II(O)_012 Impact Assessment of Climate Change on Maize Yield of Long An Province (Vietnam) under B2 Scenario by DSSAT

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Abstract

Maize is a very important food and economic crop not only in Vietnam but all over the world and the influence of climate change on it has been shown in several previous studies with different models. Basing on the climate change scenario B2 generated by Ministry of Natural Resources and Environment, the maize yield of Long An Province in 2020, 2030 and 2050 was simulated by crop model DSSAT. Input data for DSSAT consists temperature, soil characteristics, climate, fertilizer, irrigation, farming technology and management and was collected from 2003 to 2010. At the first step, the results of maize yield simulated from 2003 to 2010 by DSSAT examined on two fields which had different soil characteristics were compared to the real yield values in order to calibrate the model. Then, a basic year would be selected and simulation of maize yield in 2020, 2030 and 2050 would be based on climate data of this year under B2 scenario. After comparison, Pearson r correlation between simulated and real yield values on two fields were both estimated $r > 0.8$, which meant that model calibration turned out to be unnecessary and DSSAT was an appropriate model to be used in simulating maize crop yield in Long An Province. The results from the next steps showed that increase of temperature and change of precipitation would cause decrease in maize yield in winter-spring and summer-autumn crops. In general, the yield would begin to decrease sharply from 2030 to 2050. Inferring from its lower crops yield, summer-autumn crops would be affected more significant than winter-spring ones. According to B2 scenario, the highest decreasing yield was forecasted 8,9% for summer-autumn crop and 6,5% for winter-spring crop in 2050. There were differences of changing maize yield between two fields which had different soil characteristics. Basing on the results obtained, this study proposed solutions in order to maintain and improve maize yield in climate change condition in the future.

Keywords: DSSAT; Maize crop yield; Simulation; B2 scenario

1. Introduction

Over the past few decades, climate change has become the most significant concern to international public and multi-country governments. Besides natural disasters such as flood, typhoon, drought and severe weather resulted from climate change (Aalst, 2006), human being's life in socio-economical and environmental concept are also affected via issues such as submerged coastal and low-lying areas (Maria Snoussi, Tachfine Ouchani, Saida Niazi, 2008), deterioration in quantity and quality of water resources (Arnell, 1999), increase in energy consumption (Jane Ebinger, Walter Vergara, 2011) by global warming.

Among numerous factors, which shape and drive the agricultural sector such as biology characteristics, management practices, land-use regulations, the climate variation is recognized as a complex factor because of its uncontrollability. Climate change will lead to reduction of crop yield (Rosenzweig, C. et al., 2002), drought and desertification and loss of agricultural land (Houérou, 1996); therefore food security is in severely threatened status. To understand the basic interactions of the soil – plant – atmosphere system, to serve the need of mitigation adverse impacts of climate change on agriculture and to monitor crop conditions and production estimates, crop simulation models have been studied and developed in several years. Application of models such as DSSAT, CROPGRO, MODIS-NDVI, EPIC in prediction crop productivity proved the usefulness of these tools in crop management, policy making and climate change impacts assessment on agriculture (Arjan J. Gijsman et al., 2002) (Reimund P. Rötter et al., 2012) (M.S. Mkhabela, 2011).

In 1996, a project on simulation crop yield by using crop model EPIC (Erosion Productivity Impact Calculator) together with remote sensing data (Landsat TM) at regional scales was conducted in U.S. Magnitude and variation of crop conditions parameters such as precipitation, temperature, fertilizers was adapted as input data for simulating spring wheat yields at the sub-county level and for calibrating model in case the modeled and observed conditions did not get agreement. The results showed that after calibration, the model could generate crop yield predictions at studied site and application of this crop model for larger scales was virtually possible (Paul C. Doraiswamy et al., 1996).

