sources of atmospheric CO2 enrichment, they offer an opportunity in the coming decades to reabsorb substantial

amounts of CO2 from the atmosphere and sequester the carbon as additional organic matter. The historical loss of carbon in the world's agricultural soils has been variously estimated to total some 42 to 78 Gt. Ideally, we might hope for complete restoration of that loss. In reality, however, soil degradation resulting from tillage, erosion, and other processes has diminished the capactiy of many soils to fully recover their original organic matter content in reasonable time. The actual carbon-sink potential of many soils, assuming the adoption of recommended strategies of soil management (minimum or zero tillage, maintenance of soil-enriching vegetation and mulching, as well as agroforestry) may be about two-thirds of the histoical C loss. The potential sequestration of carbon in global agricultural soils through improved management practices has been estimated to total between 600 and 900 Mt per year over a period of several decades. In addition, agriculture may contribute to mitigation of the greenhouse effect by the production of renewable-energy crops to replace fossil fuels. If implemented on a large scale, such practices may help to reduce global warming, boost crop yields, control soil erosion, improve soil structure and water quality, enhance biodiversity, and save energy.

USING DIVERSITY IN TIMES OF CLIMATE CHANGE: PRODUCTIVITY, NUTRIENTS AND WATER USE

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To support a growing human population under conditions of climate change, it is essential to increase agricultural production and its efficiency in terms of land, nutrients and water. Plant diversity has in several studies been found to be positively related to biomass production (*1-6*). Coexisting plant species can preferentially use distinct nutrient pools (*7, 8*). Therefore, there may be less competition between species than the intra-specific competition, stimulating biomass production in diverse swards. Species may also root in different depths, thus leading to a better use of available nutrients and water. This may also increase the species' resilience to climatic changes, which may be further improved in the more species-rich systems, because of a larger probability of including a species that can deal with the changed conditions.

Besides stimulating productivity, an increased use of nutrients may lead to reduced losses of nitrogenous species such as nitrous oxide (N_2O). Agriculturally managed soils are the main sources of this greenhouse gas, with agriculture accounting for 84% of global anthropogenic N_2O emissions (*9*). However, there is also evidence for an uptake and further reduction of N_2O from the atmosphere into the soil, so that soils may act as a sink for N_2O (*10, 11*). The influencing factors for this net N_2O consumption are not understood yet (*10*), but lower soil N contents due to increased plant uptake may stimulate the soils' sink strength for N_2O.

So far, the relationship between productivity, efficiency and species' richness has mainly been studied in experimental grassland plots sown and weeded several times per year to yield different species numbers (e.g., 4, 12*).* Such management is unrelated to agricultural situations. However, early studies show that the benefits of plant diversity are also valid and relevant for agricultural grassland (*13*) and cropping systems (*14-16*). Thus, the use of plant and crop diversity may be a tool to improve the sustainability, resilience and productivity of agriculture in times of climate change and at the same time protect diversity.

M. A. Altieri, Agriculture, Ecosystems and Environment 74, 19 (1999).

J. M. Bullock, R. F. Pywell, M. J. W. Burke, K. J. Walker, *Ecology Letters* 4, 185 (2001).

M. B. Dodd, D. J. Barker, M. E. Wedderburn, *Grass and Forage Science* 59, 29 (2004).

A. Hector *et al.*, *Science* 286, 1123 (1999).

J. van Ruijven, F. Berendse, *Ecology Letters* 6, 170 (2003).

J. van Ruijven, F. Berendse, *PNAS* 102, 695 (2005).

A.Weigelt, R. Bol, R. D. Bardgett, *Oecologia* 142, 627 (2005).

M.S. Bret-Harte *et al.*, *Journal of Ecology* 92, 635 (2004).

P. Smith et al., Philosophical Transactions of the Royal Society B: Biological Sciences 363, 789 (2008).

L. Chapuis-Lardy, N. Wrage, A. Metay, J.-L. Chotte, M. Bernoux, *Global Change Biology* 13, 1 (2007).

N. Wrage et al., Rapid Communications in Mass Spectrometry 18, 1 (2004).

D. Tilman, P. B. Reich, J. M. H. Knops, *Nature* 441, 629 (2006).

Y. Bai et al., Journal of Applied Ecology 44, 1023 (2007).

S. Di Falco, J.-P. Chavas, *Land Economics* 84, 83 (2008).

A. Omer, U. Pascual, N. P. Russell, *Journal of Agricultural Economics* **58**, 308 (2007).

S. Di Falco, J.-P. Chavas, M. Smale, *Agricultural Economics* 36, 147 (2007).

THE IMPACT OF GLOBAL CHANGE ON N_2O EMISSION RATES BY CHANGE IN ENVIRONMENTAL CONDITIONS AND IN MICROBIAL COMMUNITY STRUCTURE

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Nitrous oxide (N_2O) emission to the atmosphere is a major environmental concern due to its contribution to global warming, and to the destruction of the stratospheric ozone layer. Microbial processes in soils contribute up to 70% of the atmospheric budget of N_2O, as a by-product during nitrification and as an intermediate product during denitrification. Variation in N_2O emission rates has been demonstrated for different pure cultures of bacterial ammonia oxidizers (AOB) incubated under similar conditions, suggesting a potential impact of community structure on N_2O emission rates.

Increases in precipitation, in nitrogen input and in temperature, as expected under cinerarium of global change, have shown to greatly increase N_2O emissions from soils. These environmental factors have also shown to influence the community structure of ammonia oxidizers and denitrifiers. Furthermore, interactions between these environmental factors affected N_2O emission rates from a manipulated Californian meadow soil, resulting in different overall effects than those predicted from studies of each factor alone. For example, in soils receiving high amounts of fertilizer, the rates were influenced by an interaction between soil moisture and temperature, such that at 20°C increasing soil moisture resulted in an increase in the rates, and at 30°C the highest rate was observed at moderate soil moisture. Also community structure of ammonia oxidizers in this soil had been influenced by the same interaction.

The inter-relationships of the variables that best explain the N_2O emission rates in this Californian soil were studied by path analysis, an extension of multiple regression. Path analysis revealed that in the high fertilizer treatment, the major path by which ammonia influenced N_2O rates due to nitrification was indirect, through an influence on the

abundance of one particular phylogenetic group (AOB "cluster 10"), the dominant population of AOB in the non-manipulated source soil. In contrast, in the low and moderate fertilizer treatments, soil moisture influenced the rates both directly (the major path) and indirectly through AOB community structure. This study thus demonstrates also the potential indirect contribution of change in environmental factors to variability in N_2O emission rates, by AOB community shifts.

ECONOMIC ANALYSIS OF CLIMATE-CHANGE IMPACTS ON AGRICULTURAL PROFITABILITY AND LAND USE: THE CASE OF ISRAEL

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We develop a regional scale economic model for analyzing climate-change impacts on agriculture. Non-linear production functions describing yield responses to land allocation, water application and water salinity are integrated into a mathematical programming model. The responses to water quantity and quality are estimated by the use of scientific-based models simulating equilibrium at the root zone among plant's water uptake, soil salinity and soil's water content. Internalization of land allocation among crops is based on Howitt's PMP calibration approach (1995). The model, therefore, enables assessment of climate-change impacts on optimal agricultural management, where adaptation is considered endogenously with respect to both the extensive and intensive margins.

The model is applied to the case of Israel. We divide the country into 14 regions and estimate regional future precipitation levels by implementing a climate-change down-scaling procedure. Then the model computes optimal agricultural managements under these projected rainfall levels. The results indicate a reduction of about 20% in statewide annual agricultural net-revenues by the year 2100 in comparison to 2002. Land allocated to field crops is increased at the expense of forages and vegetables. The share of field crops and forages in the agricultural irrigation-water allotment increases, while that of vegetables declines.

Session 3: Irrigation, Plant Nutrition and Pollution

Chaired by Kashchandra G. Raghothama

BEST AGRICULTURAL MANAGEMENT PRACTICES (TILLAGE, CROPPING AND NUTRIENTS) FOR REDUCING WATER POLLUTION AND HYPOXIA IN LARGE WATER BODIES IN THE WORLD

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Today, more than one billion people out of the total global population of about 6.5 billion lack access to safe drinking water. More than 2.5 billion people in the world do not have access to good sanitation systems to avoid water borne diseases. Several thousand children die every day from water borne diseases because of lack of availability of good quality drinking water. The major question for the scientific and academic community gathered here today for the Daliha Greidinger Water Symposium is to determine what needs to be done to reverse these trends and bring water security, especially adequate supply of good quality water for all living species on the planet, including humans, animals, plants, and rest of fauna and flora. What are the research, training, policy, and economic needs for this water agenda?

The intensification of agriculture has led to heavy use of agricultural chemicals and negative impacts of the use of pesticides and fertilizers on human health and the rest of the environment have become a source of major concern for the society. Much of the untreated municipal and industrial waste water is flowing directly into rivers, and groundwater resouirces are becoming polluted in majority of countries. Poor environmental practices and lack of desire to implement local environmental regulations are the main causes for this dilemma. Water quality challenges, especially landscape activies causing water pollution, and the relationship to water borne diseases and human/animal health should be the focus of major research efforts in the 21st century. If we do not increase research efforts in this area, society is likely to face many unknown consequences affecting human health, especially the pathways of migration of chemicals and pathogens from water to food and to humans. The purpose of this presentation would be to share some of the emerging research priorities and curriculum needs for universities in the world to help solve water supply and water quality problems in the 21st century.

Agricultural production systems in the USA and rest of the world have changed significantly in recent years and the public is concerned about the impacts of these production systems systems on surface and groundwater quality. Due to these concerns, several studies were conducted between 1990-2008 at Iowa State University, to develop tillage, cropping, and nutrient best management practices (BMP) with the goals of reducing input costs and controlling surface and groundwater pollution. This paper presents the results and overall evaluations of Iowa water quality studies on chemical and cropping management practices and their impacts on water quality. This paper also presents the outcome of implementation of BMPs in watersheds in reducing nutrient loadings to large water bodies such as the Gulf of Mexico, and assessing the overall impacts on hypoxia. These studies indicate that better land use activities on Midwest soils have the potential to mitigate environmental concerns of the production agriculture.

PLANT NUTRITION CHALLENGES AND OPPORTUNITIES FOR THE GLOBAL FERTILIZER INDUSTRY

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Population growth, urbanization and advances in technology aimed at increasing productivity were the main driving forces affecting agriculture in the second half of the 20th century. More recently, additional driving factors have emerged, such as income growth and related changes in consumption patterns; greater attention to environmental and social concerns, and to food quality and safety; and the development of technologies aimed at optimizing resource use efficiency.

Fertilizer nutrients are important for crop growth and development; however, their misuse can impact the hydrosphere and the atmosphere through eutrophication of surface waters or emission of greenhouse gases. The fertilizer industry is challenged to supply the needed fertilizer products and help the farmers to apply them at the right rate, time and place, not only to increase production from a limited land area but also to ensure safe and high-quality food. In order to respond to these challenges and opportunities, the fertilizer industry has to innovate and adopt best available techniques in fertilizer production, and develop and promote site- and crop-specific fertilizer best management practices tailored to the socio-economic context of the farming systems.

ON THE FEASIBILITY OF DESALINATING WATER FOR IRRIGATION: AGRICULTURAL AND TECHNOLOGICAL PERSPECTIVES

Uri Yermiyahu

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Desalination of brackish water and of seawater is fast emerging as a feasible solution to the increasing global scarcity of fresh water. In December 2005, a new seawater desalination plant was opened in Ashkelon, a city on Israel's southern Mediterranean coast. Its 100 million m^3/year production makes it the world's largest reverse osmosis desalination facility presently in operation. The facility constitutes the first operational phase of a broader national policy to add over 500 million m^3/year of water to present resources, providing an additional 15% to Israel's fresh water supply. While the Ashkelon facility was designed to provide potable water for domestic consumption, because of the relatively modest population densities in the south of Israel, a substantial percentage of the desalinated seawater is delivered to agriculture.

The lowered total salinity and lowered concentrations of NaCl salts are beneficial to agriculture, allowing higher yields and lower salt leaching requirements. Yet, desalination separates not only the undesirable salts from the water, but also removes ions that are essential to plant growth. Findings that characterize the effects of desalinized waters on vegetable crops in Israel are presented. The negative implications of low concentrations of calcium, magnesium, and sulfur in desalinized water as well as the high concentrations of boron, high pH and low buffer capacity are examined.

Desalinated water has a tendency to react, with deleterious effects on agricultural production, when blended with other water sources or when agricultural supplements are added. Recommendations for modification of present strategies and standards for desalinized brackish water or seawater for alternatively providing water for agricultural use only or for mixed municipal and agricultural consumption are presented, to ensure that the transition to desalination will contribute to increased yields and will strengthen the farming sector.

THE USE OF POTASSIUM NITRATE FOR INCREASING WATER-USE EFFICIENCY AND FOR COMBATING SALINITY IN AGRICULTURAL CROPS

Oded Achilea

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As potable water is becoming more and more scarce, less water of adequate quality is left for irrigation of agricultural and horticultural crops, and the existing water becomes more saline.

Water-use-efficiency (WUE) quantifies the gain in dry (or fresh) plant weight in response to the irrigation of a measured amount of water.

Potassic fertilizers generally exhibit high WUE due to K's crucial role in a great variety of plant physiological processes. Adequate, and sometimes, abundant application of potassic fertilizers, markedly improves vegetative biomass production, and improves their defense mechanisms against biotic and abiotic stresses. Potassium, enhances, therefore, the WUE by increasing the crop biomass.

Additionally, potassium has a positive effect on plants' water status via its role in stomata closure mechanism, water acquisition by the roots and limiting water conductance within the plant. These effects were found in plants which considerably vary in their major characteristics, such as sunflowers, olive trees, faba beans, maize and rice.

Nitrate too was found to positively affect WUE by both restricting water loss, and increasing photosynthesis and biomass production in a variety of crops (wheat, zucchini, and fir and poplar trees).

In view of the above said, experiments in which potassium nitrate fertilizer was applied by fertigation and foliar feeding have shown a very clear effect of marked increase in WUE in tomatoes, mango trees, and various citrus cultivars. A large record of increased yields, in response to potassium nitrate-based mineral nutrition, in an extensive list of crops, should be interpreted in the same context.

The applicative conclusion is that growers should adopt enhanced use of potassium nitrate fertilizer, where temporary, mild or severe dry periods are expected. This step will minimize yield losses.

Most cases of reduced crop yields due to salinity can be related to the increased presence of sodium cation and chloride anion in the irrigation water and/or in the soil solution composition. Copious application of potassic fertilizers has proved instrumental in restoring normal plant metabolism that was suppressed by the deleterious effect of the sodium cation under saline conditions. The competition relationship between nitrate and chloride has proved a potent tool in suppressing the harmful outcome in chloride-struck plants, by plentiful application of nitrate fertilizers under salinity conditions, as shown by experiments with maize, beans, avocado and tobacco.

Considering the above said, experiments in which potassium nitrate fertilizer was applied by fertigation under salinity conditions have shown a very clear effect of marked increase in yield and in WUE. The addition of potassium nitrate to sodium chloride-rich nutrient solutions has produced increased yields in citrus, tomatoes, maize, peanuts, lettuce and cabbage, proving, thereby, that the synergistic effect of the specific combination of potassium and nitrate overweighs the increase in the electrical conductivity of soil solution.

The applicative conclusion is that growers should adopt enhanced use of potassium nitrate fertilizer, where temporary or continuous, mild or severe salinity conditions are expected. This step will minimize yield losses and yield quality deterioration.

PLANT RESPONSES TO NUTRIENT STRESS AND WATER DEFICIENCY

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Plants continually adapt to water and nutrient stress by activating a multitude of mechanisms. Some of these adaptive mechanisms overlap and complement each other. A commonly observed modification in plants in response to water and nutrient stresses, particularly phosphate, is modification in root system. While the phosphate deficiency results in proliferation of lateral roots to increase the surface area, deeper roots in drought tolerant plants help them acquire water from the lower horizons. In addition, mycorrhizal

association strongly promoted and regulated under phosphate deficiency, also helps the plants to acquire water from the rhizosphere. Reduced transpiration and closure of stomata are hallmarks of water and phosphate deficiency. Phytohormones such as ABA, auxin and cytokinin are involved in these responses. Expression of hundreds of genes including many transcription factors is altered under phosphate starvation. Altered expression of phosphate starvation-induced transcription factors such as WRKY, Zinc finger protein, MYB and Ethylene Response Factor (ERF) resulted in altered root system architecture and phosphate homeostasis. MYB and ERF genes also regulate the synthesis of the phytohormone GA. These results suggest that multiple responses of plants to phosphate starvation could impact plants' ability to adapt to drought stress. Genetic modification of plants by biotechnological or molecular breeding approaches using these genes could lead to modification in root system architecture, phosphate homeostasis and adaptation to water stress.

Session 4: Carbon Sequestration and Soil Productivity

Chaired by Dan Yakir

CONSERVATION TILLAGE AND COVER CROPPING: EFFECTS ON SOIL CARBON, NITROGEN AND CROP WATER USE IN THE COASTAL PLAIN OF GEORGIA

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Agriculture in the Southeastern Coastal Plain of the USA faces several challenges. Rising season temperatures, humidity, pressures from weeds, insect and diseases are all high. Soils in the region typically have sandy surface horizons that are low in carbon and nitrogen, have low water retention capacities, and are susceptible to erosion. These characteristics require intensive management of water, nutrients, and pesticides and may increase the potential for surface water pollution as well as competition with other sectors for water allocation.

Although not typically thought of as a rainfall deficit region, rainfall during the growing season is highly variable and often in the form of locally-intense convective storms or

tropical depressions. Irrigated acreage in southern Georgia has increased substantially since the 1970s. By the year 2000, the agricultural sector had become the largest water user in the state. In 2004, cotton, corn, and peanuts represented 85% of row crop production in Georgia, with nearly 90% of the acreage in the Coastal Plain. For the period 2000–2002, a study by the University of Georgia reported that growing season monthly irrigation levels may vary from 2.5–41 mm per month during typical rainfall years and from 2.5–66 mm per month for drought years. Reduced tillage and surface residue retention has been demonstrated to increase infiltration, soil water content, and plant available water while decreasing runoff and erosion. Conservation tillage systems are currently in place on approximately 45% of the agricultural acreage in Georgia and approximately 45% of the acreage under conservation tillage is irrigated (about 21% of total agricultural acreage).

Previous results from our team demonstrated: conservation tillage can reduce rainfall runoff and increase infiltration in these systems by 29% to 46%; decrease soil erosion by 350%; and decrease soil carbon loss associated with eroded sediments by 700%. Our work has also demonstrated the high potential for organic matter mineralization in these sandy soils, by showing the depletion of NH4-N from poultry litter within 21 days of application followed by peak soil NO3-N concentrations within 28 days of application.

Here we report preliminary data from several new projects that suggest a tight relationship between management (winter cover cropping and conservation tillage); patterns in soil physical properties (surface structure and depth to compacted layer); patterns in soil carbon and nitrogen; and patterns in crop nitrogen availability, water use, and resilience to water stress.

AFFORESTATION IN THE SEMI-ARID REGION DURING CLIMATE CHANGE: TRADEOFFS AMONG CARBON SEQUESTRATION WATER USE AND SURFACE RADIATION BUDGETS

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Water and carbon are strategic commodities. Rapidly growing population and a trend towards urbanization as well as predicted climatic changes will heighten shortages in water and in open land available for forestation and carbon storage. An alarming turn in this respect comes from the IPCC 2007 report predicting ~20% decrease in precipitation in the Mediterranean basin region, associated with warming of 2-4˚C by the end of the century.

Here we focus specifically on the complex impact of land use, forestation/shrubland/agriculture on carbon (C) sequestration potential, earth surface temperature (energy budget), and water yield (WY, the difference between precipitation and loss by evapotranspiration). These aspects and the unavoidable tradeoffs among them are often neglected, but should be used as a critical tool in formulating national and regional water and carbon management policies. A possible consequence of widespread decrease in evapotranspiration, due to land use changes or high CO2 induced reduction in plant transpiration, is increased runoff, contributing to floods, erosion and loss of fertile soils. Evapotranspiration, however, not only influences WY, but also provides the driving force for forest growth and carbon sequestration.

We have demonstrated, using the Yatir forest as a case study, that the semi-arid zone has, in fact, greater potential than initially expected in the development of productive pine forests with significant carbon storage capacity. In addition to the obvious tradeoffs between WY and C sequestration, afforestation in the semi-arid region also has larger than expected effects on surface temperature. This is because of the prevalent high solar radiation/low cloud cover, and the large changes in surface albedo (reflectivity) associated with forestation of local bare surfaces. On sufficiently large scales, such changes in surface energy budget can influence local climate. Therefore, changes in forest cover due to climate change or human activities have complex but important consequences for water, carbon and the local environment, which are poorly understood

at present. We are at a good position to extend our present research to significantly advance our knowledge on this front.

