Analyzing Drought Adaptation Practices of Sugarcane Growers in Thanh Cong, Thach Thanh District, Thanh Hoa, Vietnam

Giang T.H. Nguyen[1*] & Thao T. Quac[1]

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Summary

To understand drought adaptation practices, we compared two groups of sugarcane growers in Thanh Cong commune, Thach Thanh district, Thanh Hoa province in Vietnam. Results of this study point out that farmers, depending on their preferred type of market channels, reacted differently to the impacts of drought. Contractual farmers paid more attention to the impact on sugarcane tillering and sugar content, while market-oriented farmers paid more attention to sugarcane colour, as this trait directly determined the market price on the cane that is either consumed as cane or as juice. In responding to water stress in the growing season, the open market-oriented farmers showed more flexibility in changing their cropping calendar. They were also more willing to invest in enhancing the water management system and in providing organic fertilizer than the contractual farmers. On the other hand, the low cane price and the harvesting date set in contract by the processing company lessened the contractual farmers' flexibility in investing in water management technologies; thus, hampering their adaptation to drought.

Résumé

Analyse des pratiques d'adaptation à la sécheresse des cultivateurs de canne à sucre de Thanh Cong, District de Thach Thanh, Thanh Hoa, Vietnam

Afin de comprendre les pratiques d'adaptation à la sécheresse, nous avons comparé deux groupes de cultivateurs de canne à sucre dans la commune de Thanh Cong de la province de Thanh Hoa au Vietnam. Les résultats indiquent que la réaction à la sécheresse de ces producteurs variait en fonction du type de marché qu'ils visaient et dont ils dépendaient. Les producteurs ayant un contrat avec une usine portaient plus d'attention à l'impact de la sècheresse sur le nombre de pousses de canne à sucre et à sa teneur en sucre. Par contre, les producteurs orientés vers le marché libre portaient plus d'attention à la couleur de la canne à sucre. Ce trait détermine son prix de vente pour la consommation directe ou comme jus après extraction. En réponse au stress à la sécheresse pendant la période de production, les agriculteurs orientés vers le marché libre montraient plus de flexibilité à changer leur calendrier cultural. Ces agriculteurs étaient plus disposés à investir dans l'amélioration du système d'irrigation et à utiliser des engrais organiques que les fermiers contractuels. Pour ces derniers, le bas prix offert et la date de récolte fixée dans le contrat réduisaient la flexibilité à investir dans des technologies d'irrigation, ce qui a des effets sur leurs capacités à s'adapter à la sécheresse.

[1] Vietnam National University of Agriculture, Faculty of Environment, Vietnam.
*Corresponding author: E Mail: nthgiang.qlmt@vnua.edu.vn

Introduction

Climate change and several other causes, such as market sector, policy changes, cultural and personal perception drive adaptation practices of stakeholders. Thus, understanding the process of the stakeholders' autonomous adaptive responses is as important as studying the change of climate, its impacts and adaption solutions (2, 5).

Among other extreme climatic events, recently, drought has affected largely the agricultural areas in Viet Nam, especially, those in the Central and Mekong Delta. At the provincial level, Thanh Hoa Department of Agriculture and Rural Development (DARD 2010) reported that drought affected 13,500 ha of sugarcane and destroyed 1,290 ha (12). At the national level, the Ministry of Agriculture and Rural Development estimated the loss caused by drought at about 15 thousand million VND from the late of 2015 to the mid of 2016.

While farmers of most crops experienced difficulties and loss of productivity, many sugarcane growers, however, succeeded during this period. Sugarcane is a drought-tolerant plant, but it is still negatively affected by water shortage during its germination, tillering and ratooning stages.

In Thanh Cong commune, where sugarcane is the main agricultural crop of many households since about 20 years ago (10), drought adaptation practices among farmers are strikingly different. The complexity of farmer's perception on the impacts of drought and other climate-related changes has been investigated by others. The common conclusion of studies, for example, in rural Sahel (8), Semi-arid and Sub-humid Regions of Kenya (7), South Africa (13) and in Punjab Pakistan (1) showed that farmers considered, in particular, market and economic profitability for their autonomous adaptation to climate change. Fujisawa and Kobayashi (4, 5); likewise, found that the type of market mattered among farmers. In order to understand the causes of success and/or failure of growing sugarcane in Thanh Hoa, we studied the drought adaptation and farming practices of two groups of sugarcane growers: farmers who sold their product by annual contract to sugar companies (contractual type) and farmers who sold to markets or to retailers (market type). After describing the methods, we discuss the results and conclusions of our study.

