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Research Application Summary

Effects of water stress on yield and yield components of selected African landrace tomato (*Solanum lycopersicum)* accessions and commercial varieties

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Abstract

Drought stress is one of the major constraints to enhancement of tomato **(***Solanum lycopersicum***)** productivity in Kenya. There exists a wide range of water stress tolerant tomato landraces in Africa that could be harnessed to improve the current available commercial varieties for adaptability to limited moisture conditions. A study was conducted to evaluate the yield and yield components responses of 10 African landraces and five widely grown Kenyan commercial tomato varieties. Greenhouse grown tomato plants were subjected to three water levels, i.e., 100% field capacity (FC), 70% FC and 40% FC, in a randomized complete block design with three replications. Number of fruits per plant, total fruit weight per plant, average single fruit weight, fruit length and fruit weight were determined. Data collected were subjected to analysis of variance using Genstat version 15 and means were separated using least significant difference test at ($P<0.05$). Results showed that tomato genotypes varied significantly ($P<0.05$) in fruit yield parameters studied. The landraces VI005895, VI006840 and VI005871 compared well with the commercial varieties particularly in the total fruit weight per plant and average single fruit weight aspects with VI005895 being similar to the leading commercial variety with respect to average single fruit weight . Water stress significantly ($P< 0.05$) affected the genotypes as reduction of watering level from 100 % FC to 70 % FC to 40 % FC caused a general decrease in yield components such as total fruit weight per plant. Projects for development and improvement of tomato varieties for drought tolerance can objectively exploit the genetic variance among genotypes especially the superior ones that performed well in comparison with the commercial varieties in the market.

Key words: Fruit length, fruit width, landraces, Kenya, *Solanum lycopersicum,* tomato genotypes, water stress, yield performance

Résumé

Le stress dû à la sécheresse est l'une des principales contraintes à l'amélioration de la productivité de la tomate (*Solanum lycopersicum*) au Kenya. Il existe un large éventail de variétés locales de tomates tolérantes au stress hydrique en Afrique qui pourraient être exploitées pour améliorer les variétés commerciales actuellement disponibles afin de s'adapter à des conditions d'humidité limitées. Une étude a été menée pour évaluer le rendement et les réponses des composantes de rendement de 10 variétés locales africaines et de cinq variétés de tomates commerciales kényanes largement cultivées. Les plants de tomates cultivés en serre ont été soumis à trois niveaux d'eau, c'est-à-dire 100% de capacité au champ (FC), 70% FC et 40% FC, dans une conception en bloc complet randomisé avec trois

répétitions. Le nombre de fruits par plante, le poids total des fruits par plante, le poids moyen d'un seul fruit, la longueur et le poids des fruits ont été déterminés. Les données recueillies ont été soumises à une analyse de la variance à l'aide de Genstat version 15 et les moyennes ont été séparées en utilisant le test de différence la moins significative à (P <0,05). Les résultats ont montré que les génotypes de tomates variaient considérablement (P <0,05) dans les paramètres de rendement en fruits étudiés. Les variétés locales VI005895, VI006840 et VI005871 se comparaient bien aux variétés commerciales, en particulier en ce qui concerne le poids total du fruit par plante et le poids moyen d'un seul fruit, VI005895 étant similaire à la principale variété commerciale en ce qui concerne le poids moyen d'un seul fruit. Le stress hydrique de manière significative (P <0,05) a affecté les génotypes car la réduction du niveau d'arrosage de 100% FC à 70% FC à 40% FC a provoqué une diminution générale des composants de rendement tels que le poids total des fruits par plante. Les projets de développement et d'amélioration de variétés de tomates pour la tolérance à la sécheresse peuvent exploiter objectivement la variance génétique entre les génotypes, en particulier les génotypes supérieurs qui ont bien performé par rapport aux variétés commerciales sur le marché.