According to study of simulation maize crop yield with CERES-maize model in the midwestern region in United States (including 5 states: Indiana, Illinois, Ohio, Michigan, and Wisconsin) under climate change scenarios by Jane Southworth et al. (2000), maize crop yield was affected differently in climate change (Jane Southworth et al., 2000). This study also highlighted the difference in crop responses to changed environmental conditions. Potential impacts of climate change on maize production of Africa and Latin America to 2055 was published in study of Peter G. Jonesa and Philip K. Thornton (2003). While MarkSim and HadCM2 were applied to forecast the change of climate parameters, maize crop yield was simulated by CERES-maize model. Resulted from their research, 10% total maize crop of Africa and Latin America could be reduced under the influence of climate change. However, areas where the maize crop fell down most have not been found. More recently, aiming to assess the impacts of climate change on maize crop, a research of Simona Bassu et al was conducted in 2014. Results from 23 models applied to simulate maize crop of 4 areas including Lusignan (France), Ames (United States), Rio Verde (Brazil) and Morogoro (Tanzania) reached extremely accuracy and showed that temperature increase produced negative impacts on maize crop (Simona Bassu et al., 2014).

Agriculture sector of Vietnam can be extensively affected due to decrease in crop yield, water shortage by rising sea level and changes in precipitation and temperature (Susmita Dasgupta et al, 2007). In Vietnam, with maize planted area up to 1172.5 thousand hectares and yield of main annual crop up to 44.3 quintal/ha in 2013 (General Statistical Office, 2014), maize is ranked as the second most important food crop after rice, planted in soils with different characteristics and plays an important role in feeding people, poultry and livestock. While countries which achieved very high maize crop yield such as United States, Brazil have implemented various studies in simulation maize crop yield interacting with climate change for more than 10 years ago, application of crop models for agriculture productivity prediction under changed climate parameters in is little known in Vietnam. Especially, there is a very few studies on maize crop simulation with Decision Support System for Agrotechnology Transfer (DSSAT), a software application program that comprises crop simulation models for over 28 crops (as of v4.5). DSSAT is supported by data base management programs for soil, weather, and crop management and experimental data, and by utilities and application programs. Thanks to this model, stimulation of many crops can be conducted and estimated the influence of climate change on farming industry.

This study aims to assess the potential impacts of climate change on maize crop yield in 2020, 2030 and 2050 in Long An province in Vietnam via the change of meteorological parameters under climate change scenario B2 generated by Vietnam Ministry of Natural Resources and Environment. Basing on the results obtained, solutions for management practices was proposed in order to maintain and improve maize yield in climate change condition in the future.

2. Materials and Methods

2.1 Steps of research

Firstly, input data such as temperature, soil characteristics, climate, fertilizer, irrigation, farming technology and management collected from 2003 to 2010 were applied to DSSAT for simulating maize yield on 2 fields in 2 types of crop from 2003 to 2010. Because Duc Hoa District accounted for

90% maize planting area and more than 90% maize yield of Long An Province, real values of maize crop yield of this district from 2003 to 2010 was used for comparing to the yield resulted from DSSAT in the period 2003-2010 in order to calibrate the model (if any). The real yield values were collected and released by Agriculture and Rural Development Office of Duc Hoa District in 2010. Appropriateness of DSSAT model is assessed by Pearson r correlation in below formular with simulated yield values (x), average simulated yield values $(\bar{x})$, real yield values (y), average simulated yield values $(\bar{y})$, total crops (N) ((Hoang Trong, Chu Nguyen Mong Ngoc, 2008).

$$r = \frac{\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N}(x_i - \bar{x})^2 \sum_{i=1}^{N}(y_i - \bar{y})^2}}$$

Then, a basic year would be selected and simulation of maize yield in 2020, 2030 and 2050 would be based on climate data of this year under B2 scenario. Assessment of climate change impacts on maize production could be implied from the simulation results and became foundation for proposing management solutions.

