Vulnerability of Water Resources due to Climate Change in Eastern Mediterranean Ecosystems – An Integrated Approach to Sustainable agricultural Management

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A. Regional climate change . P. ALPERT, S. KRICHAK, C. PRICE

Section 1 ABSTRACT

The 2003 progress report is divided into four different sections including analysis of past data and global warming models (sections 1, 2, 3a and 4), analysis of future model predictions (sections 1, 2) and building of the regional climate modeling tool (sections 3b, c). In section 1, we were approved as a subgroup of CMIP (Coupled Model Intercomparison Project) which allows us a full access to the major global warming models (19 in the first cycle). In this section also global analysis of land-use changes are being carried out to allow estimation of this factor in the EM. In section 2 we have completed the objective daily classification of the weather synoptic systems over the EM for 1948-2000 y. ECHAM4/OPYC global warming run simulates very well the relative percentages of the different systems but not the critical trends. For instance, the ECHAM4 model does not capture the increase (nearly doubling) of the frequency of Red-Sea Troughs days from the 1950s to 1990s. In section 3 we describe the preliminary regional climate modeling experiments both statistical and dynamical approaches. Our ability to run the RCM for long periods of 30-y are hampered by the lack of enough computing power. We have obtained an account on DKRZ super-computer in Hamburg, and are in the process of realization of this effort in Germany. In section 4 analysis of trends in typical EM monthly circulation patterns for rainy months and their trends are described.

Section 2: CONCLUSIONS

- We got output of 19 global CMIP models, which will allow us a careful analysis of the global warming models over the Mediterranean. Also of land-use changes impact on model errors.
- The MM5 was preliminary tested as a tool for regional climate modeling. We were registered as members on the on-going PRUDENCE EU project on testing RCMs for Europe region.
- Daily classification of synoptic systems for 1948-2000 completed. This includes: change of seasons, identifying significant increasing trend in the Red-Sea Trough relatively dry system.
- ECHAM 4 run for 1950-2000 simulates quite well the various synoptic systems, not so the significant observed trends.

Body of the report

1a. Global Warming Simulations over the Eastern Mediterranean

One of our main research goals is the evaluation of Climate Models scenarios in the Eastern Mediterranean region, and the projections to the 21st century, by investigating their ability to simulate the observed recent 50 y climate trends over the eastern Mediterranean region and to investigate the simulated greenhouse gas induced changes in temperature and precipitation in this area. For that purpose we make use of the CMIP (Coupled Model Intercomparison

Project) data. The CMIP is an intercomparison of idealized climate change experiments with coupled atmosphere-ocean GCMs. The purpose of CMIP is to provide a database of coupled GCM simulations under standardized boundary conditions. A primary strength of CMIP2 data set is that it includes most of the climate models currently in use. CMIP provides 3 field variables at monthly mean time resolution: surface air temperature, sea level pressure and precipitation.

1b. Global investigation of Land Use effect on the lower atmosphere, using the Increment Analysis Update (IAU) approach.

In our research we employ the Increment Analysis Update (IAU) method to estimate the contribution of land use changes to the climatic trends in the past 50 years. We have completed the spotting and delimiting of regions of major land use changes over 20 years (1970 – 1990) all over the globe according the HITE (Human Impacts on Terrestrial Eco-systems) – CDROM. A land use index, which represents the type of land use change and is attributing each grid point to a specific process (such as deforestation, agriculture, afforestation, desertification), was calculated. Our current aim is to create a scatter plot for IAU (T) versus land use index for the spotted regions. This latter step will enable the estimation of the contribution of land use changes to the "models errors" (IAU) and evaluation of uncertainties in regional climate information in the Eastern Mediterranean region concerning land use changes derived from multiple sources.

2. Climatological analysis of Eastern Mediterranean synoptic systems (1950-2000) based on NCEP-reanalysis and ECHAM4-modeled B2-scenario

The Eastern Mediterranean (EM) daily synoptic systems have been classified into 19 typical synoptic classes. The modified discriminant analysis method was used for classification. The classified systems were grouped into large groups by seasons (Alpert et al., 2003 a, b).

