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Impact of Soil Salinity on the Yield of Two Butternut Squash (*Cucurbita Moschata L. Mellonia*) Varieties in Mwea, Kenya

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Abstract

Eighty percent of Kenya's land is covered by the arid and semiarid areas that are prone to salinity. Salinity occurs due to natural and anthropogenic actions. Farmers in these arid and semi-arid areas are adopting growth of alternative crops and plants that do well in moderate conditions of salinity. Due to the growing importance of butternut squash farming in Kenya, this study was to examine the impact of salinity on yield of two butternut squash varieties, Waltham butternut (Waltham) and Jupiter F1 hybrid (Jupiter). The two butternut varieties were subjected to five NaCl concentrations *i.e.* 0, 25, 50, 75 and 100 mM resulting in ten treatments. These were arranged in a randomized complete block design with three replicates. A net plot was established from which the following data were recorded; fruit number per plant, fruits weight, shoots and roots fresh and dry weight. The data were subjected to Analysis of variance (ANOVA) and means were separated using least significant difference (LSD) at 5 percent level. The number of fruits per plant, weight of fruits per plot, shoot and root fresh and dry weights decreased significantly with an increase in NaCl concentration in Waltham and Jupiter. Sodium chloride concentration above 75 Mm severely affected the yield of Waltham and Jupiter however, the effect was less on Jupiter hence it is more salt tolerant. Farmers in areas where salinity is endemic are therefore recommended to adopt growing Jupiter as this would boost butternut production and hence income of the farmers.

Keywords: Number and weight of fruits; Fresh and Dry weight; Randomized Complete Block Design; Butternut squash (Waltham, Jupiter); Salinity

Introduction

When the soil solution electrical conductivity (EC) reaches 4 deciSiemens per metre (dS/m) its considered to be saline. 4dS/m has an osmotic pressure of -0.2MPa [1] that decreases the yield of the crops significantly. Plant's response to salinity depends on osmotic regulation, toxic ion uptake, carbon (iv) oxide assimilation, ion exclusion, chlorophyll content and fluorescence, photosynthetic electron transport and antioxidant defenses [2]. Salt stress is a brutal environmental stress that hamper production of crops in the world [3,4].

Some physiological processes of plants are disturbed by high salt concentrations resulting in a decline in the plant performance [5]. Salinity make it hard for plants to absorb water leading to ion toxicity which results from excessive concentration of toxic salts within plants [4]. Plants growing in saline soils may encounter various stresses, severe ion toxicity, nutrient

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imbalances hence reduction in plant water uptake [6]. Salinity stressed plants have increased release of Reactive Oxygen Species (ROS) causing degradation of cell membrane which results to the death of the whole cell [7]. Kusvuran et al. [8] stated that many researchers have reported deficiency of water in older leaves and carbohydrates in young leaves due to long term salinity stress. Under stress condition, resistance of salt therefore depends on the plant's ability to develop adaptive strategies [9].

There is gradual salinization of arable land as a result of salts accumulating due to poor irrigation methods as well as underlying rocks that have high salt contents thus release salts to the soil when they weather [10]. Salt stress is on rise due to climate change [11]. According to Wang et al. [12], if the salinity stress persists, fifty percent of cultivated land will be unproductive. Irrigated soils are prone to salinization [4]. Approximately 60 million ha are under over irrigation which causes solute salts to be transported to the top layers of the soil by the raised water table [13]. ACZ V, and VI cover 80% of Kenya's land where the problem of salinity is on the rise due to insufficient rainfall. Mwea is in agroclimatic zone V hence farmers have adopted irrigation method.

Butternut can be classified as a food security crop because it is adaptable in drier regions. Interventions that enhance its grain and foliage yield are beneficial in a country where two thirds of its land is ASAL. Although studies on salinity in plants have long been studied, little research on the impact of soil salinity on the yield of butternut squash varieties has been reported. This study therefore aimed at investigating the impact of salinity on the yield of two butternut squash (Cucurbita moschata) varieties namely, Waltham Butternut (Waltham) and Jupiter F1 hybrid (Jupiter).

