Special session: ***Progress in plant ecology and vegetation science research in Africa***

COMPARATIVE ASSESSMENT OF THE RESPONSE OF SEEDLINGS FROM DIFFERENT PROVENANCES OF TETRAPLUERA SPECIES (AIDAN TREE) TO DROUGHT

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Introduction

- The *Tetrapleura* species are leguminous tropical rainforest tree species of the Fabaceae family. They are *Tetrapluera tetraptera* (Schum. & Thonn.) Taubert and *Tetrapluera chevalieri* (Harms) Baker F. (Hawthorne and Gyakari, 2006).

- They are of significant nutritional and medicinal benefits to local communities throughout Africa especially in Ghana and elsewhere in the tropics (Uyoh et al., 2013).

- The species attracted scientific interest because of its medicinal properties (Hawthorne, 1995).

Background

- Tropical forests are faced with changing trends in climatic conditions. More intense and extreme events are anticipated.

- Seedlings communities are vulnerable to drought and consequently affect forest regeneration and species assemblages (Song et al., 2016).

- Species respond differently to drought and other environmental stresses

- They develop mechanisms to either cope or die.

Background cont.

- Strategies plants exhibit to withstand drought.
  - ❖Drought avoidance
  - ❖Drought tolerance
  - ❖Drought delay
  - ❖Drought escape
  - ❖Drought recovery

- Strategies not mutually exclusive. Some plants may combine strategies under drought conditions (Guo et al., 2017)

Background cont.

- Growth productivity trade-off theory: Woody plant species have the ability to tolerate and survive dry conditions at the expense of a normal growth describes one main strategies adapted when plants are stressed (Amissah *et al.*, 2018; Maseda and Fernandez, 2016).

- Optimal allocation theory: Plants apportion biomass differentially to different organs in response to resource deficiency (Amissah *et al.,* 2015; Maseda and Fernandez, 2016, Medeiros *et al.,* 2016).

Problem statement

- The species are threatened by overexploitation, wildfire, tropical deforestation and poor natural regeneration (Omokhua and Aigbe, 2015).

- In addition to the above, there is uncertainty as to how this species will respond to climatic extremes such as drought

- Given the projected increase in drought frequency and intensity, there is the need to understand how;
  - ❖ drought will affect the morphology and performance of *Tetrapleura* seedlings.
  - ❖ different provenances response to drought to aid in the selection of the right provenance for *Tetrapleura* species plantation.

Aim

- The overall aim is to examine how selected traits (LMF, SMF, SSL, SLPM, RMF, SRL, RLPM) explain the performance of *T. tetraptera* and *T. chevalieri* seedlings under extended dry conditions.

Specific Objectives

1. To determine the effects of drought on the survival and growth of *T. tetraptera* and *T. chevalieri* seedlings from different provenances.

❖ H_o: Reduced water availability will reduce survival and growth of plants especially those from the wet areas.

2. To determine the effect of drought on morphology and biomass allocation of the *T. tetraptera* and *T. chevalieri* seedlings.

❖ H_o: Seedling growing in limited water will allocate more biomass to root compared to those being watered