NCEP-reanalysis data:

The main results on the NCEP-reanalysis classified synoptic systems for 1948-2000 follow:

1. The annual number of the Red Sea Trough days in late 1990s was doubled as compared to the late 1960s (90-110 vs. 50-60).
2. The annual number of the Cyprus Low days slightly dropped from 35 to 30 in the 1980s compared to 20-25 in the 1970s. This points on a drying tendency of the EM winter climate. But in the last decade this oscillates from 20 to 40 indicating high instability of the EM climate.
3. The annual numbers of the Persian Trough days dropped from 130 (1950s) to 110 (1990s) on average. This suggests a slight northward shift of the northern periphery of the subtropical high in the EM area and therefore stabilizing of the summer climate.
4. The timing of the winter and summer seasons as the periods of the typical weather conditions were studied. The 4-monthly duration of both has been found as typical.

Synoptic analysis of SRES B2 scenario run performed with ECHAM4/OPYC:

1. The annual number (averaged over 1950-2000) of all typical synoptic systems were found very close to those of the NCEP reanalysis, with the differences of only a few percents. This is a very encouraging result.
2. The first pick in the ECHAM-modeled yearly cycle of intensity of the RST days (~ 50% of time) is in late October/early November like the NCEP-reanalysis one. The second ECHAM pick (~ 36% of time) is delayed by about one month (late January/early February) as compared to the NCEP one (late December/early January).
3. The ECHAM-modeled annual cycle of the intensity of the Persian Trough days does not have a slight drop from the early July to late August with the minimum in late July. That feature characterizes the NCEP cycle of this system and follows from the northward shift of the subtropical high in the high summer. Therefore, the maximum ECHAM Persian Trough intensity (~ 90% of time) is slightly higher than that of the NCEP reanalysis (~ 87%).

4. The ECHAM-modeled Winter Lows days' annual cycle provides in January intensity that is less than the NCEP by ~ 25% and therefore looks like a significant drop in the seasonal picture. The other months are modeled better on average.

5. The maximum ECHAM Sharav Low day's intensity is in the late April to late May that is delayed by about one month as compared to the NCEP one (late March/early May).

6. The long-term annual frequencies of all synoptic systems oscillate around their average values by ~ 30% changes and do not show any significant climatologically trends as found in the reanalysis.

3. Regional Climate and Modeling for ICCAP Turkey

3a. Domain parameters for regional climate modeling for ICCAP Turkey Statistical approach

The approach is applied for the determination of the size of the regional climate simulation domain according to the level of mean statistical significance of the mean October-March winds-precipitation relationship (section 4). According to the obtained result, statistically reliable description of the EM precipitation processes requires the large enough model domain, which includes not only the EM area but also eastern part of northern Africa, regions located to the south of the Caspian Sea, Turkey and the Black Sea. Due to the orientation of the circulation regime the eastern boundary of the domain here is positioned at 65°E.

During the last several decades the main European circulation patterns (NAO and EA/WR) have experienced positive trends. The trends caused an eastward displacement of the area with the southward airflow over the northern Mediterranean. Results presented allow the following explanation of the recent trends in the EM precipitation. The observed decrease in the annual EM precipitation during the last decades could be associated with a displacement of the area with the predominant positioning (and migration) of the EM cyclones. Intensity of precipitation over the Sea could be increasing however. The suggestion is probably supported by the recently demonstrated tendency to an increase of intensity of extreme rains during 1950-1995.

The last years were characterized by low values of the NAO index and, consequently, a decrease of the Azorean High' role in comparison to that of Siberian High. According to results of the current study the large-scale change could be leading to a westward displacement of the zone with the southward airflow over the northern Mediterranean. The effect could be leading to a slight shift of the zone with the precipitation to Turkey. Additional analyses may be required for an evaluation of the hypotheses.