2.2 Study region

Lying next to Ho Chi Minh City, Long An is a mid-sized province located within the Mekong Delta region in Southern Vietnam. The weather of Long An province is determined with monsoon sub-equatorial climate characteristics such as annual average temperature 2005 – 2013 varied from 26.1°C to 28°C (Statistical Office Long An Province, 2012), the dry season from November to April and the rainy season from May to October, unsteady annual average precipitation, annual average humidity varied from 80.7 to 87.7% and 176.8 – 236 hours for annual average sunshine. Duc Hoa is one of 13 districts of this province. Soil profile of Duc Hoa District typically includes 3 main types: thionic fluvisols, gleyic fluvisols and acrisols (Agriculture Planning and Design Sub-institute, 2010). Tan-Phu and Mi-Hanh-Bac are 2 wards located in Duc Hoa District and their soil characteristics are totally different from each other (Table 2.1 and Table 2.2). Soil property of Tan-Phu was classified as Plinthic Ferralic Acrisols while Mi-Hanh-Bac was defined as Haplic Ferralic Acrisols (Agriculture Planning and Design Sub-institute, 2010).

Table 2.1. Soil characteristic of Tan-Phu fields (Agriculture Planning and Design Sub-institute, 2010)

The depth (cm)	pH		C(%)	Total (%)			Soil Texture (%)		
	H_20	KCl		N (%)	P_2O_5(%)	K_2O	Sand	Silt	Clay
00 – 18	4.29	3.74	0.786	0.154	0.010	0.132	24.50	65.00	10.50
18 – 28	4.30	3.63	0.210	0.098	0.006	0.108	19.50	65.30	15.20
28 – 65	4.11	3.51	0.105	0.091	0.007	0.277	16.20	68.10	15.70
65 – 150	4.09	3.40	0.107	0.085	0.012	0.482	17.10	58.50	24.40

Table 2.2. Soil characteristic of Mi-Hanh-Bac fields (Agriculture Planning and Design Sub-institute, 2010)

The depth (cm)	pH		C(%)	Total (%)			Soil Texture (%)		
	H_20	KCl		N (%)	P_2O_5(%)	K_2O	Sand	Silt	Clay
00-11	4.58	3.76	1.970	0.086	0.014	0.143	68.60	29.80	1.60
11-30	4.43	3.70	0.336	0.071	0.009	0.180	69.30	30.50	0.20
30-62	4,74	3,63	0,310	0,064	0,010	0,260	58,10	32,90	9,00
62-120	5,03	3,55	0,155	0,063	0,011	0,428	56,30	37,70	6,00

2.3 Generation of climate change scenario

B2 is a medium emission scenario generated by Ministry of Natural Resources and Environment of Vietnam. According to Vietnam Ministry of Natural Resources and Environment, temperature, precipitation of Long An Province in 2020, 2030 and 2050 were calculated and predicted by climate model SimCLIM under B2 emission scenario (Table 2.3). This research used data from the report including the daily maximum, minimum temperature and forecasted precipitation in order to simulate maize crop yield.

Table 2.3. Change of temperature and precipitation in 2020, 2030, 2050 under B2 scenario (Vietnam Ministry of Natural Resources and Environment, 2011)

		Years		
	Month	**2020**	**2030**	**2050**
Temperature (^oC)	12 - 2	0,36	0,49	1,02
	3 - 5	0,38	0,51	1,07
	6 - 8	0,36	0,49	1,02
	9 - 11	0,34	0,45	0,94
Precipitation (%)	12 - 2	-3,1	-4,3	-9,3
	3 - 5	-1,3	-1,8	-3,9
	6 - 8	2,8	3,9	8,4
	9 - 11	1,4	1,9	4,2

2.4 DSSAT crop model

DSSAT 4.5 was applied to explore the impacts of climate change on maize production of Long An Province. Data on soil profile, climate and farming management were input information for DSSAT operation.

Soil profile folder

Created for updating, storing and analyzing characteristics of selected site such as cation exchange capacity, soil texture, organic carbon, concentration of N, P, K, soil profile folder was an essential factor in creating another simulation folders and determining the accuracy of model. Information of soil profile of 2 fields was expressed in Table 2.1 and Table 2.2. In this research, soil profile folder was used for maize crop yield simulation in period of 2003-2010 and in 2020, 2030, 2050 under B2 scenario. Data for building soil profile folder was produced by Agriculture Planning and Design Sub-institute in 2010.

