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Response to Climate Change from the New King Orange Seedless Variety by Farming Techniques Suitable to Drought and Salinity in Natural Conditions in Tra Vinh Province of Vietnam

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ABSTRACT

In order to select the drought resistance for the new king orange seedless, the prominent local king orange was collected from the area under the shortage of irrigation water in dry season at the Mekong delta region in southern Vietnam. The experiment was carried out under the actual field conditions at Cau ke dist, Tra Vinh province in two lots. A lot was the drought treatment condition and the other, four meters apart, was the checked lot, followed in the randomized block design with the 12 replications. One plant for each genotype was exposed to drought stress by withholding irrigation for 30 days in the dry season, March 2020. Based on the response ability of king orange seedless plants in drought, salty stress under field conditions compared with the control (not stress), there was no reduction in total chlorophyll content 10.83 mg/dm^2, chlorophyll fluorescence of phytosystem II (0.63), soluble sugars (154 mg/g), proline in leaves (5.6 mg/dg), plant height (154.08 cm), stem diameter (5.6 mm), wilting index (71.6%) of the leaf set, the king orange seedless had a better tolerance to natural drought in the field for 30 days when the plant reached growth 48 months after planting than the local king orange variety. The king orange seedless variety with good quality by planting model with appropriate farming techniques (new varieties, appropriate water distribution, reduced chemical fertilizers and increased organic fertilizers) and effective net profit of VND 250,074 million was accepted by the people.

Key words : Drought, farming techniques, fertilizer, king orange, salty stress

INTRODUCTION

According to the statistics of the Department of Statistics in 2019, the Mekong Delta had 362.4 thousand hectares of land for growing fruit trees (accounting for 57% of the total area of fruit trees in the south and accounting for 35% of the whole country). The average area has rapidly increased by nearly 4.5% each year from 2013 to now. The provinces currently have large fruit-growing areas such as : Tien Giang (78,6750 ha), Vinh Long (47,146 ha), Hau Giang (36,619 ha), Ben Tre (27,985 ha), Soc Trang (28,167 ha) and Tra Vinh (18.052 ha) with specialty fruits, typical of the Delta, including green-skinned pomelo, local oranges and seedless oranges. Currently, fruit trees are being transformed into strong production in localities in the direction of restructuring the development of the agricultural sector and being a commodity with high economic value are contributing to changing the face of rural areas (Hoang and Tran, 2019; Nguyen *et al.,* 2019). Tra Vinh region growing fruit trees in particular still has many potential risks due to water-related factors and will continue to have more adverse impacts when mining activities in the upper Mekong River increase and the water level increase. For fruit trees, the most important issue is that the irrigation system must actively control the water environment (Li *et al.,* 2021; Wang *et al.,* 2021). Compared with other crops, fruit trees are very sensitive to environmental changes and have poor tolerance to drought and salt water intrusion (Nhung *et al.,* 2019); and the investment cost is much larger to build from planting to care until the plant bears fruit (Gholamin and Khayatnezhad, 2020). Hence, response to climate changes from the new king orange seedless variety by farming techniques suitable to drought and salinity in natural conditions in Tra Vinh province had been carried out (Nguyen *et al.,* 2020).

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MATERIALS AND METHODS

The research was undertaken within main fruit growing region of Tra Vinh Province's Cau Ke District which is about 180 km south-west of Ho Chi Minh City. Since the region is situated in a flood plain with average land elevation of 0.5-2 m above the sea level, fruits are usually grown on raised beds which are separated by a 2-8 m wide canal system to minimise flooding. The major soil type is alluvial soils and salty soil 1 g/l with a high degree of fertility which are deposited from the sediment of the Co Chien River, a branch of the Mekong River. The mean annual rainfall of the province is around 1,500 mm with the rainy season from December until May. A total of seven sites were selected on the basis of the ease of access and similarity in Cam sanh seedless varieties, soil and vegetation types. The treatment (XL) and site (DC) control were located in the centre of the 20 ha king orange seedless and local king orange varieties areas where trials were set up.

Average rainfall and temperature in Cau Ke district in 2020 showed that the weather conditions of Cau Ke in 2020 had an average humidity of 82.13% (Table 1), 1369.10 mm total rainfall out of which lowest from January to April with humidity of 74-77%, whereas the highest humidity in October was 90%. The rainy season started from May to November. The average annual temperature was 27.55°C, the highest temperature was in the 5dl months. Salinity in the river changed from January dl to June dl salinity ranged from 2.5-10.6 parts per thousand.

