Journal of Agrometeorology 23 (4) : 396-401 (December 2021) : https://doi.org/10.54386/jam.v23i4.143

Potential benefits of altering the cassava farming practices in the water shortage regions of Vietnam

VAN HONG, NGUYEN[1] and TRUONG AN, DANG[2]

[1] Sub-Institute of Hydrometeorology and climate change, Dist., 1, Ho Chi Minh City, Vietnam
19 Nguyen Thi Minh Khai, dist 1, HCM city, Vietnam
[2] University of Science, Vietnam National University, Ho Chi Minh 70000, Vietnam
227 Nguyen Van Cu Str., 5 Dist., Ho Chi Minh City, Vietnam
*Corresponding author email : dtan@hcmus.edu.vn

ABSTRACT

The work was proceeded to define the suitable period for planting cassava crops in Han Thuan Bac district of Binh Thuan province, Vietnam to reduce the negative impacts of weather factors. The work was deployed applying the FAO-Aqua Crop model to calculate the tuber yield of cassava plants under the cassava farming practices (CFP) to seek the suitable planting period (SPP). The applied model was appraised through the calibration and validation procedures with the index of agreement (IA), correlation coefficient (CC) and the Root Mean Square Error (RMSE) varying from 0.82 to 0.88, 0.81 to 0.89 and 0.21 to 0.29, respectively. Based on the calibrated and validated procedures it can state that the proposed model is suitable for simulating the tuber yield of cassava across the study area. The simulated results indicated that the application of the CFP on Julian days from 110 to 150 for Vu Xuan crop and from 100 to 140 for Vu He crop the tuber yield of cassava can improve up to 8.9 per cent and 6.0 per cent, respectively compared to the current farming practices.

Key words: Farming practice, potential risks, cassava, off-seasonal rainfall, tuber yield

Weather change has negatively influenced the aspects of socio-economic fields (Lee and Dang, 2019; Miyan, 2015). Agricultural sector is assessed as vulnerable compared to other sectors (Dhatt and Jhanji, 2021). An investigation on the impacts of climate change (ICC) on tuber yield of cassava plant in the Togo region showed that cassava crops are meeting the potential challenges. Emaziye (2015) conducted a study on the weather factors on tuber yield of cassava in the rural households of Delta State, Nigeria and reported that precipitation is the major factor which has been significantly affected by altering in climate factors. In Nigeria, Ropo and Ibraheem (2017) investigated the ICC on the tuber yield of cassava plant in Port Harcourt and stated that the precipitation is one of the weather factors has dominated on the tuber yield. In Ham Thuan Bac district, cassava is commonly grown in most rural areas and is evaluated as a key crop to contribute increase the income of local cassava growers (Bien *et al.,* 2007; Mai, 2017). According to Emaziye (2015), cassava cuttings are easy to sow, no require much care, suitable for nutrient-poor and arid soils (Mai, 2017; Fermont *et al*., 2009). Cassava plants is also considered a low-risk cropand uses as anideal raw material for other manufacturing fields.

In the cassava cultivation regions of BinhThuan province such as Tanh Linh, Bac Binh and Ham Thuan Bac,cassava growers usually sow the cuttings based on rainfed (Mai, 2017). According to Howeler (2010) cassava is maintaining an increasing important in human life and humanity is increasingly looking for clean fuel sources to replace fossil fuels (Dhatt and Jhanji, 2021). As an acknowledgment of the importance of cassava for human life, the research projects on cassava have been widely deployed across continents such as in the Delta State of Nigeria by Emaziye, (2015), in East Africa by Fermont *et al*. (2009), in Asia by Howeler (2010) and in Vietnam by Bien (2007) and Mai, (2017).

Studies on the ICC on irrigation use water for cassava crops reported that the CFP plays an important role in mitigating the lack of irrigation water and reducing the crop yield (Mai, 2017). According to Howeler (2010), climate change has impacted on the growth and harvest stages of cassava cultivation regions, and they recommended that it is necessary to build a CFP for cassava crops in the context of climate change. Thus, the detection of the suitable growing periods to sow the cassava cuttings is stated an effective adapt solution to limit the adverse weather factors. The primary aim of this work, therefore, was to detect the suitable periods for CFP across the study area to maintain as well as improving the tuber yields of cassava crops.