ROOT RESPIRATION IN RESPONSE TO HIGH SOIL TEMPERATURE AND COMPETITION AND ITS AFFECT ON GLOBAL CARBON METABOLISM

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Respiration is a major carbon metabolism process. The current paper presents two different studies that examined root respiratory characteristics associated with high soil temperature and root competition.

In the first study we examined two Agrostis species: thermal Agrostis scabra, and A. stolonifera. Roots of both species were exposed to high or low soil temperature. Root respiration rate, alternative respiration (AP), specific respiratory costs and the acclimation potentials were significantly different between the two species. The results suggest that acclimation of respiratory carbon metabolism plays an important role in root survival of Agrostis species under high soil temperatures and is related to the capacity to control respiratory rates and increase respiratory efficiency by lowering maintenance and ion uptake costs.

The second study examined the effects of self/non-self root competition with neighboring plants on root respiration. Roots of pea (Pisum sativum) plants were grown either with split roots (non self) or without (self) for three weeks. Root respiration increased close to 30% in the "non self" plants as compared to the "self" plants.

The two studies presented provide new data on carbon metabolism affected by, root respiration that is essential for climate change models. These, neglect respiratory changes in general, and root respiration specifically, especially in such wide phenomena in nature such as high soil temperatures and self vs. non-self respiration competion.

BIOCHAR FOR 21ST CENTURY CHALLENGES:

CARBON SINK, SOIL AMELIORANT, AND ENERGY SOURCE

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Biochar, a charcoal produced from biomass, can sequester carbon in soil for hundreds to thousands of years. Pre-Columbian Amazonian Indians used it to enhance soil productivity, and it is still found in large concentrations in Amazonas soils abandoned thousands of years ago. Its modern equivalent is produced by pyrolysis, the direct thermal decomposition of biomass in the absence of oxygen to an array of solid (biochar), liquid (bio-oil) and gas (syngas) products. The specific yield from pyrolysis depends on process conditions, and can be optimized to produce either energy or biochar. Being an exothermic process, biochar production produces 3-9 times more energy than is invested, and is carbon-negative (withdraws CO_2 from the atmosphere). In addition, modest additions of biochar to soil have been found to reduce N_2O emissions by up to 80% and to completely suppress methane emissions, thus directly reducing agricultural greenhouse gas emissions. While some fresh organic matter is needed by agricultural soil to maintain its productivity, much agricultural waste (and other kinds of waste streams) can be turned directly into biochar, bio-oil, and syngas.

In addition to its potential for carbon sequestration and decreased greenhouse gas emissions from agriculture, biochar has numerous benefits as a soil amendment: increased plant growth yield, improved water quality, reduced leaching of nutrients, reduced soil acidity, increased water retention, and reduced irrigation and fertilizer requirements. The quality of biochar as a soil ameliorant depends on the character of the biochar and on regional conditions including soil type and condition (depleted or healthy), temperature, and humidity.

Estimates for biochar residence time in soil range from 100 to 10,000 yrs, with 5,000 being a common estimate. Whilst the means by which biochar mineralizes are not

completely known, it is apparent that mineralization rates depend on the feedstock material, the extent of charring, the surface:volume ratio of the particles, and the soil environment. Lab experiments confirm a decrease in carbon mineralization with increasing pyrolysis temperature, so careful control over the charring process can increase the soil residence time of the biochar C.

Bio-oil created in the pyrolysis process can be used as a replacement for numerous applications where fuel oil is used, as well as a feedstock for chemical production. Syngas and bio-oil can also be "upgraded" to transportation fuels like biodiesel and gasoline substitutes. If biochar is used for the production of energy rather than as a soil amendment, it can be directly substituted for any application that uses coal. Syngas can be burned directly, used as a fuel for gas engines and gas turbines, or used in the production of methanol and hydrogen.

At least three different deployment tactics can be suggested for employing biomass pyrolysis efficiently: (i) a centralized system where all the biomass in a region is brought to a pyrolysis plant for processing; (ii) a lower-tech pyrolysis kiln used by a single farmer or shared amongst a small group of farmers; or (iii) a mobile system where a truck equipped with a pyrolyzer is driven from farm to farm to pyrolyze biomass. The mobile system can be powered by the syngas stream, the biochar returned directly to the earth, and the bio-oil transported to a refinery or storage site.

Session 5: Advances in Plant Sciences

Chaired by Peter Neumann

HYDRAULIC CONDUCTANCE TRAIT TO IMPROVE CROP YIELD IN WATER-DEFICIT ENVIRONMENTS

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Plants were confronted with an arid atmosphere when they moved from the seas to land. To survive, plants evolved a waxy cuticle to prevent free water evaporation and stomata to open when conditions were appropriate for photosynthesis. While opening stomata allowed CO_2 diffusion into leaves, the stomata pore also allowed water vapor to diffuse from leaves. The driving diffusion gradient for CO_2 is established by the CO_2 concentration that exists in the leaf and for water vapor by the vapor pressure deficit (VPD), defined by the difference between saturated vapor pressure in the leaf and atmospheric vapor pressure. Accounting for these gradients, diffusion of these two gases through the same pores results in an intimate, physical relationship between growth and transpiration. This relationship has been studied for more than 300 years and now

appears to be fully resolved. A coefficient defininining this physical ratio has been both theoretically and experimentally defined for crop species.

An option to improve the overall ratio of growth to water use by plants is possible by simply restricting plant gas exchange when VPD is high. In this approach, stomata closure could be a result of limited hydraulic conductance in the plant, imposing a maximum water flux rate. Limiting transpiration when VPD is high would conserve soil water for sustained crop growth late in the season when water deficits may develop. The possibility of limited plant hydraulic conductance was studied in soybean (*Glycine max* Merr. L) genotype PI 416937, which had been observed in the field to have delayed wilting under water deficit, as compared to all other genotypes. This genotype was found to express a maximum transpiration rate at VPD above about 2 kPa. Studies showed that low hydraulic conductance existed in the leaves in this genotype.

We have now found that the heritability of this trait is complex and phenotyping for this trait in the field appears necessary. Since the trait should result in increased canopy temperature under high VPD, inexpensive infrared thermometers were used to make measurements in the field. While a range of canopy temperatures was readily measured, this approach proved to be useful only as a negative screen, and hot canopy temperature was not necessarily associated with the maximum transpiration trait.

For practical application of this trait, the key questions are how often and where would the trait result in increased soybean yield. A simulation model was used to study the possible yield gain across the U.S. where soybean is grown. This analysis showed that the trait would be beneficial in about 75 % of the years in most regions of the country; even in wet years the yield loss was small. Dr. Tommy Carter, a soybean breeder with the ARS-USDA, Raleigh, NC, has now released two lines that express the delayed wilting phenotype, and have increased yield under water-deficit conditions. These lines have now entered the breeding programs of nearly all commercial soybean seed companies in the U.S.

IMPROVING PLANT STRESS TOLERANCE AND YIELD PRODUCTION: IS THE TONOPLAST AQUAPORIN A KEY TO ISOHYDRIC VS. ANISOHYDRIC CONVERSION?

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Anisohydric plants are thought to be more drought tolerant than isohydric plants. However, the molecular mechanism determining whether the plant water potential during the day remains constant or not regardless of the evaporative demand (isohydric vs. anisohydric plant) is not known.

Here, it was hypothesized that aquaporins take part in this molecular mechanism determining the plant isohydric threshold. Using computational mining, tonoplast intrinsic protein 2;2 (SlTIP2;2), a key tonoplast aquaporin, was selected within the large multifunctional gene family of tomato (*Solanum lycopersicum*) aquaporins, based on its induction in response to abiotic stresses. *SlTIP2;2*-transformed plants (TOM-SlTIP2;2) were compared with controls in physiological assays at cellular and whole-plant levels.

Constitutive expression of *SlTIP2;2* increased the osmotic water permeability of the cell and whole-plant transpiration. Under drought, these plants transpired more and for longer periods than control plants, reaching a lower relative water content, a behavior characterizing anisohydric plants. In 3-year consecutive commercial glasshouse trials, TOM-SlTIP2;2 showed significant increases in fruit yield, harvest index and plant mass relative to the control, under both normal and water-stress conditions.

In conclusion, it is proposed that the regulation mechanism controlling tonoplast water permeability might have a role in determining the whole-plant ishohydric threshold, and thus its abiotic stress tolerance.

THE PATTERNS OF SYNCHRONIZED PHYSIOLOGICALLY-INDUCED OSCILLATIONS IN WHOLE-PLANT TRANSPIRATION AND THEIR ROLE UNDER DROUGHT CONDITIONS

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Regulation of stomatal aperture is the plant's major means of controlling transpiration rate and CO_2 uptake. Beyond their effect on the daily transpiration pattern, short-term fluctuations in ambient conditions can induce an oscillatory pattern of the momentary transpiration rate. However, oscillations in momentary transpiration, independent of the existence or the pattern of momentary fluctuations in ambient conditions, have been reported at the stomatal, leaf-patch, and whole-leaf levels.

Here we report on synchronized oscillations in transpiration rate at the whole-plant level that are connected to temporal variations in the ambient conditions, and on synchronized oscillations whose pattern is independent of this driving force. The latter oscillations have frequencies of 20 to 50 min, which indicate involvement of a synchronizing mechanism and long-distance signaling. The momentary transpiration rate was calculated by the first derivative of the measured weight-time series. Since differentiation of a time series acts as a high-pass filter and, as such, significantly amplifies high-frequency noise, these noises were eliminated by smoothing (detrending) the measured data prior to differentiation. The smoothing retained the leading variation of the whole-plant transpiration rate patterns. The data analysis indicated that under high water availability, oscillations of whole-plant transpiration rate for tomato were partially self-regulated, and for poplar (isohydric plant) and sunflower (anisohydric plant) they coincided with fluctuations in ambient conditions. As the soil progressively dried, the gradual decrease in transpiration rate of tomato plants was accompanied by an increase in self-regulated oscillations and changes in pattern. The differences in oscillation patterns among the studied plants indicated that self-regulated oscillations in whole-plant transpiration rate are a means for plants to control leaf water potential homeostasis. The generation of self-

regulated oscillations in whole plant transpiration rate as water stress increases may indicates that the oscillations prevent xylem water tension from reaching levels at which cavitation can form or maintain xylem tension below a threshold value, to impede runaway cavitation.

A MECHANISM THAT TIMES THE SWITCH TO REPRODUCTION IN PLANTS IS SENSITIVE TO MODERATE CHANGES IN AMBIENT TEMPERATURES

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Plants use seasonal cues to flower at the most appropriate time of year for successful reproduction. It is likely that plants within a certain ecosystem evolved an appropriate mechanism to respond to seasonal environmental cues and the response is moderated in a way that will allow the plants to flower at a time that ensures most successful reproduction.

Difficulties may occur when plants are moved by man, mostly for agricultural purposes, to a different ecosystem and expected to perform in response to environmental cues that they are not adapted to. A different and more serious problem occurs when due to relatively fast global climate changes plants are no longer adapted to their environment and therefore might flower at a time of year in which reproduction is jeopardized. We are studying this process in several species, so that we may be equipped with a better understanding of ways to reduce its damaging effects. Specifically, we try to reveal molecular mechanisms that turn flowering on or off in response to increased ambient temperatures. Here we will provide findings from one species in which increased temperatures changed the ratio between two different transcripts made by the same gene, each encoding a protein with opposite effects on flowering time.

ISO AND ANISOHYDRIC RESPONSES TO SHADING; PREDICTING WATER USE UNDER SCREENS

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Water use of crops shaded by screens and screenhouses has been a focus of our research for a number of years. All shade screens reduce radiation load and decrease wind speed at the crop. If leaf conductance does not respond to shading (i.e., anisohydric), these effects reduce crop water use significantly.

Isohydric plants limit their leaf water potential (LWP), preventing it from dropping below a certain level. That level is apparently related to the hydraulic limits of the plant's water transport system. Isohydric behavior is usually defined as a response to reduced soil water potential. But well irrigated isohydric tree crops that we have studied in Israel typically close stomata during mid-day in hot, clear-sky conditions. For these crops, shading can lead to increased leaf and canopy conductance and productivity, as observed in citrus trees. However, the decrease in water use is minor or even insignificant, although water use efficiency increases.

Quantifying isohydric behavior is important to realistically predict crop water use and requirements, as well as the photosynthetic productivity under screens and in screenhouses. Here, we show that leaf specific hydraulic conductance, leaf area index, critical LWP and climate variables (via the Penman-Monteith equation) can be used to accurately predict canopy conductance and water use in shaded isohydric crops.

ASSESSMENT OF THE EFFECT OF CLIMATE CHANGE ON THE INTERACTIONS OF PLANT, PATHOGEN AND MICROORGANISMS

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Plants are challenged by pathogens, among which fungi are important organisms. A plant pathogen that infects plants may either live in balance with the host plant or may gradually cause an infection that ultimately kills the host plant. The development of a plant disease requires a susceptible host tissue, a compatible pathogen and involves also the natural microflora. Plant pathogens can roughly be divided into two groups, i.e., (i) pathogens whose activity is promoted by high relative humidity (low vapor pressure deficit) and/or water presence on host surface and, (ii) pathogens that are active over a wide range of RH conditions including low RH. The response of pathogens to ranges of temperatures is also distinctive. The prevalence of suitable environmental conditions can tilt the plant-pathogen relationship into a disease situation. The general objective of our project is to model the effect of climate change on plants and their pathogens, illustrate expected scenarios and suggest adaptive measures. Examples of various pathogens and their antagonists will be illustrated.

As an example, we studied parameters related to key components of the development of *Oidium neolycopersici* on tomato leaves and to the development of tomato powdery mildew that it causes. Changes in microclimatic conditions may affect the behavior of the pathogen on the plant surface (i.e., conidial germination, germ tube growth and appressoria formation) during infection, the growth of the fungus within plant tissue and/or the formation and survival of conidia. Ultimately, all of these factors affect disease severity. The range of microclimatic conditions tested was initially wide (5 to 35ºC, 23 to 99% RH and 0 to 5150 lux) and was later narrowed to temperatures of 18-28ºC, 70-99% RH and three levels of irradiation. The relationships between the different microclimate parameters and disease severity were studies.

In the growth chamber experiments, temperature changes (in 2ºC increments) resulted in significant changes in disease severity. For instance a change from 22 to 24ºC resulted in a more than two-fold increase in disease severity and a change from 26 to 28ºC caused

diminishing of the disease. Reductions in RH were associated with significant reductions in disease severity. The ability of microorganisms and plant extracts to suppress disease was generally more significant at 26 than at 24ºC. After finding that these microclimate changes significantly affected disease severity, we tested two climate regimes in commercial greenhouses. In the warmer greenhouse (27-32ºC), which was closed during the day, the level of disease severity was significantly lower than in the standard commercial greenhouse (20-28ºC). In parallel we demonstrate the effect of microclimate on populations of beneficial/ pathogen-antagonistic microorganisms.

Disease development is the cumulative effect of the effects of various factors on the host and pathogen. Various a-biotic factors affected different aspects of the disease cycle. It was demonstrated that a slight change in microclimate conditions can affect the outcome of the interaction of plants with a pathogen, as well as the outcome of the interactions of the plant-pathogen relationship with microbial control agents. The effects of climate change may be different in different plant-pathogen systems. Nevertheless, it is clear that such effects will occur and that adaptive measures need to be developed in order to respond to these expected changes.

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Session 6: Water Resources Management

Chaired by Amjad Aliewi

MANAGING WATER FOR A SUSTAINABLE LIFE

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Water is essential for all forms of life and a viable economy. Water is also essential for food and a quality environment. Without adequate food, environmental quality and a supporting ecosystem, life and the economy will suffer. When water is scarce, just how do we decide how much water to allocate to all competing uses of water that enhance a sustainable quality of life? This paper addresses some of the complexities of answering such a question, especially related to environmental flow allocations. Only relatively recently have we all begun to recognize the importance of not only keeping humans from becoming too thirsty, but also of maintaining healthy functioning ecosystems, as indeed these ecosystems are what we depend on to sustain our own lives. We are indeed a part of our ecosystems. We depend upon our environment and ecosystems to sustain the quality of our lives, if not life itself.

Balancing water demand allocations, especially when the demands exceed supplies, is a complex, and largely political problem. It is likely to become even more complex, political and contentious in the future, as populations grow and as water quantities and qualities become even more variable and uncertain. At least the political process of making allocations should be informed by scientific studies of the likely impacts of alternative allocation decisions, especially with respect to environmental flow demands.

How do we allocate scarce water supplies optimally among all demands that impact on the quality of, or even on the existence of, life – both human and ecosystem life – in times of critical water scarcity? The temptation is to ignore environmental flow demands. Such decisions can be at the expense of maintaining a sustainable place to live and prosper.

CHALLENGES AND OPPORTUNITIES FOR DEVELOPING INTERNATIONAL COLLABORATIVE PROGRAMS TO SOLVE WATER QUANTITY AND WATER QUALITY ISSUES OF THE 21ST CENTURY

Sylvana Li

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Clean, potable water is the single greatest need in both developing and developed nations. Approximately two-thirds of the world's population is exposed to water-borne disease each year and nearly 70% of the world's population lives in water stressed environments. Globally, agriculture is responsible for 80-90% of the water use – particularly irrigated agriculture.

Water resources management is one of the high priority areas for the U.S. Department of Agriculture (USDA)'s Foreign Agricultural Service (FAS). The goal is to achieve agency missions through the development of knowledge and technologies for improved water management. Countries in the Middle East and North Africa are currently facing significant issues of water scarcity. Addressing these issues requires new technologies for pollution control and water re-use. USDA/FAS has taken a leading effort to develop worldwide capacity building programs related to water, environment and agriculture of bilateral and multilateral collaboration in countries and regions including China, India, Iraq, Romania, the Middle East (Jordan, Israel, and West Bank/Gaza), North Africa (Morocco, Algeria, Tunisia and Libya) and Gulf countries (UAE, Oman, Lebanon, Bahrain, Qatar and Kuwait). The purpose of this presentation would be to highlight some of the ongoing programs of the USDA-FAS in Asia, the Middle East, Gulf countries and

North Africa and discuss challenges and opportunities for international collaboration between institution of higher education and global granting agencies.

MANAGEMENT TECHNOLOGIES FOR SOIL AND WATER RESOURCES

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The decline in availability of freshwater for irrigation due to its allocation to other sectors (urban and industry), especially in arid and semi-arid regions such as the Mediterranean basin, has resulted in intensive use of waters of poor quality. Furthermore, inappropriate management of coastal aquifers, highly sensitive to disturbance, may lead to their destruction as a source of fresh water much earlier than other aquifers that are not connected to the sea. Besides, large hydrotechnical interventions such as construction of dams, hydroelectric power plants and other hydrotechnical structures can also change the water regime within a catchment area, and consequently lower the quality of water for different purposes. Estuaries and river deltas are one of the coastal areas most at risk from human activities worldwide, and many of them are intensively-farmed arable land. All the mentioned combinations occur in the Mediterranean part of Croatia as well as in most Mediterranean and other parts of the world. Water management that focuses on issues such as water allocation and water quality almost always have a cross-border component. Neretva River Valley is located in the southern part of the Croatian Adriatic coast. Most of the catchments area spreads to the neighbouring country. The delta of the Neretva River is a hydro-ameliorated area being intensively used nowadays as fertile agricultural land. Agriculture mainly involves growing of citrus and other Mediterranean fruits, as well as early vegetables, regularly applying irrigation. Irrigation, as a regular growing measure, has led to significant increase in water abstraction, giving rise to growing environmental problems. Both the quantitative aspect and the problem of water quality and pollution in Neretva River Valley are continuously increasing, whereas agriculture certainly is not the only player disrupting the water cycle and quality. Based on all of the information mentioned above, the research program set out to develop and validate

appropriate knowledge and technologies for improving the production capacity of the available soil and water resources of the region. In order to achieve this goal and purpose in the most efficient way, research in soil and water management is carried out under two main research programme components, namely, land resources surveys and inventory and soil and water management in saline conditions.

Rational management of soil salinization requires an understanding of how soil salt concentrations vary across the land. The key to successful management of salinization is the early recognition of salinized soil; implementation of methods to combat incipient salinization, such as improved irrigation, drainage, and farming practices; and monitoring of salinized land on a regular basis. Conventional techniques of identifying and monitoring salinized land are time-consuming and rather expensive. Therefore, the potentials of remote sensing for identification and monitoring of soil salinization have been used and monitoring of the water quality in addition to the adequate management may certainly prevent the damages on the agricultural land and crops. Thus, the surface water monitoring program was established in 1997 at 22 locations that are considered potential sources of irrigation water in the Neretva River Valley. Analyses of the data showed that salt concentrations in surface waters of the Neretva River Valley change substantially during the year as a result of the hydrological regime, demonstrating a spatial as well as a temporal variability of the water electrical conductivity and sodium and chlorine concentrations.