King orange (*Citrus reticulate* x *Citrus sinensis*) is a citrus hybrid originated in Vietnam. It was recognized by the Ministry of Agriculture and Rural Development under Decision No. 242/ QD-TT-CCN dated May 19, 2011. Fruit characteristics of king orange : seedless yellow green easy to peel, flesh fruit yellow-orange, easy to separate, yellow, even, smooth, succulent shrimp, characteristically rich in taste, sweet, slightly sour, not bitter in taste, 7.5-8.0% Brix degree, 3.4-3.7 pH, number of seeds/fruit varied from 0-3 seeds/fruit and 40-42% juice, getting fruit in 2nd year after planting.

For local orange-growing area, the information and data were collected from reports, conferences, seminars, statistics of the Ministry of Agriculture and Rural Development, the Ministry of Industry and Trade, the Vietnam Fruit and Vegetable Association, the south-western provinces, websites and foreign market information (Hoang *et al.*, 2020). Direct interviews with orange farmers were conducted to collect primary data.

The experiment was conducted on 20 ha in Cau Ke district, Tra Vinh province from 2017-20. The experiment was arranged in a pairwise comparison, each plot was arranged in a completely randomized design, with 12 replicates, 1 seedling/repeat. The distance between 2 lots was 4 m.

Treatment 1 : The treatment lot (XL) was dry (30 days) without water in the dry season (March 2018, March 2019 and March 2020), soil moisture depth of 40 cm : 4.35%±3. 37% (v/v).

Treatment 2 (control) : The control plot (DC)

Table 1. Changes in weather conditions of experimental king orange seedless garden in Cau Ke district from January to December

Month in Tra Vinh province	Average maximum temperature (°C)	Average temperature (°C)	Low minimum temperature (°C)	Average humidity (%)	Total amount of rain (mm)	Total hours of sunshine	Salinity of river water in Tra Vinh (g/l)
January	31.6	26.1	22.7	77	0.8	278.9	10.60
February	31.8	26.5	23.3	74	-	266.9	11.70
March	35.9	27.8	22.6	77	-	282.0	9.50
April	34.1	28.9	25.6	77	30.5	265.0	6.30
May	36.9	29.7	25.0	81	125.3	240.3	7.30
June	33.2	27.9	25.4	88	231.0	162.9	2.50
July	33.1	27.7	25.0	86	302.0	182.3	
August	32.7	27.8	25.1	85	98.7	176.8	
Sept.	32.9	27.7	25.0	84	141.3	174.7	
October	31.2	26.7	24.7	90	291.3	126.7	
November	32.2	27.4	24.6	85	116.5	195.2	
December	31.2	26.4	23.4	83	31.7	177.4	
Average	33.06	27.55	24.36	82.13	1369.10	2529.10	7.98

plants (30 x 30 cm apart) were watered according to the density.

Data collected in May 2020 included plant height, root diameter before and after drought treatment, photochemical efficiency (Fv/Fm, chlorophyll by Fluorometer OS-30), chlorophyll content, total chlorophyll, starch, soluble sugars, proline in leaves and assessing the degree of damage of the leaf set (0 to 9). The degree of damage increased gradually to death and the damage index (CSH%) was calculated at the end of drought treatment (48 months after planting in the field). Financial efficiency was computed for 1 ha of seedless oranges.

RESULTS AND DISCUSSION

The Mekong Delta region currently had over 30,000 ha of orange earthenware area, concentrated in towns such as Hau Giang, Can Tho, Tra Vinh and Dong Thap. Output was estimated at 360,000 t/year, accounting for 67% of the country's output (Table 2). According to the Ministry of Agriculture and Rural Development report, Vietnam is in the group of 16 countries with the largest area and output of oranges in the world (corresponding to 1.06% of the world's area and 0.74% of the world's output) and ranked second in south-east Asia after Indonesia (Hoang *et al.*, 2020). Vietnam's orange domestic production was consumed mainly as fresh. The export value of fresh oranges was insignificant in 2015. Vietnam exported fresh oranges for only 15 thousand USD and 43 thousand USD in 2016. Oranges in southern provinces accounted for 45.5% of the area, 53% of the national output, of which the south-west region accounted for 86% of the orange growing area in the south. According to VIBIZ.VN (Vietnam Business Monitor, 2018), the citrus area in 2017 was about 110,000 ha, the output reached 948.1 thousand tonnes, an increase of 148.6 thousand tonnes (18.6%) compared to 2016. And in 2018 the area of oranges and tangerines was 120 thousand ha and the output was estimated at 976.5 thousand tonnes (Table 3).

Table 3. Area and production of oranges in king madarin, Vietnam

Targets	Years			
	2015	2016	2017	2018
Area ('000 ha)	66.8	97.4	110.0	120.0
Production ('000 t)	566.1	799.5	948.1	976.5

VIBIZ.VN (Vietnam Business Monitor, 2018).

At the end of natural drought treatment in the field, the total chlorophyll content of the treated batch varied from 11.35 to 10.31 mg/dm^2. The percentage of chlorophyll content in batch XL was lower than that of local king orange variety (16.36%) and was not significantly different. King orange seedless variety in Lot XL and Lot DC was not significantly different (Table 4).

