Differential response of two cultivar groups of *Solanum aethiopicum* to water deficit stress

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Outline

- Introduction
- Materials And Methods
- Results
- Discussion
- Conclusion And Future Plans
- Acknowledgement

Introduction

- *Solanum aethiopicum* (Gilo and Shum) is one of the most widely cultivated and consumed vegetables in Sub-Saharan Africa. This crop has got both economic and nutritional importance that contributes significantly to household income and diets (Omulo, 2016). It is low in calories, has high carotene content and is a good source of iron, thiamine, riboflavin, and nicotinic acid (Sodamade *et al*., 2015).
- Increased vegetable production of this crop is constrained severally by water stress among other challenges (Limbu et al., 2018).
- Breeding for drought tolerance is considered as an important strategy in mitigating drought effects, therefore, identification of parental material for drought resistance is key.

- Development of drought-tolerant varieties requires a good understanding of the different drought adaptation mechanisms which are dependent on cultivars (Zandalinas et al., 2017).

- Different crop cultivars have evolved morphologically, physiologically and biochemically in order to adapt to different environment using different strategies (Zu et al., 2017).

- For example, the gilo cultivar has stellate hairy leaves. The hairiness nature helps to prevent excessive evapotranspiration thereby enabling the plant leaves to maintain its turgor.

- Even though research has been done to exhibit resilience amidst water stress at critical stages of seedling establishment and reproductive stages of development for example in rice (Silveira et al., 2015), millet (Seghatoleslami et al., 2008)
- There is little information on the response to drought screening within *S.aethiopicum* cultivar groups. The stage of growth that is most affected by drought is also not clearly determined in these cultivars.
- Therefore, this study was carried out to identify the appropriate soil moisture level for screening of S. *aethiopicum* groups for drought tolerance.
- Specifically, to determine an appropriate growth stage for drought tolerance screening based on morphology and physiology.

Materials and methods

- **Study location -** Mukono district, at Uganda Christian University in a screen house.
  - During two seasons were experienced a dry season (December 2017 up to March 2018) and wet season (April to June).
  - This experiment generally run from December, 2017 to June, 2018 and the temperature ranged between 18^0c to 42^0c.
- **Plant material and experimental conditions -** two genotypes of *Solanum aethiopicum* (gilo- and shum-)
  - A factorial experiment was laid in a completely randomized design with four replications.
  - Serial planting was done for each stage of evaluation: seedling stage in January 2018; vegetative stage in February 2018 while Flowering stage in April 2018.

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- Seed was directly sown in pots with a mixture of sterilized loam soil: manure in a ratio of 3:1.
- Plants were watered on a daily basis after emergence, maintaining field capacity (47-49%) after soil moisture determination.
- Drought stress was imposed to plants at seedling stage (four weeks after planting-4WAP); vegetative stage (six weeks after planting-6WAP) and reproductive stage at flowering (eight weeks after planting-8WAP) respectively.

Data collection - for each developmental stage and water level

- Eighty plants were evaluated and data was collected on all individual plants every after two days.
- Parameters: leaf length, leaf width number of leaves, wilting score, stomata conductance and chlorophyll content. Soil moisture content, screen house temperature and relative humidity were also recorded on a daily basis (Blackman et al., 2018; Vitra et al., 2019).

Statistical analysis - the obtained data were subjected to general analysis of variance (Anova) using LSD test at the significance level of 0.05.