The second topic referred to the sustainability of the existing land use practices, and aimed to development and test a generic framework for assessing ecological risks associated with farming practices in the Croatian coastal part. The first experiment was designed to determine the influence of increasing salt concentrations in irrigation water using different irrigation systems (sprinkler and drip) on crop growth, changes in soil solution composition, changes in leaf tissue mineral content, and changes in crop yield. Saline irrigation reduced the crop growth and thus had detrimental effects on yield. Application of saline water rapidly changed the ion composition of soil solution. Significant changes in Ca, Na and Cl concentrations in soil solution were determined parallel to increasing the irrigation water salinity. The experiment has shown as well that salinity affects nutrient uptake and accumulation and also nutrient partitioning within the plant.

Estuarine sediments are frequently rich in contaminants transported from land. It is also well known that sediments can faithfully record environmental impact, including the heavy metal contamination, on fluvial systems over time. For the Neretva estuary, the main source of contaminants is industries in the upper part of the catchment area. The lower part is an intensively agricultural region, producing generally vegetables and fruits, and salinity poses an increasing threat in the Neretva estuary, since the major route of human exposure to toxic elements is via consumption of vegetables grown on contaminated soil. Soil salinity, especially increased concentration of dissolved Cl^- ligands, significantly influences solubility of some trace elements like cadmium. Results of the greenhouse experiment with muskmelon grown on Cd-enriched peat provide evidence that cadmium transfer from saline and contaminated organic soil to edible fruity tissue is low and not mediated by NaCl salinity.

In conclusion, appropriate soil and water conservation technologies for protection and proper conservation of productive soils and rehabilitation of salinized soils should be fostered and monitored. Appropriate technologies for the management of saline soils should be developed and adopted, as well as recommendations for the improvement of irrigation schemes. Networking between countries and research centers dealing with soil and water management is inevitable in preventing problems, especially trans-boundary pollution.

COMBINATION OF CATCHMENT BASIN MODELING AND ECONOMIC ANALYSIS TO DETERMINE OPTIMAL REHABILITATION STRATEGIES FOR MULTIPLE USE TRANSBOUNDARY STREAMS

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This paper deals with a hydro-economic modeling of the Alexander-Zeimar river basin, which is a transboundary river originating in the Palestinian Authority (PA) and flowing through Israel to the Mediterranean Sea. As a result of population growth, most of the flowing water in the region's streams was captured and diverted to meet the growing needs for water supply. Thus, most rivers and streams turned into dry river-beds, which deliver only sporadic floods during the winter. Simultaneously, the same accelerating population growth resulted in uncontrolled discharge of raw sewage into the rivers, transforming many of them into open sewage channels. In recent years, various organizations (governmental and non-governmental) have invested increasing efforts to improve the poor condition of the rivers and streams. Thus, questions arise as to how water should be allocated to the streams, what quality should be achieved, for what it should be used (recreation, agriculture, etc.) and what might be the economic implications of all the above. The situation is even more complicated, since many of the region's streams (especially in Israel and the Palestinian Authority) are actually transboundary streams flowing through different political entities.

The goal of this research was to optimize water uses in a river basin while assessing the benefits and costs accrued by various water quality levels and different uses of the potential water. In order to achieve this goal, the research consisted of the following steps:

- Quantification of all water and pollution sources (past, present and a projection into the future).
- Modelling water quality and quantity within the stream on a basin scale.
- Development of various scenarios for water quality, quantity and water uses. These were explored by considering various alternatives for treatment of pollution sources

(wastewater), options for allocation of different quantities of water to the stream (at different qualities), and options for various uses for the water (agricultural, recreational, environmental, urban, etc.). These scenarios provide detailed descriptions of varying rehabilitation states and their impact on the possible uses of the stream and its water.

- Assessment of the possibilities of cross-border cooperation and non-cooperation and their consequences for both sides.
- A cost-benefit analysis of the various scenarios was performed assessing direct costs and benefits as well as the non-market values (e.g., value of recreational uses, value of environmental enhancement etc.) of the various uses. The non-market values were assessed using economical methods, such as TCM (Travel Cost Method) and CVM (Contingent Valuation Method).
- Analysis of the sustainability of the project in terms of compensation to losers (stakeholders who lose from the policy outlined in any scenario) and self sustained investments. In terms of sustainability, two basic alternatives were studied: 1. Allowing the region to stand on its own with respect to investments and benefits, whereby the governments serve only as a trigger by imposing water quality regulations and other constraints; 2. Allowing national governments to play a more active role, in which they invest and reap part of the benefits.

The research is interdisciplinary in nature, combining river hydrology, water quality and economic and social aspects, to demonstrate the possibility of finding the optimal alternative for restoration of transboundary streams. It tries to show how bi-national cooperation might affect or change the choice of strategy for stream restoration and increase net benefit to the region, emphasizing the importance of cost allocation and economic self sustenance in a restoration project when there is more than one national entity involved.

The talk will describe the work performed so far on the Alexander-Ziemer stream basin, which can serve as a pioneering example of the use of economic – engineering – ecological tools for answering such questions. This stream starts at the Palestinian Authority, flows westward into Israeli territory and eventually reaches the Mediterranean Sea. Each entity has its own vision about water quality, which is not necessarily accepted by all stakeholders; nevertheless, river management between two entities has to consider the vision of both entities in order to achieve best management of the river basin.

Session 7: Advances in Soil-Water-Plant Modeling

Chaired by David Russo

MODELING THAT INTEGRATES ACROSS SCALES AND DISCIPLINES

Holger Meinke

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Water is arguably the most critical resource for agriculture. Increasingly competing claims for water lead to disputes and conflicts in many parts of the world. The causes of water shortages are multi-faceted, ranging from natural climate variability and climate change to higher demand, due to increased population pressure and governance issues. To maintain a viable agricultural sector, science needs to play an important, yet partial role in providing effective and socially acceptable solutions to overcome water shortages and to survive droughts. For instance, water saving techniques, biotechnology and adaptive farm business management suggest a wide range of potential adaptation options that need to be

assessed in terms of their broader environmental, economic and social consequences. Such assessments require "systems thinking" – the ability to quantitatively think through the consequences of proposed systems changes, thereby covering a wide range of temporal, spatial and disciplinary scales. Modeling can help to ensure that technological innovations go hand-in-hand with changes in climate risk management via ex-ante, probabilistic evaluation of technology × management interactions. Used in such a way, models then become essential tools for operational risk management.

This presentation will outline how modeling approaches can be used to evaluate efficacy of potential innovations at various levels of integration: from genotypes to cropping systems (including the human dimension). Through modeling, scale-specific knowledge can be integrated to generate insights into complex system interactions such as the production consequences of alternative biochemical photosynthesis pathways under water stress (C3 vs C4); predicting phenotypic expressions of complex traits in breeding programmes; optimizing crop management via functional-structural plant modeling and quantifying G×M×E interactions in a changing climate. The presentation will draw on examples from Asia and Australia.

MODELING WATER RESOURCES SYSTEMS – TRADITIONAL AND NEW PERSPECTIVES

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The scientific and practical challenge of modeling water resource systems is the need to take into consideration social, economical, environmental, and technical dimensions, and integrate them into a single framework for tradeoff between competing objectives in both time and space. Inherently, such problems involve modeling of water quantity and quality for surface water, groundwater, water distribution systems, reservoirs, rivers, lakes, and other systems, as stand alone or conjunctive components.

This presentation will incorporate two sections: (1) an overview of conceptual issues involved in water resource systems modeling, including simulation tools; optimization methodologies (e.g., simulated annealing, genetic algorithms, ant colony, cross entropy, non-linear programming); and integration approaches, specifically, "embedding" versus

"linking;" and (2) a case study entitled "A Hybrid Model Tree (MT) – Genetic Algorithm (GA) Scheme for Toxic Cyanobacteria Predictions in Lake Kinneret," for demonstrating a new approach for water resource systems modeling.

DETAILED MODELING AS AN ESSENTIAL STEP IN DEVELOPING NEW ANALYSIS TECHNIQUES: THE ISOTOPE PAIRING TECHNIQUE (IPT) CASE STUDY

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Stable isotopes are widely used as a research tool in environmental studies. While large-scale studies use isotope fractionation to identify dominant processes and their end-members, small-scale studies commonly use labeled isotopes as tracers. Regardless of the scale of interest, a mass balance calculation is typically necessary to complete the isotopic analysis.

One such method is the Isotope Pairing Technique (IPT) which utilizes labeled nitrogen isotopes (^{15}N) to quantify denitrification rates in aquatic sediments (Nielsen, 1992). The technique assumes that the only two natural sources of nitrogen are $^{14}NO_3^-$, which is formed by nitrification in the oxic sediments layer, and $^{14}NO_3^-$, which diffuses from the water column above the sediments. Nitrate molecules from both sources diffuse into the anoxic layer, undergo denitrification and produce nitrogen gas ($^{28}N_2$). The IPT, which was developed in order to separately quantify the two paths of natural nitrate denitrification, defines the rate of denitrification of $^{14}NO_3^-$ that is produced by nitrification as D_n and the rate of denitrification of $^{14}NO_3^-$ that diffuses from the water column as D_w. In order to determine the actual values of D_n and D_w, labeled nitrate ($^{15}NO_3^-$) is added to the water column ideally replacing the $^{14}NO_3^-$,which results in the formation of three nitrogen gas isotopes: $^{28}N_2$, $^{29}N_2$ and $^{30}N_2$. In the case where there is ambient $^{14}NO_3^-$ in the water column, a ratio of the added labeled nitrate ($^{15}NO_3^-$) and the total water column nitrate ($^{14}NO_3^- + {}^{15}NO_3^-$) is defined as ε and used in the calculation (Steingruber et al., 2001). The IPT thus offers two simple equations to calculate D_n and D_w using the rate of production of the nitrogen gas isotopes and the value of ε. These two

equations are based on an integral mass balance calculation applied over the whole sediments system. It is assumed that ε represents the ratio of diffusion fluxes (that of the labeled nitrate over that of the total nitrate) and that the formation statistics of the nitrogen gas isotopes ($^{28}N_2$, $^{29}N_2$ and $^{30}N_2$) within the sediments is binomial.

The IPT encounters two major difficulties when applied with ambient $^{14}NO_3^-$. The first is related to the fact that the diffusion flux ratio cannot be estimated by the concentration ratio ε. The second difficulty is related to the fact that the binomial distribution function that controls the formation of the nitrogen gas isotopes is depth dependent and is not uniform across the sediment profile.

These two issues were recently highlighted by a numerical transport model that was developed by us to test the IPT. The model solves four transport differential equations (following the concentration of $^{14}NO_3^-$, $^{15}NO_3^-$, $^{14}NH_4^+$, and O_2) and accounts for all the processes that are assumed valid by the IPT. The solution of a reference model shows that the IPT overestimated D_w by 250% and underestimated D_n by 93.5%. These large discrepancies can be reduced through better experimental design and analysis. Without such modeling efforts similar issues may be overlooked leading to IPT results with potentially large errors.

Nielsen, L.P., 1992, Denitrification in sediment determined from nitrogen isotope pairing, FEMS Microbiology Letters, 86(4): 357-362.

Steingruber, S.M., Friedrich, J., Gachter, R. and Wehrli, B., 2001, Measurement of denitrification in sediments with the N-15 isotope pairing technique, Applied and Environmental Microbiology, 67(9): 3771-3778.

NITRATE INFLUX KINETICS TO VARIOUS COMPONENTS OF THE CORN INTACT ROOT SYSTEM: DATA ACQUISITION FOR UPTAKE MODELING

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Modeling uptake of nitrate by a root system combines the root system growth and distribution, flow of nitrate towards the root and its absorption by the various sections of the root system. We report here a method to measure uptake kinetics of nitrate by selected sections of corn (*Zea mays* L.) root systems, to be used in an uptake model.

Nitrate influx is assumed to occur from low concentrations, by high-affinity mechanism that obeys the Michaelis-Menten kinetics. The method is based on pieces of PVC tubes mounted on the target root section, sealed on both sides, and allowing the absorption of nitrate from the occluded solution for one hour at 25ºC. Gaseous oxygen was injected to ensure adequate respiration. Net influx was calculated from the change in nitrate concentration with time before and after the tube mount, and the dimensions of the tube and the root section. The procedure was repeated with different initial concentrations, with and without 100 μM nitrate pre-treatment for 6 hours. Michaelis-Menten kinetics coefficients were obtained by curve fitting of the influx data against the mean nitrate concentration during the depletion.

The results indicated that the pre-treatment with nitrate is essential to obtain a full activation of the nitrate transporter. Oxygen supply for root respiration was not a limiting factor in this procedure. Comparing the K_m values of different root sections indicated that root classes significantly differed in their affinity to nitrate.

CROP WATER REQUIREMENTS FROM THE PENMAN-MONTEITH MODEL - SENSITIVITY TO CANOPY PARAMETERS

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The Penman-Monteith equation is widely used to calculate crop water requirements. It combines the supply of energy and transport of water vapour from the canopy. Physiological control of transpiration is taken into account by introducing a canopy resistance. Determining and modeling this resistance remains a partially resolved problem. The heterogeneity of environmental conditions and resulting non-uniform stomatal responses within crop canopies are difficult to quantify. Moreover, interactions between plant nutrition, metabolism, and water transport are highly complex and adaptive. Efforts to standardize the practical application of the Penman-Monteith equation to manage irrigation have led to formulations compromising between scientific accuracy and practical convenience (concept of crop coefficients).

Aiming for a practical application of the model, a simple approach to determine canopy resistance was chosen for closed canopy conditions when the soil is a negligible source of heat and vapor. It is based on correlations between *in-situ* measurements of light interceptance and stomatal conductance. A radiation model was used to scale the resulting regression function from leaf to canopy level. The aim of this study was to quantify the effects of parameter uncertainties and contrasting radiation model parameterizations on calculation accuracies.

The study was conducted from 1995 to 1997 in commercial corn fields near Witzenhausen in Central Germany (52.21° N, 9.51°E). Maize (cv. Helix, KWS Einbeck) was planted and managed according to standard optimum practice. The crop experienced typical summer weather fluctuations of the region and was not irrigated. Model outputs were tested against independent sap flow measurements in maize stems.

Statistical uncertainties of canopy conductance parameterizations led to computation errors of up to 2.1 mm/day. The model responded most sensitively to changes of net radiation, followed by alterations of canopy resistances, vapour pressure deficits and aerodynamic resistances.

The computation error decreased considerably on daily and diurnal time scales when the radiation model was driven in multi-layer instead of single layer mode. The application of a dynamic light response function further increased the calculation accuracy of the model. Interactive effects of canopy geometric and stomatal parameterization modes on model performance were not observed.

The Penman-Monteith model was also rearranged for *a posteriori* calculations of canopy conductances using sap-flow measurements as inputs. Computation errors decreased with increasing detail of canopy parameterization, but were generally high. Measured and calculated canopy resistances followed similar values and trends under clear sky conditions, but disagreed under strongly fluctuating weather conditions.

The empirical parameterization of the transpiration model does not account for short-term perturbations within the plant system that are caused by different responses of the canopy and root fractions to dynamic changes of their respective environments. Better mathematical characterizations of causal relations between leaf and root processes controlling transpiration behavior will likely improve the performance of the Penman-Monteith equation under practical conditions.

RELATIONSHIPS BETWEEN SOIL CARBON SEQUESTRATION AND THE CLIMATE CHANGE AS WELL AS ELEVATED ATMOSPHERIC CO2

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Soil carbon sequestration is expected to mitigate the global warming and in turn is affected by the climate change and elevated atmospheric CO_2. Effects of changes in annual average temperature and annual precipitation, as well as elevated atmospheric CO_2 on soil organic carbon (SOC) sequestration for various vegetation covers (i.e., soybean, corn, and grass) were studied, based on the data collected in Nelson Farm and simulation results of CENTURY. Relationships were established between the relative changes of SOC and the relative changes of annual average temperature, precipitation, and atmospheric CO_2 concentration as well as their inter-products for the different vegetation covers. For all the cases, the relationships fit the simulation results very well with high coefficients of determination (R^2) (0.964 to 0.995). Results showed that the SOC was negatively related to the annual average temperature and positively related to the elevated CO_2 for all the vegetation covers, while the SOC was positively related to the precipitation changes for soybean and corn ($p < 0.001$). The SOC was also significantly impacted by the interaction effects among warming, precipitation change, and elevated CO_2 for soybean and grass ($p < 0.001$). Using these relationships, we defined a "cutoff surface" for each of the vegetation covers, which clearly quantifies the conditions for soil carbon sequestration or release under climate change and elevated CO_2. The relationships were also applied successfully to predict the SOC with weather uncertainties. Compared with the simulation results using CENTURY, more than 90% of the predictions using the relationships were within absolute relative error of 10%. The relationships provide a simple yet accurate method to estimate the SOC dynamics under climate change and elevated CO_2.

Session 8: Irrigation with Reclaimed Wastewater

Chaired by Anat Lowengart-Aycicegi

USE OF RECLAIMED WASTEWATER FOR IRRIGATION IN ISRAEL

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The utilization of reclaimed wastewater (RW) in Israeli agriculture has increased in the last two decades by more than threefold, providing nowadays almost half of the irrigation water. The significant increase occurred in parallel to several years of drought during the last decade, which allowed demonstrating the importance of using RW in a region with limited water resources. While the utilization of the RW represents important values of conservation, waste recycling and re-use of nutrients, it also has the potential of exposing human beings and the environment (soil, water, plants) to salinity problems, accumulation of Boron, Sodification and damage to structure (SAR/ESP), potential N and P accumulation in soil and water and undesired effects of dissolved organics. All these potential threats led to a conceptual change in the attitude to RW utilization, emphasizing more the sustainable use of this source, the need to consider much more carefully long-term effects, rather than "believing" that the "soil buffering" ability can tolerate low to medium quality of RW. Significant efforts were devoted to (i) R&D both in developing improved wastewater treatment techniques and agricultural and irrigation practices; (ii) Surveying the effects of RW on farmland and the environment; and (iii) Re-examining

and modifying regulations. This in turn results in improved management of irrigation and fertilization; development and construction of new wastewater treatment plants with improved RW quality. The heavy droughts faced in the last decade led to government recognition (and hence legislation) in the urgent need to create new sources of water mainly via desalination of sea water. The great challenge now is to assure that the overall increase in RW re-use occurring concomitantly with sustaining high agricultural production will continue, while preserving the quality and the availability of this precious resource in the region.

POTENTIAL MICROBIAL RISKS ASSOCIATED WITH UTILIZATION OF TREATED EFFLUENT FOR AGRICULTURAL IRRIGATION

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Scarcity of water in arid and semi-arid regions throughout the world makes treated urban wastewater an unavoidable alternative water source for irrigation. The use of treated wastewater for agricultural irrigation may result in human exposure to pathogens, creating potential public health problems. Outbreaks of foodborne illnesses are increasingly linked to consumption of contaminated fruits and vegetables and irrigation with wastewaters.

A variety of human pathogens are present in raw sewage water. Although the concentrations of the human pathogens decrease during the wastewater reclamation process, the secondary treated effluents most commonly used for irrigation today still contain bacterial human pathogens. Several bacterial pathogens, introduced through contaminated irrigation water, were demonstrated to survive long periods in soil and water, where they have the potential to contaminate crops in the field. Therefore, there is a risk of direct contamination of crops by human pathogens from the treated effluents used for irrigation, as well as a risk of indirect contamination of the crops from contaminated soil at the agricultural site.

Until recently, it was generally recognized that potential health risks to consumers from edible agricultural produce irrigated with contaminated water were associated with the application of contaminated water to the aboveground, edible plant organs. However, recent studies have demonstrated that human pathogens can, to a limited extent, also enter the plants through their roots, translocate and survive in edible, aerial plant tissues.

The practical implications of these new findings for food safety are still not clear. Potential microbial health hazards associated with irrigation with treated effluents no doubt rely on the pathogenic microorganisms' ability to survive and multiply in water, irrigated soil and the harvested edible crop, as well as on their ability to penetrate or adhere to plant tissue, and persist in the crop through the marketing chain.

SELECTED EDCS AND CARCINOGENIC POLLUTANTS IN ISRAEL AQUATIC ENVIRONMENT: IMPLICATIONS FOR SUSTAINABLE WATER REUSE IN AGRICULTURE

Uri Zoller

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Israel is located in a semi-arid region, thus experiencing an extreme shortage of water supplies. More than 5 x 10^8 m^3 of sewage water are produced annually; about 70% of this quantity is currently reused, following treatment, for agricultural irrigation. Since (a) basically, only secondary treatment is applied for sewage water in the country; (b) both the "hard" alkylphenol ethoxylates (APEOs) and the polycyclic aromatic hydrocarbons (PAHs) are barely affected by this treatment; and (c) about 2/3 of the *nonionic* surfactants used until recently in Israel were of the "hard" APEO type, these surfactants and/or their metabolites and, similarly, the PAHs, originating in non completed natural and anthropogenic processes reach surface water -- rivers, estuaries, reservoirs, e.g., Lake Kinneret and groundwater, where they persist as such or as their metabolites/degradation products.