Methodology: Seed sources

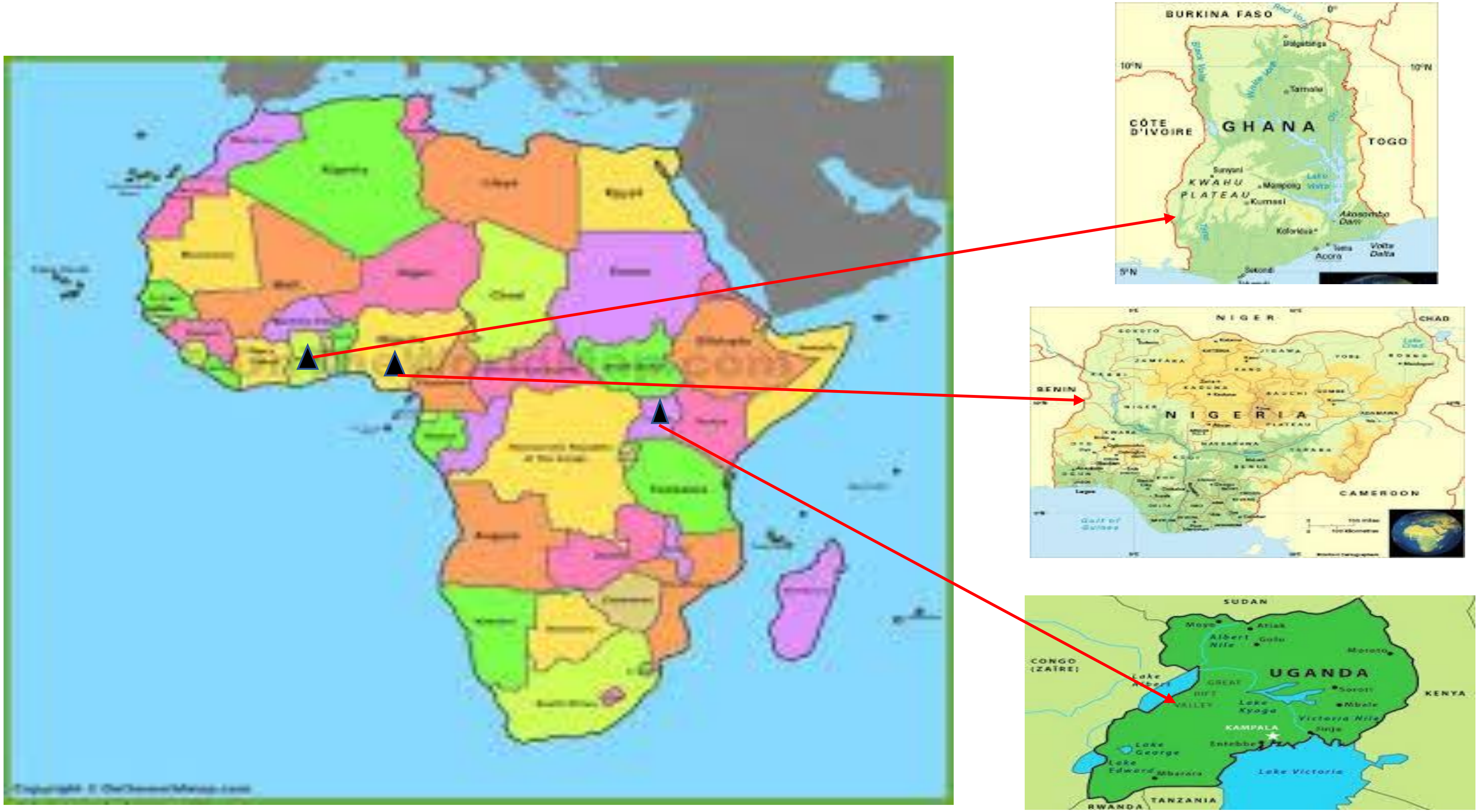


Fig. 1 Map of Africa showing the various seed sources

- 6 provenances of *T. tetraptera* and 1 provenance of *T. chevalieri* species
- 1 provenance of *T. tetraptera* species
- 4 provenances of *T. tetraptera* species

METHODOLOGY

- Germination was done in bowls at Mesewam research nursery and transported to a shade-house at CSIR-FORIG.

- Shade-house conditions
  - ❖Temperature- 25.8◦C
  - ❖Humidity- 69.53

- The seedlings were potted, watered and left to acclimatize until they were four months old.

Methodology

- Treatments: Based on 3 watering frequency
  - ❖Well watered (field capacity), Partially watered and no watering
- Seedlings: Total of 528 seedlings
  - ❖8 seedlings from 12 provenances were harvested (Initial)= 96
  - ❖12 seedlings from 12 provenances per treatment (12*12*3) =432
- Experimental design
  - ❖Completely Randomized Design
- Duration
  - ❖11 weeks (First week of August 2017 to third week of October 2017).

Data collection

1. Growth measurement - Weekly
    - ❖Diameter using a digital caliper
    - ❖Height using a ruler
    - ❖Number of leaves were counted.

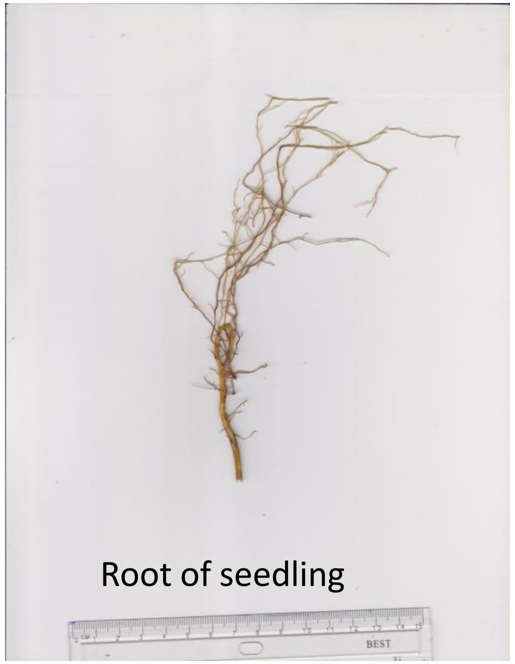
2. Environmental monitoring - Daily
    - ❖Light intensity
    - ❖Humidity
    - ❖Temperature