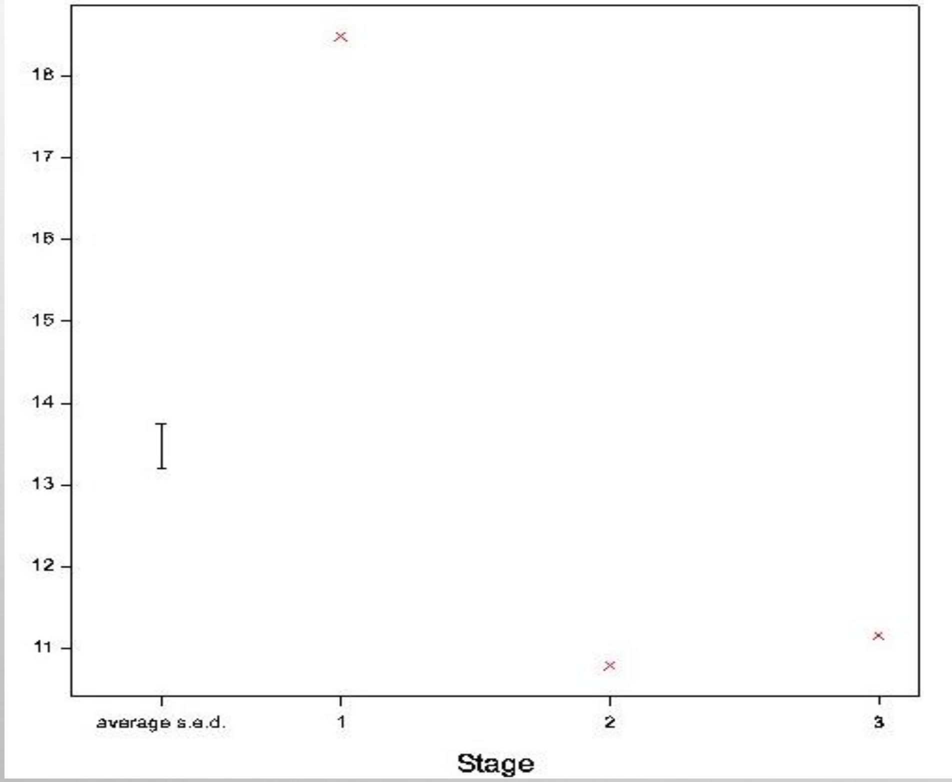
- A correlation analysis was conducted to evaluate the relationship between yield traits and plant status traits.
- Separate regression analysis was performed to determine the relationship between soil moisture content and chlorophyll, leaf length and leaf wilting score. All analyses were done using STATA/MP 14.0 and Genstat software twelfth version

Results - Summary of F.Pr for different evaluated traits

Source of variation	Degrees of freedom	Chlorophyll	Conductance	No. of green leaves	Leaf wilting score	Leaf length	Leaf width	Soil moisture content
Group	1	<.001	**0.775**	<.001	<.001	<.001	<.001	0.02
Stage	2	<.001	<.001	<.001	<.001	<.001	<.001	<.001
WL	1	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Group.WL	1	<.001	**0.762**	0.012	<.001	<.001	**0.117**	**0.122**
Stage.WL	2	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Group.Stage.WL	2	0.153	0.405	<.001	0.249	<.001	<.001	0.228

ANOVA indicated that there was a significant difference between the three growth stages, two water levels, and cultivar groups for almost all evaluated variables except for stomata conductance between groups.

Water requirement for *S. aethiopicum* shum and gilo at different stages (1-Seedling stage, 2-Vegetative stage, and 3-Flowering stage)



- A significant difference was observed in how both groups respond to drought at different stages.
- The vegetative stage had the highest water requirement and highest wilting score over few days; six days for Shum and five days for Gilo.

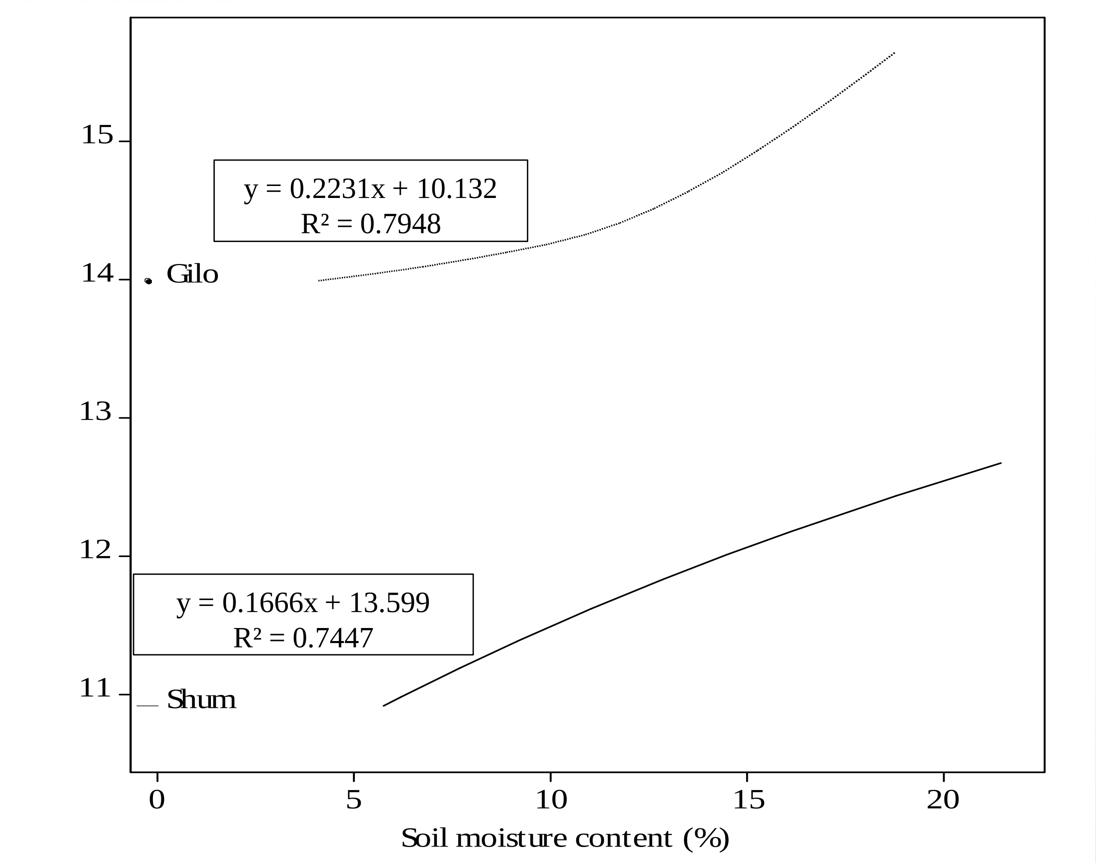
Correlation between evaluated yield and drought tolerance indicator traits at vegetative stage