Study area and methods

The study area and sugarcane production

The study was conducted in Thanh Cong commune, Thach Thanh district, Thanh Hoa province. Similar to other areas in Thanh Hoa, climate of Thanh Cong has two seasons, summer and winter. In the early summer, western foehn wind usually occurs and increases water stress in Thanh Cong Commune and in most of the areas in Than Hoa. The hydrothermal coefficient is relatively low from December to March and coincides with the dry season (Figure 1). Thanh Hoa province covers 11.3% of Vietnam's total national sugarcane area and contributes 10.4% to the national sugarcane production (11). There are three types of sugarcane in the province. The first type is named "purple sugarcane." It is also known as "the cane to King" or "Kim Tan," and is mostly eaten directly as cane. The 2nd type is the white sugarcane which is mostly extracted as raw juice for drinking. The last type is the cane for industrial sugar extraction introduced by the Viet-Dai Sugarcane Company since 1996.

DARD reports that for the three main types of sugarcane, the average productivity ranges from 47 ton ha^{-1} to 55 ton ha^{-1} in Thanh Cong. Thach Cong Commune has a total sugarcane production area of 242 hectares (DARD 2015) which is much larger than that for paddy rice (168 hectares) and permanent fruit trees (156 hectares) (10).

Primary data collection and analysis

Between February 2016 and April 2016 we interviewed 40 households. We started with collecting the general information on the household, and then proceeded with questions aimed at helping sugarcane growers to recall the years in which the productivity, the crop season or the profits of sugarcane were peculiar. We did not mention drought or other climate risks in order to avoid bias about the factors which affected sugarcane production. We also asked about their cultivation practices. In the last section of the questionnaire, we asked their experiences with drought and its impacts.

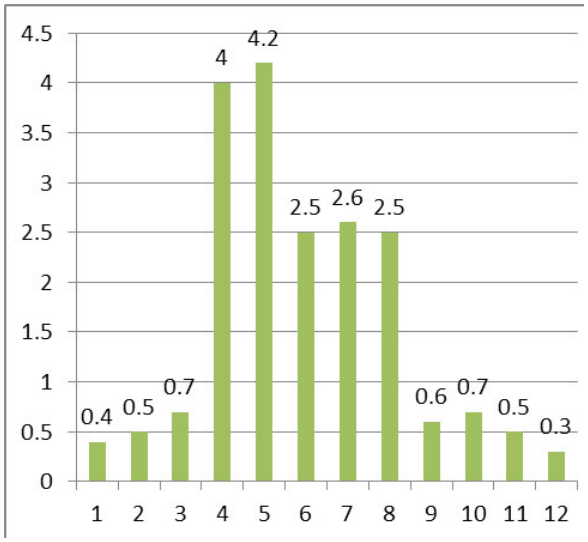

Figure 1: Hydrothermal coefficient in 2015 (6).

To understand sugarcane growers' perception on drought and its impacts, we analyzed their personal perception about the good and the bad years in sugarcane production history. Then, we compared this information with that on the years when they observed heavy impacts of drought on sugarcane production to find overlap of the good, the bad and the drought years when drought occurred. To understand better their circumstances during that time, we collected additional information. Finally, we asked the farmers to evaluate, based on their own perception, the impacts of drought by using a 5-point scale.

Results and Discussion

Characteristics of interviewed sugarcane growers
On the average, the income from sugarcane production contributed more than 60% to the total household income from the 40 interviewed farms. The average age of farmer was about the same for both groups: 47 years (Table 1). The households had been growing sugarcane for at least 6 years; some even had more than 20 years of experience. The farmers who planted sugarcane for sugar extraction had longer experience (over 18 years) than those who planted white or purple sugarcane (over 7 years).

The "purple sugarcane" and "white sugarcane" types that were sold in the market or bought by retailers were mostly used for juice extraction or raw consumption.