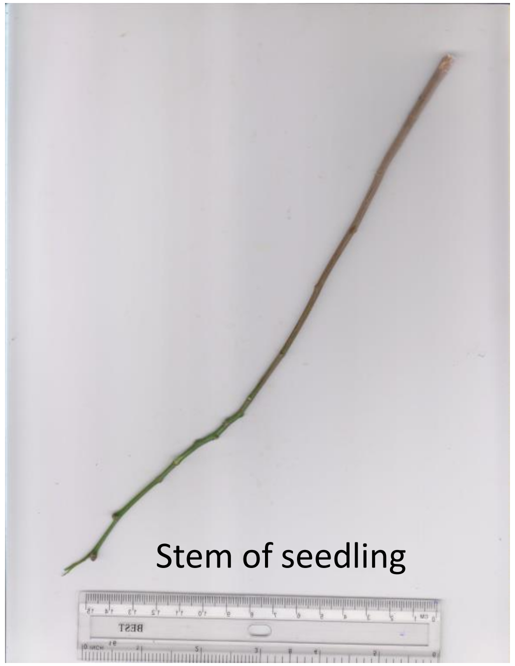
Data collection: Trait Description

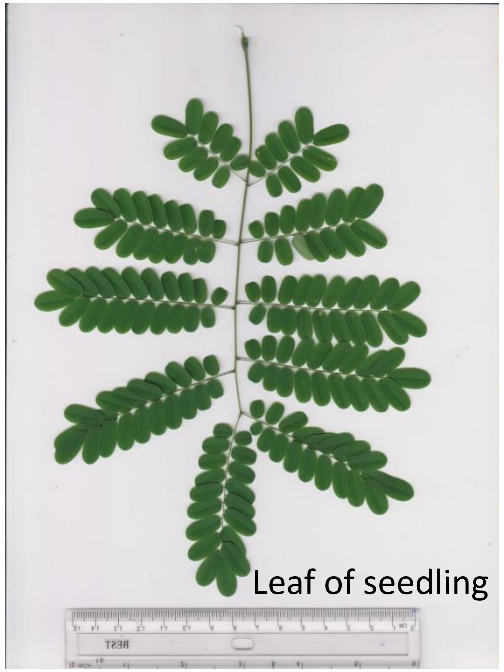
TRAIT	DESCRIPTION	Abbreviation	Unit
Leaf Mass Fraction	leaf mass divided by plant mass	LMF	$g\ g^{-1}$
Stem Mass Fraction	stem mass divided by plant mass	SMF	$g\ g^{-1}$
Root Mass Fraction	root mass divided by plant mass	RMF	$g\ g^{-1}$
Specific Root Length	Total root length divided by root mass	SRL	$cm\ g^{-1}$
Specific Stem Length	Total root length divided by stem mass	SSL	$cm\ g^{-1}$
Stem Length per Plant Mass	Stem length divided by plant mass	SLPM	$cm\ g^{-1}$
Root Length per Plant Mass	Root length divided by plant mass	RLPM	$cm\ g^{-1}$

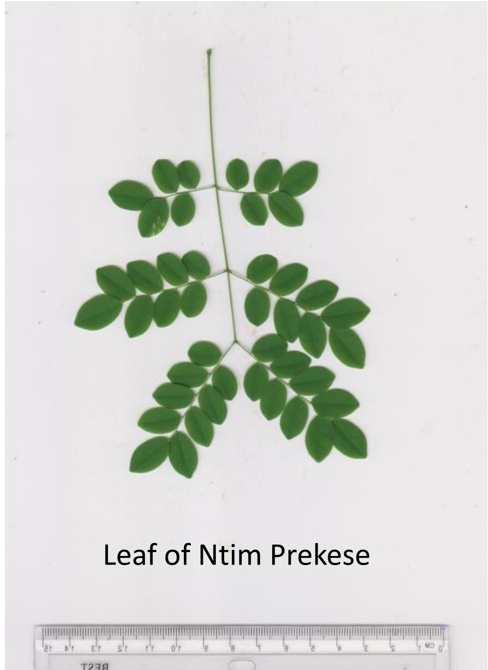
Data collection

3. Initial and final biomass harvesting
    - Separation of leaves, stem and roots.
    - Fresh and dried weights were recorded (oven-dried at 65 ± 2 ◦C for 48 hours).
    - Stem and root lengths were measured.


Root of seedling


Stem of seedling


Leaf of seedling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Data analysis

- Microsoft excel 2016 and SPSS Statistics 20.
- Checks for normality and stability of variance before analysis.
- Calculations were based on 8 replicate seedlings per treatment per provenance.
- Proportional traits were Arcsine transformed (LMF, SMF, RMF, RDMC, SDMC, LDMC).
- Remaining traits were log10 transformed (SSL,SRL, SLPM, RLPM).
- Total plant dry mass was used as a covariate to correct for ontogenetic effects due to variation in seedling size.

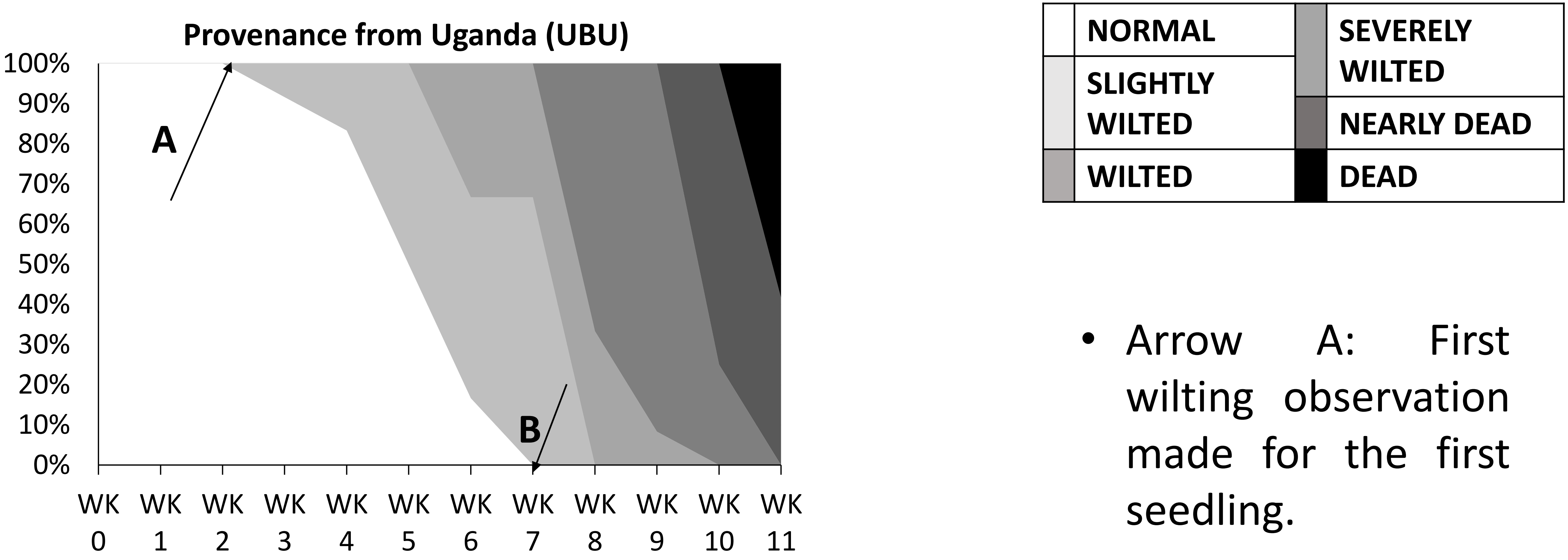
Statistical analysis

- Two-way ANCOVA was performed to evaluate the effects of provenance and water on relative growth rate.
- One-way ANCOVA was performed to evaluate the effects of water on morphological traits and biomass allocation.

