

SIMULATED YIELD AND WATER DEMAND FOR CHILLI PEPPER PRODUCTION IN THE DRY SEASONS IN FLOOD-AFFECTED CHAU PHU DISTRICT

**Nguyen Van Tuyen, Pham Van Toan, Nguyen Huu Chiem,
Le Anh Tuan, Dang Kieu Nhan, Van Pham Dang Tri**

Can Tho University

ABSTRACT

Storing flood water and subsequently using it for rice-based upland crop production in the dry season is an issue for sustainable agriculture in the Mekong Delta of Viet Nam. An on-farm trial, conducted in between August – December 2015 in the Chau Phu district of An Giang province, was conducted to determine irrigation requirement and water use efficiency of chilli pepper that could replace a rice crop in the dry season in the flood-prone areas for higher water use efficiency. Irrigation requirement and yields of chilli were simulated by using the AquaCrop software (version 4.0) with various varieties for air temperatures and water irrigation level. Results showed that simulated yield of chilli pepper was 6.13 ton per hectare, and this simulated yield was similar to the practical harvesting yield of chilli pepper (6.33 ton per hectare). This water volume accounted for 59% of output components of the water storage. The study revealed that changes in rainfall and temperatures significantly influence irrigation requirement and the yield of chilli pepper. Irrigation requirement is expected to increase as the temperatures rise. Irrigation requirement is expected to increase as the rainfall reduce. Further studies for other crops and ways of how to reduce pond storage water losses by evaporation and seepage are necessary.

Keywords: *chilli pepper, flood water storage, AquaCrop, An Giang province*

1. INTRODUCTION

Further improving crop water use efficiency is a concerned issued to deal with freshwater shortage from projected climate change and sea level rise [1]. Rain-water capture and flood water storage are considered solutions. In Cambodia, farmers retained floodwater in bunded areas and then used it to irrigate the rice grown in the dry season around the Tonle Sap [2]. In Viet Nam, freshwater storage in forests, lakes, swamps or canals for agricultural, domestic and industrial purposes have been studied [3]. In the Vietnamese Mekong delta, flood water is abundant during the monsoon flood periods. A question is whether or not storing flood water in a pond is feasible for upland crop cultivation water in the dry season in the flood-affected Mekong delta, in terms of technological and economical considerations. If the proposed solution is practically feasible, it would contribute to improve flood water use efficiency and mitigate negative flood impacts in upstream delta in the wet season as well as salinity intrusion downstreams

in the dry season in the delta. The present study was conducted to determine the water irrigation requirement and water use efficiency of chilli pepper grown in a paddy field through using pond-retained flood water for irrigation in the dry season. The proposed study will contribute to improving efficiency of natural floodplain resource management in the Mekong Delta in the future. Chilli pepper (*Capsicum frutescens L*) is common planted around the world because of its color, flavor, and nutritional value [4]. In addition, chilli peppers can also be used in pharmaceutical processing industry [5]. To achieve the research objectives the study focused on: (1) Simulation of chilli pepper yield; (2) Simulation of irrigation requirement for chilli peppers in varieties.

2. MATERIALS AND METHODS

2.1 Experimental design

The study was conducted in a rice-dominant area area with partly flood-control structure located, from August 2015 to December 2015, in the Vinh Thanh Trung commune, Chau Phu Distrist, An Giang Province (10°29' north latitude and 105°12' east longitude) (Figure 1).