*Appendix The SRES scenarios

The IPCC Special Report on Emission Scenarios (SRES) provides 40 different scenarios, which are deemed "equally likely". For the Third Assessment Report, the IPCC facilitated the conversion of two of these emission scenarios (A2 and B2) into concentration scenarios for use in climate simulations. The A2 scenario envisions population growth to 15 billion by the year 2100 and a rather slow economic and technological development. It projects a relatively intense increase of greenhouse gases (GHG) emissions partly compensated by an aerosol loading. A relatively intense global warming process corresponds to this scenario. The B2 scenario envisions a slower population growth (10.4 billion by 2100) with a more rapidly evolving economy and more emphasis on environmental protection. It therefore produces lower emissions and less future warming.

B. Global warming biomass production and water requirements.

Jiftah Ben-Asher, Dan Blumberg, Pedro Berliner and Abraham Zangvil

1. ABSTRACT

Two goals were formulated for this branch of the project: Quantification and development of models to predict the effect of extreme GCC scenarios on biomass production (Goal No. 1) and the integration with two of the other branches of the project, "Climate predictions" and "Socio-economic evaluation" (Goal No. 2).

Four specific objectives defined in order to meet Goal 1 and to enable us to transfer the necessary information to the other groups as required. The specific objectives and the results obtained so far follow.

1. Physical simulations of climate change in a greenhouse. Greenhouse simulations have been completed with clear conclusions that tripling the CO_2 in the atmosphere may have a positive effect only if the CO_2 is the limiting growth factor.

2. Developing of remote sensing tools to identify surface changes in vegetation and water content. Remote sensing studies have succeeded in establishing a reliable approach to estimate surface water content. The techniques necessary to estimate the spatial variability of vegetation are being developed.

3. Model crop response to climatic changes. The decrease in relative humidity, a possible result of global warming may result in yield reductions. We adopted the official EU model SWAP and collected all required parameters to obtain high correlation between measured and modeled results.

4. Use the remote sensing tools to map the spatial variability of vegetation and water content. Preliminary attempts were made to use ERS-SAR imageries to describe the spatial distribution of water content in the Negev desert. Simultaneously a combined spatial variability study and GIS has yielded the relationships between CO_2 flux from the soil to the atmosphere and soil salinity in the Chukurova basin Turkey. Continuation of the project will include extension of the results to other crops. Next year we shall focus on the use of the model together with several GCC scenarios and completion of several missing tasks for example the spatial distribution of natural vegetation and agricultural crops.

2. CONCLUSIONS.

Although significant information was obtained in our last year activity the element of the study that requires more attention in the next few years is the integrated scientific approach to understand future changes in Eastern Mediterranean agricultural and natural primary production in the context of global climate change. The proposed acquisition of predictive information will provide the foundation for decision-makers to develop policies on a regional scale, particularly for water use and land management.

Among the main issues we may cite:
Continue the modeling efforts to obtain daily variation of soil water content under the climatic conditions of the Chukurova Basin Turkey.
Reconstruction of soil water content from archival ERS SAR images.
Continue the development of the linkage between the Geo-statistical methods and GIS for the assessment of the spatial distribution of several major entities related to the bi-directional impact between GCC and earth surface. This may include biomass production, NDVI, LAI soil moisture and energy balance components.

1a. Greenhouse simulations
Investigation of crop factors that are influenced by global warming

The factors that are either influenced by crop production or affecting crop production were studied in the first stage and results are currently analyzed. We concentrated on studying the effect of CO2, relative humidity and dew formation on crop production. The physical simulations were carried out in the Besor greenhouses in Israel. The bulk of the work related to the CO_2 and relative humidity simulations has been completed. Still to be developed are the explanatory models in particular those related to the impact of relative humidity on stomata resistance to gas exchange (water and CO_2).

Impact of CO_2

Results of the greenhouse study in which the impact of soil fertility on carbon use efficiency by Amaryllis growing in a CO_2-enriched atmosphere showed that if site fertility was very low, the responses to the tripling of CO_2 concentration were muted. Without Potassium application, enriching the atmosphere with CO_2 (from 350 to 1000 ppm) resulted in an increase of only 3-6 %, whereas the same increase in CO_2 resulted in a significant increase of 11-23% in the presence of fertilizer. These results clearly indicated that at suboptimal nutrient availability there was very limited response to CO_2.enrichment

No interaction between CO_2 enrichment and Nitrogen fertilizer was found. But it should be mentioned that this result is crop specific while the principle of the factor at minimum is more general.