RESULTS AND DISCUSSION

Seedling wilting progress after 11 weeks of drought

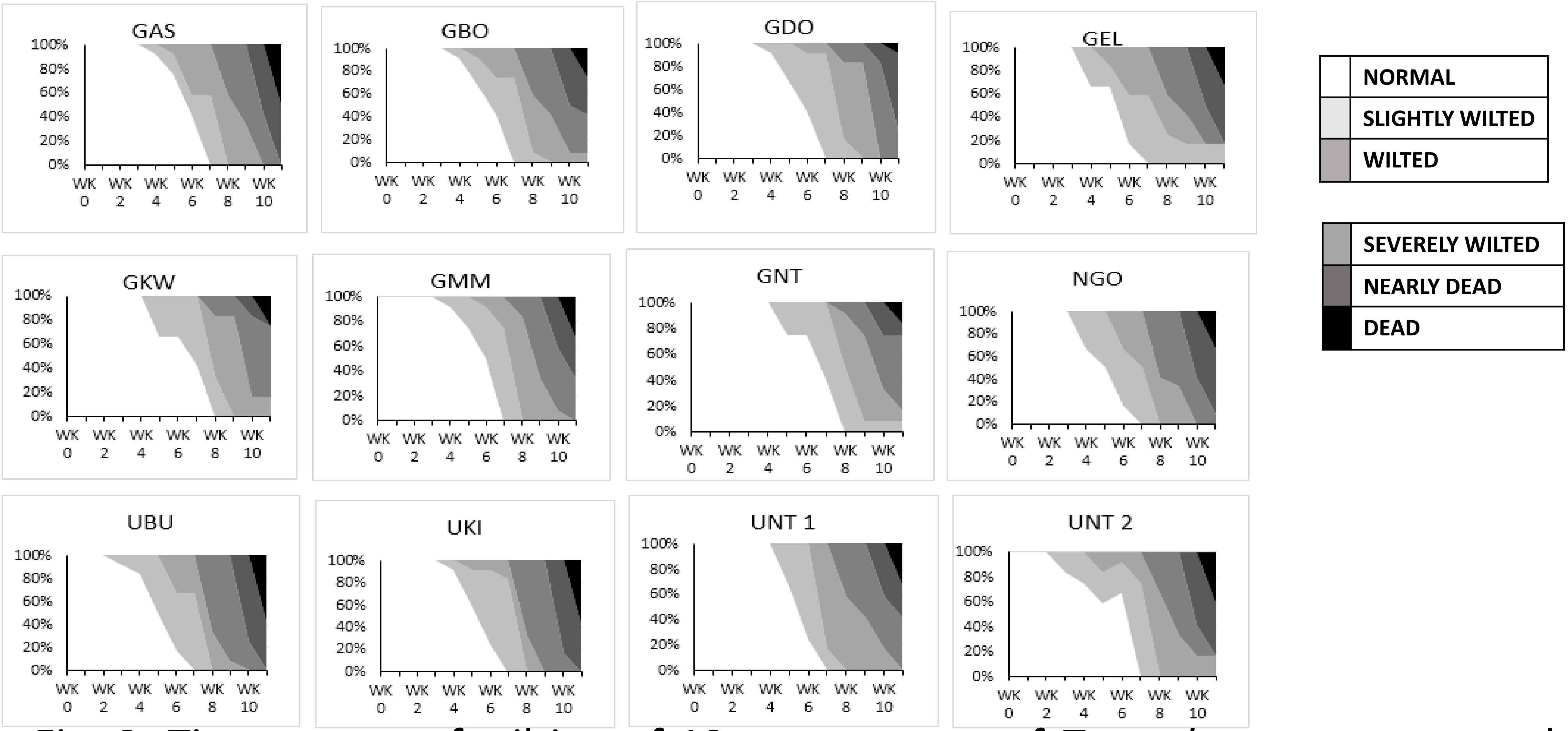
OBJ. 1: To determine the effects of drought on <u>survival</u>.



- Fig. 2: Time course of wilting of seedlings from Bunimwari exposed to 11-week drought.

- Arrow A: First wilting observation made for the first seedling.
- Arrow B: Week when all seedlings had shown wilting.

OBJ. 1: To determine the effects of drought on <u>survival</u>



- Fig. 3: Time course of wilting of 12 provenances of *Tetrapleura spp.* exposed to 11-week drought.

OBJ. 1: To determine the effects of drought on **survival**

- **Observation**: Different provenances / species vary slightly in their dehydration and survival response to drought.
- This could be attributed to -:
  - Tree position on rainfall gradient (Engelbrecht *et al.*, 2005).
  - Slow depletion of water in pot (Amissah *et al*., 2015).
  - Tendency to maintain stomatal conductance, hydraulic conductance, photosynthesis, and growth at lower soil water potentials (Mukeshimana *et al.*, 2014).