The price of these types depends on the quality (colour and size) of each stalk and the time of selling. In 2015, farmers sold these types of sugarcane for an average price of 4,000 to 6,000 VND per stalk. Normally, the cash revenue for one hectare of white or purple sugarcane varied from 200 to 250 billion VND ha^{-1} yr^{-1}, and some households even got much higher income. However, these types of sugarcane require higher investment, good soil quality and more labour days in order to meet the required quality. Thus, in Thanh Cong, only a few households can afford to cultivate "white" or "purple" sugarcane.

Farmers sold sugarcane by tons to the sugar company they were in contract with. In recent years, the sugar company uses the sugar rate as an indicator for pricing the sugarcane.

The average price in 2015 was 920,000 VND per ton of sugarcane, and farmer received an estimated 45 billion to 55 billion VND ha^{-1} yr^{-1} . The income from this type of cane is much lower than that coming from the white and purple sugarcane types; but this cane can grow on sloping lands with poor soil quality.

Cropping calendar

All types of sugarcane have approximately one year to complete the growth cycle. However, they have slightly different cropping calendars (Figure 2).

Table 1

Characteristics of interviewed sugarcane growers in Thanh Cong Commune.

Characteristics	Contractual	Non-contractual	
Type of planted sugarcane	Cane for sugar extraction by Sugar Company	Purple sugarcane for raw consumption	White sugarcane for juice extractiom
Sale channel	Annual contract with company; Price set per ton of sugarcane	Market or retailors Price was set per stalk of sugarcane	
Indicators to define the price	The rate of sugar in the canes	Quality of the stalks: colour, size. Time of demand	
Number of interviewed farmers	16	12	12
Average ages of farmers	48	47	47
Average number of years growing sugarcane	18,6	7,8	7,3

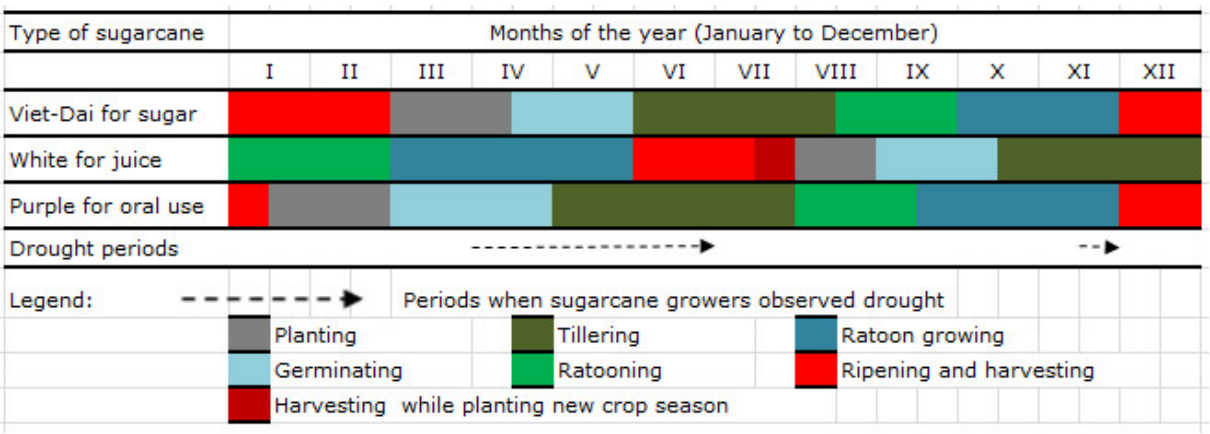

Figure 2: Crop calendar of sugarcane in Thanh Cong, Thach Thanh, Thanh Hoa.

Compared to the other types, the purple sugarcane is planted earliest, from January to the mid of February in order to be harvested around the time of next Lunar New Year, when it could be sold at the best price. The planting of sugarcane being supplied for sugar production always starts from mid-February to March and then collected by the sugar company from December to mid-February. The cropping calendar of the white sugarcane used for juice extraction is very different: planting is from mid-July to mid-August in order to be harvested next year in summer when the demand for sugarcane juice peaks. The planting time of the latter type coincides with the time of drought and when the foehn occurs seriously in the north central of Vietnam. The cropping calendar of this type is changeable depending on the market forecast.