Materials and Methods

This study was carried out at the Kenya Agricultural and Livestock Research Organization (KALRO) Centre, Kimbimbi in Mwea East Sub County, Kirinyaga County which is in Agro Climatic Zone (ACZ) V. Two butternut varieties (Waltham butternut and Jupiter F1 hybrid) were subjected to 0, 25, 50, 75 and 100 mM NaCl. The experimental design was Randomized Complete Block Design (RCBD) with 3 replications resulting in 30 plots. The experiment was carried out over two dry seasons to avoid leaching out of the NaCl added in the soils.

An electronic weighing balance (Shimadzu TX4202L) was used to weigh the fruits and expressed in kg/ha. The roots and shoots were harvested, separated and weighed separately using an electronic weighing balance (Shimadzu TX4202L) immediately to determine the fresh weights. To determine dry weight, separate packing of the roots and shoots was done in paper envelopes and dried to a constant weight in an oven at 70°C after which weighing was done using an electronic weighing balance (Shimadzu TX4202L).

The data collected were subjected to Analysis of variance (ANOVA) whereby Statistical Analysis Software (SAS) was used. Means from ANOVA tests that were statistically significant were separated using least significant difference (LSD) at 5 percent level.

Results

Impact of soil salinity on fruit number per plant and the weight of fruits (g) per plot

Salinity treatments significantly ($p \leq 0.05$) decreased the fruit number per plant and the weight of the fruits per plot for both varieties in season one and two. Potential significant interactions on the number of fruits between the treatments and varieties was also observed in season one and two for the two varieties (Table 1).

Impact of soil salinity on shoot and root fresh and dry weights

As the soil salinity increased, there were significant ($p \leq 0.05$) decreases in shoot and root fresh and dry weights among the NaCl treatments in season one and two. Potential significant interactions on shoot and root fresh and dry weights between the treatments and varieties was also observed (Table 2).

Table 1: Impact of soil salinity on the fruit number and the weight of fruits (g) of Waltham and Jupiter (Season 1 and 2).

Fruit number and fruit weight (g)					
		Fruit number		Fruit weight (g)	
Variety (a)	NaCl Concentration (b)	Season 1	Season 2	Season 1	Season 2
Waltham	0	7.3a	9.3a	449.5a	713.8a
	25	6.0ab	7.7a	394.7a	617.9b
	50	3.3bc	5.0b	324.0ab	465.6c
	75	3.0bc	3.3b	254.1ab	368.8d
	100	1.3c	1.0c	97.4b	114.9e
Jupiter	0	6.0ab	8.3a	947.3a	1299.8a

Nyambura M, et al., Int J Plant Anim Environ Sci 2024
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	25	5.7ab	6.7ab	814.9ab	1080.1b
	50	4.7ab	5.3bc	735.1bc	860.2c
	75	4.3ab	4.3c	621.8cd	753.2c
	100	4.0b	3.7c	506.6d	569.9d
NaCl Concentration (b)		<.0001	<.0001	<.0001	<.0001
variety (a)		0.0594	0.2912	<.0001	<.0001
a × b		0.0225	0.0283	0.0937	0.0937

Table 2: Impact of soil salinity on shoot and root fresh and dry weights (g) of Waltham and Jupiter (Season 1 and 2).