OBJ. 1: To determine the effects of drought on <u>survival</u>

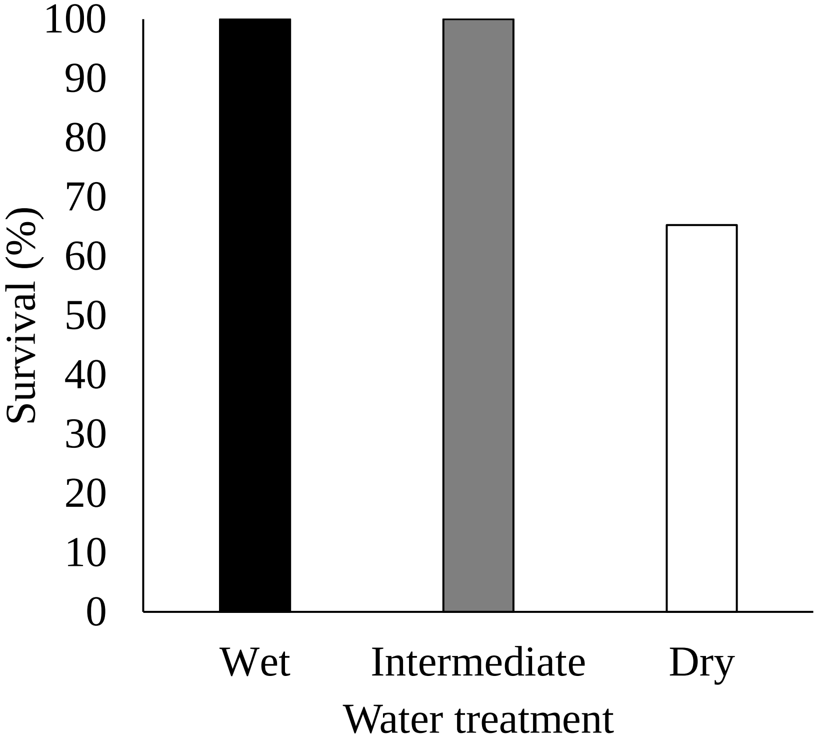


Fig. 4: Survival of Tetrapleura species in response to drought

- **Findings**: Low survival was recorded in the droughted seedlings (65%). 100% survival was recorded for the watered seedlings. Similar observations were made in Ghana (Amissah *et al*., 2015) and Panama (Engelbrecht *et al*., 2005).
- Seedling mortality during drought can occur both as a direct result of water stress.
- Drought can exacerbate the effects of non-drought factors such as pathogens, herbivores, etc.

OBJ. 1: To determine the effects of drought on **growth**

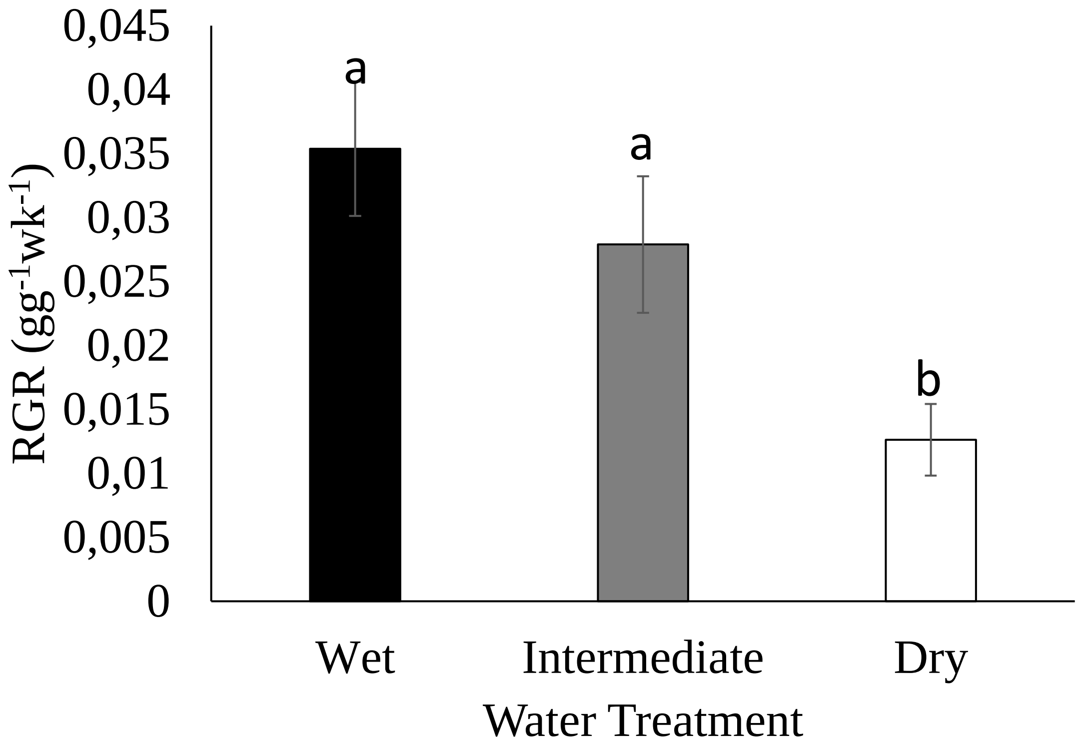


FIG. 5: Relative growth rate of Tetrapleura species in response to drought.

- **Findings:** Seedling growth rate was significantly reduced by drought because of lower water availability. Similar observations were made in Ghana (Amissah *et al*., 2018) and Panama (Bunker and Carson, 2005).

