Maize yield under a changing climate in Uganda with impacts for Climate Smart Agriculture practices

Alex Zizinga (PhD)

Workshop

07. 06. 2023

INTRODUCTION

- Climate change is a major threat to food security and livelihood in most developing countries (IPCC AR6, 2022).

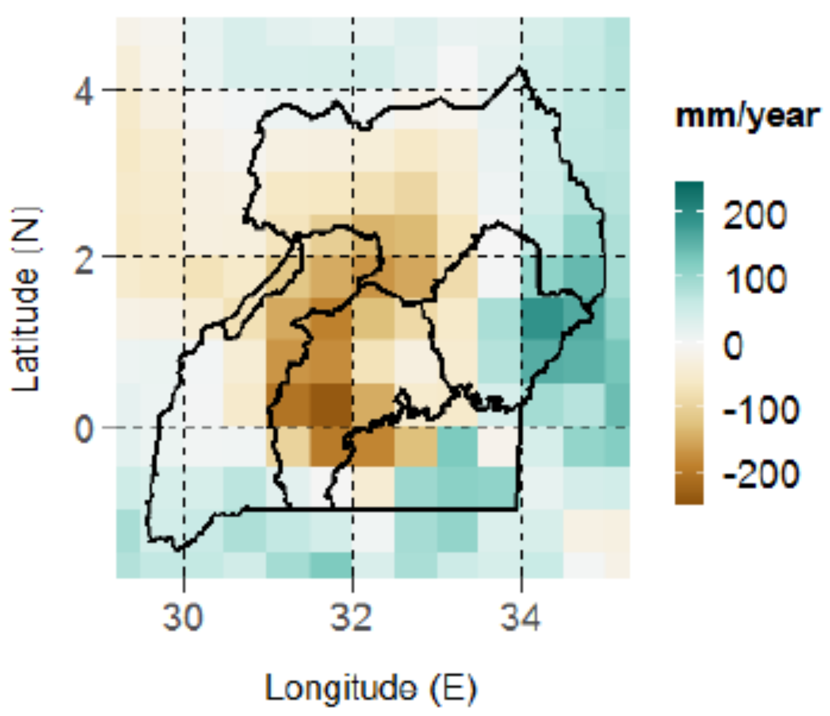
- Global temperature is expected to rise up to 5.8 ℃ by the year 2100 (Houghton *et al.,* 2001; Adhikari *et al.,* 2015).

- By 2050, crop yield will decrease by 20% globally & 50% in Africa.
  - Maize yield loss of up to 50% reported in East Africa due to water stress (Kaizzi et *al.,* 2012; Ongoma *et al.,* 2018).

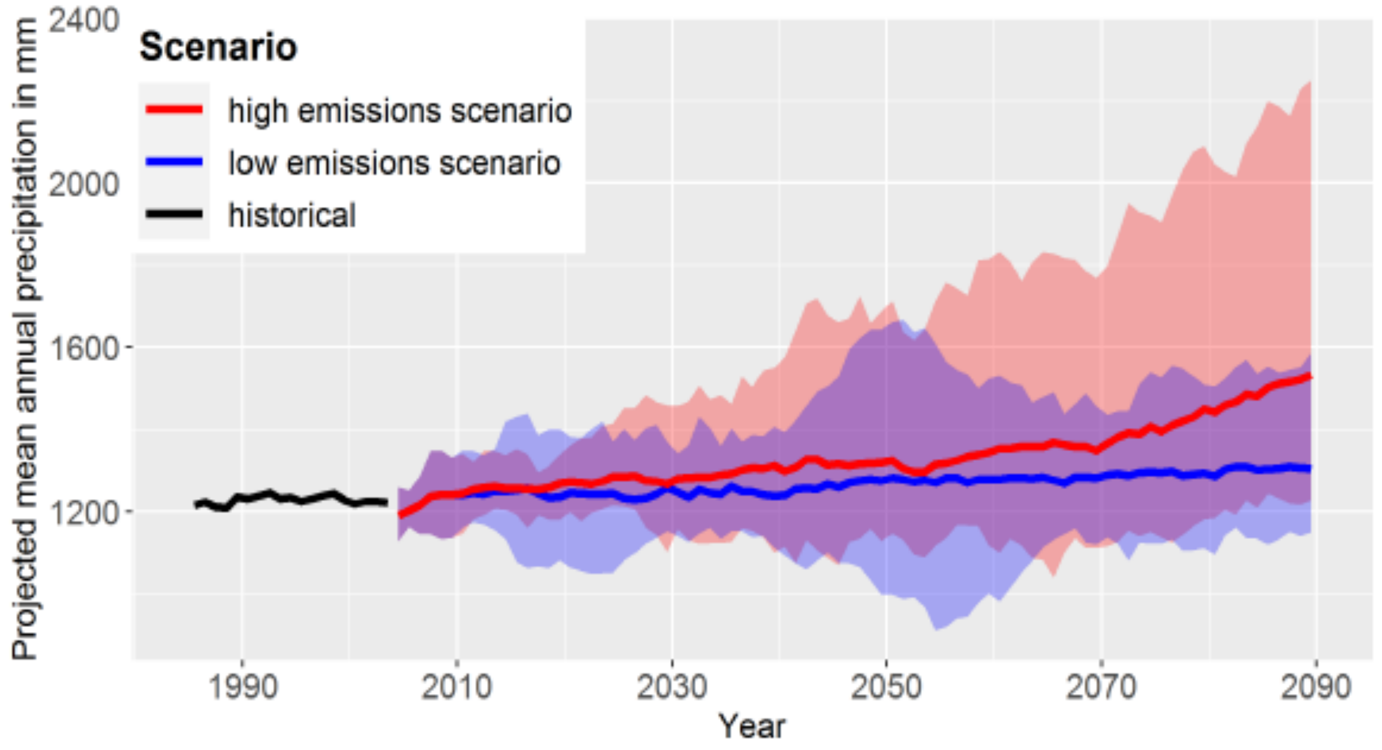
- Uganda is one of the countries that are most vulnerable to climate change impacts.
  - Agriculture is employs >80%, contributes 42% to GDP & accounts for >90% of export earnings (MAAIF, 2017; UBOS, 2019).