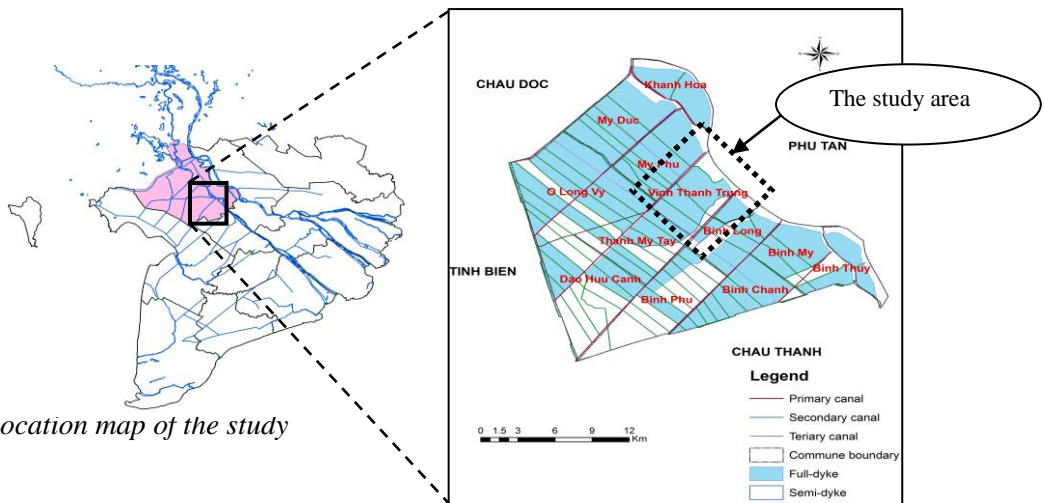


Figure 1. Location map of the study

The study used chilli pepper is one of target plants are being cultivated in the study area. Chanh Phong chilli pepper variety was used for the study. Cropping duration was 90 – 100 days and the planting density was 50,000 plants/ha. An on-farm experiment consisted of three plots measuring 600 m² each and a flood water-storing pond of 1,000 m². A sprinkler irrigation water system was applied with an irrigation rate of 6 mm/day [6].

2.2. Simulation of pepper yields

Using AquaCrop software version 4.0+ is summarized in Figure 2

The AquaCrop software version 3.1+ was applied to simulate crop water requirement and yield (Figure2). Input data included soil parameters (texture, wilting point, field capacity, saturated moisture, permeability coefficient), weather data (temperature, precipitation, evaporation wind speed, sunshine hours, CO₂ concentration), plant data consisting of canopy cover, depth of roots, yield, crop production schedule were directly

collected in the field. The output consisted of water demand and yield generated by AquaCrop software version 3.1+. The model was operated at a daily time step. Soil data, temperatures, precipitation and evaporation were recorded from the field, while wind, sunshine and CO₂ concentration data were collected from the nearest weather station.

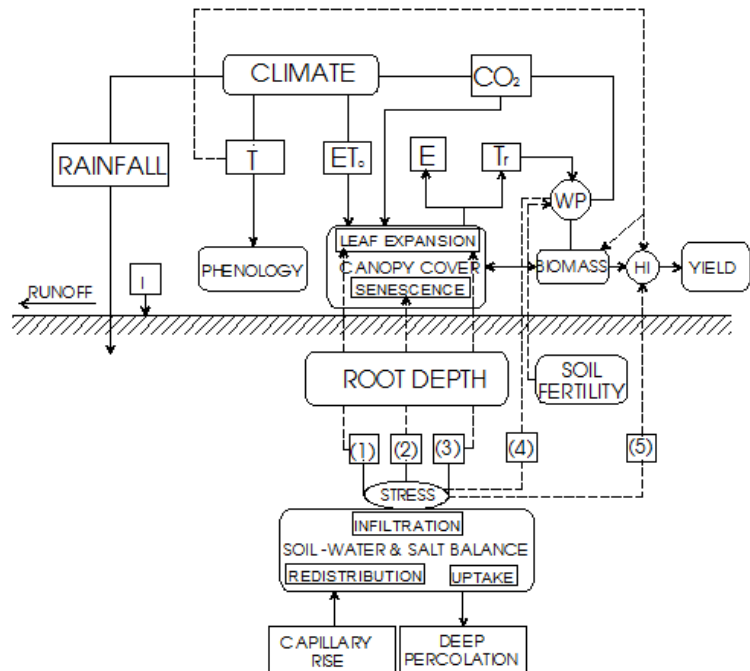


Figure 2. The structure of AquaCrop model with soil components - plant – atmosphere (Source: [7]).

Weather data during the experimentation are shown in Figure 3. Air temperature at the study area ranged from 21.4°C to 35.0°C. The average sunshine was 7.05±2.53 hours per day. The average wind speed was with 4.9 ± 1.42 m/s. The average humidity was 80.92±3.89 % [8]. The Figure 4 shows the parameters of humidity, sunshine hours and wind speed.

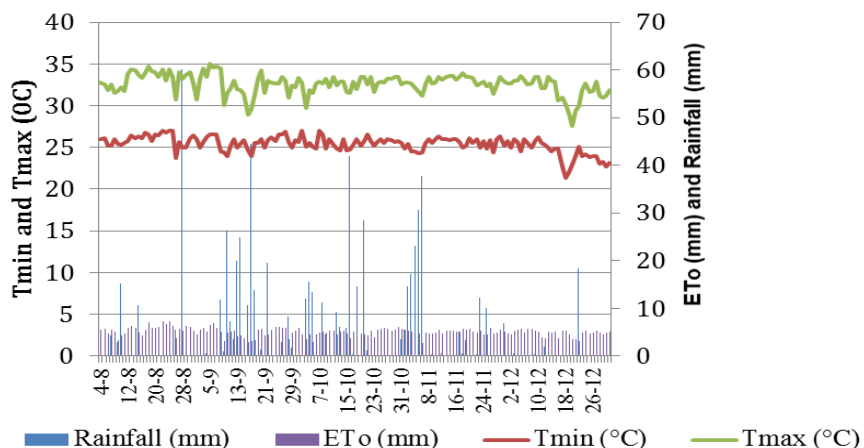


Figure 3. Temperature, rainfall and reference evapotranspiration (ET₀) at study site (source: [8])