Mots clés : longueur du fruit, largeur du fruit, variétés locales, Kenya, *Solanum lycopersicum*, génotypes de la tomate, stress hydrique, rendement des rendements

Introduction

Tomato (*Solanum lycopersicum*) is the second most important exotic vegetable crop in Kenya. Its production increased from 360, 679 tons in 2015 to 341,026 tons in 2016, partly attributed to expansion in greenhouse production. However, various constraints have hindered consistency in production and utilization of tomato leading to unfavorable fluctuations in supply hence prices (Sigei *et al.*, 2014). Among these constraints are high costs of hybrid seeds and control of pest and diseases, drought and heat stress associated with climate change, lack of drought tolerant varieties and poor agronomic practices. Drought stress especially in critical growth stages is one of the main hindrances of potential yield achievement in tomato production by the Kenyan farmers (Sibomana *et al*., 2013). Improvement of current tomato varieties with respect to adaptability to drought stress is thus critical to improvement of tomato production. Landraces and wild tomato genotypes are potentially good sources of drought tolerance genes for tomato improvement through crossing and breeding. This evaluated selected African tomato Landraces and commercial varieties for yield and yield components response to water stress.

Methodology

The study was conducted in a greenhouse at the University of Nairobi's College of Agriculture and Veterinary Sciences Field Station between the months of October 2017 and February 2018. The site is situated in agro-ecological zone (AEZ) three lying at an attitude of 1940 meters above sea level, latitude of 1° 15'S and longitude of 36° 41'E. It is normally a humid and high potential zone with a mean minimum temperature of 11.8° C, mean maximum temperature of 25.1°C and mean annual rainfall of 1000 mm.

Ten tomato landraces and five commercial tomato varieties were grown in pots under three watering levels through the season. Tomato genotypes tested were VI005895, VI007540, VI005987, VI006840, VI006825, VI006828, RVI01885, GBK050580, VI005871, VI005990 as landraces and Rio grande, Cal J, Stallion F1, Master F1, ATM F1 as commercial varieties. The watering levels treatments were 100 % field capacity (FC), 70 % FC and 40 % FC of the soil samples in growing pots were established

using gravimetric moisture determination method. The period of time that lapsed before successive watering was determined by interpreting readings of tensiometers inserted in pots at a depth of 15 cm. A randomized complete block design was employed with fifteen by three factorial arrangement with three replications. Data were collected on yield parameters namely total number of fruits harvested from each plant, total weight of harvested fruits per plant (g), average single fruit weight (g), average fruit length (cm) and average fruit width (cm). Data collected were subjected to analysis of variance using Genstat 15th Version and means separated using Fisher's protected least significant difference (LSD) test ($P<0.05$)

Results

Tomato genotypes varied significantly ($P<0.05$) in fruit yield parameters (Table 1). Landrace VI007540 had significantly higher number of fruits per plant than all other tomato genotypes in the study. All landraces had similar number of fruits per plant as commercial varieties Stallion F1, used Master F1, Cal J and ATM F1. Commercial variety Rio Grande had a lower number of fruits than commercial variety Stallion F1 and landraces VI005871, VI007540 and VI006828. Landraces VI005895, VI006840 and VI005871 compared well with the commercial varieties particularly in the total fruit weight per plant and average single fruit weight with VI005895 being similar to the leading commercial variety with respect to average single fruit weight (Tables 1 and 2).

Total fruit weight per plant in both landraces and varieties significantly increased with reduction in moisture stress. Increasing moisture levels from 100% FC to 70% FC to 40% FC for instance reduced the mean weight of fruits per plant from 123.5 g to 72.8 g to 48.9 g (Table 2). Interaction of the accessions and moisture level factors only affected significantly ($P<0.05$) the total fruit weight per plant among the accessions and varieties in the study (Table 2). When moisture level was reduced from 100% FC to 70% FC, Cal J, VI005871 and VI006825 registered reduced fruit production ranging from 73.3, 67.2 and 51%, respectively, whereas VI007540, GBK05058 and VI005987 registered total fruit yield increase ranging from 3% to 4 %. When moisture was reduced from 100% to 40% FC, Cal J, Master F1, Stallion F1, VI005895, VI005990, VI006825 and VI006828 registered over 50% reduction in total fruit weight (Table 2).