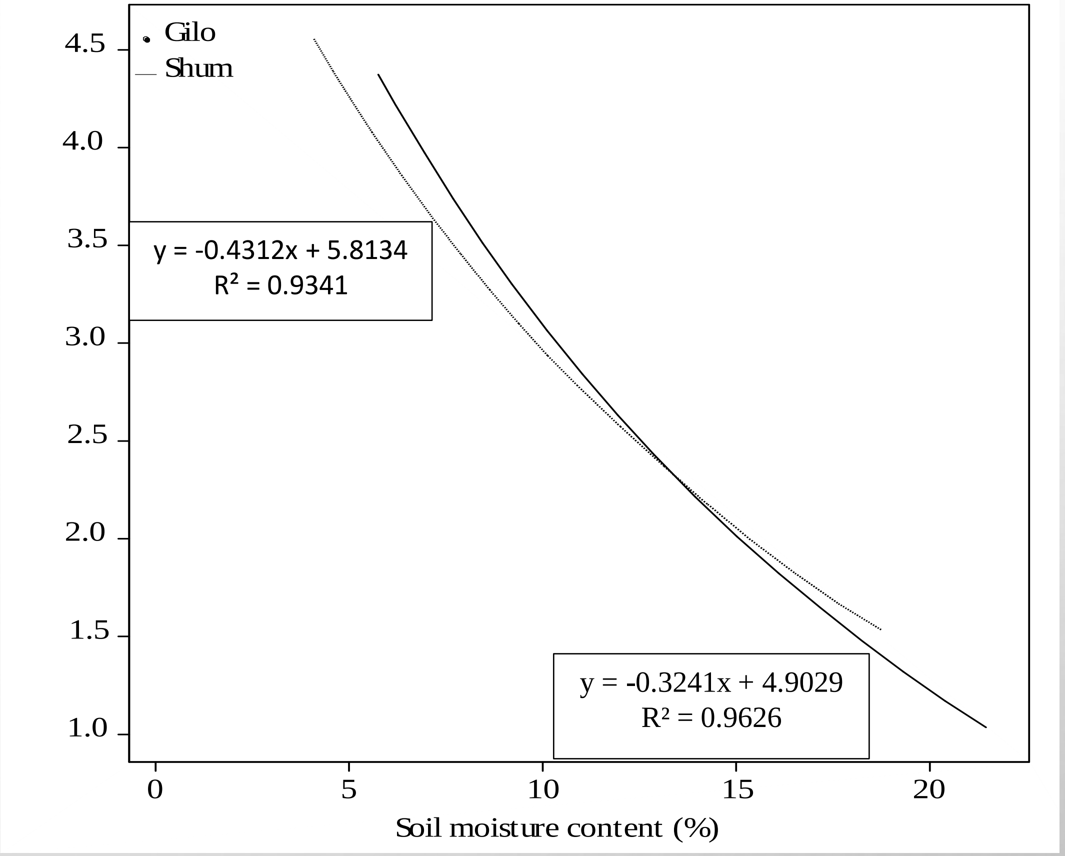
	LBL		LBW		LA		LPP		LWS		CHL		SMC	
	Shum	Gilo	Shum	Gilo	Shum	Gilo	Shum	Gilo	Shum	Gilo	Shum	Gilo	Shum	Gilo
LBL	1.000	1.000												
LBW	0.997	0.984	1.000	1.000										
LA	0.975	0.981	0.978	0.948	1.000	1.000								
LPP	0.809	0.983	0.821	0.958	0.806	0.971	1.000	1.000						
LWS	-0.804	-0.863	-0.828	-0.797	-0.883	-0.915	-0.665	-0.925	1.000	1.000				
CHL	-0.750	-0.558	-0.721	-0.593	-0.696	-0.423	-0.554	-0.619	0.461	0.437	1.000	1.000		
SMC	0.928	0.904	0.934	0.867	0.933	0.917	0.759	0.966	-0.881	-0.975	-0.809	-0.611	1.000	1.000