The proportions of chlorophyll fluorescence of photosystem II batch XL compared with each other local king orange and king orange seedless were not significantly different.

This result was explained as under drought stress, leaf chlorophyll content decreased due to chlorophyll degradation and/or synthesis

Table 2. Orange growing areas in the south-west region by 2020

Province of Mekong delta	Cultivation relics (ha)	New planting (ha)	Area for product (ha)	Production (t)
Long An	31.8	0.1	28.9	220.1
Tien Giang	4477.6	8.8	3942.8	96918.1
Ben Tre	1583.0	87.0	1234.0	11714.0
Trà Vinh	2630.2	78.1	2362.9	48113.5
Vinh Long	7802.5	357.7	6954.4	80754.5
Dong Tháp	1513.0	106.0	1240.0	14535.0
An Giang	13.2	1.6	8.4	26.9
Kiên Giang	162.0	6.0	125.0	10156.0
Can Tho	945.5	43.6	802.5	7945.6
Hau Giang	7683.1	889.2	6094.0	68414.4
Sóc Trang	2272.0	255.0	1875.0	19742.0
Bac Liêu	50.0		50.0	295.0
Cà Mau	334.0	3.0	324.0	1030.0
Average	29.497.9	1836.0	25041.9	359865.1

Table 4. Chlorophyll content (mg/dm^2), chlorophyll fluorescence of photosystem II (Fv/Fm), starch in leaves (mg/g)

S. No.	Varieties	Total chlorophyll content (mg/dm^2)			Fv/Fm			Starch in leaves (mg/g)		
		DC	XL	P (Sig)	DC	XL	P (Sig)	DC	XL	P (Sig)
1.	Local king orange	10.31	8.38	0.001	0.75	0.62	0.164	226.81	210.18	0.035
2.	King orange seedless	11.35	10.83	0.234	0.77	0.63	0.266	205.00	185.52	0.026

DC – Control and XL – Dry treatment.

process. Chlorophyll was inhibited. The king orange seedless variety had little reduction chlorophyll content.

The starch in leaves content of local king orange lot XL (210.18 mg/g) compared with the batch DC (226.81 mg/g) was significantly different. Under water shortage (stress) conditions, the starch content in leaves decreased due to a decrease in photosynthetic part and a part of starch decomposition, increasing sugar content (Table 4).

Proline content in the local king orange in the batch DC was 4.08 mg/dg, in the XL batch 6.32 mg/dg similar to the king orange seedless. The difference was not significant. It was due to its ability to maintain and increase proline synthesis in leaves under drought tolerance (Table 5).

Plant height in the local orange plot XL 163.03 was significantly lower than that in the DC plot 168.63 cm (Table 6). King orange seedless height in XL and DC plots was not significantly different, the variety tended to be more drought-tolerant and salinity-tolerant than the local king orange variety. Both varieties trunk meridians o83 plots XL and DC were not significantly different. The index of leaf damage in the two varieties was not significant.

Overview of king orange seedless varieties infected with pests such as leaf worm, ulcer disease and scarring to a higher degree than that of the old orange variety under the same experimental conditions (Table 7). The subjects with the same and average damage levels on the two varieties of oranges were aphids and red spiders. The subjects of leaf eating caterpillars, multi bud caterpillars, young shoot worms, thrips, green beetles, green bugs, brown bugs, root rot diseases were low and similar on two varieties of oranges. Pests such as mealy bugs, sticky aphids, winged plant hoppers, jumping plant hoppers, greening leaf disease, Tristeza and resinous root rot of these diseases were present in the garden at the investigation stage.

The basic construction phase of the orange garden was usually 2-3 years (Yi-ling *et al.*, 2015). But two years were common. The cost for the basic construction stage (planting tissue, planting seedlings, tending, fertilizer and watering) was 224.56 million VND/ha on an average and had an average fruit harvest time (from 3rd year) lasting from 7-12 years

Table 5. Concentration of soluble sugars, proline in leaves and leaf damage index (%)

S. No.	Varieties	Concentration of soluble sugars (mg/g)			Proline (mg/dg)			CSH (%)		
		DC	XL	P	DC	XL	P	DC	XL	P
1.	Local king orange	163.63	168.03	0.061	4.08	6.32	0.081	77.59	66.13	0.185
2.	King orange seedless	147.60	154.08	0.246	3.82	5.60	0.627	85.38	71.60	0.304

Treatment : DC – Control, XL – Dry treatment and CSH – Wither index.