Shoot and Root fresh and dry weight (g)									
		Shoot fresh weight		**Root fresh weight**		**Shoot dry weight**		**Root dry weight**	
Variety (a)	**NaCl Concentration (b)**	**Season 1**	**Season 2**	**Season 1**	**Season 2**	**Season 1**	**Season 2**	**Season 1**	**Season 2**
Waltham	0	423.7a	559.7a	12.8a	14.3a	85.6a	117.7a	1.9a	2.1a
	25	230.2ab	363.1b	11.2ab	11.9b	53.2ab	88.3b	1.4b	1.3b
	50	88.4b	237.6c	10.1bc	8.6c	19.8b	56.0c	1.1bc	0.9c
	75	65.5b	135.7d	8.9c	6.3d	16.1b	37.6d	0.8cd	0.7d
	100	52.2b	65.4d	6.8c	3.9e	11.8b	15.0e	0.5d	0.4e
Jupiter	0	405.1a	451.4a	17.0a	19.7a	77.6a	100.7a	2.3a	2.4a
	25	226.6ab	383.0b	13.8b	14.7b	52.6ab	90.5a	1.7b	2.1a
	50	167.1b	257.3c	12.3bc	12.7c	40.8ab	63.0b	1.3bc	1.6b
	75	147.8b	164.1d	11.2cd	9.9d	36.8b	42.1c	1.1c	1.1c
	100	101.3b	127.3d	9.5d	8.4d	29.2b	36.8c	0.8c	0.7d
NaCl concentration (b)		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
variety (a)		0.2645	0.7521	<.0001	<.0001	0.0942	0.1915	<.0001	<.0001
a × b		0.8011	0.0093	0.1538	0.0875	0.3810	0.0060	0.9901	0.0142

Discussion

Impact of salinity on the fruit number per plant and the weight of fruits

Waltham and Jupiter butternut varieties recorded a reduction in the number and the weight of the fruits which can be attributed to decreased photosynthetic rates as a result of decreased chlorophyll content. Low chlorophyll content can be due to reduction in minerals uptake like magnesium needed for chlorophyll biosynthesis [14]. Decreased photosynthetic rates could also be due to low water uptake as water is a raw material of photosynthesis. Under saline conditions, reduction in yield and yield components could be due to reduced photosynthesis, reduced growth due to decreased uptake of water and toxicity and also decreased development of tissues [14,15]. Taffouo et al. [5] observed similar responses as he noted a decrease in grain yield of three tropical cucurbit species due to salt stress. More also, Puvanitha and Mahendran [16] reported an exponential decline in selected rice (Oryza sativa) cultivars yields as salts levels increased.

Impact of salinity on shoot and root fresh and dry weights

Waltham and Jupiter butternut varieties recorded a decline in shoot and root fresh and dry weights which could have been caused by reduced root mass increasing water deficit in the plants. Low water uptake in plants causes low photosynthetic rates and a decrease in the rate at which essential nutrients are translocated to the shoots as it is the medium of transport. The reduced fresh and dry weights can also be attributed to restricted elongation of roots and shoots due to high salt levels. This is because, absorption of water is low as a result of reduced osmotic potential and decreased root mass as well as decreased photosynthetic rates as a result of reduced chlorophyll content. The decrease may also be attributed to

Nyambura M, et al., Int J Plant Anim Environ Sci 2024
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reduced number of leaves which reduces photosynthetic rates and leaf turgor due to low water absorption [17]. Under salinity stress, hydrolysis of stored food is prevented which results in a decline of fresh and dry weights [17]. These results are similar to Puvanitha and Mahendran [16] results who noted a decline in shoot and root fresh weights in Oryza sativa when salinity levels increased. Muhammad et al. [18] also noted a decline in shoot and root fresh weights of Brassica species at early growth when salinity levels increase.

Conclusions

From the results obtained in this study, Salinity level above 75 mMNaCl had adverse effects on selected physiological parameters of the two butternut varieties. The effect of salt was however less adverse on selected physiological parameters of Jupiter hence it is more salt tolerant compared to Waltham. Farmers in areas whose soils are saline are therefore recommended to adopt growing Jupiter F1 hybrid which showed tolerance at higher levels of salts and also maintain salinity levels below 75 mMNaCl to ensure maximum performance of the plants hence yield.

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