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Short Communication

Assessment of efficient crop planting calendar for cassava crops using the FAO-Aqua crop model

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In recent decades, climate change has negatively affected the aspects of human life and the agricultural sector is identified as the most vulnerable.(Mbanasor *et al*., 2015). There is potential risks for agricultural production due to the negative impact of climate change in developing countries (Boansi. 2017). Lee and Dang, (2019) stated that precipitation is one of the main factors which will be impacted strongly by climate change. According to Vongcharoen *et al*., (2018), the variation of precipitation due to climate change leads to the changing in crop water demand and crop planting calendar. The biggest challenge of farmers in recent years is the lack of irrigation water due to drought and heavy rainfall events leading to flooding (Lee and Dang, 2018; Janket *et al*., 2018).

As an acknowledgment of the impact of climate change on cassava in different regions of the world, studies on the irrigation water requirement (Lee and Dang, 2019b) and cassava yield in the context of climate change have been conducted widely in Nakhorn Ratchasima province, Thailand by Wichitchana and Skolpap, (2014), East Africa by Fermont *et al*., (2019) and Phu Yen province of Vietnam by Mai, (2017). Almost the above-mentioned studies stated that the Crop Planting Calendar plays an important role in mitigating the negative Impact of Climate Change and contributing to improve the crop yield. The goal of this study, therefore, was to define the right time to plant for cassava crops at Son Hoa district as an adaptation solution as well as optimal the crop yields in the context of weather change in recent years.

Study area

Son Hoa district (13.00°-13.38°N and 108.75°-109.15°E) is one of the cassava planting areas in Phu Yen province. The study area is a transition region between the highlands and the lowlands. Its topography is, therefore, very complex covers a land area of 950.3 km^2 of which hills account for about 77%, alternating between the narrow vales. The terrain gradually decreases from West to East. The study area has a high average temperature of about 26 °C and annual precipitation up to 1800 mm (Mai, 2017) and over eighty percent of annual precipitation arrives in the wet season (September-December) while the dry season from January-August is hot and only gets approximately twenty percent of precipitation (Lee and Dang, 2018).

FAO-Aqua Crop is one of the most comprehensive crop models developed by the Food and Agriculture Organization (FAO) for calculating water use demand, predicting the effect of environment and estimating the ICC on crop yields (Abedinpour *et al*., 2012; Balvanshi and Tiwari, 2019). The advantages of the model are that using only a relatively number of parameters and the simulation steps are quite simple however output results still ensure an accuracy (Silvestro *et al*., 2017; Lee and Dang, 2018). A detailed description of the FAO-AquaCrop model is given in FAO (2017).

The input weather data for the model were collected from Son Hoa Meteorological station for period 2000-2018 and detailed descriptions are shown in Fig.1.A detailed description of the key parameters used in the present model is provided in Table 1.

Model performance

The model performance was appraised through the validation process comparing the observed and simulated biomass and cassava yields for spring and summer crop seasons during period 2013-2018. The statistical indices such as the root mean square error (RMSE), the index of agreement (d) and correlation coefficient are applied to investigate the model performance. The RMSE is defined by:

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

Table 1: Key parameters used in the FAO-Aqua Crop model

Parameters	Values	Unit
Cut-off temperature	30	°C
Maximum root extraction at the top	0.03-0.06	m^3/m^3.day
Maximum root extraction at the bottom	0.001-0.06	m^3/m^3.day
Canopy cover per seedling at 90% emergence	10	cm^2/plant
Maximum canopy cover	99	%
Maximum rooting depth	1.7	m
Canopy expansion shape factor	2.5	-
Early canopy senescence p	0.7	%TAW
Normalized water productivity	15	g/m2
Reference harvest index	40	%

Table 2: Change in cassava yield under different planting dates

Cropseason	Change in cassava yield under different planting daters (%)									
	Backward (day)					Forward (day)				
	-35	-28	-21	-14	-7	7	14	21	28	35
Spring	2.68	5.97	8.85	5.88	2.73	-0.66	-2.13	-3.23	-5.98	-2.57
Summer	-1.99	-3.88	-2.96	-0.59	1.35	3.88	6.06	3.99	3.55	1.48