The response of growth to CO_2 enrichment changed throughout the growing season. It decreased during the first 50 days of growth and increased from then onwards. Thus, the short-term dynamics of the elevated CO_2 response may not portray the longer-term effect. A long growing season, as was the case in this study, highlighted the need for caution when generalizing from short-term studies and from one major element to the other.

1b. Impact of relative humidity with special emphasis on Dew.

The study was carried out jointly with the Turkish team.

Methods : Field study was carried out in the Chukurova basin Turkey (representative coordinates: 37° 01' N, 35° 21' E; elevation 10-150 m). The basin is situated in the Mediterranean region. The Northwest, North and Northeast areas are surrounded by the Central Taurus Mountains and the Mediterranean is in the south. It is the largest delta plain in Turkey; Soils are composed of the alluvium carried by Seyhan, Ceyhan Rivers and Berdan (Taurus) creek. The region is influenced by the Mediterranean climate, and shows differences depending on the hilly terrain. Generally, it is hot and dry in summers and mild and rainy in winters.

Main measurements were conducted with a PM48 infrared gas analyzer (IRGA) which measured three replications of continuous CO_2 and H_2O fluxes throughout 24 hours. The plants were: forty days old Cotton (*Gossypium hirsutum*) and Soybean (*Glycine max*), mature Maize (*Zea mays*) representing field crops. Lemon (*Citrus limon,*) representing perennial groves. Three typical Mediterranean trees were tested on the Taurus mountains (Turkey): Pine (*Pinus pinea*), Pistachio (*Pistacia terebinthus*) and Oak (*Phyllyrea media*).

The new portable device (PM 48 PhyTech Israel) has the unique capability to monitor, continuously, photosynthesis , transpiration and other environmental variables. It is a four-channel automated system equipped with a set of four self clamping leaf chambers which operate one by one in such a manner that the one leaf chamber is closed at a time while the others remain open to allow undisturbed gas exchange between the leaf and the atmosphere. Each leaf chamber has a reference CO_2 probe connected to a built-in CO_2analyzer and data logger. Additional set of built-in accessories included sap flow sensor, PAR, global radiation wet and dry air thermometers, and 2 leaf thermometers. Hydraulic canopy conductance was calculated from ratio between transpiration and VPD in terms of partial vapor pressure[11,15,16]. Transpiration was obtained from the product of potential transpiration and whole plant relative sap flow. This sensor measured the ratio between actual and potential transpiration.

Statistical considerations

We analyzed the standard deviation of three leaf chambers per plant while the forth chamber was used to measure soil respiration. Ambient CO_2 was detected with four probes including the probe attached to soil respiration. The dimensionless data are average of actual values from three dew affected plants with three replications such that each data point represent a population of 9 samples taken from June 16 to June 22,2003. Average standard deviation of the normalized values was 0.13 for both photosynthesis and transpiration.

Each day, dew point temperature was determined when relative humidity (RH) was at its maximum. It ranged between 93 and 99% but on the Taurus mountains it was 85.6%. Additional information is provided in theMethods section.

The measured dew point temperature and associated climatic conditions are given in table 1.

According to Table 1 dew was formed in four nights each for a different crop (Cotton, Soybean and Corn). In the early morning hours of the 16,17,18,and 19 of June the canopy temperature was below the dew point temperature of the surrounding air and leaves were covered with dew. It was formed between 3:30 and 5:30 am. (Local time) whereas dew formation was not detected on the mornings of 20 and 21st of June when leaf temperature was slightly higher than the dew point temperature.

