Global Climate Ghange and Food Security for Small Farmers in Honduras

Carlos G.H. D?az-Ambrona[1], Ruben Gigena Pazos[2] and Carlos O. Mendoza Tovar[2]

[1] Escuela T?cnica Superior de Ingenieros Agr?nomos. Universidad Polit?cnica de Madrid Ciudad Universitaria, 28040 Madrid,
Spain, www.etsia.upm.es Email chernandez@pvf.etsia.upm.es
[2] Escuela Agr?cola Panamericana El Zamorano, Tegucialpa, Honduras www..zamorano.edu

Abstract

Rainfall variability will increase under climate change in the Subtropical dryland of Honduras (Central America).We investigated the impact of traditional management practices on the maize productivity of subsistence farming systems in a dry subtropical environment. In Honduras, food production has not increased as rapidly as population growth in the last 40 years. The CropSyst model was tested locally and used with long-term weather data to analyze the variability of yield associated with alternative farming practices. Experiments were also carried out at the *Escuela Agr?cola Panamericana Zamorano*. Model estimates were compared with yield, phenology and soil organic matter collected from different experiments conducted from 1998 to 2002 under a wide range of weather, rotations, cultivars, management practices and soils. The simulations of yield were close to measured yield for maize (observed range from 0.6 to 6.5 t ha^{-1}; RMSE = 1.2 t ha^{-1}). The model provided reasonable estimates of crop yields and phenological development**.** Climate series from Zamorano showed significant relationships between the six month anomaly of the Southern Oscillation Index and the rainfall during the wet season. The impact of climate change on subsistence maize production was explored with CropSyst. To evaluate different future scenarios. Under current management practices, future climate change scenarios increased yield variability and reduced yield by 0 to 22 %. Sowing opportunities and the crop maturity date are particularly sensitive to climate change. Further studies are needed to investigate strategies to reduce those impacts and to explore mitigation tactics.

Media summary

Rainfall variability will increase under climate change in the Subtropical dryland of Honduras (Central America), the impact on subsistence maize production was explored with a crop simulation model.

Key Words

Maize, CropSyst, Subsistence, Sustainable, Central America, Subtropical.

Introduction

In Honduras, subsistence and smallholder farmers used traditional agricultural practices for food production. A typical rotation comprises maize (*Zea mays* L.) and common bean (*Phaseolus vulgaris* L.). Both crops are cultivated during the same year. The growing period of maize is from June to October. Average maize yields range from 1 to 2 t ha^{-1}. These two grains are consumed every day in 98% of the households. Since 1970 arable land has reduced and the food production *per capita* has decreased due to an increase in population (Fig. 1). Maize yield increased less than 40 % in the last 40 years (yearly rate of 10 kg ha^{-1}), and common bean productivity increased only 15 % (yearly rate of 2 kg ha-1). In the same period the total population of Honduras grew by 300 %. Low productivity systems together with an uncertain future climate maintains a high level of risk to food security in this region.

Agricultural impact studies have considered some technological options for adapting to climate change such as seasonal changes of sowing dates, use of different crop varieties or species, water supply during the dry season, or tillage management. Cropping system simulation models can be used to study those options under different climate scenarios (Reilly, 1996). Management of climate predictor links are an important part of agricultural extension. The Southern Oscillation Index (SOI), as part of the phenomenon called El Ni?o, is used for linking farmer tactical decisions to seasonal climate predictions.

There is a general lack of data with which to quantify the relationship among the traditional management practices and annual weather conditions. Without this information, any attempt to improve traditional practices remains difficult to increase maize and common bean yields. Impacts of climate change urgently need to be assessed at household level, so that poor and vulnerable small farmers dependent on agriculture can be appropriately targeted in research and development activities for poverty alleviation (Jones and Thornton, 2003).

The objective of this work was to study the relationship between current small farmer management practices in the region and the stability of maize yields in the future. Steps to achieve this objective were: (i) calibrate and validae the CropSyst model under dry subtropical environment for the traditional cropping systems, and (ii) explore the impact of climate change on the subsistence food supply system.

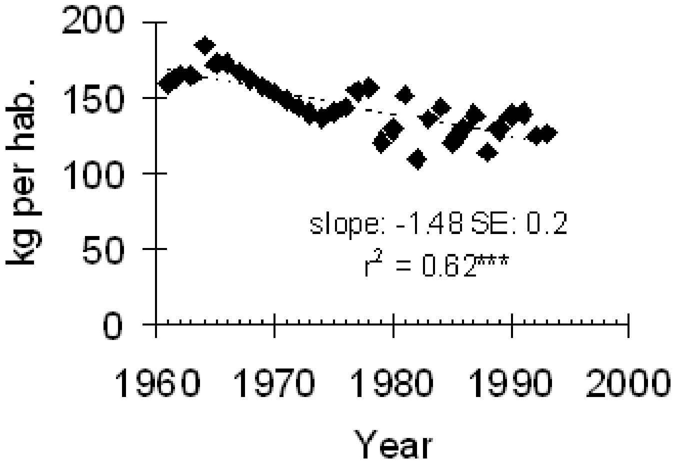

Figure. 1. Supply of basic food grain in Honduras during the last 40 year (Data from FAOSTAT 2004).