- This suggests that drought induced changes in water use, plant structure and even biomass production for seedlings (Appiah, 2003).

- It could also be attributed to reduction in photosynthesis and root respiration rate (Farooq et al., 2009; Mukeshimana et al., 2014)

OBJ. 1: To determine the effects of drought on **growth**.

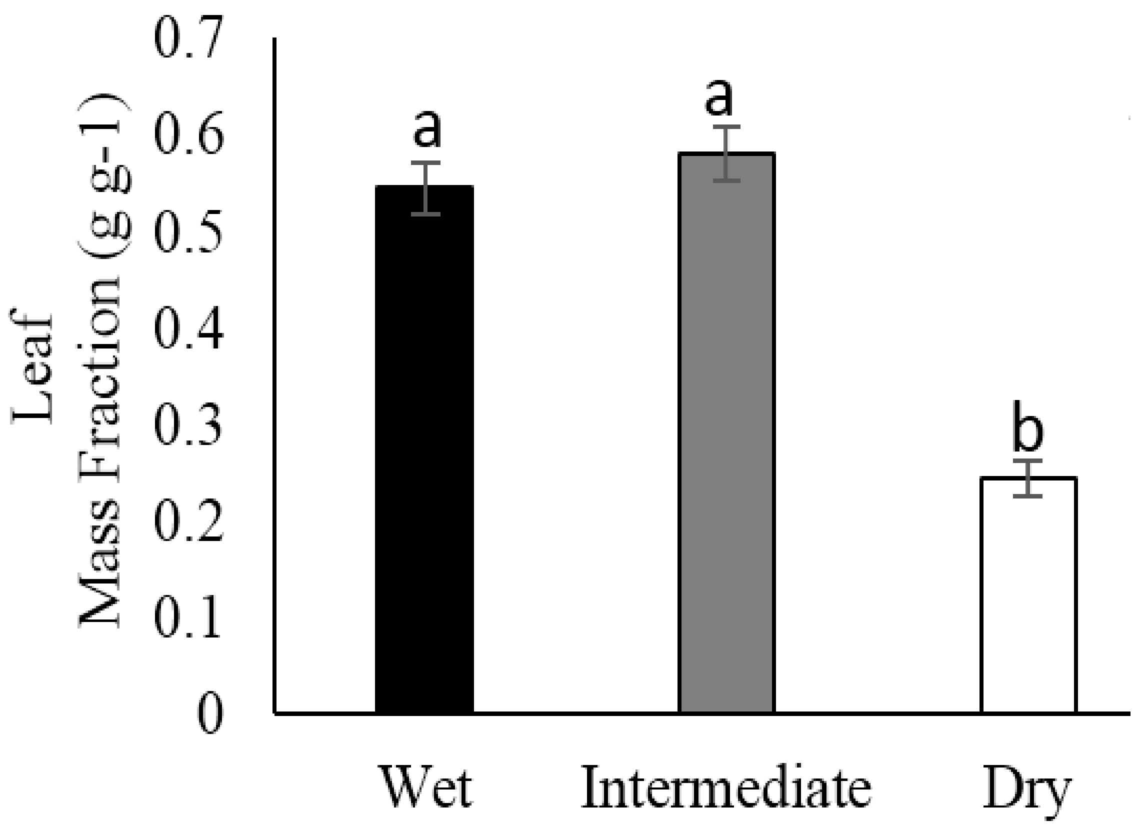


Fig. 6: Leaf production in Tetrapleura species in response to drought.

- **Findings:** Seedlings ceased to produce leaves in order to increase production of stem and root. Drought significantly reduced leaf production.

- Reduction in leaf production in the droughted seedlings affected photosynthesis and consequently growth (Guenni *et al.,* 2017, Farooq *et al.,* 2009).