MATERIALS AND METHODS

Study area

Binh Thuan is located at latitude 10°33'42"-11°33'18" N and longitude 107°23'41"-108°52'18"E and Ham Thuan Bac is one of the districts in Binh Thuan province. The study area has a large cassava cultivation area compared to other provinces in Vietnam (Bien, 2007; Mai 2017). The weather is governed by two main monsoon circulations namely northeast and southwest, which alternately blow throughout the year. The wet season is also known as the southwest monsoon, lasting from May to October while the dry season is also called north east monsoon from November to April. Annual mean temperature about 27.0°C and precipitation around 1000 mm with approximately 80 per cent of annual precipitation falls the wet season (Mai, 2017).

Model description

The AquaCrop model is designed by FAO-Food and Agriculture Organization for simulating irrigation use water, calculating components yield as well as crop yield (Abedinpour *et al*., 2012). The model is designed based on combination of four sub-models namely climate, crop, soil, and management module (Abedinpour *et al*., 2012; FAO, 2017). Detailed introduction of the model can be found in Abedinpour *et al*. (2012).

Data description

To deploy this work, the climate parameters *viz*., temperature, radiation, wind speed, rainfall, relative humidity for simulating the climate module are provided (Fig.1). For crop and management module, the detailed data information about cassava variety, sowing density as well as fertilizer rates has also been presented in Table 1. A high yielding cassava variety called KM98-5 is widely grown with the cycle varying from 9 to 14 months based on local weather conditions (Bien, 2007; Mai, 2017). The information of crop management has been provided in Table 1. In the entire study area, KM98-5cassava cuttings were sownwith spacing of 0.8 m x 0.8 m around the first week of May for Vu Xuan crop while Vu He crop cassavas was sown with spacing of 0.85 x 0.85 m in the fourth week of March (Table 1). In addition, the rate of fertilizer used to fertilize cassava cuttings was up to 10 t ha^{-1} manure, 0.2 t ha^{-1}nitrogen fertilizer, 0.15 t ha^{-1} P_2O_5, and 0.15 t ha^{-1} K_2O, respectively for Vu Xuan crop while the respective ratios to 10 t ha^{-1} manure, 0.25 t ha^{-1} nitrogen fertilizer, 0.20 t ha^{-1} P_2O_5, and 0.20 t ha^{-1} K_2O, respectively for Vu He crop. For the simulation of the soil module, the soil samples across the study area were analyzed and has shown that the soil was sandy loam with pH of 5.5 - 5.7 and its physicochemical properties has been described in Table 2.

Evaluating the performance of the AquaCrop model

The AquaCrop model was evaluated analyzing the correlation between the observed tuber yield of cassava and simulated AquaCrop model for both Vu Xuan and Vu He crops during the study period 2011-2020. The statistical methods as such correlation coefficient (CC), Root Mean Square Error (RMSE) and index of agreement (IA) are adapted (Kumar *et al*., 2021).

The CC is defined as follows:

$$CC = \frac{\sum_{i=1}^{n} S_i * O_i - \sum_{i=1}^{n} S_i * \sum_{i=1}^{n} O_i}{\sqrt{\sum_{i=1}^{n} S_i^2 - \left(\sum_{i=1}^{n} S_i\right)^2} * \sqrt{\sum_{i=1}^{n} O_i^2 - \left(\sum_{i=1}^{n} O_i\right)^2}} \quad (1)$$

where O_i and S_i are observed tuber yield of cassava and simulated AquaCrop model, respectively; is the mean value of O_i, and n is the number of data points

and the RMSE is calculated by:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(M_i - S_i)^2} \quad (2)$$

And the IA is given by Eq.(3)

Table 1: Crop characteristics of cassava plants in the study area

Crop	Crop calendar		Sowing density	Fertilizer rate (tha^{-1})			
	Plant	Harvest	($plantha^{-1}$)	NPK	Urea	Kali	Manure
Vu Xuan	10-May	05-July	16000	0.20	0.15	0.15	10
Vu He	30-Mar	20-Feb	14000	0.25	0.20	0.20	10