The occurrence and persistence of anthropogenic pollutants with estrogenic-endocrine modulating effects (EDCs – endocrine disrupting chemicals) in aquatic organisms is an issue of major health- and ecology/environment-related concern, worldwide. The population growth and the increasing scarcity of water in many regions of the world have led to a comprehensive reuse of treated wastewater that, ultimately, may cause a long-term concentration buildup of persistent organic chemicals in the closed cycle of water supply, treatment and reuse. The endocrinic/mutagenic potencies of the APEOs, PAHs and their metabolites are well-documented. Less so is the ecotoxicological/health risk potential in groundwater, rivers, sediments and sea water.

Given the reuse, mainly for agricultural irrigation, of ~2/3 of the WWTP effluents in Israel, the major relevant question is: Is this practice compatible with sustainability?

A few years ago we found the APEO concentration profiles of Israel's rivers/streams, Mediterranean Sea coastal water and groundwater to be 12.5-75.0, 4.2-25.0, trace-2.2 μg/L, respectively. Of particular ecotoxicology-related significance is the homologic distribution of the APEOs in the aquatic environment [Fig. 1].

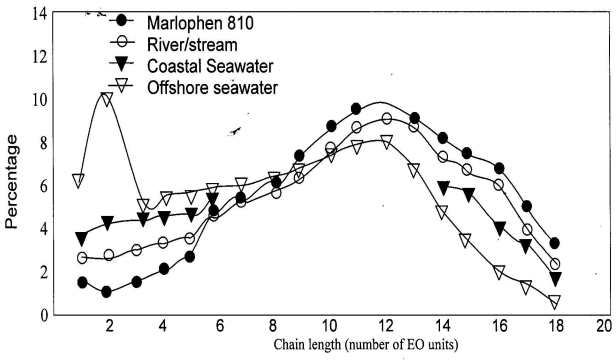

Fig. 1. The homologic distribution of APEOs in Israel surface- and groundwater

Despite the well-established carcinogenic/endocrinic potential of PAHs in rivers, soils, sediments and lakes, the estimation of their impact, in the context of treated wastewater reuse, particularly on groundwater, is rather difficult.

We have found the current concentrations of APEOs and PAHs in a “representative” Israeli river (Hadera) and its sediments to be 11.8-35.7 μg/L and 0.02-0.19 ng/g, respectively. The concentrations of the APEOs in “representative” WWTPs were found to be 41.1-48.0 and 27.4-34.8 μg/L in influents and effluents, respectively, meaning 27.5-34.9% removal. Also we have found the total PAHs concentrations in north Israel’s

WWTPs to be 0.48-5.89 and 0.29-1.17 μg/L in the influents and effluents, respectively. Based on (a) the results of the zebrafish egg production test (ZFEPT) with APEOs; and (b) the low effectiveness of APEOs and PAHs removal in Israel's WWTPs, our preliminary conclusions are that (1) there exists a potential ecotoxicological/health risk problem; and (2) the practice of *conventional* WWTP-treated water reuse in agriculture is incompatible with sustainability.

Reference

Zoller U. Wat. Sci. Tech. 2008, 57(2), 237-242.

THREATS AND VIABLE SOLUTIONS FOR OLIVE MILL WASTEWATER IN ISRAEL: SOME ECONOMICAL, ENVIRONMENTAL AND PRACTICAL CONSIDERATIONS

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About 50,000 m^3 of olive mill wastewater (OMW) are produced in Israel each year. The majority of this industry is based on the three-phase extraction process, and a large portion of it is centered in the Galilee area, in northern Israel. As in other parts of the Mediterranean area, this industry is growing both in Israel and in its neighboring countries. A common and acceptable solution has yet to be found for OMW in Israel. OMW is released to the environment in an uncontrolled manner. This situation is extremely undesired in Israel, because of possible contamination of drinking water resources.

In this work, we analyze several economical, environmental and practical considerations that should be taken into account when recommending viable solutions for this problem. The following considerations are discussed: 1. Choosing an engineered technology versus environmental/agricultural recycling approach; 2. Establishing a regional treatment

facility versus a local one; 3. Setting only a local preliminary engineered treatment system; 4. The viability of two agricultural recycling approaches: land spreading and co-composting of olive mill solid and liquid wastes; and 5. The potential advantages of moving large mills into the two-phase extraction process.

Based on this analysis, agricultural recycling approaches seem superior to some engineered solutions. Yet, critical knowledge gaps still require more research, mainly to address potential agronomic values and the absence of phytoxicity in the two- or three-phase waste composting product. Further study is also needed in order to better select the areas most suitable for OMW spreading with minimum risk to groundwater. This analysis addresses the special conditions that exist in Israel; however, it has more universal implications.

IRRIGATION WITH SEWAGE WATER - YES OR NO?

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The wish to reuse sewage water is understandable. However, it is far from sensible to hope to make it affordable and yet bring it to a quality level appropriate for general use including drinking. The use of only secondary level treatment of the sewage water turns it into a destructive factor to the whole water supply system and a definite factor in destroying agriculture The best the cheapest and in fact the only way to handle sewage for any use is to desalinate it and bring it into the best drinking water quality, and get rid of the concentrates to the sea.

The growing demand for water comes from several factors: (a) A growing population; (b) Climatic changes; (c) Pollution of the water resources. All of these exist in Israel. Impeding the efforts to compensate for the above three is first of all the misbehavior of the decision makers. Furthermore, government policy leads to extremely high costs of electricity, resulting in increased costs of desalination. Finally we need more efficient desalination methods. By now we could have had them all. However the government serves as an impassable obstacle.

We find that using secondary level sewage water treatment and then irrigating leads to about 13 fundamental errors that make its use for irrigation an unforgivable mistake. It leads to a huge waste of money, between 1.5 a 2.5 billion dollars a year. It leads to a loss of water, damage to the crops, very serious diseases and deaths, spoilage of the agricultural markets and destruction of the aquifers.

The Barcelona convention disallows dumping sewage water in the sea. This is to protect the sea. However every soluble particle in the sewage eventually reaches the sea anyhow, despite this convention. However, this convention forces us to fill up first, about a quarter of our drinking glass, with this sewage without any cleaning.

The solution must be to provide a system of conduits collecting the concentrates of the spoiled water and throwing these in the sea. No more water will be put into the ground which is not of a drinking quality. Even if someone in the ministry of environment or the

ministry of health is not convinced that the Barcelona convention is an idiotic crime and that it is a disaster to close all the wells that were found polluted or saline, a law must be passed to ensure that neither the government, the Barcelona convention ,nor anyone else be allowed to pollute our drinking water or prevent us from cleaning it.

REUSE OF WASTE WATER IN AGRICULTURE : THE INDIAN EXPERIENCE

Gurbachan Singh

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About one quarter of the ground water resources used for irrigation of agricultural crops in India are saline and/or sodic. In states like Rajasthan and Haryana 84% and 62%, respectively, of the underground water is of poor quality. In many situations, salty underground waters also contain other toxic ions and heavy metals, such as arsenic, fluoride, selenium and nitrate etc. Continuous use of such waters for irrigation is bound to result in salinity and sodicity problems on the one hand and entry of heavy metals in the food chain on the other hand. Already 6.73 m ha in India are affected by salinity and sodicity. The estimates reveal that if the present level of land degradation continues, the country will face salt problem in about 11.7 m ha by 2025. Over exploitation of ground water for irrigation of rice and wheat cropping systems in good water quality zones in Punjab, Haryana and Western Uttar Pradesh has resulted in draw down of the ground water, thus necessitating the need for replacement of shallow cavity wells (centrifugal pumps) with deep tubewells (submersible pumps). Little or limited exploitation of ground water for irrigation in poor quality ground water regions is resulting in underground flow of poor quality waters from these zones into over exploited fresh water areas. Recent surveys have revealed a shift in the ground water quality in good quality zones.

Another issue is the likely change in the share of water use in agriculture from about 85% at present to about 77% by 2025. This indicates that sustainability of agriculture in the near future will be largely determined by how well the domestic sewage and industrial waste waters will be exploited for irrigation purpose. At present, about 83,000 million

litres of industrial wastewater is generated per day in India, an amount that is expected to double in next two decades. Similarly, about 22,900 million litres/day domestic waste water is generated. Hardly 24% of the wastewater in India is treated.

The Central Soil Salinity Research Institute has developed and standardized guidelines and techniques for the judicious use of poor quality waters, including sewage and industrial effluents. A brief account of these technologies is cited in this paper. The issues and strategies related to wastewater use in agriculture are summarized under the following sub-heads: (i) nature, quality and distribution of poor quality waters in India, (ii) generation of sewage and industrial effluents and their scope for use in agriculture, (iii) guidelines and agronomic practices for reuse of waste water, (iv) phyto and bio remediation approaches for detoxification of soils and waters loaded with heavy metals, (v) experiences of US-India AKI initiative on reuse of waste water in agriculture and (vi) future research, development and required policy initiatives.

Session 9: Advances in Irrigation

Chaired by Shabtai Cohen

ADVANCED IRRIGATION ENGINEERING: PRECISION AND PRECISE[1]

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Irrigation advances in precision irrigation (PI) or site specific irrigation (SSI) have been considerable in research; however, commercialization lags. A primary necessity for PI/SSI is variability in soil texture that affects soil water holding capacity and crop yield. Basically, PI/SSI uses variable rate application technologies, mainly with center pivots, lateral-move or linear irrigation machines, to irrigate prescription-specific management zones within a field, by varying the application to match crop needs or soil water holding constraints. PI/SSI can avoid irrigating management zones with poor internal drainage; zones with poor crop growth or development (from fertility or salinity or other soil factors or even crop diseases); or zones with known problems (rock outcrops, physical obstructions, etc.). One limitation for PI/SSI is defining the objective function for the production goals/constraints. Examples of objective functions include optimizing overall field productivity, minimizing water use, or reducing environmental on-site or off-site impacts. The variable rate applications are achieved by a range of engineering options, from variable nozzle flow rates, pulsing nozzle flows, or multiple nozzles on separate

submains to vary application rates. Newer center pivot and linear machines are controlled by on-board microprocessor systems that are easily integrated with Supervisory Control and Data Acquisition (SCADA) controllers, to integrate communication and variable rate application controls for specific sets of nozzles or individual nozzles for determined management zones. Communication from PI/SSI to center pivot or linear controllers is typically done using radio telemetry, wireless internet links, or cellular telephones.

Precision irrigation is of limited utility without precise irrigation scheduling. Irrigation scheduling has advanced considerably in the past 20-30 years with improved technology to measure soil or plant water status and, especially, within the past 10-15 years utilizing remote sensing tools. Plant or soil sensors are most often utilized to initiate or complete an irrigation event based on specific criteria. Automated weather stations are now widely used to provide basic site information on the irrigation requirement, using either crop development models or simpler reference evapotranspiration (ET) data, to be used with crop coefficients (Kc). Remote sensing is being increasingly utilized to measure crop water status (usually through crop surface temperature), crop development or ground cover, based on spectral reflectance from specific electromagnetic wave bands, but future satellites (i.e., Landsat 8) may not contain a thermal radiation band critical for crop stress and ET. Usually, the red band (0.63-0.69 μm or band 3 on Landsat TM or EM+) and near infrared band (0.76-0.90 μm or band 4 on Landsat TM or EM+) are used to determine the Normalized Difference Vegetation Index (NDVI). Inexpensive infrared thermometers (IRTs) are being used as crop thermal temperature detectors, from hand-held to fixed units in the field, to newer wireless IRTs using mesh networks to communicate to controllers. Remote sensing provides critical spatial integration from point weather networks and useful feedback on crop ET and irrigation controls in advanced automated systems, particularly for PI/SSI.

THERMAL REMOTE SENSING OF CROP WATER STATUS: PROS AND CONS OF TWO DIFFERENT APPROACHES

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Recent climate change has led, in many places around the world, to a decrease in the availability of water resources. This limited water availability is decreasing the cost-effectiveness of irrigated agricultural crops and therefore practices that reduce the required amount of water without decreasing the quantity and/or quality of the yield are desirable. Routine monitoring of crop water status may provide useful information, allowing growers to conserve water by irrigating only when and where needed. The continuously growing availability of airborne and spaceborne data has led to the development of various methods that utilize thermal remote sensing to detect and monitor water status in agricultural crops. In general, these methods can be divided into two main approaches.

The first approach, in use since the 1960s, is based on the understanding that canopy temperature is indicative of crop water status. Generally, the canopy temperature is normalized to upper and lower bounds, representing non-transpiring and fully transpiring leaves, respectively, forming the crop water stress index (CWSI). The normalization allows for a comparison of the CWSI under different environmental conditions. This approach is simple to apply and requires fewer inputs, but necessitates thermal images at high spatial resolution, since the remotely sensed temperature must represent the canopy only, extracted from the surrounding soil. Such high resolution thermal images are not routinely available to date.

The second approach is based on more complex physical models, for which the prime input is thermal images. Numerous models have been developed, which can be further

divided into two main categories. The first is based on the "big leaf" theory, according to which the land surface is assumed homogeneous and is treated as a whole. In the second category are the Two-Source models, which relate to the vegetation and the soil separately. The physical models in general and the Two-Source models particularly require more inputs than the CWSI approach, but can utilize thermal images at a coarser spatial resolution. Such imagery is regularly available from several satellite systems.

A discussion of the pros and cons of each of the two approaches will follow a brief description of their principles and utility.

HIGH RESOLUTION MONITORING OF ROOT ZONE AND VADOSE ZONE PROCESSES

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Advanced agricultural irrigation practices require precise application of water and nutrients to the plants to maximize efficiency and minimize losses. This approach led to the development of drip and mini sprinkler irrigation techniques, as well as fertigation practices. Traditionally, the root zone and the vadose zone were treated as pseudo homogeneous domains. However, these modern practices clearly create and require more detailed spatial treatment. We present here two different applications of geophysical tools for monitoring water distribution in the root zone and the vadose zone. Both make use of electrical resistivity tomography and supporting tools. The first aims at mapping the root zone of a single plant for water content at relatively high resolution, for a detailed understanding of both flow patterns and root water uptake and its dependence in environmental conditions. The second aims at mapping the flow patterns under drip irrigated orchard.

Preliminary results for the single root investigation clearly indicate that different environmental conditions create significantly different plant behaviour that is expressed,

among other indices, in different uptake rates and therefore different water distribution schemes. The outcome is that for modern irrigation techniques, simplistic assumptions regarding root distribution and root uptake are insufficient. For the vadose zone monitoring, results show significant heterogeneity in water flow patterns, which is season dependent. By spatially monitoring water content distribution throughout the year we identify water that is not used by the plant and therefore leads to lower irrigation and fertigation efficiency.

RELATIVE WATER UPTAKE AS A CRITERION FOR THE DESIGN OF TRICKLE IRRIGATION SYSTEMS

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Previously derived analytical solutions to the 2- and 3-dimensional water flow problems characteristic of trickle irrigation are not widely used in practice, because these formulations either ignore root water uptake or refer to it as a known input. In this lecture we describe a new modeling approach and demonstrate its applicability for designing the geometry of trickle irrigation systems, namely, the spacing between the emitters and drip lines.

The major difference between our modeling approach and previous ones is that we refer to the root water uptake as an unknown solution of the problem and not a known input. We postulate that the solution to the steady-state water flow problem with a root sink that is acting under constant, maximum suction defines an upper boundary to the relative water uptake (water use efficiency) in actual transient situations, and propose to use it as a design criterion. Following previous derivations of analytical solutions, we assume that the soil hydraulic conductivity increases exponentially with its matric head, which allows the linearization of the Richards equation, formulated in terms of the Kirchhoff matric flux potential. Since the transformed problem is linear, the relative water uptake for any

given configuration of point or line sources and sinks can be calculated by superposition of Green's functions for all relevant water sources and sinks.

In addition to evaluating the relative water uptake, we also derived analytical expressions for the stream functions. The stream lines separating the water uptake zone from the percolating water provide insight regarding the dependence of the shape and extent of the actual rooting zone on the source-sink geometry and soil properties. A minimal number of just three system parameters, i.e., Gardner's (1958) α as a soil type quantifier and the depth and diameter of the pre-assumed active root zone are sufficient to characterize the interplay between capillary and gravitational effects on water flow and the competition between the processes of root water uptake and percolation. To account also for evaporation from the soil surface, when significant, another parameter is required, adopting the solution of Lomen and Warrick (1978).

WATER QUALITY-WATER QUANTITY SUBSTITUTION APPROACH: IMPACT ON WATER UPTAKE, ACTIVE ROOT VOLUME AND SOLUTE LEACHING UNDER DAILY DRIP IRRIGATION

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This study evaluates the consequences of water quality - water quantity substitution on water uptake, active root volume and solute leaching under daily drip irrigation in fine (clay) and coarse (sandy) textured soils. This was achieved by analyzing movement and spread of water and solute originating from multiple trickle line laterals under cropped conditions, by means of physically-based flow and transport models, taking into account characteristics of the soil, crop and concentration, Co, and relative amount, Qr, of irrigation water.

Novel findings of this study suggest that in clay soil the mean water-extraction to Co-Qr substitution rate is quite robust, and the decrease in transpiration, T, induced by

increasing Co, is mainly due to the decrease in the soil volume active in water uptake, Vs. On the other hand, in the sandy soil, Vs may increase with Co-Qr substitutions, and the decrease in T is mainly due to the decrease in the uptake rate. In addition, the results suggest that in fine-textured soils, Co-Qr substitutions corresponding to the FAO recommendations may lead to an increase in root uptake efficiency, T/Vs, while it may cause the opposite effect in coarse-textured soils.

Results of the present study also suggest that under daily surface drip irrigation, control of both the solute concentrations in the root zone and the amount of salt leached below the root zone is more efficient in a fine-textured soil than in a coarse-textured one. In both soils, the salinity control efficiency decreases with increasing Qr and decreasing target level of the entity of interest. Finally, results of this study suggest that in both soils, the rate of change of the solute mass fraction that is leached below the root zone with respect to the change in Qr, or with respect to the change in Co can be controlled by proper Co-Qr substitution.

Symposium Poster Abstracts

Graduate Student Presenters

Wastewater Treatment

PHYTOTOXICITY, TOTAL PHENOLS AND DISSOLVED ORGANIC CARBON IN OLIVE MILL WASTEWATER BEFORE AND AFTER DEGRADATION BY *PLEUROTUS OSTREATUS*

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The phytotoxicity associated with olive mill wastewater (OMW) represents a major difficulty regarding its remediation and safe disposal. Therefore, elucidating the origin of OMW phytotoxicity and the fate of its toxic substances during biological treatments is of major importance. OMW was fractionated in this study using two approaches: 1. Molecular weight (MW)-based fractionation, including <1000, 1000-5000 and >5000 Da fractions. 2. Solvent extraction using ethyl acetate, which yielded solvent and aqueous fractions. It was found that the *aqueous* <1000 Da fraction was most phytotoxic. The <1000 Da fraction contained 82% of the total dissolved organic carbon (DOC) and 48% of total phenols (TP), of which only 8% of DOC and 18% of TP were fractionated into ethyl acetate. Catechol, which was previously considered as a key phytotoxic compound, was found to have a relatively small contribution to the overall OMW phytotoxicity. Incubation of the whole-OMW and the three size fractions with *Pleurotus ostreatus* resulted in a 4-5 fold decrease in TP, but exerted a diverse impact on phytotoxicity. A

second fractionation of the <1000 Da after incubation with *P. ostreatus* using ethyl acetate revealed no phytotoxicity in the solvent fraction, but the phytotoxicity associated with the aqueous fraction persisted. Residual TP seems not to be a main source of phytotoxicity in treated OMW and should not be used as a sole indicator for treatment success. It is recommended that future studies focus on the *aqueous* <1000 Da fraction, in order to elucidate the causal agent and fate of phytotoxicity of fresh OMW and during various treatment processes.

SYNERGETIC EFFECT OF PHOTOCATALYTIC DEGRADATION AND ADSORPTION PROCESSES ON THE REMOVAL OF PHENOLIC COMPOUNDS FROM AGRO-INDUSTRIAL EFFLUENT

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Agro-industrial wastewater is considered a major environmental pollutant. Most of its effluents contain high concentration of phenolic compounds. These compounds contribute to toxicity and antibacterial activity, potentially limiting the microbial degradability of the biological treatment systems. Thus, the development of alternative physicochemical methods used for pre- or post-treatment of agro-industrial wastewater is required. This work examines heterogeneous photocatalysis (TiO_2) as an efficient technology for degradation of phenolic compounds. To resolve the problem of achieving optimum adsorption strength of TiO_2 while increasing photocatalytic efficiency, activated carbon was added as a co-adsorbent to TiO_2. The activated carbon adsorbs the pollutant and its metabolites that are in close vicinity to TiO_2, thus enabling their transfer and decomposition on it.

