Simulating optimal productivity for winter wheat under variable soil moisture regimes for Pacific Northwest USA

Ashutosh K. Misra, Claudio O. Stockle and Byju N. Govindan
Biological Systems Engineering, Washington State University, Pullman, WA, 99163

REACCH Regional Approaches to Climate Change – Pacific Northwest Agriculture

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

WASHINGTON STATE UNIVERSITY

Introduction

Irrigation water requirement is considered as the most important limiting factor for efficient use of water resources and optimize the crop yield under changing future climatic conditions. Scarce and uncertain information exists on soil water availability into the future for any region and hence crop simulation modeling can be an efficient and cost effective technique to estimate the crop irrigation water requirement.

We identified four locations viz., George, Sunnyside, Othello and Imbler having at least 12 years of daily weather data from Inland Pacific Northwest region of USA during the winter wheat growing season. Amounts of average rainfall during the cropping season in these locations ranged from 134.32 mm to 378.85 mm. A calibrated and validated CropSyst model for these locations was run for winter wheat to develop response curves of leaf are index (LAI), biomass production and yield for different irrigation levels. The crop production function (CPF) allowed simulating irrigation events in the benchmark as function of soil water level ranging from a completely rainfed to a fully irrigated scenario. Simulation outputs suggest optimal crop productivity at 60% of full irrigation amount in locations with high rainfall viz. Othello and Imbler. No significant increase in grain yield and biomass were observed at high rainfall locations with further enhancement in irrigation water levels. In contrast, low rain fall sites viz. Sunnyside and George, crop productivity was optimized only when 80% or more of full irrigation amount of water was provisioned.

Introduction

Knowing the crop water requirement is crucial for optimum use of irrigation water which differs for each crop and location depending on the soil type, climatic conditions and crop management practices. To optimize productivity, optimal use of irrigation water is crucial to enhance the water use efficiency when water is scarce (Wang *et al.*, 2001).

To know the water requirement for a crop, long term observed data for crop and irrigation parameters for specific locations is crucial. These data can be difficult to obtain and not readily available most of the time (Saseendran *et al.*, 2015). Therefore, crop simulation models can be an efficient alternative to get reasonable estimates of water-limited yield over a range of environmental conditions (Kiniry *et al.*, 2014).

The crop production function (CPF) is used to express the relationship between crop yield and total seasonal irrigation and it can be a very useful tool for irrigation planning purposes (Brumbelow and Georgakakos, 2007).

CropSyst is a comprehensive daily time step crop growth simulation model which can be efficiently used to study crop response and water management studies (Stöckle *et al.*, 2003). In this experiment, an attempt has been made to simulate the wheat productivity using CropSyst under varying moisture regimes for four locations of Inland Pacific Northwest region of USA.

Objectives

1. To develop a water response curve for major parameters for winter wheat at different locations.
2. To know the optimum CPF level for wheat crop at selected locations.

Methodology

Identification of study sites-

For this study we selected four locations from US Inland Pacific Northwest region who had at least 12 years of daily weather data consisting minimum temperature, maximum temperature, either minimum relative humidity and maximum relative humidity or average dew-point, solar radiation, wind speed and precipitation data.

The properties of these locations are shown below-

Table 1: Location parameters and data length used for selected sites

S. No.	Location	Latitude	Longitude	Altitude (m)	Weather Data Length (years)	Average rainfall during wheat growing season (mm)
1	Othello	46.79 °N	119.04 °W	371	12	256.83
2	George	47.04 °N	119.64 °W	351	14	134.32
3	Sunnyside	46.37 °N	119.99 °W	308	14	197.53
4	Imbler	45.43 °N	117.96 °W	838	15	378.85

Wheat Modeling using CropSyst-

CropSyst model was calibrated and validated for winter wheat crop for selected locations. Thereafter, it was run for all the years for which weather time series was available using a wheat-fallow crop rotation. For the modeling purpose, date of sowing was taken as 15th September with a seed rate of 300 seeds m^{-2}.