OBJ. 1: To determine the effects of drought on **growth**

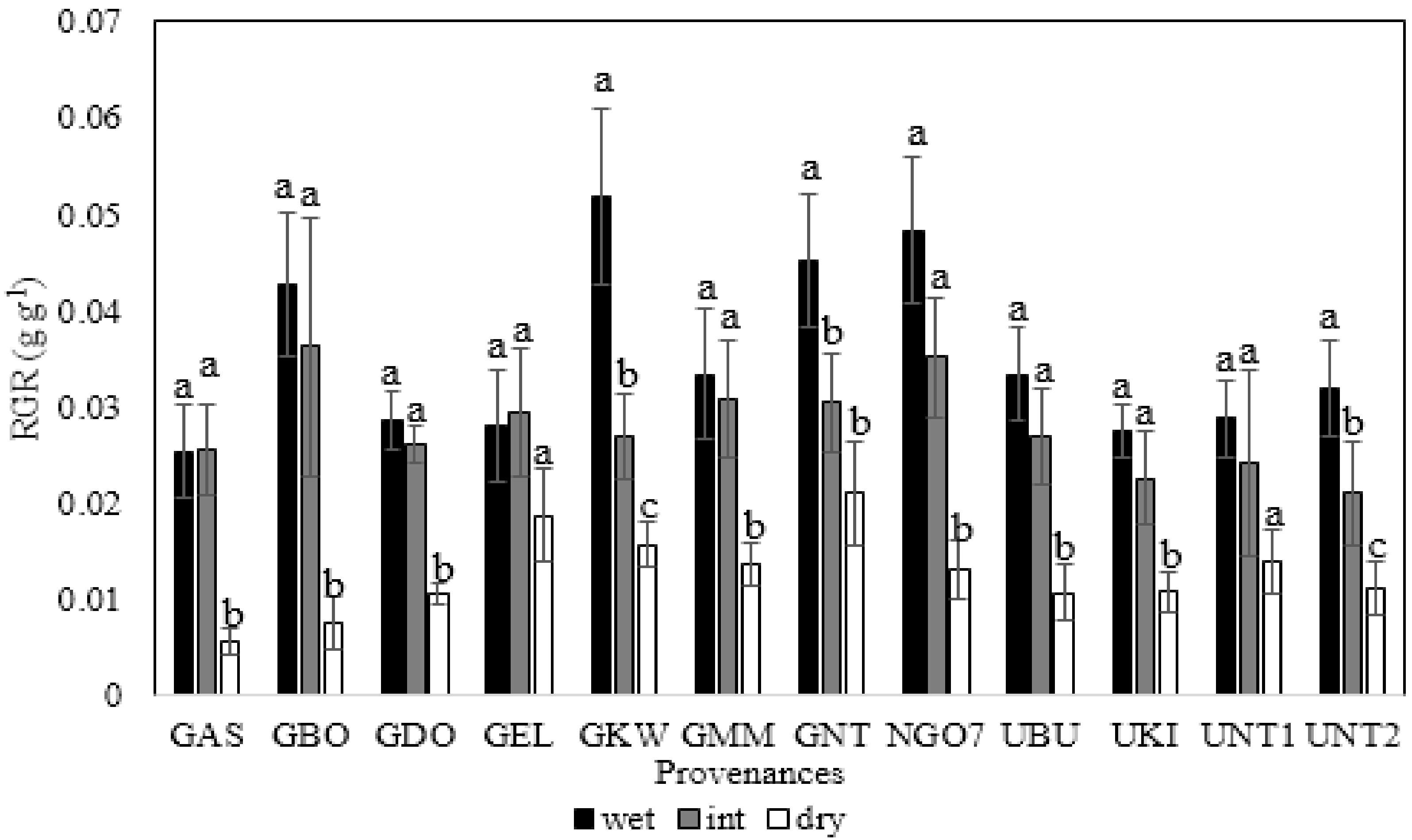


Fig. 7: Performance of individual provenances of *T. tetraptera* and *T. chevalieri* seedlings in terms of relative biomass growth rate (RGR) in response to drought.

- The results shows that drought had significant effect on the growth of all provenances except GEL and UNT1.

- This could be attributed to a more conservative water use strategy adapted by the seedlings (Koech *et al.*, 2016)

OBJ. 2: To determine the effects of drought on <u>biomass allocation</u>

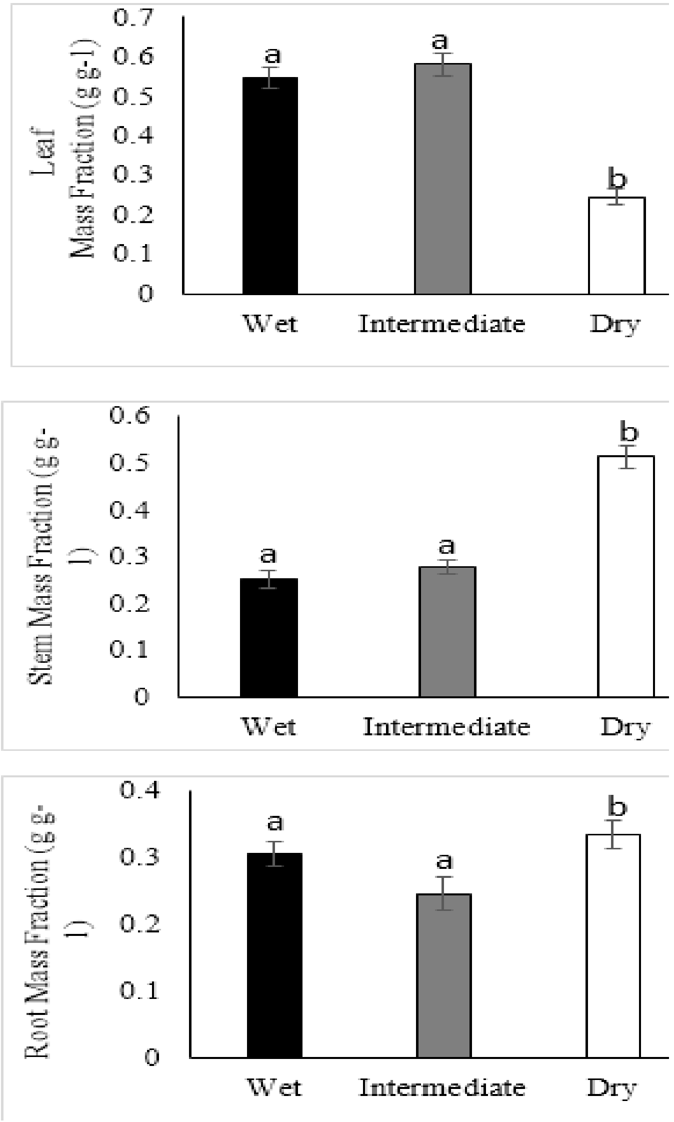


Fig. 8: Seedling responses to drought in terms of allocation

- **Findings**: Drought significantly affected biomass allocation pattern and morphology in *T. tetraptera* and *T. chevalieri* seedlings.
- Under drought condition, stem and root allocation increased at the expense of leaves.
- Higher biomass allocation to the exploitative root system through elongation or production of thinner roots to forage, capture and store available water (Amissah *et al*., 2015, Smedt *et al*., 2012)
- Higher allocation to stem is a strategy utilised by some Mediterranean species in arid conditions (*Hernandez et al*., 2010).
- Reduction in leaf mass fraction to reduce water loss through transpiration (Amissah *et al*., 2015).