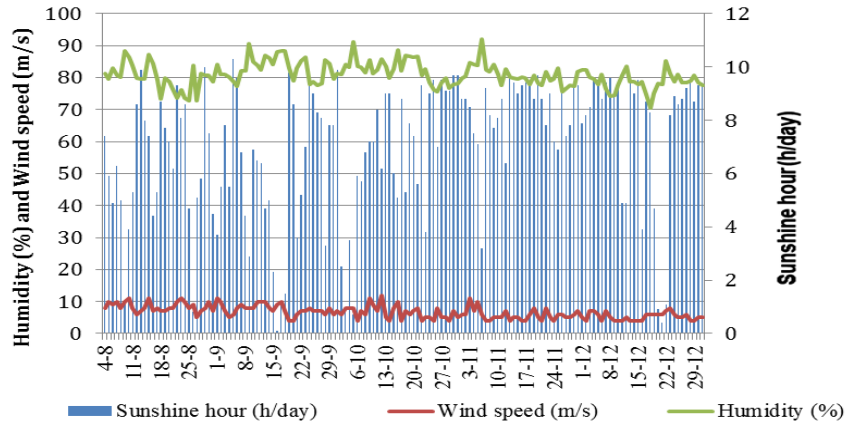


Figure 4. Average humidity, wind speed, sunshine hour at study site (source: [8])

Soil samples in the early cultivation were collected at 0 to 30 cm deep, physical and chemical indicators of this early stage is presented in Table 1.

Table 1. Physical characteristics of soil at study site

Layer	Depth (cm)	Clay (%)	Silty (%)	Sand (%)	Texture	OM (%)	PWP (%)	FC (%)	SAT (%)	Ksat (mm/ngày)
1	0-10	41.40	55.20	3.40	Silty clay loam	1.13	28.71	48.39	52.18	142
2	10-20	47.30	49.50	3.20	Silty clay loam	1.74	28.14	49.49	54.07	151
3	20-30	45.60	50.60	3.80	Silty clay loam	1.20	28.21	47.62	52.77	158

Notes: OM: Organic matter; PWP: Permanent wilting point; FC: Field capacity; SAT: Saturation.

In order to assess weather factors (temperature, precipitation) to take form irrigation requirement for chilli pepper crop, chilli pepper yields under various conditions were simulated in Table 2.

Table 2. Impacting of factors are analysed in varieties.

Varieties	Factors		Notes
	Temperature	Precipitation	
1	unchanged	unchanged	Using 2015 as the base year
2	unchanged	P=90%	Average 10 years have probabilities to appear 1 time the highest temperatures and 1 time the lowest rainfall.
3	P=10%	unchanged	
4	P=10%	P=90%	
5	unchanged	P=80%	Average 5 years have probabilities to appear 1 time the highest temperatures and 1 time the lowest rainfall.
6	P=20%	unchanged	
7	P=20%	P=80%	

3. RESULTS AND DISCUSSION

3.1 Simulated yield of chilli pepper

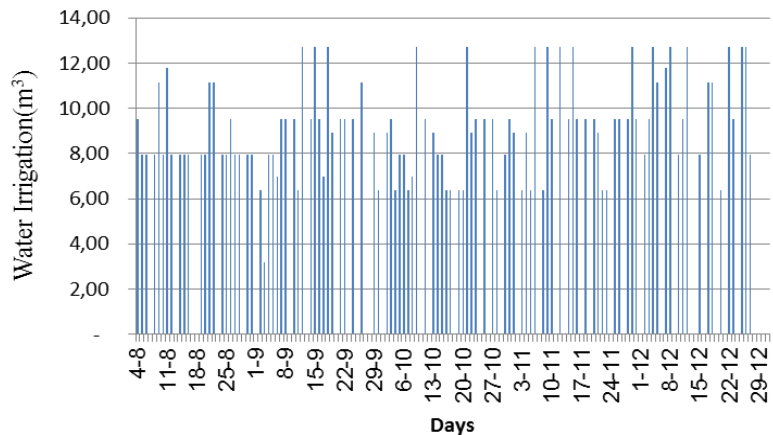
Soil physical characteristics in Table 1 were used as inputs of the model. The reference parameter values of chilli pepper in Table 3 were calibrated to provide compatible between simulation and actual result. [9]