Table 1.measured dew point temperature and associated climatic conditions

Date	Occurrence Time	Crop	Dew point Temperature	Leaf temperature	Air temperature	Relative Humidity (%)
16/6/03	3:30	Cotton	20.2	20.0	21.3	93.2
17/6/03	4:00	Cotton	21.1	19.8	21.7	96.2
18/6/03	5:30	Corn	20.4	20.1	21.5	93.3
19/6/03	5:30	Soybean	20.9	20.6	21.7	95.4
20/6/03	5:30	Lemon	20.6	20.8	21.4	95
21/6/03	5:30	Oak, Pine&Pistachio	20.4	20.7	22.9	85.6

Results :

In order to compare diurnal evolution of transpiration and photosynthesis of the different plants within the exact same boundaries, diurnal mass balance data were normalized to the maximum fluxes. The normalized results in Fig.1a display the lag time between peak photosynthesis and peak transpiration of the dew affected crops (3 crops with 3 replications n=9, 1 s.d. = 0.13) From Fig.1a , maximum photosynthetic rates were measured several hours earlier than maximum transpiration rate which occurred at about 2 pm. Fig 1b shows the same trend but with actual fluxes of H_2O and CO_2 measured in the cotton field.

diurnal evolution of transpiration and photosynthesis

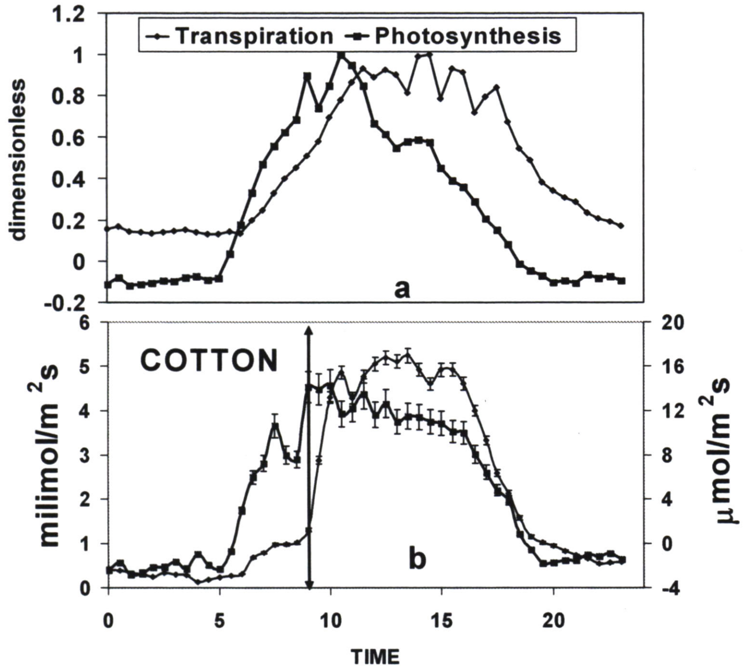


Fig.1 Diurnal evolution of transpiration and photosynthesis

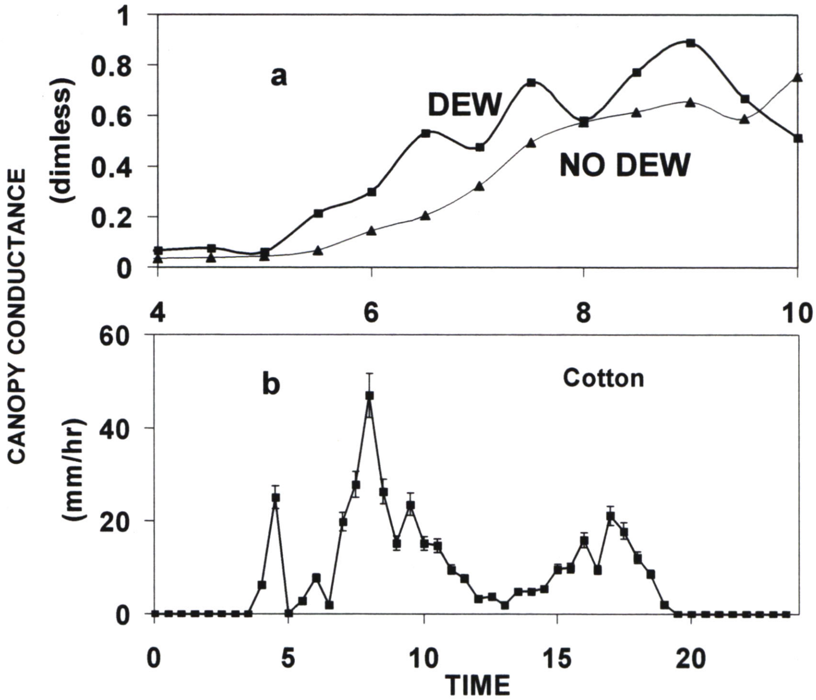
Separated, early peaks of photosynthesis and late peaks of transpiration are contrary to expectations because the pathway for diffusion of CO_2 into leaves is similar to the pathway for diffusion of H_2O out of leaves and under optimal growth conditions both are linearly affected by the amount of solar radiation that they absorb and stomatal conductance. That is, when water is available, plants show wide stomatal opening for CO_2 intake and water transport upward , but stomata are closed during drought periods, thereby slowing CO_2 and vapor exchange.[13-14]. Thus the two processes are expected to be in phase. In Fig 1 however, photosynthesis in the early morning hours was weakly linked to transpiration or not linked at all. We argue here, and later demonstrate it experimentally that, thanks to the dew, this weak linkage is an inherent part of strategy aimed at

maximizing WUE which is most important in habitats where water supply is limited.