OBJ. 2: To determine the effects of drought on morphology

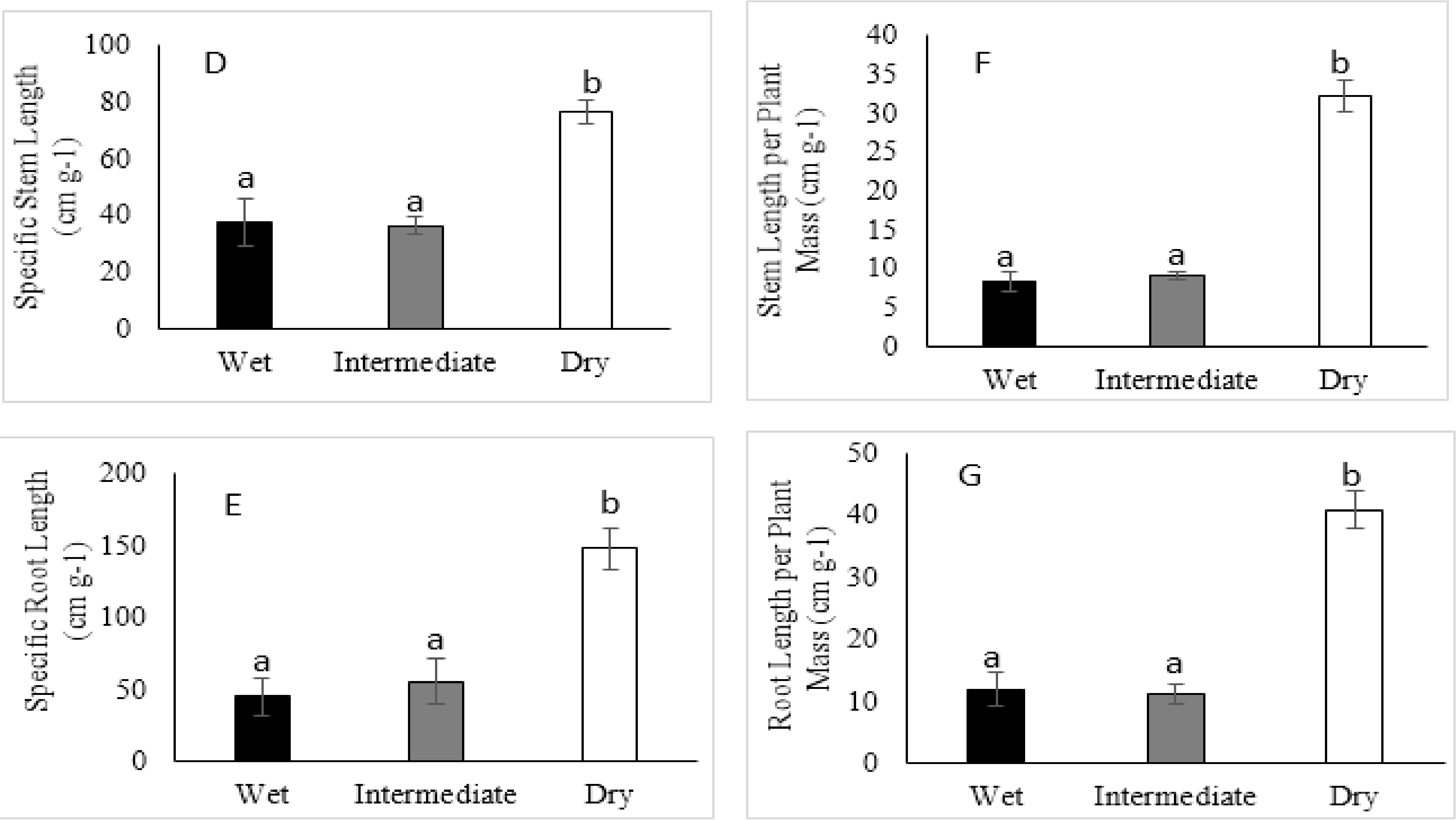


Fig. 9: Seedling responses to drought in terms of morphology

OBJ. 2: To determine the effects of drought on <u>morphology</u>

- Droughted seedlings had higher SRL but they did not produce roots with high RLPM on a whole plant level.

- Drought significantly affected SSL and SLPM at the whole plant level.

- Higher SRL increase plant root's efficiency to explore the soil for water and nutrients (Brunner et al., 2015)

- Increasing root length and biomass are essential for exploring the soil for water and nutrients.

Conclusion

- From the results, the research confirmed that reduced water availability reduces growth and survival of *T. tetraptera* and *T. chevalieri* seedlings.

- These species survived under low water availability by:
  - ❖ adjusting their morphology (increased Specific Root Length and Root Length per Plant Mass),
  - ❖increasing biomass allocation to roots (High RMF) to enhance water foraging and uptake and
  - ❖Reducing biomass allocation to leaves (low LMF) to reduce water loss.

- The results suggest that some evergreen species could potentially survive drought in future. Therefore, experiments could be conducted to screen some of these evergreen species to determine their drought tolerance.

- In the face of changing climate, mitigation efforts must be doubled to relieve the tropical forest of the anticipated loss of biodiversity and species richness. Globally rare *Tetrapleura chevalieri* among other species can be integrated in degraded forest enrichment programmes and on farmlands to broaden their resource base.

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