Table 2: Chemical attributes of the soil in the study area

Depth (cm)	pH	Sand	Silt	Clay	Al	Fe	Mg	Mn	Ca	K	Na	Si
			(%)					(g)				
0-20	6.7	60	20	20	13.5	1.7	0.4	0.2	1.6	3.9	0.6	71.5
20-40	6.5	50	20	30	12.8	2.1	0.6	0.6	1.2	4.2	1.7	63.3
40-60	5.9	58	15	27	11.7	2.4	0.3	0.3	1.1	3.6	0.8	58.9

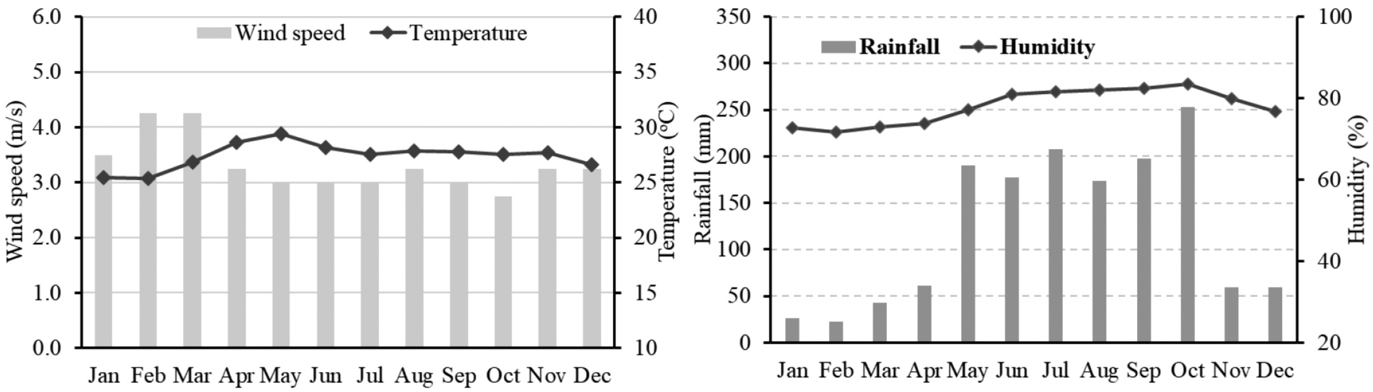

Fig. 1: Input weather parameters for simulating the climate module of the AquaCrop model

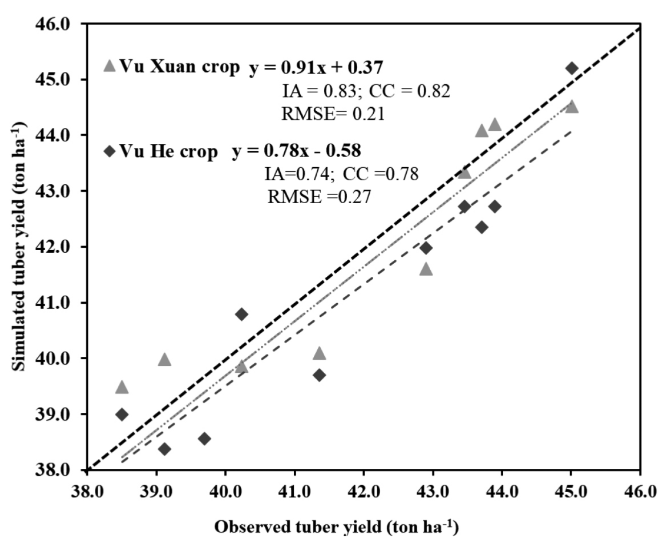

Fig. 2: Compared results between the observed tuber yield of cassava and simulated model of Vu Xuan and Vu He crops

$$IA = 1 - \frac{\sum_{i=1}^{N}(O_i - S_i)^2}{\sum_{i=1}^{N}(|O - \bar{O}| + |S_i - \bar{O}|)^2} \quad (3)$$

O and S in the Eq. (3) are the observed tuber yield of cassava and simulated AquaCrop model and n is the number of data points while is average value of observed tuber yield data.