Grower's perception on drought and its impact on sugarcane production

Most farmers observed that drought affected their sugarcane production in 2013 and 2014, but more in 2015. For each type of sugarcane, drought affected different phases of the sugarcane growth cycle. The contractual farmers observed that drought affected sugarcane during germination, ratooning and tillering. They said that during the drought years, sugarcane plants germinated and tillered slowly and weakly, shoots turned yellow and some cane cuttings died.

They also observed borers and congested tops. The farmers who cultivated purple sugarcane observed similar symptoms.

Table 2

Successful, difficult and drought years observed by three types of sugarcane growers (%).

Year of event	Types of farmer		
		Market or retailer	
	Contractual (n= 16)	Purple (n=12)	White (n=12)
Successful			
2012	19	8,3	0
2013	40	16,7	0
2014	44	66,7	33,3
2015	44	16,7	66,7
Difficult			
1996	13	0	0
2010	19	17	17
2011	19	0	33
2012	19	25	25
2013	13	33	25
2014	6	0	0
2015	25	8	0
Drought			
2012	6	25	0
2013	31	17	17
2014	19	17	50
2015	81	50	83

Drought additionally affected the ripening time; farmers saw a change in colour and the size of ratoons.

For those who planted white sugarcane, they observed that drought mostly affected the ratoon growth and ripening. With high temperature, ratoons cracked, colour became lighter; overall, plants germinated and grew slowly (table 2).

Surprisingly, only few farmers thought drought years were bad years of sugarcane production; these were, in particular, farmers who grew white and purple sugarcane. One third of the white sugarcane growers claimed that 2015 was their most successful year, while one third of the purple sugarcane growers mentioned that 2014 was their most successful year. On the other hand, 44% of the contractual farmers claimed that 2013, 2014 and 2015 were their most successful years. In these years, most of the sugarcane growers produced high yields with high selling price. The farmers who planted purple and white sugarcane also mentioned that the appropriate match of selling time, the high demand for market and the presence of a good irrigation system all contributed to their success.

Meanwhile, the percentage of farmers who claimed that the drought years were bad years for them comprised only a smaller proportion of the total number of respondents. One quarter of growers who supplied canes to the sugar company claimed the 2015 was a bad year for them. Only 8 % of the purple sugarcane growers had the same opinion and none of white sugarcane growers thought this was a bad year.

One third and one quarter of the purple and white sugarcane growers, respectively, mentioned 2013 as a bad year for them.

Most of these farmers mentioned that the lack of rain, lack of good irrigation source, low productivity, low quality, low price and inappropriate selling time all contributed to their failure during the dry years.

Table 3

Changes (%) in the sugarcane management practices for the three types of sugarcane growers in 2015.

Management practices	Type of farmers		
	Contractual	Market or retailer	
		Purple	White
Increase of growing area	13	0	0
Decrease of growing area	19	0	0
Increase of productivity	44	67	100
Decrease of productivity	31	8	0
Early planting	0	0	50
Late planting	13	25	8
Early harvest	6	0	67
Late harvest	31	0	8

To understand the responses of different sugarcane growers, we analyzed the changes in 2015, the year for which most of the farmers agreed that it was the worst drought year for them. We asked them to recall the changes in sugarcane production in terms of productivity, production area, and planting and harvesting time (Table 3).

In 2015, 19% of the contractual farmers reduced their sugarcane production area. The main reasons were water shortage, disease, low financial capital and low quality of sugarcane. One household stopped growing sugarcane due to water shortage; others reduced their production area by one third to a half due to poor irrigation and low financial capital. None of the farmers of the market type, however, reduced their production area in this year. In terms of productivity, in 2015, on the average, more than half of the farmers confirmed that their sugarcane production was higher in 2015 than that in other years: 44% of the contractual farmers, 67% of the market type farmers who sold purple sugarcane and 100% of those who sold white sugarcane.

Contractual farmers reported that the reasons for their increased productivity were good water source and strong sugarcane variety, while market farmers said that the presence of good irrigation source contributed the most to their increased sugarcane productivity. However, 31% of the contractual farmers reported a decrease in their productivity due to diseases, weak tillering and low drought tolerance of the variety. Only 8% of the market type farmers who cultivated white sugarcane observed a decrease in productivity, but none of them mentioned that water shortage was the reason behind it.

