Characterization of Selected Sorghum (*Sorghum bicolor* L. Moench) Genotypes for Tolerance to Aluminium Toxicity

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Introduction

- Development of Aluminium tolerant Sorghum (*Sorghum bicolor* L. Moench) genotypes is important resilience of crops in acidic soils to withstand are cultivated largely for its Kernel
- Sorghum is a crop grown in hot environments with a wide range of well aerated soil types with pH range of 5.5-8.5 (Balole and Legwalia, 2006)
- The toxic Al^{3+} inhibits root cell division, elongation and membrane permeability in acidic soils (pH<5.0)(Kamparath,1980)
- There is reduced absorption of water and nutrients by plants leading to poor kernel yield and quality (Samac and Tesfaye, 2003; Duncan *et al.*, 1980)
- Growing of Sorghum tolerant genotypes is convenient method to reduce damage caused by acidic soils
- Liming of soils to reduce acidic effects is costly and not sustainable in long run (Kisinyo *et al.*, 2013)
- It is important to screen and identify Al tolerant genotypes in order to improve sorghum production

Objectives

Overall:

To evaluate sorghum genotypes for tolerance to Al toxicity and contribute to the improvement of resilience and high yield production

Specific:

- To identify sorghum genotypes tolerant to Al toxicity using morphological traits

Materials and methods

- A total of 14 farmer preferred sorghum genotypes with a check were screened for Al tolerance
- Nutrient solution screening and phenotypic characterization of selected genotypes were carried out in botany laboratory university of Eldoret (0^0 34'N, $35^0$18' E)
- Genotypes were laid down in a Randomized Completely Block Design (RCBD), replicated twice with 2 levels of Al : 0 and 148µM

- Seeds were thoroughly sterilized with 1% sodium hypochloride (NaOCl) and dH_2O
- Sterilized seeds were pre-germinated in moistened paper towels at 26 ^oC
- After 4 days, seedlings were evaluated on the basis of Initial Root Lengths (ISRL) and transferred to Maganavaca basal screening solution pH 4.2 (1987)
- Al was added to half of the trays and seedlings allowed to grow for 5 days in growth chamber before measuring the Final Root Lengths (FSRL)

Materials and Methods

- ISRL and FSRL were used to compute Net Seminal Root Length (NSRL),

NSRL= *Final seminal root length- Initial seminal root length.*

- Relative Seminal Root Length (RSRL) = $\frac{Net\ seminal\ root\ lenght\ of\ Al\ treated}{Net\ seminal\ root\ lenght\ of\ control} \times 100.$
- Root Tolerance Index (RTI) : $= \frac{Final\ Root\ lenght\ of\ Al\ treated\ roots}{Final\ Root\ lenght\ of\ control\ plant}$
- and % Response to Al $= \frac{Root\ lenght\ of\ control\ plants - Root\ lenght\ Al\ treated\ plant}{Root\ lenght\ of\ zero\ Al\ (control)\ plant} \times$ 100.

Data analysis

- Means for NSRL, RSRL, RTI and % Response to Al were computed and subjected to Analysis of Variance (ANOVA).
- Means were separated using Duncan's Multiple Range Test at 5% level of significance

Results and Discussion

Results obtained revealed that genotypes Gadam, Wagita and IS 41764 were tolerant, Macia and Kiboko local 2, moderately tolerant while 9 genotypes were sensitive (Table 4.1)

Table 4.1: Effects of Aluminium (148µM) on root development of sorghum genotypes.

Genotype	**NSRL**	**RSRL**	**RTI**	**% Response**	**Tolerance status**
Kari Mtama 1	1.39 bcd	32.02 a	0.655 a	68.0 e	Sensitive
IS 8193	0.47 a	33.91 ab	0.615 a	66.05 e	Sensitive
Seredo	1.09 bc	34.31 ab	0.675 ab	66.65 e	Sensitive
Serena	1.38 bcd	50.13 abc	0.755 abc	46.90 cde	Sensitive
Gadam	2.61 e	88.14 d	0.95 cd	16.37 a	Tolerant
E 1291	1.11 bc	37.32 ab	0.625 a	62.70 de	Sensitive
E 6518	0.43 a	35.72 ab	0.75 abc	64.30 de	Sensitive
Macia (SDS 3220)	1.53 bcd	54.94 bc	0.84 abcd	41.05 bc	Moderately Tolerant
Makueni Local	1.21 bcd	49.12 abc	0.765 abc	42.90 bcd	Sensitive
IS 41764	1.74 d	82.95 d	0.935 bcd	17.05 a	Tolerant
Wagita	1.71 d	96.72 d	1.085 d	22.25 ab	Tolerant
Kiboko Local 2	1.62 cd	59.41 c	0.825 abc	37.65 bc	Moderately Tolerant
Nakhadabo	1.10 bc	49.39 abc	0.67 ab	50.60 cde	Sensitive
Tegemeo (2KX17/B/1)	0.98 b	45.05 abc	0.685 abc	54.95 cde	Sensitive
Grand mean	**1.312**	**53.5**	**0.774**	**46.9**	
C.V %	**17.7**	**16.5**	**14.1**	**19.3**	
S. E	**0.232**	**8.82**	**0.1094**	**9.06**	