CropSyst was run using different crop production functions (CPF) at an interval of 10 ranging from 0 to 100 percent. Zero percent CPF represents a completely rainfed scenario while 100 percent represents fully irrigated crop. Full irrigation here is based on automated irrigation replenishing the entire soil profile each time available soil water to a depth of 0.7 m is depleted below a given point i.e. 50%.

Results

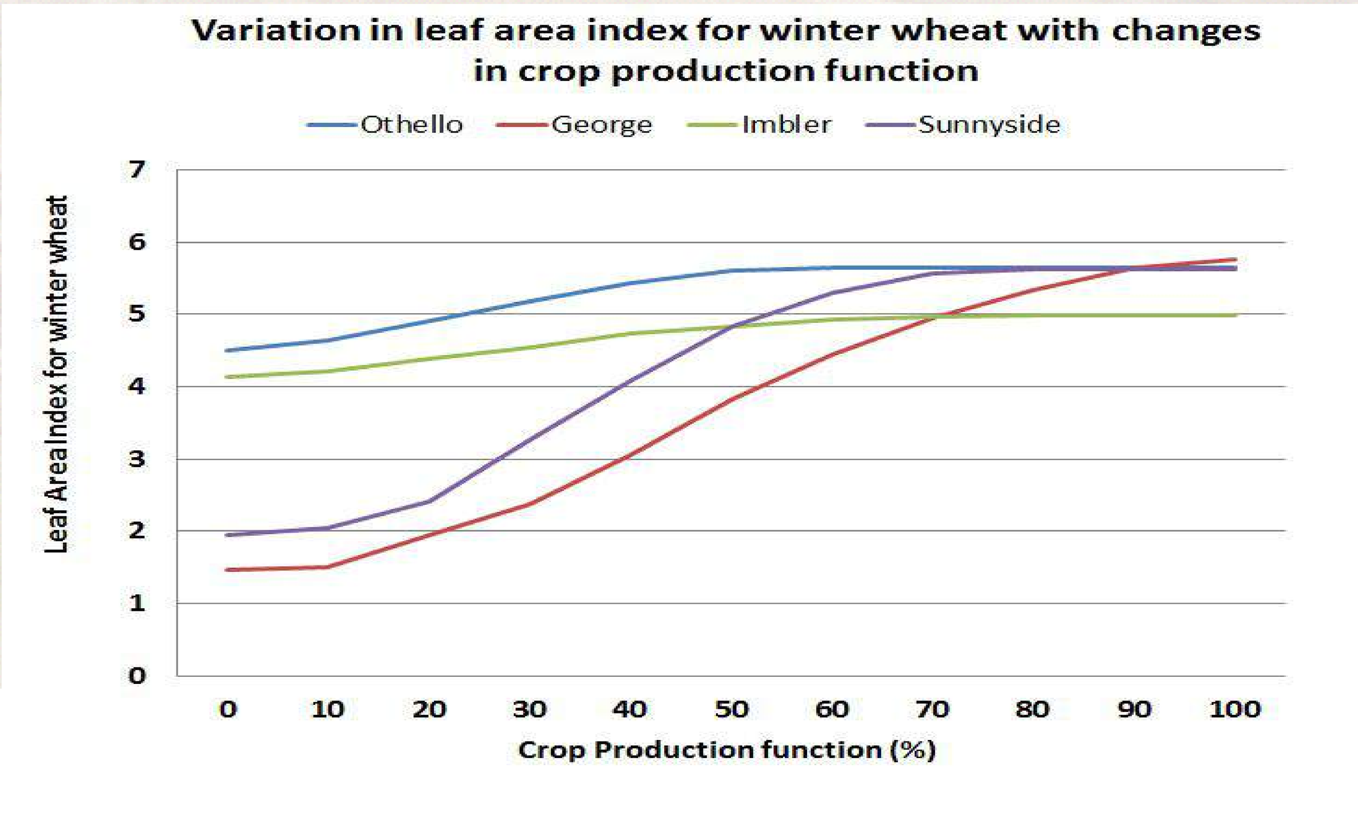

Figure 2: Variation of maximum LAI with changes in Crop Production Function for winter wheat

