Applied Research Partnerships with Developing and Transition Countries

Swiss Universities of Applied Sciences and Universities of Teacher Education

Foto: Daniel Pittet

Project title

Site-specific agricultural development as a new paradigm for small-scale tropical fruit growers in Colombia

Thematic focus

Site-specific agriculture, bio-inspired systems, crop modeling

Year

2010

Project location

Cali and south-west of Colombia

Swiss Institution

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Description

Tropical fruit growers have little reliable information on the factors that affect the development and yield of their crops and there is a dearth of information on the proper conditions to grow and manage them (so far, this criterion resides in the mind of a handful of experts and practitioners), yet native tropical fruit could be an affordable alternative for developing countries, as they have high regional demand and are potentially exportable to developed countries at interesting prices. Site-specific agriculture appears as a promising approach for helping fruit growers. However, the technologies generally applied can be expensive (e.g., distributed sensors, telemetry systems, etc.). The basic premises of our work are: (a) every time a farmer plants and harvests a crop, there is an experiment (i.e., an unrepeatable experience), and (b) by compiling the information on what the farmer did, and by characterizing (modeling) the conditions of a large number of these experiments, it should be possible to deduce optimum practices for specific conditions. Thus, we propose to use bio-inspired modeling techniques, like neural-networks and self-organizing systems to exploit fruit-grower data to model crop yield. So far, we have modeled Lulo (Solanum quitoense) crops from the south-west of Colombia as a proof-of-concept of the approach, and we are currently working on a Graphical User Interface integrating the bio-inspired approaches.

Development relevance

HEIG-VD and CIAT share a commitment to contributing positively to the lives of rural communities through this project. In CIAT it is believed that there is significant potential in site-specific agriculture for contributing to income generation for poor growers in the tropics, it is also believed that an interaction with farmers is mandatory in order to accomplish this task, especially by disseminating the results provided by the models. Likewise, it is expected to receive feedback from growers in an attempt to fine-tune our methodologies in phases such as providing and transferring results to farmers. The research described here is conducted in a multidisciplinary framework, integrating computer science engineers, agronomists, biologists, geographers, statisticians as well as small growers.

Lulo (Solanum quitoense)

Fruit grower measuring precipiation

KFH
Rektorenkonferenz der Fachhochschulen der Schweiz
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Conferenza dei Rettori delle Scuole Universitarie Professionali Svizzere
Rectors' Conference of the Swiss Universities of Applied Sciences

Schweizerische Eidgenossenschaft
Confédération suisse
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Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Main features of the project

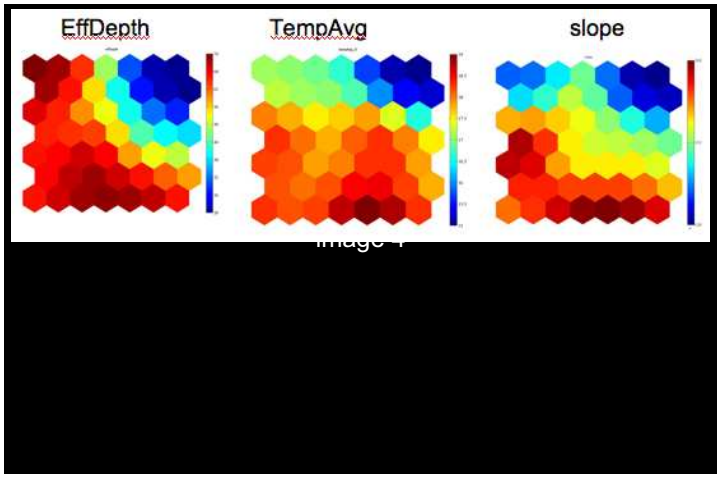
Agriculture contributes to 10.3% of the gross domestic product of Colombia, and contributes to 21% of national employment. Additionally, rural areas have the highest levels of poverty in the country (25% below the poverty line). National analyses of the fruit industry in Colombia have identified enormous unrealized potential for income generation and poverty alleviation through the increase of land devoted to fruit production, and through productivity enhancements in existing fruit production systems.

The main goal of this project is the development of a series of models to provide tropical fruit farmers with useful information of the conditions which led to high productivity. This is achieved by using bio-inspired models, capable of producing complex models to predict and describe the site-specific behavior of the tropical fruit trees under study. Such models will be integrated to a graphical user interface that will enable users to visualize what could happen if farmers made a hypothetic decision on their crops. The approach of this project is to integrate farmers in the acquisition of information about their crops.

Our partners in Colombia have conceived mechanisms for data collection and to energize farmers to take part in this process and provide regular information about their crops. Moreover, our partners have conceived an efficient and cheap technique to characterize soils, called RASTA, for Rapid Soil and Terrain Assessment. This methodology of data acquisition combined with very high resolution interpolated climate data (Worldclim and BIOCLIM databases with a spatial resolution of a square kilometer), satellite data (TRMM - Tropical Rainfall Measuring Mission satellite), landscape information (SRTM - Shuttle Radar Topography Mission) and a range of modeling approaches should enable us to provide an original way of visualizing the factors involved in fruit trees production in Colombia.

During the first half of the project, we have used two bio-inspired approaches to model Lulo (Solanum quitoense) crop data: Multi-layer Perceptron (MLP) models and Kohonen Self-organizing maps (SOM). These modeling techniques are being integrated to a Graphical User Interface (GUI) which will facilitate the modeling process of other fruit species or other databases being collected. The results of these models can be used to determine the appropriate environmental conditions for obtaining high yields for crops where only commercial data are available, and also to identify those farms that have superior management practices for given environmental conditions. The sensitivity analysis of the multilayer perceptron modeling the data from the South-west of Colombia crops, enabled us to identify slope, average temperature, and soil depth, as the most important environmental variables associated with variation in yield. For instance, the models suggest that the most suitable environmental conditions for producing Lulo (Solanum quitoense) are the combination of: an effective soil depth between 40 and 67 centimeters (cm), slope between 13 and 24 degrees and an average temperature between 15.8 and 19 degree Celsius (°C). It is also noteworthy that although in this data set not all measured variables were associated with variation in lulo yield, those variables may affect yield if they are outside the range reported here. On the other hand, our analyses using bio-inspired tools enabled us to identify that the lowest yields are obtained in the crops with the lowest values of effective soil depth, the lowest slopes and the lowest average temperatures (see figures below, where dark blue regions in the feature map indicate the lowest values).

Self-organizing feature map showing four classes of Lulo yield



More relevant environmental variables associated to variation in Lulo yield. The blue regions indicate low values, while the red regions indicate higher values of the environmental variables. By comparing these feature maps and the preceding figure, one can observe the conditions under which one can expect a high or a low yield (see text for more details).