The synergetic effect of both photocatalysis by TiO_2 and adsorption by activated carbon was tested under various conditions: different concentration levels of the phenolic compounds, pH, activated carbon addition, as well as source of UV light (sun light or

artificial UV source) for the photocatalysis process. The potential for reuse of the catalyst in additional runs was examined as well.

The acidity of the solution is of major importance in determining adsorption capacity; at low pH, high adsorption capacity followed by high photodegradation rate was achieved. Increasing the light intensity, especially over the TiO_2 band gap (approximately $\lambda < 388$ nm), enhanced the photodegradation rate of the phenolic compounds. This has an important implication for agro-industrial wastewater treatment in the Middle East: by utilizing the region's semi-arid climate and high solar intensity, one might reduce the cost of treatment. Addition of co-adsorbent (activated carbon) has been shown to increase photocatalytic efficiency, and therefore the combination of adsorption processes along with photocatalysis improved photodegradation at high phenolic concentrations. Activated carbon strongly adsorbs the contaminants and its intermediate products in close vicinity to TiO_2, enabling decomposition following the "adsorb-and-shuttle" approach.

IRRIGATION EFFLUENT TREATMENTS FOR PHYTOREMEDIATION PLANTATION ESTABLISHMENT

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The use of vegetation for remediation (phytoremediation) has recently been shown to be a low-cost remediation option for many types of contaminants. However, rapid and robust initial establishment of any phytoremediation vegetation is critical to the success of the remediation. To encourage better early root growth for this vegetation, irrigation can be used. The application of nutrient rich animal waste lagoon effluent can provide a good source of plant growth nutrients to this vegetation, while also serving as a beneficial treatment for this waste water.

A site in Manhattan, Kansas, USA was used to study poplar tree growth in response to lagoon effluent irrigations with the overall objective of increased root growth. The plantation consisted of two varieties of poplar trees (Populus L.), each of which received a drip irrigation treatment of either freshwater or a blend of 50% freshwater and 50% lagoon effluent. Based on tree height, trunk diameter, and tree crown area data, there were no significant differences in tree growth between the irrigation treatments. However, it is thought the expected irrigation treatment effect was most likely masked by the inherent high soil fertility of the site. Based on soil moisture (tensiometers and neutron probe) data, the trees were drying the soil profile, a trend which was expected to increase with the trees' continued growth.

DENITRIFICATION BIOREACTORS FOR AGRICULTURAL WATER TREATMENT

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Water quality degradation associated with agricultural production plagues many ecosystems around the world. Premier amongst these water quality concerns is nitrate loading to surface waters. While the increased use of nitrogen fertilizer over the past half century has greatly increased crop production, the time is now ripe to develop practical and cost effective methods to reduce agricultural nitrate loadings to water bodies.

Denitrification bioreactors are ideally suited to provide inexpensive, low-maintenance water treatment at the field scale to reduce nitrate in agricultural waters. These bioreactors consist of a subsurface excavation filled with any available carbon source (usually woodchips), which is colonized by denitrifying bacteria and through which nitrate laden water is routed.

Although this technology is relatively new, preliminary data from bioreactors utilized for edge-of-field agricultural tile drainage treatment in the US Midwest suggest these systems have great potential for water quality improvement. This poster provides an introduction

to the concept of nitrate treatment with the use of denitrification bioreactors in an agricultural setting. Field data from several existing bioreactors sites in Iowa, USA, are presented in addition to a discussion of design challenges and future research needs.

THE POTENTIAL OF SPECTROSCOPIC TOOLS FOR REAL TIME QUANTITATIVE ESTIMATION OF MEMBRANE FOULING APPLIED TO WASTEWATER TREATMENT AND REUSE

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Membrane filtration is currently the most advanced treatment for wastewater reclamation and reuse. Membrane treatment produces less waste compared to biological treatment, and creates reliable, high quality water. Membrane fouling, either organic, inorganic, or biological, is the main problem associated with membrane treatment. The need to remove the fouling layer from the membrane causes discontinuity in the filtration process and shortens the membrane lifespan. Accordingly, a method for estimating the level of fouling is required.

Spectroscopy methods are commonly used for water analysis and hold great potential for real-time, continuous monitoring of the compound's concentration. The present study focuses on (1) quantitative estimation of humic acid and protein in water, using UV-Visible absorbance and (2) quantitative estimation of membrane fouling using mid-infrared photo-acoustic spectroscopy (PAS).

The UV-Vis spectra of 466 aqueous solutions with 0-30mg/l humic acid (HA), 0-15 mg/l protein (bovine serum albumin - BSA) and 0-15 mg/l polysaccharide (alginic acid – AA) were analyzed by partial least square (PLS). Both HA and BSA could be estimated with a very high accuracy (estimation errors of 1.5 and 1.2 mg/l, respectively). Algenic acid, which does not absorb in the UV-Vis range could not be estimated, but its presence was found to affect the accuracy of the HA and BSA estimation.

The fouling of the Polysulfone (PSf) membrane (30 kDa) and Polyacrylonitrile (PAN) membrane (200 kDa) by BSA in the presence of AA, were also studied. The fouling by BSA was estimated using a mass balance between BSA concentration in the feed and the permeate solutions. These concentrations were estimated using both the UV-PLS models previously developed and standard total nitrogen (TN) measurements, and a strong correlation was found between the two methods. In addition, the fouled membranes were analyzed by photo-acoustic mid-infrared spectroscopy (FTIR-PAS). PLS analysis of the spectra showed that a strong correlation exists between the FTIR-PAS spectra and the fouling estimated from the BSA mass-balance.

Further improvements of the UV-PLS method could yield to real time estimation of the membrane fouling. However, this would require the calibration of a more complex PLS model, based on real wastewater compound.

Irrigation Technology and Reuse of Reclaimed Wastewater

DEVELOPING AN AUTOMATIC WATER EMITTING-SENSING SYSTEM, BASED ON INTEGRAL TENSIOMETERS PLACED IN HOMOGENOUS ENVIRONMENT

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As the population grows, irrigation agriculture uses increasing amounts of water and fertilizers to supply the growing food demand. However, the uptake by various plants is only 30 to 50% of the water applied. The remaining water, which flows as surface runoff or groundwater, poses the risk of contaminating these sources with fertilizers or other toxins, such as herbicides or pesticides. To improve the water use efficiency of crops and decrease the drainage below the root zone, irrigation water should be applied according to the plant's demand.

The aim of this study is to develop an automated irrigation system based on real-time feedback from an inexpensive and reliable integrated sensing system. This system supplies water to plants according to their demand, without any user interference during the entire growth season. To achieve this objective, a sensor (Geo-Tensiometer) was designed and tested. This type of sensor has better contact with the surrounding soil, is more reliable and much cheaper than the ceramic cup tensiometer.

An experiment to examine the effect on plants of subsurface drip irrigation regime based on the Geo-Tensiometer, in comparison to the effects of a daily irrigation regime, was conducted using lysimeters. By integrating the Geo-Tensiometer within the Geo-textile

that surrounds the drippers, a homogenous media in the entire lysimeter was created, in which the reading of the matric potential took place. This media, the properties of which were set and known to us, encourages root growth therein. Root density in this media is very high; therefore, most of the plant water is being taken up from this area. The system based on the Geo-Tensiometer (treatment A) had irrigated each time the matric potential reached a threshold that was set automatically every morning by the system. The daily treatment included a single irrigation each morning that was set to return 120% of the evapotranspiration of the previous day. All Geo-Tensiometers were connected to an automated washing system, which flushed trapped air in them.

In treatment A, the system discharge changed according to the plant water demand. The discharge changes followed the water uptake changes during the day and during the entire growth period without any user interference.

The integration of the Geo-Tensiometer into the emitter system, together with the irrigation regime, increased the water use efficiency of the plants. This system maintained high and constant water content in the root zone in comparison to other irrigation methods, such as daily drip irrigation. Reading the matric potential in this media yielded a better indication of water availability to the plants than sensors placed 3 cm from the emitters. In addition, the amount of water drainage below the root zone decreased significantly thus minimizing the risk of polluting the groundwater. In addition, the automated flushing system eliminated the need for manual maintenance of the tensiometers, creating a user-friendly system.

ENHANCED NITROGEN FERTILIZATION IMPAIRS OLIVE OIL PRODUCTION AND QUALITY

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Olive (*Olea europea* L.) is a traditionally important crop grown extensively in the Mediterranean basin. While traditional olive orchards are commonly rain-fed, modernization of olive cultivation has introduced and promoted densely planted orchards that are irrigated via systems that can also be utilized for nutrient application. On one hand, irrigation promotes plant growth and productivity, which is expected to have an effect on nutrient demand of the tree. On the other hand, nutrient uptake efficiency is expected to be enhanced under irrigation. Nitrogen (N) is the most commonly applied fertilizer and in many cases the only regularly applied nutrient. Since most fertilization trials for olives have been conducted under dryland cultivation, little is known concerning the N demand of olives under modern intensive conditions.

The effect various concentrations of irrigation solution N on growth and productivity of olive (cv. Barnea) trees was studied in a container experiment at the Gilat Research Center. Treatments included eight concentration levels of N, ranging from 5 to 200 ppm, irrigated twice a day.. The experiment lasted for two successive seasons.

Addition of N at low concentrations (5-20 ppm) led to large increases in N content in leaves and caused major increases in vegetative growth and productivity. With higher concentrations of N (70-200 ppm), flowering intensity, fruit set, fruit load and oil content were noticeably impaired while no effect on tree growth was noticed. Oil quality was also negatively affected by high N. Free fatty acid level increased and polyphenol content decreased significantly with increased exposure to N. Fatty acid composition was also influenced by the treatments. Oleic acid decreased while linoleic (6Ω) and linolenic (3Ω) fatty acids increased. The changes related to increased N were lower olive oil stability and poorer quality.

Neither visual symptoms nor reduced growth could be observed under conditions of N over-fertilization. Additionally, leaf N concentration did not increase as a function of irrigation solution N levels, suggesting that leaf analysis is not a sufficient means for identifying excessive N fertilization. Our results emphasize the importance of proper N management in olive orchards in order to insure high oil yields and quality, while minimizing soil and ground water contamination as a result of N over-fertilization. New methods for identification of excessive N in olives must be considered.

SOIL APPLICATION OF OLIVE MILL WASTEWATER (OMW) FOR WEED CONTROL IN ORGANIC AGRICULTURE

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The fast growing olive oil industry is facing severe problems of environmental pollution, due to its associated wastes. In Israel, the majority of olive mills are operated by the three phase continuous centrifugation process, during which large volumes of water are added. This process yields 3 products: olive oil, pulp and olive mill wastewater (OMW). Up to 50,000 m^3 of OMW are produced in Israel annually. OMW has extremely high organic load, high salinity and is highly acidic. It also contains high concentrations of phenolic compounds and short chain fatty acids that contribute to the toxic nature of these effluents. Yet, OMW is a plant by-product, containing no xenobiotics or heavy metal contaminants and can be a source for substantial amounts of plant nutrients. Its application to soils of low organic matter, common to the Mediterranean basin, may improve soil fertility.

In this study, we examined the potential use of OMW for weed control in sustainable agricultural systems. The efficacy of OMW was tested in a pot experiment conducted in a nethouse during winter 2008. Two-liter pots filled with *Grumosol (Vertisol-type) soil*

were sown with four weed species: *Silybum marianum, Phalaris brachystachys, Daucus carota and Synapis alba*. Three OMW application methods were examined: 1. PPI: OMW was incorporated with the soil before sowing; 2. PRE: OMW was applied after sowing but before emergence; 3. POST: post emergence application. Four application levels were tested: 0 (control) and equivalents of 20, 80 and 160 *m3/ha*. Each treatment was replicated 5 times in a randomized block design. Weed emergence and plant growth were evaluated periodically. The final shoot biomass (fresh and dry) was recorded five months after sowing.

POST treatments did not show profound herbicidal effects. PRE treatments reduced seedling emergence, depending on application rate: less than 10% of germination (relative to the control) was found at application rates of 80 and 160 m^3/ha. PRE treatments had only a negligible effect on seedling development. By comparison, PPI had a smaller effect on weed emergence, but strongly inhibited weed development, reaching less than 20% of the control's weed development at application rates of 80 and 160 m^3/ha. Both PRE and PPI treatments reduced final biomass of the examined weeds.

We hypothesize that the different effects observed in PRE and PPI treatments may be due to adsorption of phytotoxic components to soil minerals and/or organic matter, thus restricting their effect in PRE treatments to the very top soil layer. Therefore, only the seeds but not the germinated seedling roots were exposed to the phytotoxic compounds. In the PPI treatments, OMW was mixed with the whole soil medium, thus also exposing the developing roots to OMW phytotoxicity.

The results of the presented study suggest that OMW could be used as an efficient alternative to chemical herbicides in organic agriculture with a probable preference for PPI implementation. The ongoing work examines the validity of these results under field conditions.

OPTIMIZATION OF WATER RESOURCE USE FOR IRRIGATION OF TOMATOES IN THE JERICHO AREA, JORDAN VALLEY /PALESTINE

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More than many of the other countries in the world, Palestine suffers from scarcity and water shortage. Water scarcity and water degradation are the most important factors negatively affecting the development process of any country. The shortage of water resources in the arid - semi arid climate of the West Bank is attributted to over exploitation, mismanagement, uneven distribution between Palestinians and Israelis, and increased demand for water for domestic and irrigation uses. These cause the diminishing of water supplies and water quality problemsand thus lead to greater concern about optimization water resources supply.

The main objective of this study was is to identify and investigate the optimal uses of water in terms of quantity and quality for growing tomatoes in the Jericho area. The experiment was done in a plastic greenhouse of 0.25 Ha in Nueama, Jericho area near Hisham palace. The estimates of the reference evapotranspiration rates, ET0, were obtained with reference to NCARTT "National Center for Agricultural Research and Technology Transfer" in Karamah Station. ET0 was calculated as an average value for period between 2002 – 2007. A cherry tomato variety 1335 (cluster) was planted. Experimental design was divided into three blocks B1, B2, B3, each block included five lines with five irrigation rate treatments TI, T2, T3, T4 and T5 as described below

TREATMET	TI	T2	T3	T4	T5
%ETc	85%ETc	90%ETc	100%ETc	110%ETc	Farmer Irrigation

Results showed that water utilization was much lower than actual water applied for irrigation. Improved water management can save about 12.4% - 33.6% of the water currently used, which could be applied to expand the agricultural area accordingly.

The T2, which was based on 90% ETc, and field efficiency of 75% provided the best combined results, between maximal production increase and optimization of water resources used. T2 provides the best economic value, followed by T1, T4, T5, and T3.

OPTIMIZATION OF WATER RESOURCE USE FOR IRRIGATION OF CUCUMBER (*CUCUMIS SATIVUS*) IN JERICHO AREA, JORDAN VALLEY, PALESTINE

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Water scarcity has characterized this area for many decades, due to the lack of sustainable water resources and rainfall, which are considered the main sources of water that feed the groundwater and springs in the area. Many water resources suffer from water salinity and pollution from different sources, some natural and others anthropogenic. In addition, there are no national projects to reuse waste water.

Our country depends mainly on both the irrigated and the rain fed agricultural sector. The agricultural sector consumes more than two thirds of the fresh water resources. Looking for methods and techniques to save and conserve water is an essential national goal. This research proposes a method to quantify the optimal water requirement in the irrigation of cucumber crops in Jericho.

Many studies have been conducted in order to determine the water quantity consumed by cucumber crop, but the values that were published may be considered theoretical and not practical, or based on farmers' estimations, which were extremely higher than those measured in the experiment.

The experiment was constructed in greenhouse from December of 2007 to March of 2008, with a duration of 130 days. Crop water requirements for cucumber were investigated and the actual water requirement for cucumber was estimated by using evapotranspiration estimation, by applying the FAO procedure which depends on the equation: Etc = Kc * Eto, where Etc is water requirement, Kc is the adjusted crop coefficient for cucumber in greenhouses and Eto is the average daily reference

evapotranspiration, based on the Eto values for the last five years for the months of December through March, which were measured in al Karamah station for grass. The experiment was designed to include five treatments (T1, T2, T3, T4 and T5) consisting of three replicates distributed randomly. Four of the treatments were controlled by a certain percent of reference evapotranspiration (Eto) (80% Eto, 90% Eto, 100% Eto and 110% Eto) from T1 to T4, respectively, to determine the water volume delivered to each treatment. The 5th was used as a control treatment, through water delivered by farmer method, and the mulch factor was taken into consideration, as was the use of drip irrigation system in greenhouse. The water delivered for each treatment was measured by using water flowmetr, and cucumber product was weighed in each harvest case.

Treatments are arranged according to water consumption as T5>T4>T3>T2>T1 and can be arranged according to production weight as: T4> T5>T2>T3>T1, and for WUE, the treatments can be arranged as T1>T2>T4>T3>T5.T. The percent of water saved by this method, according to the result of the research, can be stated as follows: (T1 = 53.9%, T2= 48.4%, T3 = 42.8% , T4 = 36.6%). Second order equations have been verified, relating production and the water consumed by the age of plant in days for each treatment. The economical values of the research application were discussed. Thus, many benefits could be obtained by using the smallest production treatment (T1) with values close to the average cucumber production per unit area in West Bank. These could include expansion of the cultivation area and increasing production, finally saving water and environment.

HOT WATER EXTRACTION FOR RAPID CHARACTERIZATION OF CHANGES IN ORGANIC CARBON AND NITROGEN FORMATIONS IN EFFLUENT IRRIGATED SOILS

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Irrigation with treated wastewater (effluent), an important water resource in arid regions such as Israel, influences the microbial population, quality and quantity of organic matter and nitrogen dynamics in soil.

Hot water extraction is a useful method for detecting changes in soil labile organic matter, induced by different land uses and soil amendments/fertilizers. Hot water extractable nitrogen was found indicative of the availability of organic N. Hot water allows extraction of large concentrations of organic matter, providing an advantage for spectroscopic methods used for analyzing chemical components present in aqueous solutions.

EEM (excitation-emission matrix) fluorescence spectroscopy has been widely used as a method for characterizing dissolved organic matter in water and soil solutions and extracts. Yet, in order to properly utilize such spectra for soil organic constituents, appropriate signal processing models should be chosen for interpreting the three-dimensional, complex data obtained for soil samples.

The research hypothesis was that hot water extraction in combination with EEM may be a reliable analytical method for characterizing changes in concentration and content of soil labile organic matter and organic nitrogen induced by soil types and effluent irrigation.

Samples from five different agricultural soil types in Israel were collected from long-term experiments that compared effluent and fresh water irrigation. The extraction procedure was cold water extraction ($CaCl_2$ 0.01M, 20ºC, 1 hr) followed by hot water extraction ($CaCl_2$ 0.01M, 80ºC, 16 hr). TOC (Total organic Carbon), TN (Total Nitrogen) and mineral N-species (NH_4^+, NO_3^-, NO_2^-) concentrations were measured in the cold and hot water extractions. Organic Nitrogen availability (mineralizable N) was also assessed, by subjecting soil samples to aerobic incubation for five weeks.

The cold and hot water extracted solutions were characterized using an EEM fluorometer. PARAFAC (Parallel Factor Analysis) was used for interpreting the EEM data, by looking for the main components of the organic compounds and evaluating their relative concentration in each sample. In addition, multi-linear partial least squares regression (N-PLS) was tested as a method for prediction of TOC, TN and TON concentrations from EEM data.

The quantitative results emphasize the effectiveness of hot water extraction in detecting differences in concentrations of major organic carbon and nitrogen components in effluent and fresh water irrigated soils. Moreover, hot water extractable nitrogen was found to be a good predictor for nitrogen availability.

Three main components were found by PARAFAC modeling of the EEM data of the hot water extractions, related to humic acid- 375/478nm (Ex/Em), fulvic acid- 345/423nm (Ex/Em), and protein- 290/383nm (Ex/Em). The scores calculated for the humic and fulvic components were highly correlated with hot water TOC, TN and TON concentrations. Prediction of these parameters was improved by the N-PLS method. Other spectroscopic results indicate possible differences in extractable organic matter characteristics between effluent and fresh water irrigated soils and also between different soil types. The scores calculated for the fulvic component in the PARAFAC model were well correlated with mineralizable-N in all soils.

The obtained results provide encouraging indications about the potential of using hot water extractions and spectroscopy for characterizing important components of soil carbon and nitrogen in different soils.