Climate folder

Simulation maize crop yield in the period 2003 – 2010 and in 2020, 2030, 2050 required to build 4 climate folders indicating following parameters: daily maximum and minimum temperature, precipitation and sunshine hours for the period 2003-2010, 2020, 2030, 2050. Data of climate folder for period 2003-2010 was collected from January 1st 2003 to December 31st 2010 at meteorology monitoring station of Long An Province and published by Sub-institute of Hydrometeorology and Environment of South Vietnam in March 2014. Data of climate folders in 2020, 2030, 2050 were integrated and simulated from climate data of basic year and changed data under B2 scenario (as mentioned in 2.3) by SimCLIM model (Sub-institute of Hydrometeorology and Environment of South Vietnam, 2011).

Farming management folder

Because of the similarity in farming management in Tan-Phu and Mi-Hanh-Bac, information on time of crop, maize variety, planting technique, fertilizers, irrigation, plant protection chemicals usage imported to DSSAT model as input data are resemble for 2 fields and unchanged in the period 2003-2010, 2020, 2030, 2050. Time of crop is divided into 2 crops: winter-spring from November to March and summer-fall from April to August. However, summer-fall crops has been cultivated since the beginning of 2005. Data of planting and harvest days imported into DSSAT was indicated in Table 2.4. LVN-10 is a hybrid maize variety produced by Viet Nam National Research Institute for Maize with major characteristics: maturity from 100 - 125 days, suitable growing in many different soils, good quality of grain. Among maize varieties planted in Long An Province, LVN-10 was selected to apply to DSSAT model for simulating maize production. Irrigation of each crops was simulated at the beginning of planting time and additional watering was conducted for winter-spring crop with $32m^3$/day.ha for 7-to-13-leaves period and $68m^3$/day.ha for later periods. Data of fertilizers for each crops was indicated in Table 2.5.

Table 2.4. Planting and harvest days on summer-fall and winter-spring crops from 2003 to 2010

Year	Summer-fall Crop		Winter-spring crop	
	Planting day	**Harvest day**	**Planting day**	**Harvest day**
2003 - 2004	-	-	30/10/2003	01/3/2004
2004 - 2005	-	-	30/10/2004	01/3/2005
2005 - 2006	30/3/2005	30/7/2005	01/11/2005	01/3/2006
2006 - 2007	15/4/2006	12/8/2006	01/11/2006	01/3/2007
2007 - 2008	01/4/2007	01/8/2007	30/10/2007	28/2/2008
2008 - 2009	30/3/2008	30/7/2008	01/11/2008	01/3/2009
2009 - 2010	02/4/2009	01/8/2009	30/10/2009	28/2/2010

Table 2.5. Weight use of fertilizers for each crops simulated in DSSAT model

	Weight use (kg/ha)				
	Muck	**Lime**	**P**	**N**	**K**
Basal fertilizing	3000	400	600	92	62
1st Additional fertilizing (25-30 days after planting)	-	-	-	185	62
2st Additional fertilizing (40-45 days after planting)	-	-	-	92	-

3. Results and Discussion

3.1 Maize yield simulation in 2003-2010 and Model Appropriateness Assessment

After soil profile, climate and farming management folders imported into DSSAT, results for maize simulation at 2 fields in both winter-spring and summer-fall crops in 2003-2010 was shown in Table 3.1 and Table 7. Pearson r correlation between simulated yield values and real yield values in Tan-Phu fields and Mi-Hanh-Bac fields was 0.85 and 0.87, respectively. According to De Vaus (2002), $0.7 \leq r \leq 0.89$ shows a very strong relationship between variables, therefore it was unnecessary to cablirate DSSAT model to simulate maize yield in 2020, 2030, 2050. The real values of maize production from 2003 to 2010 in Long An Province have a stable and unchanged trend. Summer-fall crop yield tended to be lower than winter-spring crop yield because in summer and fall, increase of precipitation led to waterlogging, fall of tree and high pest density.

Table 3.1. Maize yield simulation in the period 2003- 2010 comparing to real yield values at Tan-Phu fields.