Table 3. Calibrated parameters of chilli pepper (source: [10])

Parameters	Unit	Reference value	Calibrated
Water Productivity (WP)	g/m ³	33.7	33.7
Reference Harvest Index (HIo)	%	48-52	48
Initial Canopy Cover (CCo)	plant/ha	50,000-100,000	50,000
Maximum Canopy Cover (CCx)	%	65-99%	80%

The calibrated parameters in Table 3 were high sensitive and they directly impact on the simulated results. Actual water requirement of chilli peppers used as the input of the model was shown on the Figure 5.

Figure 5. Actual irrigation requirement of chilli pepper.



Simulated yield of chilli pepper in the 2015 Autumn-Winter cropping season corresponding to irrigation water was presented on the Figure 5. Simulated yield was 6.13 ton per hectare, and this simulated yield was similar to the practical harvesting yield (6.33 ton per hectare).

3.2. Simulation of chilli irrigation requirement in varieties

Table 4. Irrigation requirement of chilli pepper

Varieties	Temperature	Precipitation	Irrigation requirement (m ³ /ha/crop)	Difference (%)
1	Unchanged	Unchanged	6,519	
2	Unchanged	P=90%	6,519	-
3	P=10%	Unchanged	7,169	13.4
4	P=10%	P=90%	7,396	13.4
5	Unchanged	P=80%	5,110	-21.6
6	P=20%	Unchanged	6,350	-2.59
7	P=20%	P=80%	5,945	-8,81

Table 4 showed distribution of air temperature with probabilities or exceedence P=10% and precipitation with probabilities or exceedence P=90%, the highest irrigation requirement of chilli pepper is 7,396 (m³/ha/crop). This results is different 13.4 % to compare with irrigation requirement of chilli pepper in enough irrigation water condition.

4. CONCLUSION

The study revealed that changes in rainfall and temperatures significantly influence irrigation requirement and the yield of chilli pepper. In addition, irrigation requirement is expected to increase as the temperatures rise. Irrigation requirement is expected to increase as the rainfall reduce.

REFERENCES

- [1] Khem S., Goto A. and Mizutani M.- Determination of the potential land for securing double-rice cropping in the Cambodian Mekong Delta, based on a sub-area based modeling of flood inundation, Paddy Water Enviro. **6** (3) (2008) 285-298.
- [2] Fox J. and Ledgerwood J.-Dry-season flood-recession rice in the Mekong Delta: Two thousand years of sustainable agriculture, Asian Perspect. **38** (1999) 37–50.
- [3] Son N. T. -Water balance for Kien Giang river basis by IQQM model, Journal of Natural science and Technichcal . Ha Noi National University. **25** (3S) (2009) 499–507.
- [4] Mazourek M., Pujar A. Borovsky Y. Paran I. Mueller L. and Jahn M. M.-A Dynamic Interface for Capsaicinoid Systems Biology, American Society of Plant Biologists.**150** (2009) 1806–1821.
- [5] Jolayemi A. and Ojewole J.-Comparative anti-inflammatory properties of capsaicin and ethyl-acetate extract of capsicum frutescens linn in rats, African Health Sciences.. **13**(2) (2013) 357–361.
- [6] Tuan L. A. - Irrigation-Drainage. Can Tho University, 1997, 95-126.
- [7] Steduto P., Hsiao T. C. Fereres E. and Nations U. -On the Conservative Behavior of biomass water productivity, Irrigation Science. **61** (2006) 59–61.
- [8] Hydro-Meteorological station in Chau Doc, Data of Hydrography and Meteorological station in Chau Doc Station in 2015.
- [9] Saadati Z., Pirmoradian N. and M. Rezaei, “Calibration and valuation of aquacrop model in rice growth simulation under different irrigation managements. In CID 21st International Congress on Irrigation and Drainage, 2011, 589-600.
- [10]FAO, QuaCrop. Rome, Italy, 2011.
- [11] Huy V. T. Application of AquaCrop to simulate rice yield due to climate change factors. Matter thesis. College of environment and natural resource. Can Tho University, 2013.

***Acknowledgement.** The present study was part of the project on technical development for agriculture in the Mekong delta adapting to climate change, which was financially supported by JIRCAS-Japan.*

Article history:

- Received: Sep. 1.2016
- Accepted: Nov. 25.2016
- Email: *nvtuyen@ctu.edu.vn*