Today, there are increasing evidence that in plants under humid environment (i.e. low VPD) the Abscisic Acid (ABA) signal enhance stomatal opening and CO_2 intake for carbon fixation and growth.. Inversely, plants growing in arid and semiarid regions may, in response to large VPD, synthesize the hormone Abscisic Acid, which triggers closing of stomata. The presence of dew on the leaves creates temporary humid conditions in the leaf-air boundaries and increase stomata aperture. This is the biochemical basis of the measured exponential increase of stomatal conductance in response to reduction in leaf to air VPD which occurred when dew covered the leaves. The results presented in Fig.2 coincided with this theory. We displayed the normalized hydraulic conductance of the canopy as a measure for stomatal aperture.

Fig.2 coincided with this theory. We displayed the normalized hydraulic conductance of the canopy as a measure for stomatal aperture.

Fig.2 The normalized hydraulic conductance of the canopy as a measure for stomatal aperture.



At 6:30am canopy conductance of plants affected by the dew was more than 2.5 times larger than that of unaffected plants. At 9:00am it was about 1.5 times larger than the unaffected plants. Fig 2b is the actual canopy conductance of cotton as an example of the diurnal cycle of canopy conductance. The bimodal canopy conductance of the midday depression in the cotton field was measured in all tested crops but for several morning hours before dew evaporated the large difference between the two groups was evident as shown in Fig.2a.

In terms of the molecular diffusion equations, any increase in canopy conductance will cause a linear increase in the assimilation rate of CO_2. Thanks to the dew, transpiration will not increase in proportion because, stomata are open early in the morning when water vapor gradient, the driving force for transpiration, is minimal. During these morning hours the evaporative ability of the atmosphere was also relatively small. Moreover, as shown in Fig.3, during these hours the CO_2 gradient, the driving force for photosynthesis, is at its maximum due to night respiration. Thus, with high potential for CO_2 intake and low potential for transpiration each unit of fixed CO_2 costs less water.