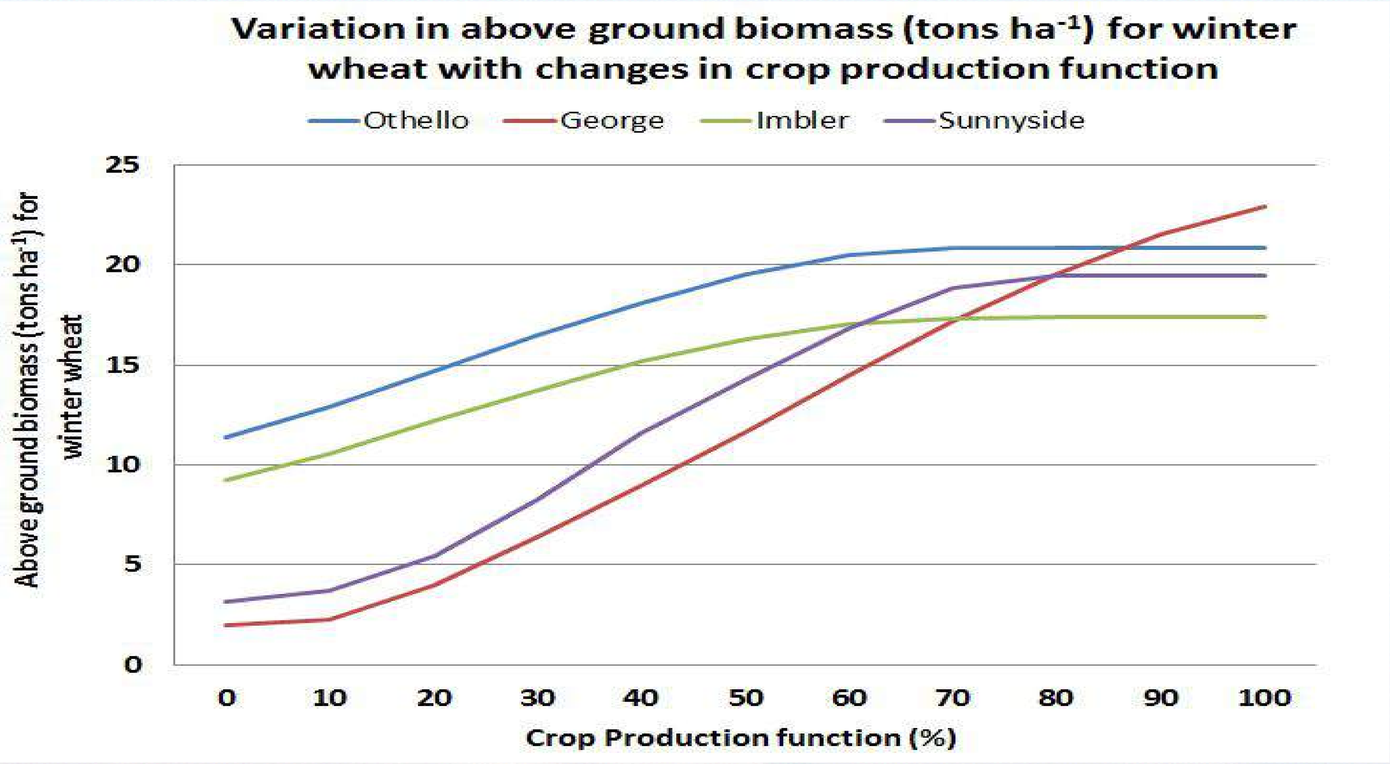

Figure 2: Variation of above ground crop biomass with changes in Crop Production Function for winter wheat