Source: Field photo 2020

Uganda's changing climate: Precipitation



Changes in mean annual precipitation in mm between 1979-1998 and 2000-2019



The 10-year moving average of historical and projected annual rainfall in mm per year

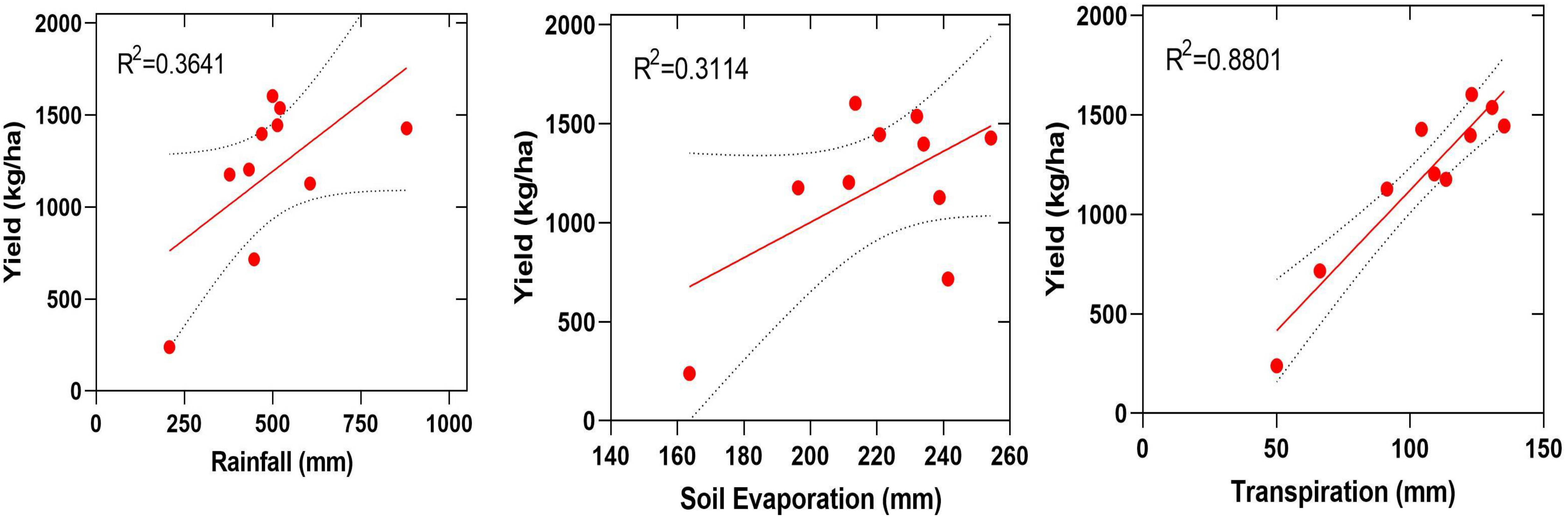
INTRODUCTION…

- Climate Smart Agriculture (CSA) has been recommended as a sustainable strategy of adapting agricultural production systems to CC (FAO, 2010; FAO, 2016).
  - Examples: Mulching (M), Permanent Planting Basins (PPB), Halfmoon pits (HM) and etc.

- CSA practices are rarely instrumented and assessed for soil water monitoring.
  - their potential have not been adequately assessed in arid, semi-arid and humid climates of Uganda.
  - future CSA practice performance is unknown.
  - Water is becoming a very limited resource in rainfed agriculture systems due to increasing competition (Fader *et al*., 2010; Xu *et al*., 2020; Chiarelli *et al.,* 2022).