Methods

Field data

Field data from the Yeg?are Valley in Central Honduras (Lat. 14?00’45”N, Long. 87?00’79”W, Alt. 780 mosl) was used to calibrate and validate CropSyst . Data from maize and common bean experiments conducted from 1998-2002 in Zamorano were used. Monthly weather data was collected from Zamorano database. ClimGen weather generator (version 4.1.05 software included with CropSyst) was used to generate daily weather series.

We used different maize cultivars to run the model (Guayape, Cargill C-343, HB-104, DeKalb B-338, H-27). This pool of maize varieties included hybrids and open pollinated varieties. Yield ranged from 0.6 to 6.5 t/ha. Common bean cultivars used in the experiment were: RAB-50, RAB-20, RAB-205, Desarrural, Desarrural gene I, Cuarente?o Brillante, Zamorano, Danl? 46, UW22-34, Dorado, Honduras43-40 and T?o Canela 75 characterized with red grain color.

Southern Oscillation Index

Historical monthly precipitation data from Zamorano was compared with the monthly Southern Oscillation Index (SOI). We chose the difference between SOI of May and previous January as the best estimate of the anomaly. This anomaly was compared with the total precipitation during the rainfall season that starts in June.

Climate Scenarios

In this exercise climate change scenario was derived from GCM-Runs based on the IPCC-IS92a from Hadley Centre for Climate Prediction and Research (UK) (Table 1). Those values were added to the historical monthly weather data and a new set of daily data was made with ClimGen.

Table 1. Honduras' climate scenario from GCM-Runs based on the IPCC-IS92a from Hadley Centre for Climate Prediction and Research (UK) derived from the HadCM2 model.

	Climate Change 2070-2100 from the base line 1960-90	
Year period	Air temperature at 1.5 m (?C)	Precipitation (mm/day)
December-January-February	+ 7.5	- 2.5
March-April-May	+ 4.0	- 1.5
June-July-August	+ 4.0	- 2.0
September-October-November	+ 4.0	- 1.5

Crop model. calibration and validation

The application of simulation models to new localities can be useful in the analysis of cropping systems that experience significant weather variation (Hammer and Muchow, 1991). The CropSyst systems model version 3.03.16 (Jan 20, 2003) was used (St?ckle and Nelson, 2001) using previously defined default parameters. We used the recorded phenological data and plant description for crop model calibration. Validation was conducted by running the model with different experiment data stes and comparing the observed and simulated data. Simulation was made under rainfed conditions. Crop management comprised sowing on July 27th, two nitrogen fertilizater applications to a total of 100 kg N/ha, and three tillage operations (primary disc and two secondary disc harrow-light).

Results

Recent changes in recorded rainfall

Long series of data for monthly rainfall recorded at Zamorano showed short and constant cycles of dry and wet periods (Fig. 2a). Relationships between the Southern Oscillation Index and annual rainfall was studied to adapt farmers decisions to these short wet-dry periods. Figure 2b shows a quadrant diagram of SOI and rainfall. Quadrant I represents negative oscillation (less than –0.6) measured as the difference between SOI for May and the previous January, which coincides with lower annual rainfall (<1000mm).

Model performance

For all maize varieties the RMSE for emergence was 0.5 days and for flowering and maturity was 2.0 and 9.0 days respectively. Observed maturity ranged from 120 to 125 days after sowing. Yield ranged from 0.6 to 6.5 t ha^{-1}. The simulation of grain yields ranged from 2.3 to 5.3 t ha^{-1} (RMSE=1.3 t ha^{-1}) (Fig. 3).