Regarding the change in cropping calendar, in particular, the time for planting and harvesting, market farmers who planted white sugarcane had more opportunities than those who planted purple sugarcane. They also had more opportunities than the contractual farmers. In 2015, 50% of the white sugarcane growers planted earlier than usual because of the early harvest and the early rain in the preceding year. Furthermore, in 2015, two thirds of the farmers harvested earlier than the usual date due to the early growing season and the prevailing high market price at the start of the harvest season. Both the contractual and market type farmers growing purple sugarcane did not plant early in 2015.

Only 13% of the contractual farmers planted late; 31% of them harvested late. The delay in planting and harvesting, however, was not caused by drought and water shortage, but by changes in the policy of the Sugar Company which affected the farmers' production plan.

All sugarcane growers gave a similar ranking on the impacts of drought on cropping calendar, cultivar, sugar rate, growth, disease, investment cost, productivity and profit (Table 4).

Both contractual farmers and market farmers confirmed that drought had little effects on the cropping calendar. They said that the most important factor for changing the cropping calendar was the purchasing demand of sugarcane. The contractual farmers depended more on the collection schedule of the sugar company, while the market farmers depended more on the demand from the free market. They said, they could have changed the cropping calendar, but their main objective was to achieve the best time of selling, and not to avoid the impact and timing of drought. Nevertheless, all farmers agreed that water shortage resulted in weak growing and tillering of sugarcane. Drought also slightly affected the choice of sugarcane cultivar because currently, only a few farmers were willing to change to the drought-tolerant cultivar for fear of losing income. This was especially true for purple sugarcane growers who used only the traditional cultivar, "Kim Tan." The farmers evaluated that drought had low impact on the sugar rate in the canes, although most of them agreed that this rate increased as drought progressed. Both types of sugarcane growers claimed that drought affected more highly on the growth, productivity, disease and investment cost of sugarcane; thus, the profit of sugarcane production. However, the market farmers paid more attention to the growth of the ratoons than the contractual type farmers (Table 4).

The different perceptions of farmers clearly present their opinions about the impacts of drought on sugarcane tillering and sugarcane colour. The average scores of contractual farmers were 4.6 and 1.2 for the impacts on tillering and colour of sugarcane, respectively. For market type farmers, these average were 0.8 and 3.7 for the impacts on tillering and colour of sugarcane, respectively. These results reflect the market preference of different types of sugarcane. The profit of contractual farmers highly depends on the rate of tillering because they sell their sugarcane in tons. For market type farmers, their profit depends on the quality of each cane that is sold. Thus, when the colour of the stalk becomes irregular or deviates from that preferred by the consumer, this may induce the retailers or buyers to lower the buying price.

Growers' actions against drought

To reduce the impacts of drought, sugarcane experts recommend that farmers adjust their cropping calendar, apply water-saving irrigation method, use organic fertilizers and intercrop legumes. During the drought period (2012-2015) the two types of farmers reacted differently as regards their cropping calendar, irrigation, intercropping and fertilizer application practices.

Table 4

Contractual and market-oriented sugarcane growers' ranking of the drought impacts on several crop characteristics.

Impacts	Contractual	Market or retailer	
		Purple	White
Crop season	1,6	1	1,4
Sugarcane cultivar	0,3	0	0,4
Sugar rate	0,9	0,9	1,5
Sugarcane growth	4,8	4,8	4,8
Sugarcane tillering	4,6	0,2	1,5
Sugarcane Disease	3,9	3,2	3,8
Sugarcane colour	1,2	3,9	3,4
Sugarcane yield	4,6	4,3	4,9
Investment cost	4,1	4,3	4,9
Profit	4,1	4,5	4,8

Note: Ranking was done by using a 5-point scale: 5= highest, 1= lowest and 0= no impacts.

Adjusting cropping calendar

Few contractual farmers adjusted their cropping calendar. Some households decided to start cropping season despite lack of water irrigation and accepted a low yield in order to meet the collection schedule of the sugar company. The market type farmers adjusted their cropping season more often in drought years, particularly those who planting white sugarcane. They were more independent in the deciding when to start their cropping calendar. They were able to delay the cropping season and wait for favorable weather, or start cropping earlier based on their market forecast so they could achieve a better selling price. All farmers in Thanh Cong, however, indicated that drought and drought impacts were not their main reason in adjusting their sugarcane cropping calendar . The market factor, in this study, played a more important role in farmers' decision making because it connected directly to their households' economic benefit (Table 5).