Table 3: Tuber yield corresponds to optimal Julian days for cassava sowing crops in the study area

	Vu Xuan crop					Vu He crop			
	Tuber yield (t ha^{-1})	Rate of increase (%)	SD	CV(%)		Tuber yield (t ha^{-1})	Rate of increase (%)	SD	CV(%)
Current	42.5	-	-	-	Current	38.4	-	-	-
110	46.3	8.9	2.9	4.8	100	39.9	3.9	3.3	5.2
120	45.7	7.5	2.5	4.3	110	40.7	6.0	3.0	4.8
130	45.1	6.1	3.4	5.4	120	39.9	3.9	2.8	4.3
140	44.2	4.2	2.1	3.9	130	39.8	3.6	3.9	6.5
150	43.3	1.9	2.3	4.1	140	39.0	1.6	3.6	4.9

SD: Standard deviation; CV: Coefficient of variation; Current: current tuber yield; 110-150 and 110-150: Julian days

RESULTS AND DISCUSSION

Results showed that the simulated AquaCrop model is in a good agreement with the observed tuber yield of cassava plant with IA = 0.81-0.89, RMSE = 0.24-0.32 and CC =0.84-0.93, respectively for both Vu Xuan and Vu He crops. Based on the findings, it can be stated that the AquaCrop model is good agreement to apply for simulating tuber yield of cassava plants across study area (Fig.2).

Evaluating the tuber yield under the farming practices

In the cassava cultivation regions of Ham Thuan Bac district, cuttings are commonly grown depend on local precipitation situation (Bien, 2007; Mai, 2017). Climate variability has a significant impact to the meteorological parameters, especially the precipitation factor, resulting in the lack of irrigation service water and thus the CFP is poorly adapted to current weather conditions, leading to the decline in crop yield. The results indicated that the application of the CFP for Vu Xuan crop on Julian days from 110 to 150 the tuber yield of Vu Xuan crop will increase varying from 1.9 per cent to 8.9 per cent compared to the current sowing calendar (Table 3). For Vu He crop, the tuber yield can increase from 1.6 to 6.0 per cent if the CFP has deployed on Julian days from 100 to 140 compared to the current sowing calendar (Table 3). Specifically, the maximum tuber yield of Vu Xuan crop cassava can be obtained up to 45.7 tha^{-1} if the CFP is conducted on 120 Julian days while the optimal tuber yield of Vu He crop cassava can be enhanced upto 40.7 t ha^{-1} (Table 3). Generally, the alteration of the CFP for both Vu Xuan and Vu He crops can contribute to a significant improved tuber yield of cassava crops across the study area.

Relationship between the farming practices and weather factors

The analysis of historical precipitation data series across the study area pointed out that the alteration of the CFP for both Vu Xuan and Vu He crops compared to the current farming practices will enhance the furnishing of abundant precipitation on the growth stage but poor precipitation in the harvest stage of cassava tubers. Specifically, the CFP of Vu Xuan crop on 120 Julian days the growth stages of cassava will be provided with abundant amount of water from precipitation while the harvest stage of cassava tubers will be receiving low precipitation amount, resulting in a good growth and harvest of cassava tubers (Fig.3). These findings were in agreement with the reports of Ropo and Ibraheem (2017). They confirmed that for the water shortage regions, precipitation plays a key role in the growth and development stages of crop.

CONCLUSION

The research was proceed applying the FAO-AquaCrop model to simulating the tuber yield of cassava crops across the study area to seek the suitable planting period. The applied model was appraised and proven its good performance through the calibration and validation procedures with high correlation of the index of agreement, correlation coefficient and the root mean square error between the observed tuber yield and simulated model. Based on the findings, tuber yield can be improved positively compared with the current crop yield if the cassava farming practice has to be deployed