Year	Crop	Simulated yield values (ton/ha)	Real yield values (ton/ha)
2003 - 2004	Summer- Fall 2003	-	-
	Winter-spring 2004	4.292	**4.6**
2004 - 2005	Summer- Fall 2004	-	-
	Winter-spring 2005	4.263	**4.63**
2005 - 2006	Summer- Fall 2005	4.289	**4.13**
	Winter-spring 2006	5.302	**5.12**
2006 - 2007	Summer- Fall 2006	4.052	**2.96**
	Winter-spring 2007	5.892	**6.26**
2007 - 2008	Summer- Fall 2007	4.238	**4.14**
	Winter-spring 2008	5.790	**5.68**
2008 - 2009	Summer- Fall 2008	4.302	**4.02**
	Winter-spring 2009	4.685	**4.81**
2009 - 2010	Summer- Fall 2009	4.075	**4.70**
	Winter-spring 2010	5.048	**5.53**

Table 3.2. Maize yield simulation in the period 2003- 2010 comparing to real yield values at Mi-Hanh-Bac fields.

Year	Crop	Simulated yield values (ton/ha)	Real yield values (ton/ha)
2003 - 2004	Summer- Fall 2003	-	-
	Winter-spring 2004	4.981	**4.6**
2004 - 2005	Summer- Fall 2004	-	-
	Winter-spring 2005	5.314	**4.63**
2005 - 2006	Summer- Fall 2005	4.739	**4.13**
	Winter-spring 2006	4.835	**5.12**
2006 - 2007	Summer- Fall 2006	4.316	**2.96**
	Winter-spring 2007	5.963	**6.26**
2007 – 2008	Summer- Fall 2007	4.225	**4.14**
	Winter-spring 2008	5.918	**5.68**
2008 – 2009	Summer- Fall 2008	4.372	**4.02**
	Winter-spring 2009	5.395	**4.81**
2009 - 2010	Summer- Fall 2009	4.823	**4.70**
	Winter-spring 2010	5.925	**5.53**

3.2 Basic year selection and building climate folder for 2020, 3030, and 2050.

Before assessing impacts of climate change on maize production, it was essential to select a basic year whose climate information would become ground data for simulation maize yield in 2020, 2030 and 2050. Deviation of simulated and real yield values of this year was required to be the fewest than the other years.

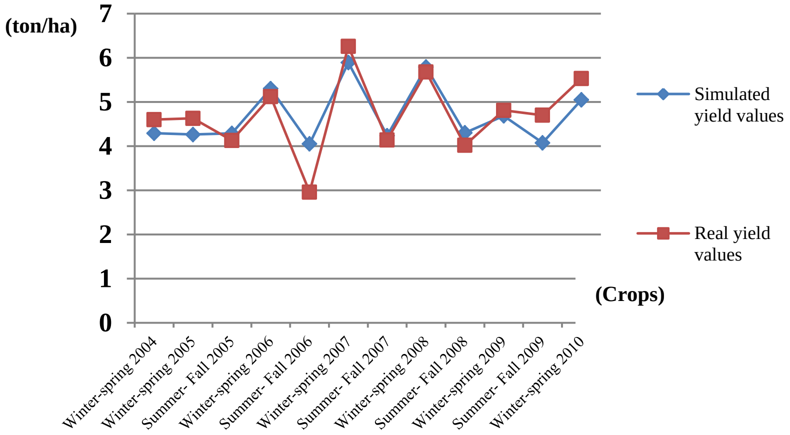

Figure 3.1. Maize yield simulation in the period 2003- 2010 at Tan-Phu fields.