Water-saving irrigation methods

Besides rainwater, farmers in Thanh Cong may avail of two water sources (Table 6): wells and local water reservoirs (lake, river and canal). None of farmers used boreholes to irrigate their sugarcane field. Most of the contractual farmers totally relied on the natural water (rain and reservoirs), while 100% of the purple sugarcane growers and 58% of the white sugarcane growers invested in their own wells. In addition, most white sugarcane growers decided to crop the cane in a field nearby the local water sources. Having their own water sources enabled these farmers to actively control irrigation; thus contributing to their success during drought years.

The contractual farmers practiced run-off irrigation method only for all types of water sources (Table 7). In contrast, all market farmers practiced additional water-saving methods, like furrow irrigation. However, other water-saving irrigation methods, such as drip irrigation, sprinkler irrigation and border irrigation, were not practiced by farmers in Thanh Cong.

Intercropping

In Thanh Cong commune, none of the contractual farmers practiced intercropping as a win-win solution to control drought, improve soil quality and increase household income. But some market-oriented farmers intercropped legume, maize and vegetables in their sugarcane fields (Table 8). One quarter of the purple sugarcane growers and one-third of the white sugarcane growers intercropped with legume. Thirty percent of the purple sugarcane growers intercropped with maize and vegetable, while only 8% of the white sugarcane growers intercropped with maize.

Fertilizer application

The contractual farmers preferred chemical fertilizer to organic fertilizer (Table 9). They applied only the micro-organic fertilizer that was provided by the sugar company in the planting time. In the later phases of sugarcane growth, they applied chemical fertilizer thrice. However, all purple sugarcane growers applied manure before planting; 75% of them did the same during tillering and ratooning. A few white sugarcane growers (17%) applied manure at planting time only. Although only a small proportion of sugarcane growers applies organic fertilizer, this practice effectively mitigates the impact of drought, and simultaneously, improves soil quality.

Growers' actions against pests

Effective prevention of pests can contribute to reducing the negative impact of drought. At the time of drought, all farmers in Thanh Cong found borers in their fields, while half of the contractual farmers and a small portion of the market farmers observed aphids (Table 10).

Although facing similar pest problem, the farmers prevented pests quite differently (Table 11). Close to 90 % of the contractual farmers sprayed insecticide as soon as they discovered the borers, while close to 60% of the white cane growers and only 30% of the purple cane growers used this method. On the other hand, 13 % of the contractual farmers peeled the old leaves and weeded grass to prevent borers from growing. Although time consuming, all market farmers practiced this solution.

Table 5

The changes in cropping calendar practiced by the three types of sugercane growers from 2012 to 2015 (%).

Year observing drought	Early planting			Late planting		
	Contractual	Market or retailer		Contractual	Market or retailer	
		Purple	White		Purple	White
2012	6	8	8	6	0	0
2013	6	0	17	0	8	8
2014	6	8	25	6	17	8
2015	0	0	50	13	25	8

Table 6

The irrigation water sources available to the three types of sugarcane farmers (%).

Source of irrigation water	Contractual	Market or retailer	
		Purple	White
Rainwater	100	100	100
Open wells	6	100	58
Local water sources (lake, river, canal)	100	42	92
Others	0	0	0

Table 7

The irrigation methods applied by the three types of farmers (%).

Irrigation methods	Contrac-tual	Market or retailer	
		Purple	White
Runoff	100	0	0
Furrow	0	100	100

Table 8

Intercropping by the three types of sugarcane growers in Thanh Cong (%).

Types of crop	Contrac-tual	Market or retailer	
		Purple	White
Legume	0	25	33
Maize	0	8	8
Vegetable	0	25	0

Table 9

The fertilizer application by the three types of sugarcane growers (%).