THE USE OF OXYGEN ISOTOPIC SIGNATURES TO TRACK PHOSPHATE TRANSFORMATIONS IN RECLAIMED WASTE WATER IRRIGATED SOIL

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Accumulation of labile phosphate (P) in top soils and its transport to receiving water bodies (e.g., lakes and streams) is an environmental threat to water quality. The use of reclaimed wastewater (RW) for irrigation is very common in Israel, due to constant shortage of fresh water (FW), but was found to enhance accumulation of labile P in top soils. Phosphate oxygen isotopic composition ($d^{18}Op$) was used previously to track phosphate dynamics in water bodies such as lakes, estuaries and oceans, but very little research has been done in regard to using $d^{18}Op$ for tracking P dynamics in the soil. Applying the tool of isotopic signature tracking to soil P research might promote the understanding of P transformations in soils treated with RW, soils treated with chemical fertilizer and untreated soils. This isotope tracking tool could be used to identify the reactivity of P associated with different soil fractions, to demonstrate how P from irrigation fluids (RW or FW) is distributed among different soil fractions and to estimate the rate of cycling and transformations of applied P by the biological activity in the soil.

In the present research, the various phosphorus fractions from neutral-alkaline soils irrigated with either RW or FW were sequentially extracted and the isotopic signature of each fraction determined. Tracking P dynamics in the soil was done by measuring $d^{18}Op$ in the soil fractions along time, after applying spiked RW or FW to the soils. In addition, the difference in $d^{18}Op$ between the applied water and the drain water can indicate P compounds' adsorption, exchange, and biological cycling along the irrigation event itself. Preliminary results indicate that RW and FW with a chemical fertilizer have distinct $d^{18}Op$ signatures and that the different soil fractions hold phosphate with different $d^{18}Op$, implying that biogeochemical processes that occur during P fixation in the soil preferentially operate on certain pools of P within the soil.

ESCHERICHIA COLI TRANSPORT, RESISTANCE, AND VIRULENCE FACTORS FROM LAND APPLIED SWINE SLURRY

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Broad spectrum antibiotics, such as Tylosin (naturally synthesized by *Streptomyces fradiae*) are used to treat infections in farm animals and are often administered at therapeutic levels along with feed rations. The presence of bacteria resistant to antimicrobials in animal waste has raised concern related to their transport to surface and groundwater. Previous studies have shown that cells preferentially attach to sediments affecting their transport in overland flow; however, a lack of quantitative understanding exists regarding the attachment mechanisms such as extracellular organelles and the relationship between these and virulence factors in humans. In a preliminary study, the presence of Tylosin resistant bacteria have been enumerated in tile drainage samples collected beneath no-till plots. While this study shows the transport potential of resistant bacteria, the method of transport (attached, bioflocculated or unattached), the relationship between transport and resistance, and the relationship between attachment and virulence factors is unknown.

The objective of this research is to study the link between virulence factors and attachment in *Escherichia coli* collected from swine slurry. Resistant and non-resistant cultures will be grown in a chemostat environment to mimic a low nutrient environment. Relationships will be studied *in vitro* using quantitative PCR and microarray methods. This study will be important in determining the relationship between antibiotic resistant bacteria and their ability to move within the environment and impact human health.

TRANSPORT OF NUTRIENTS FROM VARIOUS PASTURELAND MANAGEMENT SCENARIOS

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Various pasture management scenarios contribute different loads of nutrients to surface waters. Understanding of the overland release and transport of nutrients from pastures is needed to improve design of best management practices (BMPs) and modeling of NPS pollutants.

Field plots were established to study nutrient release and transport from lands receiving cowpat applications at a rate representative of heavily grazed lands. Release plots compared the concentrations of nutrients in the field from three different soils, while transport plots compared the concentrations in runoff at the edge-of-the-field from a single soil type. Three Virginia soils, silty clay loam, loamy fine sand, and a silty loam were placed in small box plots and placed under a rainfall simulator. Rainfall was applied to the plots until runoff flowed for 30 minutes and samples were collected every 10 minutes after runoff event initiation. Transport plots were constructed on pastureland, with high vegetative cover to simulate well managed pasture in the spring, and with low and high vegetative cover in the summer, to compare well and poorly managed pasture. A rainfall simulator generated the uniform rainfall event (2.8 cm/h) to all plots until runoff reached steady state. Samples were collected at the onset of runoff, at ten minute intervals during the storm event and four minutes after the end of the storm event.

Total phosphorous (TP) and total organic phosphorous (TOP) release concentrations of 16.7 and 8.3 mg L^{-1}, respectively, were significantly higher in samples from the loamy fine sand soils than in those from the silty clay loam and silty loam soils ($p > 0.05$). Transport plots with high vegetative cover reduced both TP and TOC concentrations by 10%, while TSS concentrations were reduced from 670 to 51 mg L^{-1}. Restricting grazing cattle access to streams will reduce direct loading, but the results from this study indicate that management practices are necessary to reduce nutrient loading to waterbodies.

OPTIMIZATION OF USING WATER RESOURCES IN IRRIGATION OF TOMATOES IN JERICHO AREA, JORDAN VALLEY, PALESTINE: HYDROLOGICAL AND HYDROCHEMICAL INVESTIGATIONS IN EIN FESHCHA SPRINGS: DEAD SEA AREA, WEST BANK

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Scarcity of water resources in the West Bank, due to arid and semi-arid climate conditions, overexploitation, mismanagement as well as the fact that these resources are shared with Israel, is of growing concern. As a resource, groundwater is gaining importance in the supply of water to rural communities in the drier regions of the Jerusalem Dead Sea Aquifer Sub-Basin, where surface waters are very scarce or absent. Understanding the groundwater characteristics is crucial for groundwater management in the study area.

This study focuses on a small area of the West Bank (Marsaba-Feshcha area), which is considered one of the few places of the region where limited additional amounts of groundwater can be developed. Jericho city depends entirely on groundwater for domestic and agricultural use. An understanding of the chemical evolution of the groundwater provides insight into the interaction of water with the environment and contributes to better resource management.

The analyzed water samples exhibited a wide range of major cations, major anions and trace element concentrations. The chemical groundwater types of the study area were distinguished and grouped by their position on a Piper and Durov diagram. Broadly, they fit into three types, with some sub-groupings. The water types found were as follows: Na-Cl group, Mg-Cl group and Mg-HCO_3 group. Ein Feshcha springs are characterized by waters which have generally outcropped through the evaporitic Triassic formations; therefore, Sr/Ca ratios are > 1.5‰. Examination of the composition of the saline water in Ein Feshcha, may lead to the source and the distribution of the saline water and its mixing

points with fresh water. Hence, this may allow us to capture the fresh water upstream before its mixing with the brines downstream.

Plant-Soil-Water Inter-relations

INTRODUCED CAPILLARY BARRIER IN THE ROOT ZONE CAN IMPROVE CONDITIONS FOR HORTICULTURAL CROPS

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Capillary barriers occur at the interface between two soil layers that have distinctly different textural and hydraulic features, as when fine soil overlays a coarse textured soil. Initial investigations in Israel indicate that appropriate use of artificial capillary barriers (ACBs) in the root zone could lead to maintenance of higher soil water content, and greater water and nutrient availability in coarse soils; improved aeration in heavy soils; alleviation of salinization above shallow water tables; and reduction of spatial variability in heterogeneous soils.

The research objectives were to evaluate ACBs installed at the bottom of the root zone used for vegetable cultivation. The root zones with capillary barriers consisted of a layer of 5 cm gravel stones overlaid by separation layer material filled with 20 cm of sand, overlaid by 10 cm of volcanic scoria. Control plots consisted of the sand-scoria layers without the capillary barrier. Soil water content, salinity, and oxygen were measured along with plant growth and yields of bell peppers. Variables studied included the type of soil surrounding the root zone (sand and clay), irrigation water quantity (**0.8**, **1.2**, **1.6** and **2.4** return of potential evapotranspiration), and capillary barrier-root zone formats, using

either 50 mesh netting or Agripal (polypropoline woven cloth) as separation layer materials.

Pepper plant biomass and fruit yield production interacted with soil type. In the sandy soil, yields in the two root zone formats did not differ from one another and were 20-45% greater than those of the control, over the whole range of water applications. In the clay soil, ACB using 50 mesh netting resulted in 20-50% greater yields over the whole range of water applications, compared to the control or the ACB incorporating an Agripal cloth.

In the sandy soil, ACBs increased soil water content which resulted in increased biomass and fruit yield production. In clay soil, when roots were allowed to penetrate into the gravel layer through the 50 mesh netting instead of being limited by the Agripal cloth, oxygen concentrations were higher and yields were greater.

ESTIMATION AND EVOLUTION OF PEDOSTRUCTURE PARAMETERS

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With the increasing concern of feeding an ever-growing population with finite land and water resources, ways to promote environmentally responsible agriculture and land use are becoming imperative to our way of life. A physically-based method of soil water modeling capable of transferring information between spatial scales is needed to accurately predict human impacts on land and water across the globe. The pedostructure (PS) concept (Braudeau et al., 2004, Braudeau and Mohtar, 2004) is a physically-based method of soil characterization that defines a soil based on its structure and the relationship between soil structure and soil water behavior.

The hierarchical soil organization inherent in the PS concept allows for the transferring of information between scales. There are 15 unique pedostructure parameters needed to describe the pedostructure. These fifteen parameters are extracted in the laboratory from the continuously measured shrinkage, swelling, potential, and conductivity curves of undisturbed soil cores. Measurement of these curves is time-consuming, and demands special equipment and trained personnel (Salahat, 2006). Therefore, few soils have been characterized in the pedostructure model using these curves. In addition, up to this point, there has been little work to determine how these parameters evolve, especially under different land management schemes, and whether the pedostructure concept will accurately capture differences in soil water behavior due to land management differences.

Two research objectives arose from these knowledge gaps: 1) the development of pedotransfer functions (PTFs) that accurately estimate the 15 PS parameters using readily available soil data and 2) an examination into how land management affects the parameters.

For the first objective, five soil series in Indiana were characterized using the PS concept. In addition, common soil properties (soil texture, organic matter, COLE index, etc.) were measured in the laboratory and estimated from the SSURGO database (Soil Survey Staff, 2004). Multiple linear regression and artificial neural networks were utilized to gather PTFs relating the PS parameters to common soil property data. It is our hope that soil properties, such as soil texture, organic matter content, soil structure, COLE index, clay mineralogy, CEC, and soil water contents at varying water potentials can accurately predict the PS parameters, in order to facilitate the use of the pedostructure concept in decision support systems.

For the second objective, two subwatersheds were monitored near the town of Waterloo, IN. They consisted of primarily one soil type and one tillage type, a fine, illitic, mesic, Aquic Hapludalf soil under no-till and a fine, illitic, mesic, Aeric Epiaqualfs under moldboard ploughing. Each soil and tillage type was characterized by the pedostructure concept using the methodology described by Salahat (2006). As tillage practices mainly affect the soil at the ped scale with little effect on the individual soil particles, we believe PS parameters related to macro-porosity will exhibit substantial changes between tillage schemes, while those PS parameters related to micro-porosity will not exhibit significant differences between tillage practices. These additions to our knowledge of the

pedostructure concept will help to make the concept more encompassing to soils across the globe.

WATER REPELLENCY INDUCED BY ORGANIC MATTER IN WASTEWATER IRRIGATION

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When a drop of water is placed on a wettable soil surface, it spontaneously infiltrates the soil thereby wetting the soil particles. In contrast, when a drop of water is placed on a water repellent soil surface, infiltration is delayed. A soil is defined as water repellent when the time of penetration for a water drop exceeds 5 seconds. Water repellency, often called hydrophobicity, is induced by organic matter (OM) adsorption and/or precipitation on particle surfaces. Hydrophobicity is related to an initial contact angle greater than 90^{o} between a drop of water and a soil particle surface. The extent of repellency depends on two traits of the system: (i) the contact angle; and (ii) the surface tension of the water. Water repellency is common in sandy soils which have a low specific surface area, although it has been reported for clay soils as well. The source of OM that induces water repellency can be natural vegetation residues and its decomposition products or, as our group firstly reported in 2003, anthropogenic OM from treated wastewater (TWW) irrigation. In addition to the initial hydrophobicity, water repellent soil exhibits lower hydraulic conductivity, lower infiltration rates, higher runoff and a preferential water flow pattern which may develop in the soil profile.

The present research relates to TWW irrigation induced water repellency. Extended irrigation with TWW can alter the soil surface characteristics and induce water repellency as a result of OM accumulation. Therefore, this study investigated the development of water repellency in TWW irrigated sites, aiming to check whether water distribution patterns in these soils differ from that in soils irrigated with fresh water (FW). To meet this goal, we conducted a field study and soil samples were brought to our laboratory in

order to characterize the quality and measure the quantity of the OM in the water repellent soils.

One of the tested experimental plots was an avocado plantation at a research station near Akko. In this plantation, water repellent characteristics were observed in a clayey soil irrigated with TWW. *In situ* measurements showed differences in water drop penetration time (WDPT), and in the size and shape of the wet area around drippers. The sizes of the wet area around the dripper in the FW irrigated soil were much larger and more symmetrical than those measured in TWW irrigated plots. Water content measurement around the drippers and deeper in the soil profile, *in situ*, revealed more dry areas in the soil surface and in the profile in the TWW irrigated plots. The dry areas were found to correlate with those measured and photographed around the drippers at the end of an irrigation event.

An additional experiment was conducted to examine the effect of water quality and soil texture on the degree of water repellency. In this experiment, peanut plants were grown in lysimeters containing three types of loess soils: Clayey (heavy; H – **31**% clay), silty (medium; M- **13**% clay) and sandy (light; L-7% clay) texture. The plants were irrigated with four types of water quality: fresh water (FW), secondary wastewater (S), tertiary wastewater (T), and ultra filtered wastewater (UF). In this experiment, no water repellent characteristics were found in any of the FW treatment soils (as expected). In the TWW irrigated soils, the highest repellency for any given soil type was found for the S TWW and the lowest repellency was exhibited by the UF TWW. For any given TWW quality, the highest repellency was found in the sandy (L) soil and the lowest repellency - in the clayey (H) soil. At the end of the experiment, the highest repellency was found for the combination of L soil and S TWW, and in contrast, the lowest repellency was found for the combination of H soil and UF TWW. From this experiment we can conclud that soil texture and TWW quality determine the degree of repellency induced in TWW irrigated soils.

EVALUATION OF RAINFALL CHEMICAL COMPOSITION AT AL-QUDS RAIN GAUGE STATION – ABU DIS, FOR THE PERIOD OF 2001-2007

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The chemical composition of rainfall events for the period of 2001-2007 are presented in this research. This work aims to identify the characteristics of main ions Ca^{+2},Mg^{+2}, K^{+}, Na^{+}, NH_4^{+}, Cl^{-}, HCO_3^{-}, SO_4^{-2}, and NO_3^{-} in precipitation, and to determine the source or sources of these ions. Moreover, the influence of meteorological parameters such as the wind direction and the rainfall amount are discussed in the study. The rainfall samples were collected from Abu Dis weather station immediately after rainfall events. The chemical analysis of main ions and physical parameters such as pH, EC, and temperature were measured in the laboratory. Titration analyses were conducted for Ca^{+2}, Na^{+}, Mg^{+2}, HNO_3^{-} and Cl^{-}, while the SO_4^{-2}, NO_3^{-}, NH_4^{+} were analyzed by using spectrophotometer.

For the period of the study 2001-2007, five samples were rejected in due to an error of more than 10% in the ion balance, 122 samples remained after the . The arithmetic average of EC during the period is 159.78 µS/cm. The average pH value was 7.1, which means that the rainfall was not acidic. The relative abundance of ions in the precipitation is Ca^{+2}> Na^{+}> Mg^{+2} >K^{+}> NH_4^{+} for cations, and Cl^{-}> HNO_3^{-}> SO_4^{-2}> NO_3^{-} for anions. The arithmetic means of cations and anions concentration (meq/L) for the raining months during the hydrological year was compared to the rainfall amount. This comparison suggested that the concentrations of ions decreased as the amount of rainfall increased. However, the weighted average (WA) concentration of cations were calculated, to find the relation between the amount of rainfall and the ions' concentration during the single hydrological year, and compare it with other hydrological years during the period of 2001-2007. The results show that WA concentration of Ca^{+2} increases when the rainfall amount decreases during the dry months such as November and April. The linear relation between some ions, such as Ca^{+2}, Na^{+}, Mg^{+2}, Cl^{-}, SO_4^{-2}, HCO_3^{-} is illustrated. The result shows that Na^{+} and Cl^{-} share similar sources which is mainly marine, while Mg^{+2} and Ca^{+2} have the same source in the beginning and the ending of the hydrological year.

To determine the continental or marine sources of ions, different ratios were calculated using Cl^{-} as tracer, and these ratios were compared to the seawater ratios. This compression suggests that SO_4^{-2} was mainly from terrestrial sources during the beginning and the ending of the hydrological year. Na^{+}/Cl^{-} results are close to the seawater ratio. Moreover, there are some rain events that show extreme ratios. Apparently, these were

caused by the long period of dry days, sudden depletion of Cl^-, or unexplained enrichment in the concentration of ions. On the other hand, a correlation matrix is presented between the major ions. This matrix illustrates a strong correlation with coefficient factor 0.83 between Na^+ and Cl^-, and weak correlation between Ca^{+2} and Mg^{+2} by 0.28. These results could be used for other studies, especially those which deal with the ground water. Moreover, it can be useful to collect the rainwater for this area in special container to reduce the problem of water shortage.

THE INFLUENCE OF WATER POTENTIAL GRADIENT BETWEEN THE RHIZOSPHERE AND THE ATMOSPHERE ON PLANT WATER UPTAKE

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Matric water head (ψ) is an energetic physical variable which characterizes water in a porous medium. Hydraulic conductivity (K) is a physical variable that characterizes the porous medium's ability to transfer water. These two variables affect plant water uptake ability, and accordingly, all models describe plant water uptake as dependent on these two physical variables. Since there is a functional dependency between these two variables, $K(\psi)$, it is difficult to identify the separate influence of each on plant water uptake.

For the first time, this research tested the separate influence of each of these two variables on plant water uptake. It was hypothesized that lowering the matric head in the root zone without changing the hydraulic conductivity would decrease plant water uptake. To test this hypothesis, a unique experimental system was built. This system allows us to separate the influence of K and ψ on plant water uptake. The hypothesis was tested in two growing methods: 1) Hydroponic growth system; and 2) Unsaturated soil growth.

The unsaturated soil growth system has the ability to measure and determine the values of K and ψ independently, while simultaneously measuring the plant water uptake rate. In the hydroponic growth system, plant water uptake is tested as a function of decreased

water head at root zone. By separating the growth column and the water uptake measuring system, we obtained accurate measurements, which allowed us to calculate the transpiration rate from the mass balance equation.

The results from the hydroponic system experiments contradict the research hypothesis and indicate that there is no direct effect of the reduced water head gradient along the rhyzosphere-plant-atmosphere on plant water uptake rate. Decreased pressure head in the hydroponic system is an energetic parallel to decreased matric head in unsaturated soils. Therefore, examination of the effect of decreased pressure head in the hydroponic system can mark the effect of decreased matric head in the soil, while Hydraulic conductivity is not a limiting factor.

During the hydroponic experiments, a linkage was found between the plant's weight changes, which resulted from plant's water content changes, and the experimental border conditions. The plant lost weight as a reaction to changes in light intensity. A relationship between plant's water content and light intensity was found.

To establish homogeneity of θ, ψ and K along the growth column in the unsaturated soil experiments, a unique system was built. The level of homogeneity along the growth column was 15 cm for ψ, and the derived water content θ out from these values of ψ. The problem with the homogeneity of ψ and K occurred due to changes in plant water uptake, temperature, and light. Hydraulic conductivity K was seen to change by two orders of magnitude, while changes observed in ψ were in a range of 25 cm. As a result, a steady state condition did not exist. Due to the requirements of the experimental system, water supply rates had to be very low, yet it was not possible to keep this rate steady, even with the use of accurate peristaltic pumps.

To conduct accurate measurements of plant water uptake rates, improvements need to be introduced. These include extension of the growth column, a greater column diameter, increased number of plants, creation of stable climate conditions and selection of the best soil for this research.

Advanced Monitoring

ULTRASOUND-ENHANCED NANOPARTICLE-BASED IMMUNOASSAY OF E. COLI O157 IN WATER

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Real-time monitoring of water contaminants is an essential component of any potable water security system. Nanoparticle-based immunoassay is the basic technique in rapid identification of pathogens. We used ultrasonic standing-wave technology to accelerate the immunoassay and for quantative determination the concentration of E. coli O157, by monitoring the change of the amplitude and the frequency of the ultrasonic waves. Calculations of the E. coli O157 bacterium surface area (6×10^{-12} m^2) and the cross-sectional area of the anti E. coli O157 antibody-coated nanoparticles (ACN) show that up to 50 ACN can attach to E. coli bacterium. We use ultrasonic standing waves and laminar flow rate of 30-60 μl / min to trap only E. coli O157 attached to ACN. Free ACN and other bacteria are not trapped at these conditions. The standing waves create an acoustic radiation force which forms two areas of pressure: high acoustic pressure (node) and low acoustic pressure (anti-node), where the particles can be trapped. At our conditions the acoustic radiation forces acting on the E. coli O157 attached to ACN drives them directly to the node. The non-bound ACN and other bacteria are washed out of the separation area

by the water flow. The acoustical pressure depends on the frequency of the standing wave resonator and on the density, compressibility and size of the immune complexes.