LBL-leaf blade length, LBW-leaf blade width, LA-leaf area, LPP=Number of green leaves per plant, LWS-Leaf wilting score, CHL-Chlorophyll, SMC-Soil moisture content

Both negative and positive strong correlations were observed among all evaluated traits. Basing on relationship between soil moisture content and all the other evaluated traits, some traits were selected for further analysis.

Results





Relationship between leaf blade length and soil moisture content (left) and the relationship between leaf wilting score and soil moisture content (right) for *S. aethiopicum* Shum and Gilo at vegetative stage

Discussions - Effect of drought at different stages

- The significant differences imply that the response of *Solanum aethiopicum* to drought is dependent on the stage of growth and group.
- Different growth stages have different water requirements therefore drought tolerance of these plants at one developmental stage does not predict tolerance of the same plant at another developmental stage.
- This also met that despite the fact that the evaluated *S. aethiopicum* groups are from the same species, they may have different adaptive strategies to drought.

- Basing interactions as reported significant by Sseremba et al., 2018, not all evaluated variables exhibited significant differences with group x water level interactions.
- In response to drought stress, the evaluated traits were significantly constrained at vegetative stage compared to seedling and flowering stage for both groups. This may be attributed to the rapid metabolic processes such as photosynthesis. Plants tend mobilize food and energy in preparation for the next developmental stage of flowering.
- A reduction in evaluated traits confirms the results obtained in sesame by Boureima and Collegues, 2012. This is because as drought stress increases, the stomata will close as a mechanism to reduce metabolism thereby resulting into un-sustained photosynthesis.

- The number of green leaves reduced due to the wilting effect which in a long run causes the leaves to dry and drop off. Leaf length and leaf width reduces due to the loss of cell turgor (Jaleel et al., 2009) and hinderance in cell division.
- Usually, the amount of chlorophyll reduces with increasing stress (Bansal *et al.*, 2016; Zu et al., 2017).
- This study the amount of chlorophyll exhibited a different pattern as it increased with increased drought stress which agreed with the results reported by Khayatnezhad (2011) and Alaei (2011) in wheat genotypes.
- This may also be attributed to the physiological change of converting chlorophyll a to chlorophyll b which is a better at tolerating dry conditions (Fani, 2012). This can further be explained by the effect of heat shock proteins.

Response of shum and gilo to drought stress

- There was a significant difference in how *Solanum aethiopicum* gilo and shum respond to drought.
- Gilo was observed to be more drought sensitive compared to shum as it attained a highest mean of leaf wilting score and lowest soil moisture content in fewer days (5) as compared to shum.
- There was a more significant difference in leaf blade length compared to leaf blade width based on group x water level interactions. This was contrary to the finds from the previous study on shum group as leaf blade width was more correlated to leaf size (Nakanwagi et al., 2018).

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- These results suggest that while leaf blade width can be a basis for determining leaf size in shum, leaf blade length is more appropriate for gilo.
- Despite the fact that the two groups are close relatives from the same species, it is evident that they use different avoidance approaches of managing drought stress (Ali *et al*., 2013).
- Their differences could also be attributed the drought resistance genes present on both groups.
- It is normal for plants under stress to maintain their metabolic and structural capacity. In the venture to do so, plants tend to modify gene expression accordingly.

Conclusion

- Both groups used in the study showed good ability to withstand drought stress. However, the shum group's ability to withstand drought superseded that of gilo.
- Although differentiation between the two groups was based on the vegetative stage, it is important to note that the traits that are crucial for drought screening in *Solanum aethiopicum* groups may be different.
- Therefore, this study provides breeders with information concerning the most probable source of drought tolerance genes as well as the most appropriate stage for screening for drought tolerance.
- This study also provides farmers with alternative crops to grow during the drought seasons since consumers of gilo and in most cases the same consumers of shum.

Acknowledgment

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Pictures

Effect of water deficit on shum (left) and gilo (right) at vegetative stage