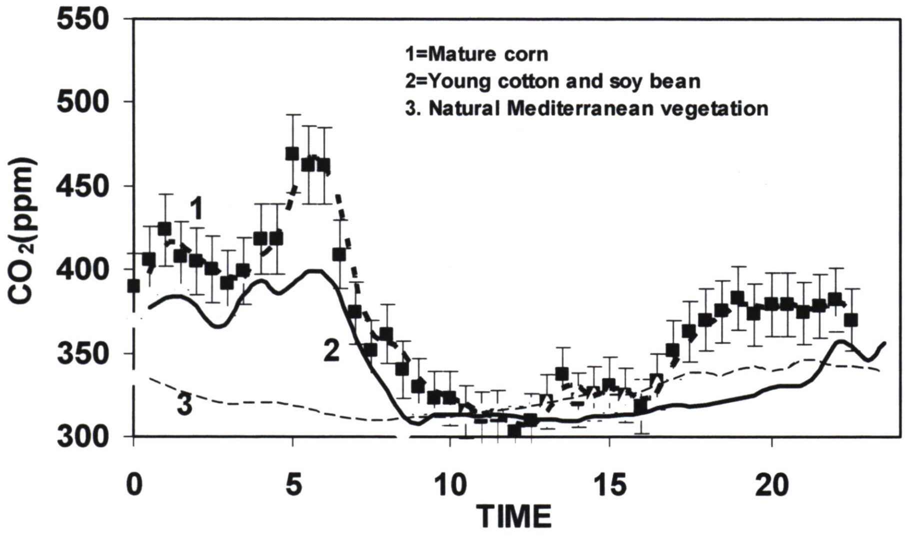


Fig.3 CO_2 concentrations as a function of time and the effect of night respiration.

Night respiration increased CO_2 concentration in the air within the corn field from 320 to 460 ppm forming a strong air to leaf CO_2 gradient . This increase in concentration was smaller in the cotton and soybean environment and even smaller for Lemon orchard and natural vegetation. The strongest gradient at 6 am was reduced to the prevailing concentration in the air at 9 am. The Mediterranean vegetation was the most stable population, in terms of diurnal CO_2 variations, and it did not create strong CO_2 gradient.

We now turn to the question of how much can the dew in dry environments improve the productivity and water use efficiently. In particular, in Table 2 we examined the concept of photosynthetic water-use.

Dew	Corn	Cotton	Soybean	Dew	Corn	Cotton	Soybean
	gr. CO_2 m^{-2} (leaf) h^{-1}				gr. H_2O m^{-2} (leaf) h^{-1}		
+	3.2	2.2	2.2	+	**116.9**	**112.3**	**103.5**
-	1.4	1.7	1.2	-	**151.2**	**291.6**	**227.5**
Photosynthetic WUE					gr. dry matter per kg. water		
				+	27.5	19.9	26.6
				-	9.1	5.9	4.9
Potential CO_2 assimilation at high light intensity[18]					3-9	1.5-5	1.5-5

The average CO_2 assimilation by dew affected wet leaves was 80% larger than CO_2 assimilation by dry leaves. The maximal assimilation rate was that of corn which amounted to 3.2 g CO_2m^{-2} hr^{-1} (about the potential production rate of C4 plants[17]) whereas dry leaves produced only 1.4 g CO_2m^{-2} hr^{-1} , a ratio of more than 2:1. In other words in one hour a corn plant covered with dew assimilated the amount that was assimilated by dry leaves in more than two hours under the same environmental conditions. In terms of WUE the results are even more convincing. Average transpiration of plants covered with dew (111 g H_2O m^{-2} hr^{-1}) was less than 50% of the average transpiration (223 g H_2Om^{-2} hr^{-1}) from dry plants. The combination of high photosynthetic rate and low transpiration of dew affected leaves led to average photosynthetic WUE of 24.6 gr. CO_2 intake per kg. water, whereas average WUE of the same group of plants under dry conditions was only 6.6 gr. CO_2 per kg. water Thus the synergistic contribution of dew to WUE was clearly demonstrated.

We clearly demonstrated the gain from higher CO_2 and dew formation which induced high stomatal conductance. As the air's CO2 content continues to rise, natural vegetation and agricultural crop will likely exhibit increased rates of photosynthesis and growth while concomitantly displaying reductions in water-use. How this synergism will be affected by global warming which is expected to reduce the number of dew nights and its formation and how the expected reduction in dew formation will affect bio-productivity is still not known.

Assessment of future carbon cycle under global warming should therefore consider the contribution of dew to carbon sequestration and consequently the impact of the warming atmosphere on dew formation.