Results and Discussions

- Effects due to Genotypes were significant (P <0.001) for NSRL, RSRL and % Response and significant (P<0.05) differences for RTI

- Significant decline on Net root length at Al of 148µM compared to controls indicated the persistence of Al toxicity as a major limiting factor to sorghum root growth

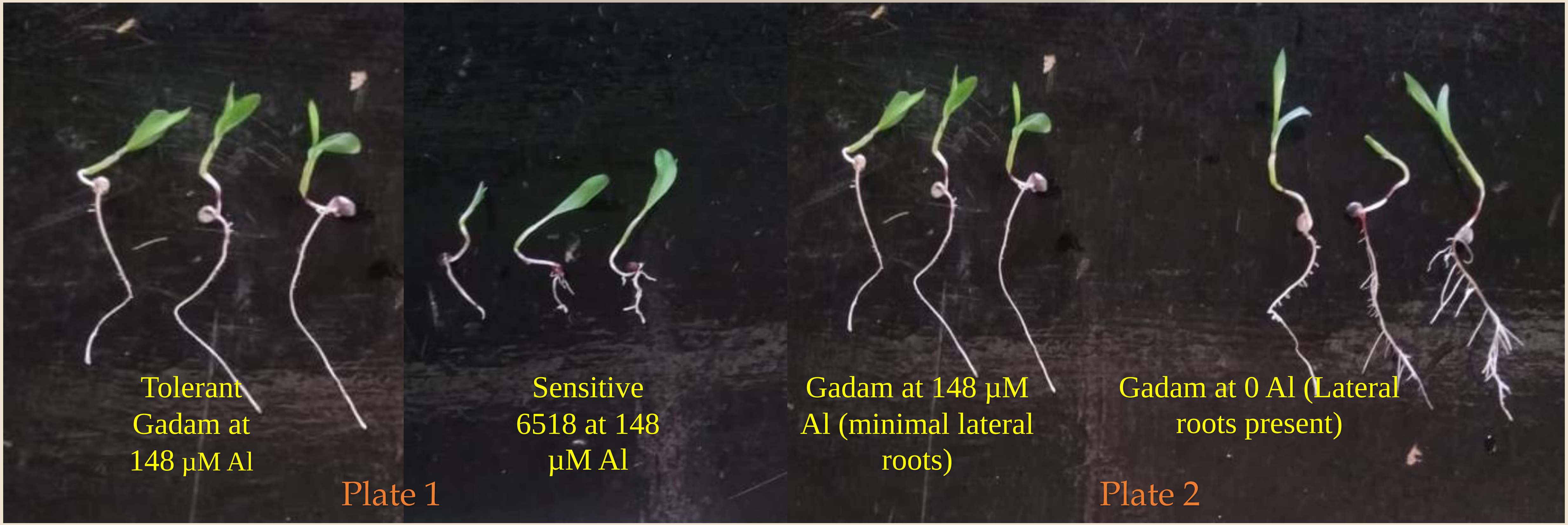
- Genotype *Gadam* outperformed the tolerant check (IS 41764) and differed significantly from other genotypes

- *Wagita* had significantly higher RTI indicating its possibility to tolerate Al level higher than 148µM
- Genotypes *IS8193*, *E6518* and *Tegemeo* were noted to be highly sensitive to 148µM level of Al. They performed poorly as compared to *Seredo* (Based on NSRL)

Results and Discussions

- Most sensitive genotypes had their roots short and stubby
- Considerable reduction on root lateralization was observed in both tolerant and sensitive genotypes
- Cereal species employ the efflux of organic acids as a strategy to tolerate Al toxicity (Ryan *et al.*, 2009)
- Tolerant Sorghum genotypes have been found to produce high volumes of citric and malic acids (Magalhaes *et al.*,2007)
- As toxic levels of Al increases, Tolerant sorghum genotypes produce more of organic acids
- Organic acids alter membrane functioning and intensified oxidative stress (Jones *et al.*, 2006)
- Such biological root cells adjustments result into poor absorption of water and nutrients that eventually lowers sorghum yield and grain quality

Results and Discussions



Conclusion and/Recommendations.

- This study showed that Genotypes *Gadam* *Wagita* were tolerant to Al toxicity in acidic soil
- Al toxicity reduced root development and growth in sensitive genotypes
- The study revealed high genetic potential for Al tolerance sorghum genotypes

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