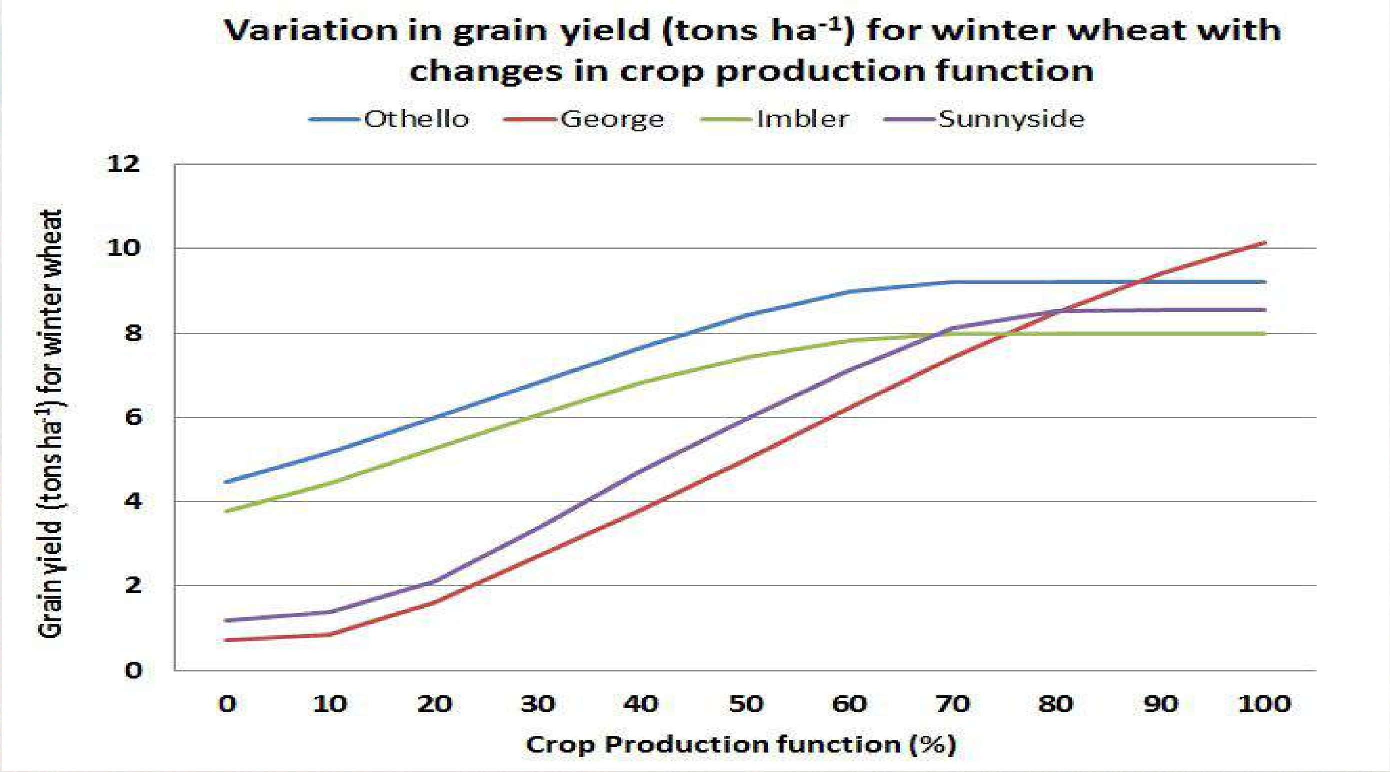

Figure 3: Variation of grain yield with changes in Crop Production Function for winter wheat

Summary

it is evident from table-1 that George receives the least amount of rainfall followed by Sunnyside and Othello, while Imbler receives the maximum amount of rain during the wheat growing season. The simulation outputs show that application of water at the rate of 60% of full irrigation resulted in near-maximum yield for high rainfall locations (Othello and Imbler). In contrast, in low rainfall sites (Sunnyside and George), near-maximum wheat yield was obtained only when 80% or more of full irrigation amount was provided. On the other hand, results also showed that small increases of rain above current seasonal dryland rainfall could have important beneficial effects.

Limitations

Automatic irrigations in CropSyst schedule applications to refill the entire soil profile. With water at the bottom of the soil not fully utilized under full irrigation. In addition, any irrigation towards the end of the period of growth may be only partially utilized by the full irrigated crop, but it can be important to gain some yield for less than full irrigated scenarios.

References

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The research was supported by National Institute of Food and Agriculture competitive grant, award number: 2011-68002-30191