__Accomplishments of objective 2__

a. Remote sensing: A series of experiments were conducted in the Negev Desert in order to develop tools for monitoring soil water content. The use of techniques based on the reflection in the visible near infrared and microwave appears promising. All provide good correlation with soil water content measured on the ground. However, the microwave techniques presented here using a P-band scatterometer and ERS-2 SAR appear to be the most promising.

In this part of the project we have tested the use of a P-band scatterometer to monitor the soil water content during a wetting and drying cycle of an agricultural soil in the Negev Desert. The low frequency (430Mhz) used has an inherent advantage in that most agricultural soils will be smooth relative to this wavelength and thus the scatterometer response is governed by the soil-water dielectric constant. We used a normalized expression for the soil water content. Using this parameter, rather than volumetric or gravimetric water content, makes the relationship independent of soil texture and extend it to interpretation of other soil hydraulic properties. (See the next objective evaluation of parameters for SWAP model). Further work is required to determine the effect of other soil constituents that may affect the dielectric properties of soils (e.g. salinity) and to apply the technique in order to estimate soil hydraulic properties.

b. Spatial variability study and GIS relationships between CO_2 flux from the soil to the atmosphere and soil salinity in the Chukurova basin Turkey.

The study was carried out jointly with the Turkish and the ICCAP Japanese team.

A GIS map of the soils in the Chukurova basin was used to plot the distribution of soil's electrical conductivity with contours ranging from 5 dS/m in the northern part of the basin to 15 dS/m in the southern part of the basin a long the cost of the Mediterranean. Data to relate the fluxes of CO2 that were measured and reported in the previous section are now available.

C. Socio-Economic Assessment of Damage and Adaptability to Regional Climate Change. Mordechai (Moti) Shechter

__Abstract__

Agriculture in the Mediterranean Region, like agriculture worldwide, has an intrinsic relationship with climate. For centuries analysts have been interested in the impact of weather on crops in order to predict what crops to grow, when to plant and harvest them. This research considers how climate change might affect Turkey's agriculture in the future. There are several approaches that deal with the above questions; we will focus on the production function approach. In many scenarios of future climate change it is often assumed that only the mean of climate variables would change while the standard deviation remains unchanged. A statistical analysis of annual rainfall distribution in the Eastern Mediterranean over a period of 60 years, covering two 30-years periods reveals some significant changes in the scale and shape patterns of the precipitation distribution. Our objective is to determine how farming would change with the expected changes in precipitation patterns. These changes are measured via an economic model of net revenue maximizing at a given location under uncertainty of rainfall patterns. The farmer makes decisions whether and what crops to grow given that he is limited by a water quota that restricts his irrigation abilities. The model outcomes are changes in net revenue in the past and

possible changes in net revenue of agriculture sector.

Conclusions

By using the model we find the connection between the net revenue of specific crop and the parameters of the climate distribution variables (precipitation).

. A statistical analysis of annual rainfall distribution in the East Mediterranean over a period of 60 years, revealed some significant spatial and temporal changes in the shape and scale patterns of the fitted gamma distribution.

Until now we examined two crops, wheat and tomatoes. We checked the net revenue for both low and high price of irrigated water.

The results are as follows: for tomatoes, the changes in the net revenue in the second period with respect to the first period are minute. For wheat we found that in the north of Israel (about 400 Km south of Adana) the net revenue decreased and in the south (600 km South of Adana) the net revenue increased. For high price of water the changes were more significant for wheat.

Based on the trend of the distribution parameters in the past, we changed the distribution parameters in order to examine the future expected changes in net revenue. First we changed the shape parameter in the same direction it changed in the past, decreasing in the north and increasing in the south; the net revenue had the same direction of change. From changing the scale parameter we get the opposite effect. When we changed both parameters, in the most regions of the country the net revenue from wheat will decrease. For tomatoes the changes are very minute.

In the next step of this research we will examine two other crops: cotton and lettuce. We will also examine the accumulative changes in the net revenue of the entire country, according to the results in each region, and the size of cropland at that region.

Acknowledgement

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