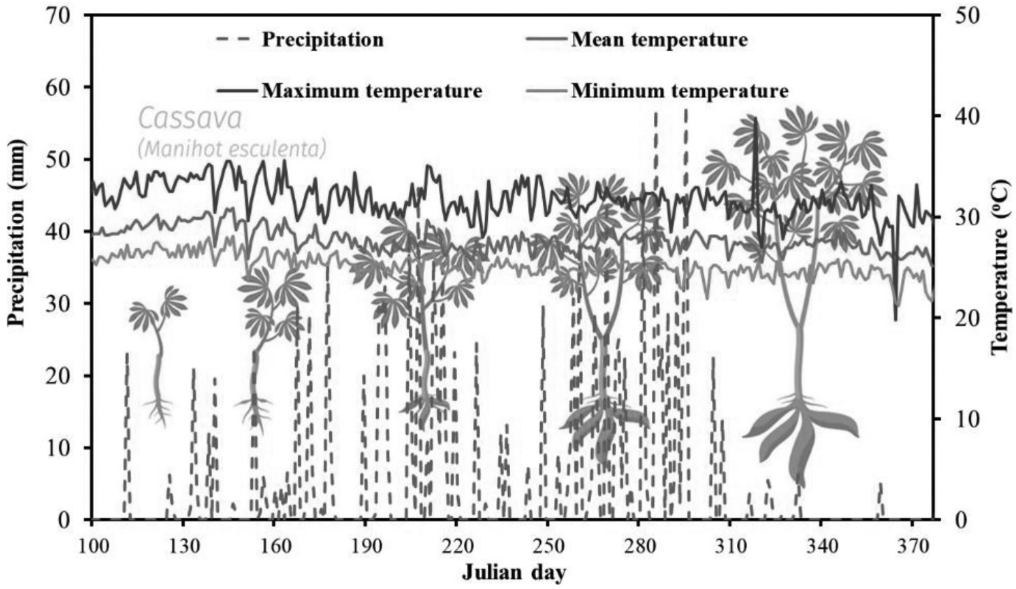

Fig. 3: The cassava farming practices in the study area adjustedto conform with changes in temperature and precipitation (Source: https://www.vectorstock.com)

on the cassava cultivation fields. The implementation of the cassava farming practice can enhance to utilize the favorable weather conditions contributing to maintain as well as improving crop productivity.

***Conflict of Interest Statement**:* The author(s) declare(s) that there is no conflict of interest.

Disclaimer: The contents, opinions, and views expressed in the research article published in the Journal of Agrometeorology are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

Publisher's Note: The periodical remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

REFERENCES

Abedinpour, M., Sarangi, A., Rajput, T.B.S., Singh, M., Pathak, H and Ahmad, T. (2012). Performance evaluation of AquaCrop model for maize crop in a semi-arid environment. *Agric. Water Manage.,* 110: 55–66.

Bien, P.V., Kim, H., Ngoan, T.N., Howeler, R. and Wang, J.J. (2007). New developments in the cassava sector of Vietnam, Cassava research and development in Asia, exploring new opportunities for an Ancient Crop. Proc. Seventh Regional Workshop, held in Bangkok, Thailand. 25-32.

Dhatt, K. K. and Jhanji. S. (2021). Evaluating gladiolus varieties for off-season planting using agro-meteorological indices. *J. Agrometeorol.,* 23 (1), 46-53.

Emaziye, P.O. (2015). The influences of temperature and rainfall on the yields of Maize, Yam and Cassava among rural households in Delta State, Nigeria. *J. Biol. Agric. Healthcare*, 5(1): 63-69.

FAO-Food and Agriculture Organization of the United Nations. (2017). AquaCrop update and new features (Version 6.0), ISBN 978-92-5-109742-7, p.75.

Fermont, A.M., van Asten, P.J.A., Tittonell, P., van Wijk, M.T. and Giller, K.E. (2009). Closing the cassava yield gap: an analysis from small holder farms in East Africa. *Field Crops Res.,* 112: 24–36.

Howeler, R.H. (2010). Cassava in Asia: A potential new green revolution in themaking. A new future for Cassava in Asia: Its use as food, feed, and Fuel to benefit the Poor. Proc. Eighth Regional Workshop, held in Vientiane, Lao PDR. Oct 20-24, 2008, pp.34-64.

https://www.vectorstock.com/faq/members/standard-license

Lee, S.K. and Dang, T.A. (2019). Irrigation water requirement of rice in Long Xuyen Quadrangle area, Vietnam in the context of climate change. *J. Agrometeorol.,* 21(1), 18-23.

Mai, N.T.T. (2017). Study on selection of high-yield starch and intensive cultivation techniques in Phu Yen province. Doctoral thesis, Hue University of Agriculture and Forestry.

Miyan, M.A. (2015). Droughts in Asian least developed countries; vulnerability and sustainability. *Weather Clim. Extremes,* 7:8–23.

Ropo, O.I. and Ibraheem, A.A. (2017). Response of cassava and maize yield to varying spatial scales of rainfall and temperature scenarios in Port Harcourt. *Res. J. Environ. Sci.,* 11(4):137-142.

Received : June 2020 : Accepted : August 2021