Table 6. Plant height growth (cm) and trunk meridians (mm)

STT	Varieties	Plant height growth (cm)			Trunk meridians (mm)		
		DC	XL	P	DC	XL	P
1.	Local king orange	168.63	163.03	0.036	4.08	6.32	0.354
2.	King orange seedless	147.60	154.08	0.304	3.82	5.60	0.362

Table 7. Harmful levels of some pests on local king orange seedless and local king orange varieties appearance level

S. No.	Pests	Appearance level	
		Local king orange	King orange seedless
Insects			
1.	*Planococcus* sp.	-	-
2.	*Lepidosaphes gloverii*	-	-
3.	*Phyllocnistis citrella*	++++	++
4.	*Papilio* sp.	+	-
5.	*Diaphorina citri*	-	-
6.	*Toxoptera* sp.	++	++
7.	*Dialeurodes citri*	-	-
8.	*Lawana conspersa*	-	-
9.	*Scrirtothrips dorsalis*	+	+
10.	*Panonychus citri*	++	++
11.	*Hypomeces squamosus*	+	+
Diseases			
1.	Greening	-	-
2.	Tristeza	-	-
3.	Root rot	+	+
4.	Ulcers	++++	++
5.	Scar	++++	++

Not appear -, mild damage (<5%) : +, pretty harmful (6-25%) : ++, serious harm (26-50%) : +++ and very damaging (> 50%) : ++++.

depending on farming methods and techniques of farmers.

The production investment cost for 1 ha per year during the fruiting period (from the 3rd year onwards) was 129,026 million VND/ha/year (Table 8), of which the cost of fertilizer accounted for 34.8% (chemical fertilizers, microbial organic fertilizers); pesticides accounted for 24.9%; expenses for soil preparation, pruning, flower treatment accounted for 28.8%; fuel cost for irrigation pump 5.4%; depreciation expenses for machinery and tools accounted for 5.6% and other expenses were about 0.6%.

Table 8. Investment cost of 1 ha of oranges, 2020

Targets	VND ('000 dong)	Ratio (%)
Labour cost	37.094	28.8
Fertilizer cost	44.851	34.8
Cost of pesticides	32.106	24.9
Cost of fuel (electricity)	7.012	5.4
Depreciation of gardens, machinery and equipment	7.208	5.6
Other expenses	753	0.6
Total	129.026	100.0

Financial efficiency of planting king orange local variety and king orange seedless variety. With an average yield of king orange local variety of 19.240 kg/ha/year, the price of local oranges was 9.000 VND/kg, so the revenue was 173.16 million VND/ha/year. With an investment cost of 129.03 million VND/ha/year average profits of households were 44.134 million VND/ha/year. Profit/revenue ratio was 0.25 times that is 1 dong of revenue from orange generated 0.25 dong profit. The profit/cost ratio was 0.34, which meant that an investment of 1 dong in the production of earthen oranges in the business stage brought 0.34 dong of profit for the household (Table 9). In the opinion of the households that grew oranges, the price of oranges on the market must be guaranteed at 14-15 thousand VND/kg, so that farmers feel secure in production (Bakshi, 2019). With the average yield of king orange seedless variety 15,200 kg/ha/year (Frankowska *et al.*, 2019), the king orange seedless price was 25,000 VND/kg, so the revenue was 380,000 million VND/ha/year. With an investment cost of 129.03 million VND/ha/year, the household earned an average profit of 250.074 million VND/ha/year. The profit/revenue ratio was 0.65 times. The profit/cost ratio was 1.9, which meant that an investment of 1 dong in the production of oranges in the business period brought 1.9 dong of profit for farmers (Table 9). In the opinion of king orange seedless growers, the lowest king orange seedless price was at 14-15 thousand VND/kg, so farmers were assured to produce.

Table 9. Production efficiency of 1 ha king orange seedless and king orange local variety

Targets	Unit	Local king orange variety	King orange seedless variety
		Value	Value
Yield	kg/ha	19.240	15.200
Fruit selling price	Rs./kg	9.000	25.000
Total revenue	'000 Rs./ha	173.160	380.000
Total expenditure	'000 Rs./ha	129.026	129.026
Net profit	'000 Rs./ha	44.134	250.074
Profit/revenue	times	0.25	0.65
Profit/cost	times	0.34	1.9

King orange seedless can grow well if appropriate farming methods are applied in climate change areas such as Tra Vinh province.

CONCLUSION

Thus, based on the response ability of king orange seedless plants in drought, salty stress

under field conditions compared with the control (not stress), there was no reduction in total chlorophyll content 10.83 mg/dm^2, chlorophyll fluorescence of phytosystem II (0.63), soluble sugars (154 mg/g), proline in leaves (5.6 mg/dg), plant height (154.08 cm), stem diameter (5.6 mm) and wilting index (71.6%) of the leaf set. The king orange seedless was tolerant to natural drought for 30 days than the local king orange variety. The king orange seedless variety with good quality and effective net profit of VND 250.074 million was accepted by the people.

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