Research Application Summary

# Test of AquaCrop model in simulating biomass and yield of water deficient and irrigated barley

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**Abstract**

With the current water shortage in Eastern Africa, improving crop water use is vital especially in the arid and semi-arid regions of Ethiopia. To understand the response of barley (*Hordeum vulgare*) to water and to simulate the biomass and grain yield of barley under various water inputs and planting dates, we tested the FAO AquaCrop model versions 3.0 using independent data sets during the cropping seasons of 2006, 2008 and 2009 at Mekelle in northern Ethiopia. The model was found to be valid in simulating barley biomass and grain yield under various planting dates in the study site. AquaCrop model can be used in the evaluation of optimal planting time. Out of the tested planting dates, planting on July 4 (early sowing) was found to maximize barley biomass, grain and water use efficiency. The model can also be used in the evaluation of irrigation strategies. Barley showed slightly lower performance under mild water stress condition compared to full irrigation condition. However, the model has indicated the possibility of obtaining more biomass and grain yield from a relatively larger barley field under (deficit irrigation) mild stress condition.

Key words: Crop yield, irrigation, irrigation strategy, planting time, water use efficiency

**Résumé**

Avec la pénurie actuelle de l’eau en Afrique orientale, l’amélioration de la consommation d’eau des cultures est essentielle en particulier dans les régions arides et semi-arides de l’Ethiopie. Pour comprendre la réponse de l’orge (*Hordeum vulgare*) à l’eau et pour simuler la biomasse et le rendement en grain d’orge sous diverses entrées d’eau et les dates de semis, nous avons testé les versions 3.0 du modèle AquaCrop de la FAO en utilisant des ensembles de données indépendants au cours des saisons de culture de 2006, 2008 et 2009 à Mekelle au nord de l’Éthiopie. Le modèle a été jugé valide dans la simulation de la biomasse et le rendement en grains d’orge en vertu de diverses dates de semis dans le milieu d’étude. Le modèle AquaCrop peut être utilisé dans l’évaluation des dates de semis optimal. Sur les dates de semis testées, les semis du 4 Juillet (semis précoce) ont été jugés meilleurs pour maximiser la biomasse d'orge, l'efficacité de grain et de l'utilisation de l'eau. Le modèle peut également être utilisé dans l'évaluation des stratégies d'irrigation. L'orge a montré une performance légèrement inférieure dans des conditions de stress hydrique modéré comparé à la condition d'irrigation complet. Cependant, le modèle a indiqué la possibilité d'obtenir plus de biomasse et de rendement en grains à partir d'un champ d'orge relativement plus important dans les conditions de stress léger (irrigation déficitaire).

Mots clés: Rendement des cultures, irrigation, stratégie d'irrigation, moment des semis, efficacité d'utilisation de l'eau

## Background

Barley belongs to the genus Hordeum in the tribe Triticeae of the grass family Poaceae (also known as Gramineae). In Ethiopia, the long history of cultivation and the diverse agro-ecological and cultural practices have resulted in wide barley diversity (Firdissa *et al.*, 2010). It is the fourth most important cereal crop in Ethiopia after Tef (*Eragrostis tef*), maize and sorghum (Birhanu *et al.*, 2005). It is also one of the major staple food crops in the country. It accounts over 60% of the food of the people in the highlands of Ethiopia and it is the cheapest food source in the local market. Traditionally barley is consumed in many different food dishes, such as; *'Injera', 'Kita', 'Beso', 'Tihlo', 'Ga'at'* and also consumed in the form of homemade drinks such as *'Siwa' ('Tella')*. Its straw is also used for animal feed. Despite its importance, the productivity remains poor with a national average yield of 1.14 tons $ha^{-1}$ (FAOSTAT, 2006). Water stress affects crop yield significantly; so that the crop requires additional water through irrigation. However, we do not know the response of barley to water and planting dates.

## Study Description

The experiment was conducted in Northern Ethiopia, at Mekelle area, which is located at $13^{0}$ $03'$ latitude and $39^{0}$ $06'$ longitude. Datasets for daily sunshine hours, wind speed, temperature and relative humidity were obtained from Mekelle University meteorological station, which is located within 200 meters distance from the experimental site. The soil at the study site is silt loam, 0.6 meter deep overlaid on white calcareous soil fragment. Soil physical characteristics such as bulk density, texture, depth, field capacity, permanent wilting point and water content at saturation of the experimental sites were determined.

Experiments were carried out for three seasons (2006, 2008 and 2009) were carried out. A locally adapted major barley cultivar (*Birguda*) was grown. The treatments were planting time and water and application mode (rainfed and/or rainfed+ irrigation). In 2008 and 2009 four planting dates based on the local farmer's practice were used: July 4 (early planting under rainfed condition), July 10 (normal planting under irrigation condition), July 12 (normal planting under rainfed condition) and July 22 (late planting under rainfed condition). In both 2008 and 2009, planting on July 4, 12 and 22 were under rainfed condition. In 2006 only one planting date (July 10) was used under both irrigated and rainfed condition. In all years planting on July 10 was used under irrigated condition.

All crop management techniques were carried out following regional recommendations. Soil water was measured using time domain reflectometry (TDR). To understand the response of barley to water and to simulate the biomass and grain yield of barley under various water inputs and planting dates, we tested the FAO AquaCrop model ( Raes *et al.*, 2009; Steduto *et al*., 2009) versions 3.0.

## Research Application

AquaCrop version 3.0 has adequately simulated the soil water in the root zone, as well as the biomass and grain yield of barley under various planting dates and water availability conditions. AquaCrop model can be used to optimize planting time under water constraint environments for barley. In addition, the model can be used in the evaluation of crop irrigation strategies. Assuming that water is scarce and land is not scarce, the model has indicated the possibility of obtaining more grain and biomass from relatively larger barley field by applying less water. This result may contribute to food security improvement through increasing crop yields especially in water stressed areas as those of northern Ethiopia.

## Recommendation

From our studies on barley, it is recommended that AquaCrop model be adapted to predict barley biomass and grain yield. Furthermore AquaCrop model can be used in the evaluation of optimal planting time. The model can also be used in the evaluation of irrigation strategies.

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