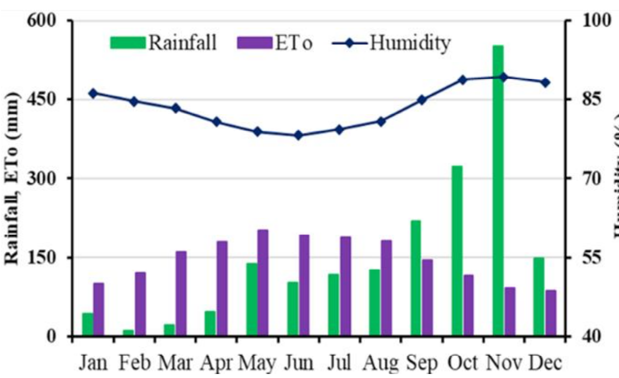

Fig.1: Illustration of input weather data for applying the FAO-AquaCrop model

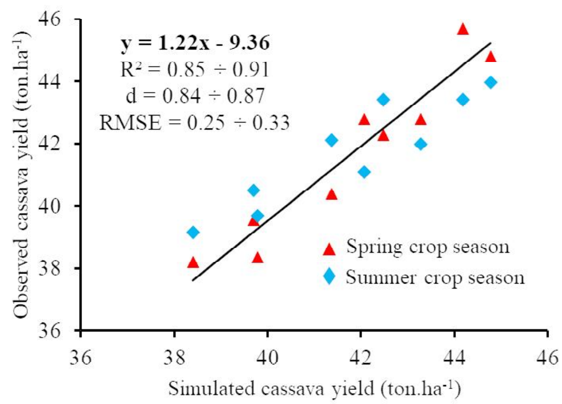

Fig.2: Comparison between observed and simulated yields of spring and summer crop seasons

And the index of agreement (d)is given by:

$$d = 1 - \frac{\sum_{i=1}^{N}(M_i - S_i)^2}{\sum_{i=1}^{N}(|M_i - \bar{M}| + |S_i - \bar{M}|)^2} \quad (2)$$

Where, M and S are the observed and simulated data and n is the number of data points, $\bar{M}$ is average value of observed data.

The performance of the model is considered satisfactory if the values of r and d are greater than 0.5 while the value of RMSE approaches zero. The validation was carried out comparing the observed and simulated yields in the stage of 2013-2018. The analyzed results showed that the simulated yield is a good correlation with the measured yield with d=0.84-0.87, RMSE=0.25-0.33 and R^2=0.85-0.91, respectively for spring and summer crop season (Fig.2). The validated results implied that the FAO-AquaCrop model applied is good matching for simulating biomass yield and cassava yield.

Shifting the crop planting calendar

The results showed that cassava yield of spring and summer crop seasons have changed by shifting the CPC (Table 2). The cassava yield can be increased by approximately 7.85% over the mean value to 44.68 ton. ha^{-1} if the CPC is early shifted from 14 to 21 days for spring crop season while the yield will decrease approximately 0.66 to 5.98% when the CPC is delayed from 7 to 35 days. On the other hand, for summer crop season, maximum yield can be increased by approximately 6.06% over the mean value if the CPC is delayed from 7 to 14 days.

The study was executed to detect the proper time for planting the cassava crops across the cassava cultivation area of Son Hoa district in Phu Yen Province of Vietnam in the context of change in weather scenario in recent years using the FAO-AquaCrop model. The cassava yield can be significantly improved if the current crop planting calendar is changed. The backward shift from 14 to 21 days for spring crop season and forward shift from 7 to 14 days for summer crop season is perfectly suited to the current features of local weather condition to achieve the optimal productivity. Shifting crop calendar may also help in getting a dry weather condition towards the end of the crop season, suitable for harvesting of crop.

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