Discussion and conclusion

The study results indicated that there exists significant genotype differences among the landraces and the commercial varieties used. The phenotypic characteristics of a plant are largely affected by the genotype of that plant and the genotype interaction with the external environment. Various crops respond differently to water stress of various levels and this is referred to as drought tolerance. Crops drought tolerance can be attributed to a crop's anatomy features eg root or leaf characteristics and physiology features such as accumulation of compatible solutes e.g. proline (Matsuda and Rayan, 1990). The genotypes that expressed superior phenotypic characteristics for yield such as the landrace VI005895 and hybrid Stallion F1 point to the existence of exploitable genes in these landraces and varieties with regard to response to drought stress. The results of this study are similar to those reported by Nahar *et al*., (2002). Genotypes are inherently different (Tembe *et al*., 2016) and superior ones can be harnessed for varietal development or improvement programmes.

Table 1. Varietal yield performances of tomato landraces and commercial varieties (l.s.d P<0.05)

Landrace/cultivar	TFPP	SFW(g)	Fruit length (cm)	Fruit width (cm)
VI005895	8.889bc	20.99a	2.287ab	3.185a
Stallion F1	11b	14.69bc	2.748a	2.37bc
Master F1	7.111bcd	22.19a	2.441ab	2.306bc
Cal J	7.444bcd	18.79ab	2.328ab	1.911c
VI006840	8.111bcd	14.57bc	2.046bc	2.719ab
VI005871	9.667b	13.18cd	1.872bcd	2.198bc
VI006825	6.778bcd	11.77cd	1.993bc	2.18bc
VI005987	9.222bc	9.27cde	2.381ab	2.931a
ATM F1	7.778bcd	10.08cd	2.419ab	2.009c
Rio Grande	4.111cd	12.68cd	2.115bc	2.076c
VI005990	7.778bcd	4.1efg	1.546cde	1.865cd
RVI01885	6.222bcd	7.73def	1.031e	1.009ef
VI007540	35.444a	0.75g	0.924e	0.757f
GBK050580	3.222d	8.67de	0.992e	1.044ef
VI006828	9.778b	2.81fg	1.287de	1.359cd

Values with similar letter in a column are not significantly different at (l.s.d P<0.05)

The study also draws a conclusion that water stress significantly affects the yield achieved from tomato plants and also affects the yield components of the fruits harvested such as fruit size and fruit size. Soil moisture insufficiency in tomatoes negatively affects the vegetative and reproductive plant growth since water is one the basic requirement for the growth and development of plants. Water stress also causes poor development of reproductive structures eg flowers or parts of flower such as anthers and stigma and flower abscission/wilting, poor pollination due to pollen desiccation or insufficient stigma moisture, poor seed set, fewer, shrunk and small sized fruit and fruit abscission (Sibomana *et al*., 2013). Tomato being a tropical herbaceous crop is very sensitive to shortage of soil moisture during growth and if intense water stress occurs at flowering or fruit formation stage, flower abscission occurs resulting in few, small sized fruits set thus lower yield (Nurrudin, 2001). Therefore farmers should be sensitized on irrigation management especially for the high value commercial production systems where irrigation is mechanized. The critical stages especially the reproductive stages when flowers and fruits are forming need keen attention to ensure sufficiency of soil moisture for high productivity.

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Table 2. Mean values for total fruits weight per plant (g) among the landraces and varieties under different moisture levels

Variety	100 % FC	70% FC	40% FC	Mean
ATM F1	108.6	63.3	76	82.6
Cal J	258.5	68.9	85.1	137.5
GBK050580	21.7	22.5	20.6	21.6
Master F1	214	193.9	40.3	149.4
Rio Grande	67.1	51.9	45.1	54.7
RVI01885	38.1	24.6	19.9	27.5
Stallion F1	222.7	162.9	101.8	162.5
VI005871	129.5	42.5	37.5	69.8
VI005895	282.7	76.7	64.7	141.4
VI005987	93.1	95.5	87.1	91.9
VI005990	49.7	34.3	20.5	34.8
VI006825	162.5	79.7	14.7	85.6
VI006828	30.3	28.5	9	22.6
VI006840	147.7	120.1	86.9	118.2
VI007540	25.8	26.6	24.1	25.5
Means	123.5	72.8	48.9	
Fpr. Var	<.001**			
Fpr. ML	<.001**			
Fpr. Var*ML	0.006			
L.S.D (P<0.05)Var	53.48			
L.S.D (P<0.05)ML	23.92			
L.S.D (P<0.05)Var*ML	92.63			
CV%	66.5			

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