The results illustrate the benefits of real-time monitoring of the E. coli O157 bacteria trapped by ultrasonic standing waves. The response time is critical, and physical sampling-based monitoring with sample collection frequency of 24 hours is much less effective than real-time monitoring.

DETECTION OF SALINITY'S EFFECTS ON AGRICULTURAL CROPS, USING BLUE RANGE SPECTRUM, SPECTRAL AND SPATIAL ANALYSIS

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Salinity stress inhibits plant growth and reduces yield. Salinity stress is a common phenomenon within arid and semiarid zones, occurring naturally or due to anthropogenic influences such as irrigation with reclaimed water. In order to treat salinity stress and respond to water quality variability, it is essential to track salinity stress symptoms, and provide relevant information such as location and intensity of its negative effects. Due to its fine spectral and spatial resolution, imaging spectroscopy or hyper spectral remote sensing has the potential to provide the site-specific information about crop status. Site-specific information has a major role in precision agriculture (PA). Applying imaging spectroscopy for PA purposes requires the development of indices that correlate to the cause of growth inhibition or to its symptoms. These indices are then applied on images, regardless of object (plant) complexity or its position within the image, based on the assumption that the response to growth inhibition has a spatially homogeneous distribution. However, most studies relate to a leaf as a homogenous reflector, looking at

average reflectance values for leaf or plant, whereas plant and leaf structure and curviness exhibit variability that affects reflectance.

In this work, the spatial aspects are considered along with the spectral ones. The work has two specific objectives: to identify a spectral indicator within the blue range spectrum reflecting plant status – in this case salinity effects, and to locate image segments that express plant status, considering its structure, illumination variation and leaves' micro-topography and organs. The current work includes two components: introduction of a spectral indicator for characterization of plant stress, and a method for determining the location where it is best expressed in the image.

Three common crops of Israel were grown in a greenhouse under salinity stress, during summer 2008. Hyperspectral images of the plants were acquired using a hyperspectral camera in the range of 350-1100nm (Applied Spectral Imaging Inc.) Five salinity treatments were employed, by maintaining different concentrations of NaCl in the nutrient solution. The proposed spectral and spatial methods were applied to characterize the status of the plants grown under different salinity stress .

The results show that there is significant information within the blue range of the spectrum. Combination of the spectral information in the blue range with spatial information increases the information related to the biophysical state of plants, in this case, the salinity effects. Using the proposed method, differences between effects of salinity treatments were detected in all three crops examined. Applying spatial analysis to specific pixels within the illuminated areas refined the ability to detect the effects of salinity on the plants.

USING ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) FOR STUDYING SPATIAL DISTRIBUTION OF WATER CONTENT AND DYNAMICS OF WATER FLOW

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We investigate the flow patterns beneath an orchard located above the Israeli Coastal Plain Aquifer. Two surface electrical resistivity tomography (ERT) lines were permanently installed along the drip irrigated rows, and perpendicular to the rows, with electrode separation of 0.5-1.0 m. Each line included 96 electrodes, allowing investigation depth of over 10 m. ERT surveys, each with approximately 2,300 individual measurements, were conducted throughout the year (with at least one measurement during each season). In addition, a four day continuous survey was conducted around an irrigation event. Calibration of the petrophysical relations was conducted in three different ways: at the laboratory scale, using undisturbed samples, and using deep FlexTDR data. A clear advantage for on-site calibration was observed.

Our results indicate distinct differences between the flow beneath the tree rows, and between the rows. These patterns are associated with the combination of heterogeneous boundary conditions (i.e., primarily due to irrigation drip lines in summer, rainfall and interception patterns in winter) and heterogeneous root uptake patterns. The signature of these distinct patterns diminishes at a depth of about 5 m, partially because of actual flow dispersion, and partially because of the weakening of the geophysical signal. Our results also show that the different regions of the subsurface (beneath trees and between rows) behave differently in time. While the wet regions below the trees are characterized by a shallower depth in summer, and deeper in winter, the wet regions between the tree rows remain permanently wet (but to lesser degree) and remained at a seemingly constant depth. This is somewhat expected as the top boundary conditions for these regions change differently in time, but it also indicates the spatial extent of root water uptake.

The distinct flow patterns indicate that treating an agricultural field as a homogeneous unit for the purpose of evaluating recharge or contamination loads may be problematic,

especially if the investigation is performed using traditional, point measurements. Such an investigation may be not representative and may lead to very high bias in estimation.

Plant Physiology Water Stress and Growth Conditions

MEASUREMENT AND PREDICTION OF AVERAGE PHOTOSYNTHESIS AND TRANSPIRATION IN A GREENHOUSE SUBJECTED TO FORCED VENTILATION

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Measurement and prediction of transpiration in greenhouses are effective tools for management of irrigation systems that enable estimation of water use of crops in the short term. Furthermore, measurement and prediction of photosynthesis of an entire greenhouse crop can improve greenhouse management by allowing estimation of crop production and of the profitability of greenhouse carbon dioxide (CO2) enrichment.

Experiments were carried out in order to examine the possibility of application of the water vapor and CO2 mass balance methods for measuring average transpiration and photosynthesis of the entire greenhouse crop. Transpiration and photosynthesis rates of bell pepper plants, *Capsicum annuum var Selica*, were measured in a greenhouse subjected to forced ventilation during the spring and summer months of 2007 at the Besor experimental station. Transpiration and carbon consumption by the crop was estimated from the mass balance of water vapor and CO2 on the whole volume of the greenhouse between the air inlet and outlet. Transpiration and photosynthesis values obtained from

the mass balance were compared to those measured by traditional methods (i.e., lysimeters and a portable gas exchange measuring system, LI-COR 6200, respectively).

Results indicate that there were non-significant differences between traditional methods and the suggested method (the greenhouse mass balance). There was a good correlation between transpiration measured with lysimeters and transpiration measured with the mass balance of water vapor of the greenhouse. The ability to use mass balance of greenhouse to measure instantaneous changes in photosynthesis and transpiration caused by the simultaneous changes in radiation (on cloudy days) suggests that this method may be applied in the future in climate control systems, with the objective of maximizing CO2 consumption of the entire crop.

In the framework of the study, three mathematical models were developed, to describe gradients in air properties as a function of the distance from air inlet to the greenhouse: the change of CO_2 concentration in air, the change of water vapor content in air, and the change in air temperature. A strong correlation was found between predicted and measured values of CO_2 concentration and water vapor content. This result indicates the feasability of future application of the models in climate control systems of a greenhouse subjected to forced ventilation, with the objective of maximizing CO_2 consumption by the entire crop and properly managing the irrigation system. Although the correlation between the measurements and the temperature predicting model was less significant than correlation results obtained for the CO_2 and humidity models, this model can also provide reliable information about temperature gradients in a greenhouse subjected to forced ventilation.

IDENTIFICATION OF DROUGHT RESISTANT FRUIT TREE CULTIVARS

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The aim of the research is to identify drought resistant fruit-tree cultivars, by testing the characteristics of the xylem in young branches. Conducting laboratory tests is much faster and cheaper than subjecting whole trees to drought stress in the field. The tests are based on measuring the loss of hydraulic conductivity of the xylem tissue under high water tension due to cavitation. As the soil becomes drier and the plant loses water, the tension in the xylem increases until the water column breaks. This leads to cavitation that causes embolism and loss of hydraulic conductivity of the xylem vessel.

We use the "Cavitron" instrument which simulates this process in the laboratory. During the test, the branch spins horizontally in the Cavitron, the centrifugal force creates tension in the water columns in the xylem in proportion to the rotation speed. As the speed increases, the tension becomes higher, more of the xylem vessels succumb to embolism and the water conductivity of the branch decreases. The resulting xylem vulnerability curve is characteristic of the plant genotype. This method has been used in the past for identifying plants adapted to arid habitats, but this is the first study that uses it for determining intra-specific differences.

Branches of stone-fruit and apple cultivars from the National Deciduous Fruit Tree Collection orchard at Newe Ya'ar Research Center, ARO were tested. The relationships between water tension and xylem loss of hydraulic conductivity were expressed by the pressure that caused 50% loss of conductivity (PLC50). Varietal and seasonal differences were tested. Attempts were made to correlate xylem anatomical characteristics with its vulnerability. Significant differences were found among various tree species, but not among cultivars. As the branches mature during the growth season they become more resistant to embolism.

THE EFFECT OF SALINITY ON THE VEGETATIVE AND REPRODUCTIVE PHASES IN *TRITICUM SP.* AND IN *AEGILOPS SP*

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Salinity is one of the stress factors that limits wheat crop production worldwide. We are looking for salinity resistance traits among wild members of the *Triticeae*. In previous experiments conducted in our lab, we demonstrated the distinction between salinity resistance in the vegetative and in the reproductive phases of plant development. Only plants that exhibit resistance in both phases will be useful for improving crop resistance.

The current research focuses on the effect of salinity stress on vegetative growth as well as on pollination and grain filling. We screened accessions of *Aegilops kotschyi, A. sharonensis, A. longissima* and *Triticum dicoccoides* from the Lieberman Germplasm Bank at the Institute of Cereal Crops Improvement, Tel-Aviv University, for growth, ion content, and reproductive parameters. Six lines of the above species demonstrated relative resistance. Embryos were found in seeds of all lines, but only in resistant lines the endosperm was complete. In sensitive lines, the endosperm was only partly developed, resulting in empty grains. In all lines, sodium and chloride ions were accumulated in the leaves, but only low ion levels were found in the spikes. Two lines of *A. kotschyi* were the most salt resistant and will be subjected to further studies.

DUAL ROLE OF THE WATER/CO_2 AQUAPORIN, NTAQP1, IN REGULATING STRESS-TOLERANCE MECHANISMS IN PLANTS

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Effective water transport via living cells is controlled by water channel aquaporin (AQP) activity in the lipid membrane. AQPs are membrane-intrinsic channels that transport water and other small and uncharged molecules such as CO_2, glycerol, boron and silicone. The tobacco plasma-membrane aquaporin *Nt*AQP1 is abundant in all tissues of the plant, with the highest expression level in the roots. This channel has been reported to facilitate CO_2 permeability of mesophyll cells and has been suggested to regulate root hydraulic conductivity. Moreover, under abiotic stress, its expression level in the roots is significantly increased. In this study, we investigated the role of *Nt*AQP1 in water and CO_2 balance in whole tomato plants under optimal and abiotic stress conditions.

Overexpression of *Nt*AQP1 in tobacco mesophyll cells significantly increases their osmotic water permeability coefficient (P_f). Overexpression of *Nt*AQP1 in tomato plants (*SlNt*AQP1) resulted in a significant increase in whole-plant transpiration rate relative to controls, under both normal and abiotic stress conditions. In addition, *SlNt*AQP1 plants had larger stomatal aperture and a higher rate of CO_2 assimilation, leading to higher fruit yield of these plants under all tested conditions.

Reciprocal grafting of *SlNt*AQP1 and control plants resulted in higher CO_2 assimilation rates under salt stress only when the scion expressed *SlNt*AQP1. However, none of the reciprocally grafted plants had increased transpiration rates. Moreover, under salt-stress treatment, *SlNt*AQP1 plants exhibited higher root conductivity than control plants.

The increased transpiration rate maintained by *SlNt*AQP1 plants could expose them to embolism damage, particularly under stress conditions. We suggest that by maintaining high root hydraulic conductivity under stress, *SlNt*AQP1 plants regulate their whole-plant water conductivity, resulting in improved abiotic stress tolerance.

CALCIUM TRANSLOCATION AND WHOLE PLANT TRANSPIRATION:

NONINVASIVE MEASUREMENTS USING RADIO-STRONTIUM AS A TRACER

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Calcium (Ca) in plants has essential roles affecting tissue mechanical strength and tolerance to biotic and abiotic stresses. Hence, understanding Ca translocation and partitioning within the plant and the factors affecting it has a high agronomic and economic value.

Ca was shown to accumulate mainly in transpiring organs and is considered to be coupled with water movement. However, as Ca moves mainly in the xylem, a transport conduit under negative pressure, any attempt to sample it en-route will cause cessation of flow allowing mostly circumstantial evidence that is limited in scope. To enable *in-vivo*, real time exploration, we developed and utilized a noninvasive novel imaging technique, using custom made sensing devices to track radio-Sr as Ca analog, together with transpiration indicative measurements.

Tomato seedlings were grown for three months in a continuously aerated hydroponic system under controlled climatic conditions. Plants, which had three fruit bearing trusses, were moved to a radioactive facility and arranged in pairs where one plant was continuously weighted for transpiration and the other attached with highly sensitive gamma radiation sensors at various locations for tracer tracking. Adding ^{85}Sr to the plant feed solution showed a relatively fast arrival of the ion to the serially located sensors on the main stem, “down stream” of the expected water flow. Turning lights on and off resulted in relatively high and low transpiration, respectively, and while radiation and transpiration patterns matched on the 1st day, some depression of radiation rate was found on the 2nd day. After a few days, bottom stem radiation levels declined while upper stem

radiation increased, in a loading-unloading pattern, possibly indicating stem Sr exchange capacity. A steady radiation increase was observed in leaf petioles near the 2nd fruit truss, somewhat resembling transpiration. Surprisingly, measurements made on a fruit of the 2nd truss showed a similar pattern with even higher radiation gains in time although lower transpiration was expected there.

Using sensitive gamma sensors clearly enabled following transport and partitioning patterns of root applied radio-Sr in a whole, living plant. We intend to introduce simultaneous water sap-flow measurements and radio-Sr radiation readings at parallel locations to enable detailed investigation of the coupling of water and Sr, as Ca tracer, for both transport and partitioning. Root and canopy treatments are planned to test the coupling hypothesis and the factors affecting it.

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BUNDLE SHEATH TRACHEID COMPLEXES ARE LIKELY TO REGULATE WATER TRANSFER FROM XYLEM TO THE ATMOSPHERE

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Plant growth and development are dependent on the tight regulation of water uptake and transport across cellular membranes and tissues.

During transpiration, water is transmitted through plants, and evaporated from the leaves to the atmosphere through the open stomata. In this process, water must exit the xylem and cross the single cell layer of the bundle sheath tissue tightly surrounding the entire vascular tissue.

Our objective was to measure the water permeability of these cells and assess their role in regulating transpiration in the whole plant.

In this work, we extracted specifically labeled protoplasts from bundle sheath and mesophyll cells from *Arabidopsis thaliana* leaves and measured their osmotic water permeability (P_f) in optimal and in stress conditions induced by abscisic acid (ABA).

Our results demonstrate a uniform P_f behavior for all the bundle sheath cells in all the leaf areas. These cells show a significantly lower P_f when compared to mesophyll protoplasts (6.3±1 versus 12.3±3, respectively). Unlike mesophyll protoplasts, the bundle sheath cells significantly reduced their P_f to extremely low P_f values (3.1±0.5) after treatment with 1M ABA.

These results suggest a novel stress response mechanism, in which the plant reduces its xylem water loss to the leaf in response to stress, employing the unique structure of the bundle sheath tracheid complex.

Modeling

MULTIPLE SOIL LAYER INFILTRATION MODELLING

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Water movement is the backbone of agriculture. The accurate estimation of quantity and quality of water moving through the soil is an important factor in sustaining high quality agricultural production. A number of methods of estimating water movement have been used for many applications; however, as estimates become more accurate, estimation methods generally become more complicated and harder to use.

The Green-Ampt method of estimating infiltration and water movement has been successfully used and modified since its initial introduction in 1911. The strength of this method comes from the relatively simple parameters used in the estimation. Work presented here has expanded on a modified Green-Ampt method to add multiple soil layers, which will increase accuracy of estimates, allowing for more appropriate management. In this case, expanding on the Green-Ampt method does make calculations more complicated; however, no data other than the base parameters is needed. The base parameters used in this water movement method include the saturated hydraulic conductivity of the soils, Ks; the pressure head at the wetting front, ψ; the porosity of the soils, n; and the initial water content, θ.

THE APPLICABILITY OF THE ISOTOPE PAIRING TECHNIQUE

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The isotope pairing technique (IPT), a method used to measure denitrification, has the capability to separately quantify the contribution of the NO3- diffusing from the water column from the contribution of NO3- produced from nitrification in the oxic layer. In the IPT, 15NO3- (nitrate-15 isotope) is enriched in the water column and then diffuses, along with the 14NO3- (nitrate-14 isotope) from the water column and from the nitrification, into the anaerobic denitrification zone, where it is denitrified into three isotopes of nitrogen gas (28N2, 29N2, 30N2). The production of the two heavier isotopes of nitrogen gas can be measured in a laboratory, and by assuming a probability distribution for the three isotopes and mass conservation over the whole system, the amount from the two denitrification contributors (the water column and nitrification) can be calculated using a simple set of equations (Neilsen, 1992).

In order for the IPT equations to be applicable, a specific set of assumptions must be applied. One major assumption is that the IPT experiment must replicate as closely as possible a homogenous system, where there is complete mixing of all the species, such that there is a uniform production of nitrogen gas over the depth of the column and that the production of the three nitrogen gas isotopes are binomially distributed. It is also assumed that the rate of diffusion of nitrate into the sediment is directly proportional to the concentration of the nitrate species in the overlying water.

In this research, a numerical model of the sediment nitrogen processes was constructed, such that the production rates could be determined numerically. The output of the model was analysed using the IPT set of equations, and the IPT results were then compared to the rates obtained by the numerical model. Differences between the two datasets arise due to the inaccuracies of the necessary assumptions. The biggest inconsistency is due to the assumption that the concentrations in the water column determine the diffusive fluxes of the species into the sediment. Hypothetically this could be true when no nitrate source exists within the sediments. However, since nitrification of mineralised organic nitrogen adds nitrate to the sediments, such a requirement does not hold. In order to correct this

error, the ratio of diffusion of the two nitrate species from the water column needs to be used rather than the ratio of concentrations. The fully mixed assumption also induces an error in the IPT calculation. The reason for this error is that applying a distribution over an average and averaging over a distribution are not the same, and inaccurate results are obtained. Unfortunately, none of the data required to resolve these inaccuracies is easily measurable, thus this research deals with a sensitivity analysis to determine the range of values for which the technique is most applicable.

Nielsen, LP 1992, Denitrification in sediment determined from nitrogen isotope pairing, FEMS Microbiology Letters, vol. 86, no. 4, pp. 357-362

Symposium Poster Abstracts

Post-graduate Presenters

CLIMATE CHANGE IMPACT ON WATER AVAILABILITY IN LAKE KINNERET: QUANTITY AND QUALITY PERSPECTIVES

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Long-term (1970 – 2005) analysis (LOWESS 0.8; Stata 9.1) of ecological conditions in lake Kinneret and its drainage basin indicated the following trends: annual precipitation amounts became smaller; river Jordan discharges declined; air and epilimnetic temperatures became lower until 1985 and increased later (1.8 ^{0}C); the water level had lowered by approximately 2 metersmean depth of the thermocline became shallower by approximately 2 meters; concentrations of total nitrogen (TN) including organic – N in Jordan waters decreased and Ortho-phosphate (SRP) increased; epilimnetic concentration of total phosphrus (TP) increased and TN declined, whilst chloride decreased until 1992 and increased later; epilimnetic TN/TP mass ratio had lowered; nitrogen deficiency resulted in decline of *Peridinium* spp biomass. Diatoms, chlorophytes and cyanophytes biomass increased, probably due to P sufficiency, but water quality improved, due to a decline in external input of nutrients. Aridity of the peat soils in Hula Valley probably enhanced P concentrations downstream. Since the mid 1990s, epilimnetic N deficiency and P sufficiency enhanced blooms of N_2 fixing cyanobacteria. The dominant bloom forming dinoflagellate, *Peridinium* spp, which is not consumed by zooplankton, but efficiently utilized by fishes, especially, Sarotherodon galilaeus (Galilee Saint Peter's fish) declined. Small sized algae (chlorophytes, diatoms) are preferably grazed by herbivorous zooplankton.

The temporal fluctuations of relative defecation (% from consumed energy) is respectively related to nitrogen limitation and changes of zooplankton food composition. The increase of epilimnetic phosphorus and the decline of nitrogen (TN and PON) accompanied by a decrease in TN/TP mass ratio are symptoms of N limitation for algal and zooplankton growth. An increase of C by 50% and a 32% decline of TN, which consequently increased C/TN ratio by 140%, were documented. The TP increased by 67% but C/TP ratio increased by only 12%. The positive impact of recycled P by

cladocerans under the present conditions of N limitation enhance chlorophytes, diatoms and cyanophytes. Of these, the former are considered high quality food for zooplankton.