Time of application	Type of fertilizer	Contrac-tual	Market or retailer	
			Purple	White
Planting	N-P-K	88	100	100
	Manure	25	100	17
	Micro-organic	75	42	0
	P	6	0	67
Tillering and ratooning	N-P-K	81	100	100
	Manure	0	75	0
	P	0	0	42
Ratoon growing	N-P-K	25	25	0
	N	75	83	100
	K	75	83	100

Table 10

The type of pests observed by the three types of growers in sugarcane fields during drought (%).

Type of pests	Contractual	Market or retailer	
		Purple	White
Borer	100	100	100
Aphid	50	8	17

Table 11

Borer-prevention practices of three types of sugarcane farmers (%).

Prevention methods	Contractual	Market or retailer	
		Purple	White
Peeling the old leaves and weeding grass	13	100	100
Spraying	88	33	58
Dipping cane cuttings in insecticide before planting.	0	58	33

They peeled the old leaves more frequently, once or twice a month, than the contractual farmers, once or twice a year.

Thirty percent of the white cane growers and 58% of the purple cane growers dipped the cane cuttings in an insecticide solution before planting; insecticide solution dipping kills pathogens and reduces the growth of borers and other pests. Although the contractual farmers knew about the effectiveness of the methods practiced by the white and purple sugarcane growers, they were not willing to practice these for fear of losing profit. Peeling the old leaves, cleaning the fields more regularly and dipping cane cuttings in insecticide solution before planting are time- and money-consuming methods. Their revenue which was around 50 to 55 billion VND yr^{-1} ha^{-1} only, was much lower than that of white and purple sugarcane, a factor that may have hindered them from practicing these environmental friendly methods. Market- oriented farmers, seeking more profits, invested more to increase the sugarcane quality to meet the consumers' and retailers' demand for quality, and premium price based on colour, size, softness and the length of stalks. The high revenue per hectare may have strongly affected the decision making of these farmers in practicing pest prevention methods, as well as other drought- mitigation activities.

Discussion

Surprisingly, some farmers said that drought is an opportunity for them. For some, drought increased their income as a result of higher sugar rate in the cane, and others experienced an increased demand and thus a high price. The latter is probably due to an increased direct consumption induced by the related hot weather. All sugarcane growers were well aware of the impacts of drought, and most of them agreed on the negative consequences of water stress and hot weather during drought periods in Thanh Cong.

They observed weak and stunted plants; experienced loss of productivity; encountered more pests, such as borers and aphids, and needed to invest more.

However, market type farmers were less constrained with drought than the contract type farmers. The former were able to sell their product at a good price provided they meet the quality demands of their consumers. They decided more independently in terms of their planting and harvesting schedules.

They actively controlled the irrigation system by digging their own wells and applying the furrow method; they planted inter-crops to improve soil quality, regularly peeled the old leaves and weeded to reduce pests. These are all autonomous responses of the growers, forecasting by themselves the market demand, deciding on the varieties in their fields and investing more willingly for higher yields and extra income.

Having the needed capital, they were more motivated to implement drought adaptation because they could earn around 200 billion VND ha^{-1} which is 4 to 5 times higher than that of the contractual farmers. Autonomous responses usually happen when farmers perceive the benefits or observe the good experiences from others (3; 9). Enhancing farmers' capacity for autonomous adaptation enables them to reduce the negative consequences of climate change. Our findings agree with those of Fujisawa and Kobayashi, (5) who investigated the climate change adaptation practices of apple growers in Nagano, Japan. Japanese free market type apple farmers focused more on meeting the different market requirements of their consumers for their goods, such as color and appearance. Being motivated by the premium price they get from meeting these requirements, they then practice and invest more on drought adaptation methods so that they could meet the consumers' demand.

Similar conclusions of earlier studies on other products show that even if agriculture is highly vulnerable to the impacts of climatic change, farmers generally consider market and economic profits as a major factor for their adaptation (1, 4, 5, 8).