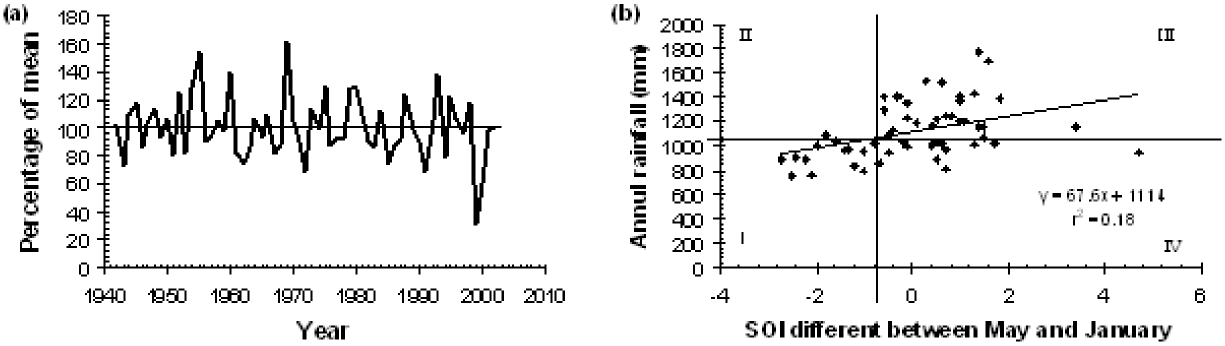

Figure. 2. (a) Zamorano (Honduras) departures from mean annual rainfall. Dot line indicates standard deviation of the mean (annual mean precipitation = 1,100 ? 247 mm yr^{-1}). (b) Relationship between the Southern Oscillation Index (different between May and January of the same year) and annual rainfall.

Climate change and maize production

Our results showed a slight impact on maize yield similar to that of previous work by Jones and Thornton (2003). Crop yields decreased when we did not consider the CO_2 fertilization effect (Fig 4a), the pooled average yield dropping from 4.3 t ha^{-1} to 3.4 t ha^{-1}. Accounting for CO_2 fertilization effect suggests stable yields (Fig 4b). In both cases, future climate change increased yield variability.

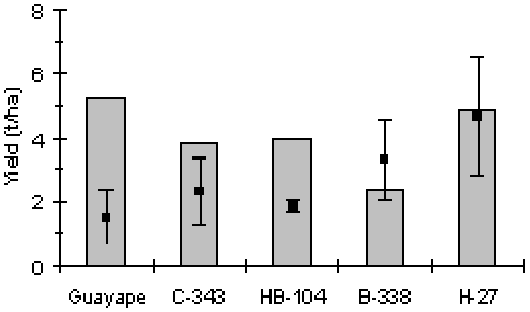

Figure. 3. Simulated maize yield for different cultivars (bar) and observed yields (average dot and range maximum and minimum recorded) and current climate conditions.
[model prediction is poor for 3 of these varieties and is not even within the range]

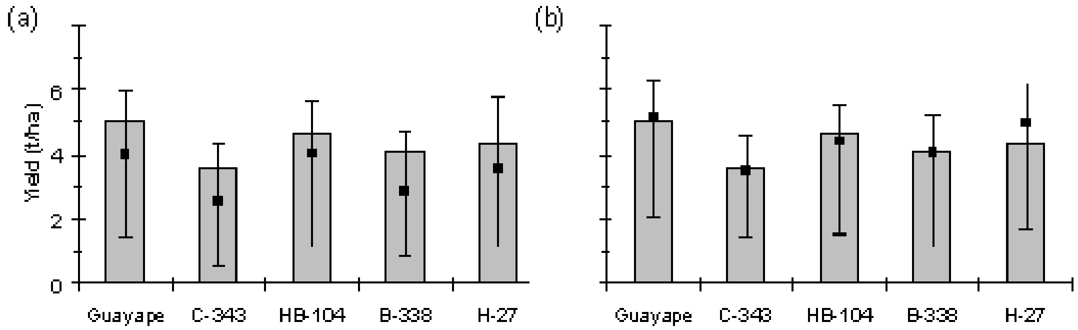

Figure. 4. Simulated maize yields baseline (bars) and changes to 2070 (dot): (a) without CO2 effect, and (b) with CO2 effect (average, maximum, and minimum yields).

Conclusion

The long term rainfall series from Zamorano in central Honduras showed a relatively constant sub tropical dry-wet climate. During the last 60 years there is no evidence of significant rainfall variation, however a positive relationship between SOI and annual rainfall. We have extended the evaluation and application of CropSyst to a subtropical environment in maize smallholder production systems. The performance of the model in this region was comparable to that in other environments and other crop models in similar conditions. The accuracy of model predictions varied considerably with the maize variety examined and may need furtherv development. The predicted impacts of climate change on maize yield (0-22% decrease) may add significantly to the challenge of ensuring food security.

Acknowledgments

This work was financed by the Spanish “Agencia Espa?ola de Cooperaci?n Internacional (AECI)” through the research project n? A/0806/03.

References

Reilly J (1996). In ‘Global Climate Change and Agricultural Production’. (Ed. F. Bazzaz and W. Sombrock), pp 237-266. (J. Wiley, Chichester).

FAOSTAT (2004). Production Yearbook. FAO Statistics Series (Rome). www.fao.org.

Hammer GL and Muchow RC (1991). In ‘Climatic Risk in Crop Production: Models and Management for the semiarid tropics and subtropics’ (Eds. RC Muchow and JA Bellamy). C.A.B.I nternational, pp. 205-232 (Wallingford, U.K.).

Jones PG and Thornton PK (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global Environmental Change 13, 51-59.

St?ckle CO and Nelson R (2001). Cropping Systems Simulation Model User's Manual. Biological Systems Engineering Department, Washington State University. http://bsyse.wsu.edu/cropsyst/.