REGIONAL IRRIGATION REQUIREMENTS FOR DRY BEAN BASED ON THE SIMULATION MODEL CROPGRO AND A GEOGRAPHIC INFORMATION SYSTEM

Alexandre B. Heinemann and Gerrit Hoogenboom

1Department of Rural Engineering/Irrigation, University of São Paulo/ESALQ, Brazil.
2Department of Biological and Agricultural Engineering, the University of Georgia, Griffin, Georgia 30223, USA (gerrit@griffin.peachnet.edu; www.gerrithoogenboom.com)

Introduction

Dry bean (Phaseolus vulgaris, L.) is one of the most important crops grown in the northern Tibagi river basin in the state of Parana in Brazil. During the spring season, i.e., September and October, water deficit caused by significant periods of drought is one of the main factors that limits dry bean growth. The use of irrigation has increased during the last decade to alleviate some of the drought stress. Due to the competition for the available water resources among agriculture, industry, and urban developments, it has become important to define efficient irrigation management strategies. To achieve effective planning at a regional level, accurate information is needed to determine crop water requirements as a function of soil and weather conditions and crop management. The crop simulation model CROPGRO for dry bean (Boote et al., 1997) was interfaced with a geographic information system (GIS) to increase the scope of the applicability of the model for regional planning and policy analysis. The objective of this study was to determine the irrigation requirements for dry bean production systems in the northern Tibagi river basin.

Material and Methods

The northern Tibagi river basin is composed of nineteen counties, with Londrina as the main county (Figure 1). Surface water, especially rivers, is the main source for most public water use by cities and industries, as well as for all agricultural related withdrawals. The region has a subtropical humid climate; daily weather data for four weather stations were obtained from the Agronomy Institute of Parana (IAPAR), located in Londrina. Climatic parameters that were available include 20 years of historical records for the period 1978 to 1997 for daily maximum and minimum temperature, solar radiation and precipitation. The effective area for each weather station was determined using the Thiessen polygon method (Figure 1).

The soils map for the region and associated soil profiles were obtained from EMBRAPA (1986). The map was digitized and the soils were grouped into 5 different soil types. Spring dry bean is usually planted during the middle of August; the actual acreage grown was obtained from DERAL (2000). The average planting date was August 15, with a plant population of 24 plants/m² and a row spacing of 0.5 m. Nitrogen fertilizer was applied at a rate of 10 kg N/ha at planting and 50 kg N/ha at 30 days after planting. The cultivar was IAPAR 57, which represents a commonly planted dry bean cultivar in the region. All simulations were started at planting and the initial soil moisture was assumed to be at field capacity. The irrigation threshold was set at
50% of remaining available soil water content (AWC) for the top 30 cm of the soil profile. When the actual soil water content in the top 30 cm dropped below 50% of AWC, irrigation was applied until the soil water content reached 90% of AWC.

A general coverage map for the northern Tibagi river basin was created by overlaying the individual county, soils and weather station maps (Figure 1). Polygons that had the same soil type and weather station were joined as one management strategy. The individual treatments were combined with the CROPGRO dry bean model using the Agricultural and Environmental Geographic Information System (AEGIS/WIN, Engel et al., 1997). The spring season for dry bean was simulated, using 20 years of historical weather data and the average irrigation requirements were calculated for each unique weather and soils combination. The center of each polygon was determined and an interpolation based on the inverse distance weighted average (IDWA) was applied to develop a contour map for irrigation.

Results and Discussion
In Figure 2 the spatial irrigation requirements for spring dry bean are shown, taking into account the spatial variation of local weather and soil type. The minimum, average and maximum irrigation requirements for the selected 20 years of simulation were 74, 165 and 228 mm, respectively, with a standard deviation of 50 mm. This shows a strong variation in annual irrigation requirements, with the driest year requiring about four times as much irrigation as the wettest year. The minimum, average and maximum yields for the same 20-year period were 2,501, 3,288 and 4,053 kg/ha, respectively, with a standard deviation of 495 kg/ha. Assuming that water is not limiting in this case due to supplemental irrigation, most of the yield variation is caused by a variation in average temperature between the different years. These results show that the application of crop simulation models combined with GIS can be an important decision support tool for policy makers and regional planners.

References