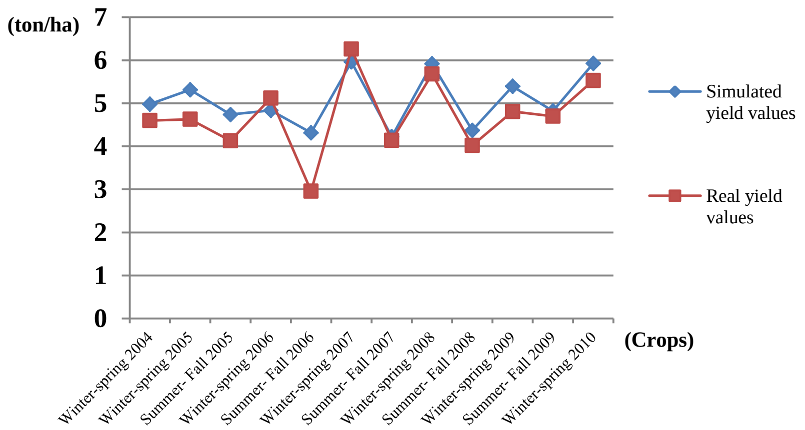

Figure 3.2. Maize yield simulation in the period 2003- 2010 at Mi-Hanh-Bac fields.

According to Figure 3.1 and Figure 3.2, deviations between simulated and real values of summer-fall crop 2007 (planting on April 2007 and harvest on August 2007) and winter-spring 2008 (planting on November 2007 and harvest on March 2008) in 2 fields are the lowest. Therefore, 2007 is defined as the basic year of this study. While climate folder of 2007-2008 (Table 3.3) was applied to build climate data for 2020, 2030 and 2050 under B2 scenario, soil profile and farming management folders for these years in 2 fields were unchanged compared to 2003-2010. Data for climate folders of 2020, 2030 and 2050 indicated in Table 3.4 were combination between Table 2.3 and Table 3.3, except unchanged sunshine hours. Real maize production values of summer-fall and winter-spring crop in 2007 are 4.14 ton/ha and 5.68 ton/ha, respectively.

Table 3.3 Climate data of basic year 2007 [7]

Month	$T_{average}$ (°C)	T_{max} (°C)	T_{min} (°C)	Sunshine hour (h)	Precipitation (mm)
1	26.1	32.6	17.3	200.4	45.1
2	25.9	33.5	18.1	256.5	0
3	27.8	36.0	22.5	247.1	40.7
4	29.2	36.6	24.2	214.4	23.3
5	28.4	35.2	24.0	217.7	90.9
6	28.2	35.2	23.5	194.0	209.2
7	27.2	34.5	23.0	156.0	178.6
8	27.2	33.5	22.5	146.0	226.3
9	28.1	34.0	23.0	178.0	230.3
10	27.3	33.0	22.7	184.0	278.4
11	26.5	32.2	19.0	185.0	87.3
12	26.8	32.7	19.6	203.0	36.2

Table 3.4 Climate data of 2020, 2030, 2050 simulated by SimCLIM model under B2 scenario

Month	2020		2030		2050	
	$T_{average}$ (°C)	Precipitation (mm)	$T_{average}$ (°C)	Precipitation (mm)	$T_{average}$ (°C)	Precipitation (mm)
1	26,46	43,7	26,59	43,2	27,12	40,9
2	26,26	0	26,39	0	26,92	0
3	28,18	40,2	28,31	40,0	28,87	39,1
4	29,58	23	29,71	22,88	30,22	22,4
5	28,78	89,7	28,91	89,3	29,47	87,4
6	28,56	215,1	28,69	217,4	29,22	226,8
7	27,56	183,6	27,69	185,6	28,22	193,6
8	27,56	232,6	27,69	235,1	28,22	245,3
9	28,44	233,5	28,55	234,7	29,04	240
10	27,64	282,3	27,75	283,7	28,24	290,1
11	26,84	88,5	26,95	88,9	27,44	91
12	27,16	35,1	27,29	34,6	27,74	32,8

3.3 Maize yield simulation in 2020, 2030, 2050 under B2 scenario

According to simulated result shown in Table 3.5 and comparing to real values of basic year 2007, maize production in 2020, 2030 and 2050 in Tan-Phu fields and in Mi-Hanh-Bac fields were predicted to steadily reduce and decreased productivity in summer-fall was more significant than in winter-spring. Decline percentage in 2005 in 2 types of crop was as twice as in 2030, and nearly as thrice as in 2020. There were differences of maize yield reduction between two fields, which had different soil characteristics and two annual crops.