On the other hand, contract farmers in this study who were tied to the stipulations of the contracting company paid less attention to the color of the cane, but more on the rate of tillering as this determined the volume of their production; more tillers meant more tons and more profit for them. In contrast to the market type sugarcane farmers who adjusted their cropping calendar to meet consumers' demand and invested more on drought adaptation methods, contract farmers adopted the planning calendar of the sugar company. The farmers who sold their products to Viet-Dai Company adapted less to drought than the market type farmers. This was due to their dependency on the purchase policies fixed in the annual contract. Due to the time schedule of collection, these growers changed their cropping calendar only if this was required by the Sugar Company (Table 3). Through incentives system the company also affected the varieties of the cane and the type of fertilizers that farmers used. Thus, compared with the market-oriented farmers' behaviour, contractual farmers tended to be more passive in their reaction to drought because they depended on the top-down policy of the collectors. Fujisawa *et al.* (3) suggested that in order to be successful, adaptation policies should be based on farmers' needs and deployed through sale channels. Although the established sale channel between farmers and Viet-Dai Company in Than Cong has positive merits, the solutions proposed by the company for coping with drought were rare (providing micro-organic fertilizers and introducing new drought-tolerant variety) and not effective. For instance, the new variety of cane introduced by the company was not widely accepted by farmers due to their fear of losing productivity, which explains the low impact of drought on the sugarcane cultivar used by these farmers (Table 4). In addition to this, the low profit gained by contractual cane farmers constrained them from applying adaptation solutions, as any additional investment might lead to further losses on their part. This could explain why these farmers had limited actions to reverse the impact of drought.

Whether market or contractual, both types of sugarcane farmers in Thanh Cong face the risks of fluctuating market demands. Since not all of them are investing in water-saving irrigation system and other improved farming techniques, they may, therefore, incur unexpected low yields and losses due to unseen extreme climatic events. To minimize these impacts and maximize their resilience, there is a need to increase their awareness on knowledge and skills on climate change adaptation methods. Abid *et al* (1), in their study of the Punjab farmers, suggested that greater investment in farmer education might be a solution, while Fujisawa et al (3) suggested to strengthen the link between farmers and their contractual partners.

Conclusion

Many factors contribute to farmers' reactions to the impact of climate change. Among others, the type of market proves to be a more significant one. In this study, we found all three types of sugarcane growers confirming the negative impacts of extreme drought, hot weather and water shortage; but reacting quite differently. The white and purple cane growers perceived hot weather as an opportunity because this increased the market price of and demand for cane for juice and direct consumption. With high market price and benefit per hectare of the white and purple sugarcane that are several times higher, market type farmers are able to invest more time and money in implementing adaptation methods than the farmers who are bound to a company with a contract to deliver sugarcane for industrial processing. Consequently, market-oriented farmers invest more in irrigation, spend more time to prevent pests and diseases and apply more organic manure than the contract type farmers. All these efforts reduce the vulnerability of the market-oriented farmers to drought, at the same time, assure them of increased profits. These farmers are also able to autonomously adjust their cropping calendar, not primarily to reduce the impact of drought on their product, but to adjust to the timing of harvest when the selling price of their product is at highest.

On the other hand, contractual farmers are constrained to apply drought mitigation methods because of the low profit and benefit that they get from the contracting company. This hindered them from investing in drought-adaptation methods; thus making them more vulnerable to drought. Even when they already foresaw the incoming negative impacts of drought, these farmers postponed solutions; they stuck to the planting and harvesting of sugarcane within the period set by the company. Understanding the complexity of farmers' coping behavior with regard to drought is important. To achieve a more effective drought adaptation strategy, policy makers and experts need to consider the factors mentioned in this study that have encouraged farmers to reach their economic goal, at the same time, strengthened their climate change adaptation resiliency.

Without a doubt, knowing first and foremost the type of market channel to which the farmers are engaging with would lend to a better understanding on the dynamics of climate change adaptation. In addition, when proposing adaptive solutions to extreme climatic events, this study recommends that planners consider other stakeholders and institutions/partners that are directly linked to the farmer-producers; e.g., contracting company, market outlet trader/retailer channels, agricultural extension service providers and local agencies, among others. Overall, individual farmers' capacity in coping with the negative impacts of climate change needs to be strengthened by increasing their knowledge and skills on adaptation technologies that make up for a stronger climate change resiliency in the future.

The policy makers and experts should consider these findings when proposing adaptive solution to extreme climatic events.

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Giang T.H Nguyen, Vietnamese, MSc, Lecturer, Vietnam National University of Agriculture, Faculty of Environment, Vietnam.

Thao T. Quac, Vietnamese, B.S, graduate, Vietnam National University of Agriculture, Faculty of Environment, Vietnam.