Under the present threat on water quality by cyanophyte blooms, the role of recycled P by grazers might be significant. Nevertheless, water quality standards for domestic supply are fairly adaptable and the need to prevent blooms of toxic cyanopyhtes might be tackled by enhancement of nitrogen inputs and reduction of P loads. Enhancement of zooplankton communities by fisheries management (top – down eco-force) and control of P fluxes from the water shed area (Hula Valley) (bottom – up eco-force) are therefore recommended. Nevertheless, if water supply from lake Kinneret is restricted to water level not lower than -214.50 m, it is suggested that under extreme drought conditions and lack of desalinated water supply,, water level can be lowered down to 215.50 mbsl.

TRENDS AND ISSUES IN WATER RESOURCE MANAGEMENT AND WATER WAR IN RURAL/URBAN AREAS OF SOUTHWEST NIGERIA

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Water is a vital substance essential for most life processes, and is the connector of all components of ecological and life systems. It is the environmental integrator that may be used by people for the benefit of society. This use is called management. As populations grow, the present situation of water resource management is far from satisfactory. To enhance sustainability of water resource management systems, in-depth research of the related barriers and relevant approaches is needed.

In this paper, the history of water availability and use, water scarcity and stress, freshwater distribution, consequences of overuse, competition for scarce water supply, as well as government development, management and policy of water usage were examined.

This study revealed the water use conflicts between rural and urban areas in southwest Nigeria. Investigations were conducted to determine how to manage the water availability

and use in the area. In this study, recent developments, advancements, challenges, and barriers associated with practices of the water-quality management were analyzed. A number ofscenarios , such as system integration, applications and policy implementations were investigated, demonstrating areas that demand enhanced efforts, including data on water availability and reliability, limitations in computer techniques for water resource management, difficulties in policy implementation, and the crtical need to train future water resource professionals. The results of this study indicated that good interaction between policy-makers, water users, and other stakeholder can lead to sustainable water management programs. This study also highlights the importance of policy makers and policy analysts in various countries to share their experiences regarding specific policy issues addressed successfully in their own countrybut may be relevant to other countries in the world.

AFFORESTATION UNDER ADVERSE BIOTIC AND ABIOTIC ENVIRONMENTS. A CONTRIBUTION TO AMELIORATE EUCALYPTUS PERFORMANCE DURING THE ESTABLISHMENT: THE ARGENTINEAN EXPERIENCE

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In the face of climate change and accompanying risks, forest ecosystem management must consider environmentally sensitive multiple uses. The increasing demand for forest products (economy), the protection of native forests from intense degradation (ecology), and recreation opportunities for the public (social function) are some issues that must be taken into account.

Managing water use appears to be one of the main issues. The paradigm linking afforestation to excessive water use relies on a number of assumptions that have not been sufficiently tested. A meta-analysis of studies dealing with the effects of afforestation on

infiltrability in the tropics revealed that infiltration capacity increased about three-fold after afforestation in agricultural fields.

One of the most important forest resources in the world are the *Eucalyptus* species. Several species have the possibility to grow under extreme environmental conditions. They exhibit multiple mechanisms to overcome seriously stressful conditions, which at the same time assure their survival and growth after stress relief.

Establishment of the most productive species is commonly hindered by both biotic and abiotic factors. This study discusses the results of a long term study carried out in Argentina over several years, which dealt with the diverse factors that can help plants overcome multiple resource deficits during the establishment phase.

Eucalyptus plantations in Argentina cover an area of 300,000 ha of mainly former grasslands, where water stress, cold temperature, leaf cutting ants, and weeds are some of the most serious constraints to tree seedlings' growth and development.

Initially we studied *Eucalyptus* responses to single resource deficiencies, analyzing genetic contribution as well as cultural techniques that could improve seedlings' behavior. We explored drought tolerance mechanisms, particularly tissue water relation variables through pressure-volume techniques, and found variability among *Eucalyptus* species, subspecies, provenances and clones in terms of the capacity to develop osmotic and elastic adjustments. Various drought acclimation techniques for triggering the adjustments were tested at the nursery stage, all of which proved to be effective for seedlings' survival and growth under drought conditions and after planting. Higher osmotic adjustment capacity was associated with better recovery after stress relief.

The ability to tolerate shaded conditions, studied in several species and provenances of *Eucalyptus,* was achieved by the adjustment in physiological, morphological and anatomical characteristics.

Differences among provenances in terms of herbivory by leaf cutting ants were observed through trials carried out in artificial nests and outdoors, in natural nests. For some provenances, levels of damage were associated with anatomical and physical properties of the leaves. Results indicated that the damage of leaf cutting ants can be increased under drought conditions, which means that water stress made the seedlings more attractive.

It is clear that resource deficiencies occur simultaneously. The combination of drought acclimation techniques plus different nutrient regimes, with emphasis in K, were tested in the nursery and proved to be useful tools for increasing seedling performance.

Exploring the interactions with herbaceous weeds, provenances with osmotic adjustment capacity showed better behavior and responses under competition. Additional information to estimate plants' competitiveness came from controlled experiments of drought and shade, simulating multiple stress conditions.

Results of this wide spectra research represent a useful contribution to mitigate the adverse conditions of the seedlings' establishment. This study also considered the implications of these results for and their applications to adequate management tools. More information is clearly necessary, as plantations occupy greater areas of different site conditions in the present framework of environmental uncertainties.

AFFORESTATION: COMBINED EFFECTS OF SHADE AND DROUGHT ON EUCALYPTUS GLOBULUS SEEDLING GROWTH

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The availability of numerous environmental resources varies simultaneously in nature. While plastic responses to single resource deficit have been thoroughly studied in tree species, the incidence of multiple resource stress is not well-understood. In afforestation (one of the options for mitigating soil degradation and runoff), tree seedlings can be subjected to herbaceous competition during the establishment, which in fact limits water and light availability, hindering expected results. Little information is available on these issues in *Eucalyptus globulus*, one of the most important forest species.

Therefore, to test the ability of *E. globulus* to withstand the effects of water stress under low light availability, an experiment under controlled conditions was conducted. A factorial design combining the effects of four provenances (two from spp. *maidenii* and two from spp. *bicostata*), two levels of light (full sunlight and shade -100% and 25% of full sunlight respectively-) and two water regimes (with and without water restriction), was applied. During three months, the interactive effects of shade and drought were evaluated on several physiological and morphological seedling attributes tightly linked to plant acclimation.

Drought reduced osmotic potential at full turgor at all levels of light, but osmotic adjustment was higher under shade. The maximum bulk modulus of elasticity and pressure potential increased due to water and light restriction. Only provenances of ssp. *maidenii* displayed significant elastic adjustment. Shoot/root ratio decreased with drought, but only in the full sunlight plants. It was lower under shady conditions, without difference between water regimes. Plants growing at full sunlight and submitted to water restriction exhibited a sharp reduction in total leaf area, while all plants under shade showed large values. Specific leaf area increased in plants of three provenances growing under shade, but it was not modified by water stress.

The provenances of *E. globulus* studied displayed both drought and shade adjustments as response to co-occurring resource stresses. Plastic responses varied according to the variable studied. The resulted of this study indicated that it is very likely that adjustments, associated with drought and shade tolerance, would help plants cope with stressful conditions, and enable more successful resource acquisition Also this study indicated that growth would be probably facilitated after stress relief.

Therefore, our results are not consistent with the trade-off hypothesis, which postulates a conflict between drought and shade tolerance. Even though *Eucalyptus* species are considered intolerant to weed competition, these results and previous reports allow us to conclude that the present mechanisms of acclimation could be triggered under multiple stress conditions generated by the competition of the herbaceous vegetation. Field experimental data are necessary to confirm this hypothesis. The results of this study would be valuable to adapt vegetation management techniques during establishment of plantations.

OPTIMAL ALLOCATION OF WATER RESOURCES IN GUANGZHOU CITY, SOUTH CHINA

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Based on the theory of decompose-coordination for large-scale systems, a systematic optimal operation model with multi-objective programming was developed, for optimal allocation of water resources in Guangzhou City, South China. The methods of hierarchical analysis and step by step toleration obligation were used in the process of coordination through the sub-systems. Through the integrated regulation of 13 reservoirs and 6 main rivers and the regional watersheds, estimated water amount for dry year (p=97%) was distributed optimally to 14 water resource units to meet water demand in the year 2020. Water shortage due to lack of runoff and insufficient water supply projects was analyzed. In this study, the scheme of water allocation within seven water resource districts was studied to match the sustainable balance of water supply to water demand in Guangzhou City.

REDUCING POLLUTION OF MACRO AND MICROELEMENTS IN FOOD-SUPPLY CHAINS BY USING GRAFTED PLANTS UNDER IRRIGATION WITH MARGINAL WATER

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Semiarid and arid regions are characterized by long dry seasons and short wet seasons. To satisfy the demand for food and to combat desertification in these regions, marginal water sources, such as treated domestic sewage (effluent) and saline water, are increasingly being used for irrigation.

In effluents, the electrical conductivity and pH values, and the concentrations of micro-elements (boron and heavy metals), nutrients, and dissolved organic matter are, in general, significantly higher than in fresh water. Long-term irrigation with effluent water could increase the concentration of contaminated elements in the soil, and may limit the sustainability of agriculture. Grafting vegetables, including cucurbits, is a common practice in many countries. The main purpose of employing this technology in vegetables is to control soil-borne diseases. In addition to disease resistance, grafted plants may have improved tolerance to high concentration of contaminated elements in the soil.

The objective of this presentation is to demonstrate a useful tool for preventing entry of contaminants and saline elements into fruits. Experiments were conducted in a greenhouse and the field, to compare the responses to irrigation with fresh and effluent water, of non-grafted melon (*Cucumis melo* L.) cv. Arava plants and melon plants grafted onto the commercial *Cucurbita maxima* Duchesne × *Cucurbita moschata* Duchesne rootstock 'TZ-148'.

In general, the non-grafted plants accumulated much more Na, Ca, Mg and Cl than grafted ones. Moreover, the concentration of microelements, such as - B, Zn, Sr, Mn, Cu, Ti, Cr, Ni, and Cd, in the fruits was lower in the grafted plants than in the non-grafted ones. It can be concluded that grafted melon plants contained lower concentrations of contaminated elements than did non-grafted ones, because of the selectivity of the pumpkin root system to theses elements.

MECHANOCHEMISTRY: SURFACE REACTIONS AND ENVIRONMENTAL APPLICATIONS

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Mechanochemical processes can be employed for a variety of environmental uses, possibly the most important of which is soil remediation. The utilization of mechanical force for the enhancement of the degradation of a number of organic pollutants (imazaquin; 2,4-D and polycyclic aromatic hydrocarbons) is demonstrated. The mechanochemical process investigated that consisted of the application of a mechanical force to mixtures of a soil-component mineral with the pollutant to be degraded. The minerals used included montmorillonite saturated with Na^{+}, Ca^{2+}, Cu^{2+} or Al^{3+}, birnessite and hematite. The mechanical force was applied through manual grinding with a mortar and pestle.

The degradation rate of imazaquin in the above solid mixtures was examined as a function of the following parameters: time of grinding, imazaquin load, temperature, acidity/basicity and moisture content. Addition of Cu^{2+} to the Na-montmorillonite/imazaquin mixture was the most effective treatment in degrading imazaquin (more than 90% of the substance degraded after 5 minutes of grinding).

The mechanochemical degradation of 2,4-D loaded on synthetic birnessite was investigated using heat conduction calorimetry. The overall transformation kinetics of 2,4-D on birnessite after light grinding were approximately first order. Two degradation products were identified, 2,4-dichlorophenol and CO_2, but no consumption of gaseous oxygen was detected.

The overall impact of mechanical force on an EPA mix of 18 polycyclic aromatic hydrocarbons (PAHs) was tested and the degradation of four representative PAHs (acenaphthene, phenanthrene, pyrene and benzo[a]pyrene) was studied in detail. As in the case of imazaquin, Cu-montmorillonite was the most effective mineral in degrading these compounds under both wet and dry conditions.

COMPARISON BETWEEN TRICKLE (DRIP) IRRIGATION AND WILD FLOODING IRRIGATION SYSTEMS AT DEVELI CLOSED BASIN

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Develi is a closed sub-basin of Kızılırmak River Basin (Basin no:15). Sultansazlığı being one of the 7 wetlands of Turkey, is located at the lowest part of Develi closed basin; at the Develi, Yeşilhisar and Yahyalı triangle. Recently, a total area of 78,065 ha is being irrigated. Generally, wild flooding irrigation is still being used; only a few farms use sprinkler and trickle irrigation systems. In wild flooding, the rate of water loss is very high and available surface water resources of the basin are not sufficient to cope with the irrigation water requirement; therefore, excess abstraction from groundwater wells and restricted irrigation are being used at the basin.

Develi Basin Irrigation Project has two development stages, the first stage, which started in 1976 and was completed in 1987, included construction of Ağcaşar and Kovalı Dams, Çalbalma Tunnel, and irrigation and drainage systems. At the first stage, it was planned to irrigate 28,046 ha using surface and groundwater. The second irrigation development stage is currently under construction. The second stage will cover Zamantı Interbasin water transfer tunnel. Zamantı tunnel will supply 111 million m^3 water in the normal season and 150 million m^3 water in dry season. Energy of the water transferred from Zamantı River will be harnessed before, to supply irrigation.

In this study, total water requirement of both trickle irrigation and wild flooding irrigation methods are compared, using the existing crop pattern. It should be noted that according to the crop pattern of the basin, some species (cereal, fodder) should not be irrigated by trickle irrigation; for these species, sprinkler irrigation is considered as the first choice. Conversion of wild flooding irrigation method into sprinkler and trickle irrigation methods will result in about a 52% water economy. Given that currently a large percentage of irrigated farming area is grains (cereal), it is likely that the present cereal

and fodder species will be converted into other types of crops so tha only trickle irrigation is used at the plain. Once this transition is in place, and only species suitable for trickle irrigation are used (for example: fruit orchards) water economy will reach 71 %. This means that with the same water, 2.5 times more land can be irrigated if trickle (drip) irrigation method is used.

NUTRIENT AND WATER MANAGEMENT OF DRYLAND FARMING ON THE LOESS PLATEAU IN CHINA

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The Loess Plateau is one of most serious soil erosion areas in the world. Winter wheat-summer maize rotation system is one of the major crop rotation systems in the south Loess Plateau. As an extensive crop rotation system, farmers usually add more water and fertilizer into the field. Different crops compete over limited agricultural resources (eg., water, fertilizer, heat), which leads to unstable crop yield. Therefore, using the cultivation methods of semi-dryland farming, i.e., combination of supplemental irrigation method with water-saving methods on dryland farming, is an option for the sustainable utilization of limited water resource in the region.

A field experiment was established in 2003 at Yangling, Shaanxi Province, to investigate the effects of different cultivation methods (furrow planting, straw mulching, conventional and water-saving cultivation) and different nitrogen fertilizer rates on winter wheat and summer maize grain yields, nitrogen use efficiency, water storage and water use efficiency (WUE), and residual nitrate N in soil profiles.

(1) Application of N fertilizer significantly increased the biological and grain yield of winter wheat and summer maize. However, while the N application was increased from 120 kg/ha to 240 kg/ha, the biological and grain yield of winter wheat didn't keep increasing. Compared to the application of N fertilizer, the effects of different cultivation methods on the biological yield in winter wheat at the different stages was not significant.

The biological yields of summer maize under furrow planting and straw mulching was higher than that of conventional and water-saving cultivation methods.

(2) As the application rates of N fertilizer were increased, the water storage in soil profile became reduced, and the water storage was significant decreased in 100-200 cm of soil after winter wheat harvesting. The grain yield and water use efficiency (WUE) of winter wheat and summer maize were increased by addition of N fertilizer. Grain yield and WUE of winter wheat was the highest under straw mulching, the next was furrow planting, and conventional and water-saving cultivation methods. However, grain yield and WUE of summer maize was the highest under furrow planting, the next was straw mulching, and the conventional and water-saving cultivation methods.

(3) With the increase of cultivating seasons and the increased application rates of nitrogen fertilizer, the rate of residual nitrate N in soil was significantly increased. After harvesting the fifth crop, the averages of residual nitrate N in 0-200 cm depth of soil under different cultivation methods ranged from 218 kg/ha to 329 kg/ha, and mainly concentrated in 100-200 cm soil depth. The residual nitrate N in 0-200 cm soil profile under treatment of 240 kg N/ha was as high as 477 kg/ha at the fifth crop harvesting. Compared to other different cultivation methods, the residual nitrate N in 0-200 cm depth of soil under the furrow planting system was the highest.

SPATIAL ASSESSMENT OF SUMMER BARLEY NITROGEN CONTENT FROM HYPERSPECTRAL DATA

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Nitrogen availability is an important determinative of crop management. Knowledge of the actual plant canopy nitrogen content makes it possible to determine nitrogen needs of plants to , as well as expected potential crop yields. Development and growth of yield components may be positively affected by nitrogen fertilzer application method, timing and rate of fertilization. An adequate nitrogen supply to crops is required to optimize yield, but excessive nitrogen application can increase nitrate contamination of soils and groundwater.

The aim of summer barley cultivation is the production of premium malting barley, an arable crop which is only cultivated for brewing beer. Compared to regular barley (protein content 14 %), malting barley only shows a protein content of 10 - 11 %. Low protein content has the advantage that the desirable starch content increases up to approximately 63 %. In addition, higher protein content may result in undesired beer turbidity. Starch is an important ingredient of malting barley, which in the later mash process is decomposed to maltose and even later on during fermentation by top-fermented yeast to alcohol and carbonic acid.

Important determinants for malting barley quality are the plant variety and the N dynamics in the production system. Nitrogen supply should be adjusted for higher yields but in no case should lead to high grain protein content. Fertilization strategy in case of malting barley aims to avoid too high nitrogen application so as not to exceed the required protein contents. If the protein content, which can be calculated from nitrogen content by multiplying by 6.25, exceeds these limits, it can only be sold as feeding barley at lower prices. This balancing act of fertilization leads to the search for a fast screening method for non-destructive protein content determination.

Therefore, this paper presents an approach to predict nitrogen content of summer barley at plot level. Reflectance spectra of summer barley canopies acquired at different phenological stages were measured in the field canopies using an ASD FieldSpec II spectroradiometer. Plant spectral properties reflect crop nitrogen status and can be used for spectral determination of nitrogen content. Partial least-square regression was used to examine relationships between reflectance spectra and nitrogen content of summer barley.

Hyperspectral image data were acquired on May 28, 2005 by a HyMap airborne imaging sensor. Image pre-processing was performed, including an across-track illumination correction and both atmospheric and geometric correction steps. For the assessment of spatial and temporal variability of nitrogen, field reflectance spectra were resampled to HyMap spectral resolution, and partial least-square regression model was adapted to hyperspectral imagery.

Nitrogen concentrations of summer barley canopies were estimated with reliable accuracy by partial least squares regression from field reflectance spectra ($r^2 > 0.9$). Implementation of the model on the HyMap imagery allowed prediction of barley nitrogen content at 5 meters resolution, with an accuracy of 84 %. Results confirm that the ASD FieldSpec II spectroradiometer can accurately predict very similar nitrogen concentrations in plants to those measured by laboratory chemical analysis.

SELECTED PHYSICAL-CHEMICAL-MICROBIOLOGICAL PROPERTIES OF SOIL AMENDED BY OLIVE MILL WASTEWATERS – THE CASE STUDY OF REVIVIM

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Extremely high organic load and the toxic nature of olive mill wastewater (OMW) prevent its direct discharge into domestic wastewater treatment systems. In addition to the various treatment schemes designed for such wastewater, controlled land spreading of untreated OMW has been suggested as an alternative mean of disposal, and is currently approved by the Israel Ministry of Environmental Protection.

Over the last two years, OMW (from the olive mill of Haluza) was annually applied between the rows of the olive plantation in Revivim (Negev, southern Israel; loess soil). Annual application rates are roughly estimated to vary drastically, from several tens and up to 100-150 m^3/ha at some local spots. The soil was sampled in January 2008 and six months later, after the last OMW application, in July 2008. Soil samples were collected from five soil depths (10, 30, 50, 70 and 90 cm) at four random sites (3-4 profiles were collected at each site), representing the visible variability of OMW application rates. At each site, both amended (between the rows) and un-amended (next to the rows) soil samples were collected. Soil extracts were analyzed for pH, EC, dissolved organic carbon (DOC), total phenols (TP), and phytotoxicity using cress (*Lepidium sativum L.*) bioassay. In addition, soil respiration was measured using the entire sample and soil suspensions were used for total microbial and fungal viable counts.

The impact of OMW application was evident across the whole profile (up to 90 cm depth) in all measured parameters. The DOC, TP, soil respiration and microbial counts were substantially higher in amended soils. This effect was highest at the top soil layer and decreased gradually with depth. These trends did not disappear six months after the last OMW application (summer sampling). Although OMW is known to be phytotoxic, no significant phytotoxicity was observed across the profiles of amended soils as compared to the un-amended soils. Moreover, OMW residues did not inhibit the general microbial activity, but rather provided available substrate for microbial

growth. The results of this study call for close control of current and future OMW land applications, especially in hydrologically sensitive areas.

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