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## Multi-functional Agriculture

Agriculture as a Resource for Energy
and Environmental Preservation

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# Biomass Production in Hilly Areas of Central Italy

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The agricultural sector can provide an important contribution to reduce the fossil fuels consumption and GHG emissions through agroenergetic production from dedicated energy crops and biomass residuals. To evaluate these topics, , a research project was started in 2006 with the contribution of Tuscany Region administration. The aim was to promote a short supply chain in hilly areas of central Italy (Tuscany), furthering the local energetic biomass production and the reduction of transport cost. In particular, this paper describes a study about potential local production of energetic biomass from two traditional crops suitable to biofuel production. The considered crops were maize (Zea mays L.) and sunflower (Helianthus annuus, L.) used respectively to bioethanol and biodiesel production. This study was conducted in Sinalunga rural district (Siena – Italy). The evaluations were carried out taking into account the impacts of climate and meteorological variability through the application of simulation models of growth and production. The results were discussed to evaluate the variation in energetic biomass potential production in relation to the climate change and global warming scenarios.

**Methodology**

Collection and control of data about study area: the farm "Fattoria Belvedere" is located in hilly area of central Tuscany. Daily minimum and maximum air temperatures (°C) and daily precipitations (mm), were recorded from 1995 to 2003. The solar global radiation daily data were calculated through RadEst v. 3.0 software. that is able to estimate global radiation in relation to a daily thermal range on the base of Bristow and Campbell model (1986). The main soil characteristics were extracted from the geological map of Tuscany. Maize and sunflower yields (Kg $ha^{-1}$), agricultural management conditions, such as modality and time table of irrigation and fertilization, sowing and harvest dates were provided by the farmer. All data collected were controlled to detect and adjust for the possible unaccounted or out-range data.

Calibration and validation of the model: the crop growth model adopted to simulate yields was CropSyst (Stockle and Nelson, 1999). CropSyst is able to simulate the crops growth and production depending on cultivar specific parameters (photosynthetic sensibility, maximum LAI, phenological phase time etc.), management parameters (modality and time table of irrigation and fertilization, sowing dates, etc.) and soil parameters (texture, soil depth, nitrogen and organic matter content, etc.). From meteorological input-data (daily minimum and maximum air temperatures, precipitations, solar global radiation) CropSyst calculates the crop yield on the base of Photosynthetically Active Radiation (PAR) and coefficients of biomass distribution and allocation. For the maize and sunflower CropSyst was calibrated for the study area through sensitivity analysis in relation to thermal time necessary to the maturation phase. The soil was 1.10 m depth, with texture (sand 24%, clay 37%, silt 39%) and an organic matter content of 1.5%, were considered. A rainfed system for the sunflower was considered, while for the maize only emergency irrigations, when water field capacity fallen down 35%, were considered. The fertilization is that actually used by farmer: the quantitative for hectare and the fertilizer type change for each years. The fertilizer used at seeding are: 11-22-16 (200-300 kg /ha for sunflower and 400-500 kg/ha for maize) or 18-46-0 (200 kg/ha for sunflower). Urea was used at seeding or in cover (100-200 kg/ha for sunflower and 200-300 kg/ha for maize). Pearson's correlation coefficient (r) and Root Mean Square Error (RMSE) between observed and simulated yields were calculated.

Impacts of meteorological climate variability on productions and plant phenology: the model was used to predict the annual yields and the onset of grain filling (GF) and maturation (M) dates, consequential to daily mean temperatures increases by 0.5 °C and 1.0 °C respect to daily temperatures recorded from 1995-2003. The climate impacts were evaluated calculating the variation of yields (%), grain filling and maturation time (Days Of the Year; DOY).

**Results**

For the maize and sunflower meteorological simulation model of growth and production was calibrated and validated on a study area (Fig. 1).

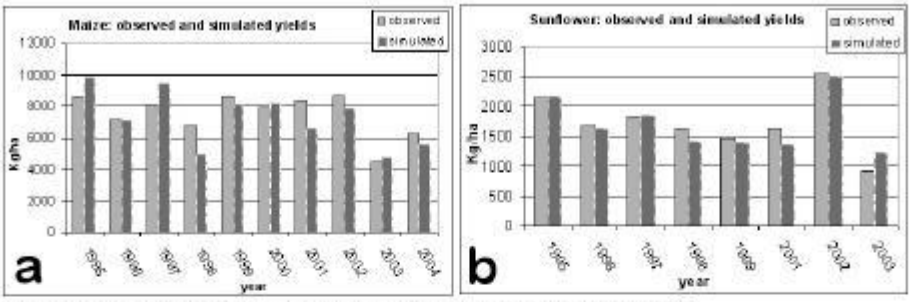


Fig. 1: Comparison between observed and simulated yields for maize (a) and sunflower (b)

With a mean temperature increasing by 0.5 °C, the yield showed a decrease of 6% and 4% respectively for maize and sunflower. For the same crops it fallen down by 12% and 11%, respectively, when considering 1.0°C of rising temperatures (Fig. 2).

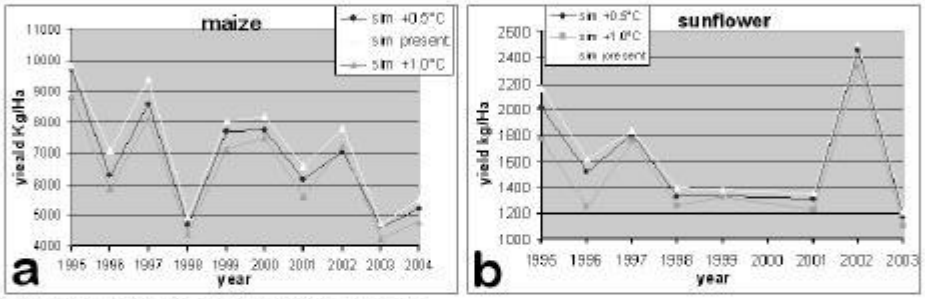


Fig. 2: Simulated yields for maize (a) and sunflower (b)

As regard crops phenology, the rising temperatures caused the duration of phenological phases to be reduced as shown in table 1 and, as a consequence, an advancing of the ripeness.

| | Time reduction between GF and M (Days) | | GF anticipation (Days) | | M anticipation (Days) | |
|---|---|---|---|---|---|---|
| T° increase | 0.5° C | 0.1° C | 0.5° C | 0.1° C | 0.5° C | 0.1° C |
| Maize | 1.4 | 2.7 | 2.1 | 3.8 | 3.5 | 6.5 |
| Sunflower | 0.9 | 2.2 | 2.4 | 4.6 | 3.3 | 6.8 |

Tab. 1: Impacts of temperature increases on the phenological phases of maize and sunflower. Legend: GF = rain; M = maturation.

**Conclusions**

The study results provide an estimation of the impacts of increasing temperatures, as resulting from global warming, on growth and production of crops traditionally cultivated in the Tuscany and suitable to biofuels production. The simulation models predicted a negative impacts of the temperature increase on yield levels for sunflower and maize. The temperature increase showed effects on phenological phases with an anticipation of grain filling and maturation dates for both the crops. The validated model can be used to carry out the same evaluation in analogous agroecosystems; it can represent a instrument particularly useful to supply information about the crop response to predicted meteorological variability.

**References**

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