Inferring from their lower crops yield, summer-autumn crops would be affected more significant than winter-spring ones. It has been shown that the growth of maize is quite sensitive to many factors such as temperature, water, soil properties, sunshine hours, humidity of soil and ambient environment, nutritions; and development of maize is shown via its morphology such as root system, leaves, stem, inflorescence, maize ear, maize kernel. The growth stages of maize consists of Emergence Stage, Leaf Stage, Tasseling Stage and Maturity Stage, whose requirements are different from each others. Optimized temperature for Emergence Stage, Leaf Stage, Tasseling Stage and Maturity Stage are 25 – 30^{o}C, 20 – 30^{o}C, 22 – 25^{o}C and 25 – 30^{o}C, respectively (Ministry of Agriculture and Rural Development, 2011). Temperature increase in 2020, 2030 ang 2050 has exceeded appropriate temperature of maize and that precipitation tended to change in the way of raise in rainy months and decline in dry months would lead to water shortage in winter-spring crop. When summer-fall crop was predicted to be affected more serious than winter-spring crop because that simulated temperature and precipitation increased from June to August enforced potential of waterlogging and pest, impacts of climate change on productivity of winter-fall crop was caused by decrease of precipitation from December to February.

Despite the similarity in farming management and climate factors, maize productivity of Tan-Phu fields was simulated gradually lower than in Mi-Hanh-Bac fields in both winter-spring and summer-fall crops. Because of difference in soil texture in the depth direction, water-trap ability of Tan-Phu fields was higher than Mi-Hanh-Bac fields. In summer-fall crop, with high precipitation and humidity, that drainage became more difficult than usual led to waterlogging risk, which was a foundation of maize production decrease.

In sum up, if climate change happens in Long An Province as the described way in medium emission scenario B2, maize crop yield of this place will be estimated to decrease from 5.4 to 8.9% depended on time of crop and soil characteristics. Result from this study strongly agreed with researches of Alexandrov and G.Hoogenboom (2000), Peter G. Jones, Philip K. Thornton (2003), Wei Xiong (2007), Fulu Tao, Zhao Zhang (2011), V.A. and M.S. Babel and E. Turyatunga (2014) on potential impacts assessment of global climate change on maize production at many place such as Africa, Latin America, Bulgari, Uganda, China that until 2055, decline percentage of maize was around 5 – 10% . The differences in studies were caused by the un-corresponding in farming factors such as soil characteristics, varieties, climate, irrigation, fertilizers.

Table 3.5 Simulated maize production in 2020, 2030 and 2050 in Tan-Phu fields and in Mi-Hanh-Bac fields

Place	**Time**	**Summer-fall crop**		**Winter-spring crop**	
		Deviation (%)	**Yield (ton/ha)**	**Deviation (%)**	**Yield (ton/ha)**
Duc Hoa District	2007	-	4,14	-	5,68
Tan-Phu fields	2020	-2,7	4,028	-1,9	5,572
	2030	-4,1	3,970	-2,9	5,515
	2050	-8,9	3,772	-6,5	5,311
Mi-Hanh-Bac fields	2020	-2,3	4,045	-1,7	5,583
	2030	-3,4	3,999	-2,6	5,532
	2050	-7,1	3,846	-5,4	5,373

4. Conclusion

In brief, inferring from that correlation coefficient between simulated and real yield values on two fields were both estimated r > 0.8, DSSAT was an appropriate crop model to be used in simulating maize crop yield in Long An Province. Simulation of maize yield in 2020, 2030 and 2050 based on climate data of basic year 2007 under B2 scenario showed that climate change would impact strongly on maize crop yield, which would rapidly decline from 2030 to 2050. It is necessary to suggest solutions in order to maintain and improve maize yield in climate change condition in the future, such as changing time of crops, keeping balance between watering and drainage basing on soil characteristics of fields, selecting appropriate varieties, applying rotational crop technique and sustainable farming practices, upgrading irrigation systems, planning for maize production areas, creating cross-breeding varieties, subsidizing for maize production programs in the way of climate change adaptation.

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