- There is need for realistic, scientific and quantitative assessment to investigate CSA efficiencies in a changing climate on:
  - Addressing water shortage during crop growth as a result of rise in temperatures and anticipated climatic changes.
  - Enhancing soil moisture conservation, maize yield and water use efficiency.
  - Appropriate adaptation and mitigation strategies for the future climate.

CSA practices and role to improve maize yield



Chemura et al., 2023 (*In press*)……………Factors important in determining maize yields?

EXPERIMENTAL DESIGN

A completely randomized block design with eight replicates for two consecutive years (2019 to 2020).

Treatment description

- Control **(a)** – comprised of a bare surface field, which is a typical common conventional cultivation practice in the study area.
- HM **(b)** – digging 6 half-moon shaped pits measuring 30 cm deep, 50 cm wide and 100 cm circumference.
- PPB **(c)** – excavation of circular pits of 15 cm diameter at depths of 30 cm.
- Mulch **(d)** – obtaining of 2cm, 4cm and 6cm thickness of dry grass materials applied at planting.

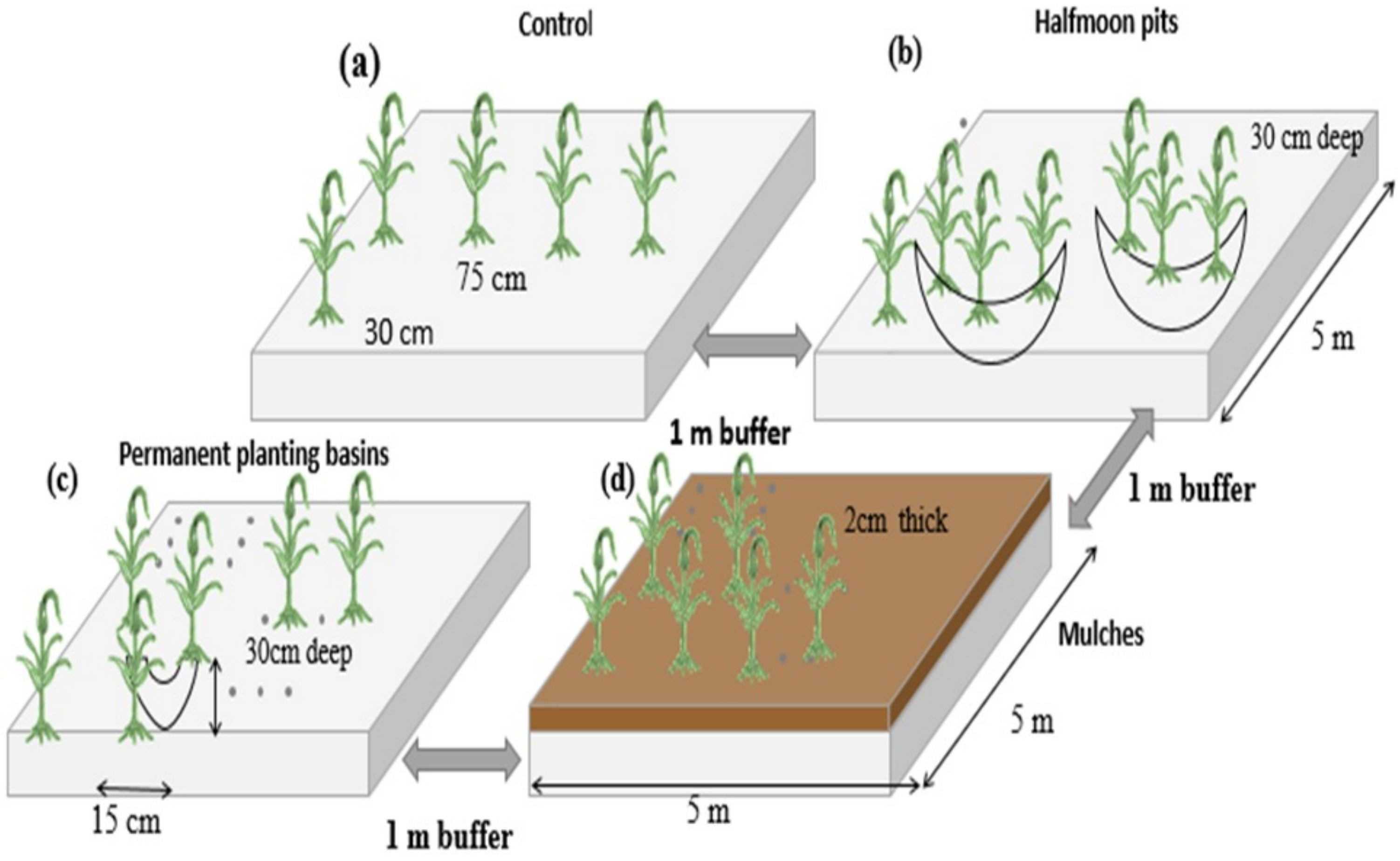


Fig. 3. Experiment layout

Comparaison for measured and simulated biomass

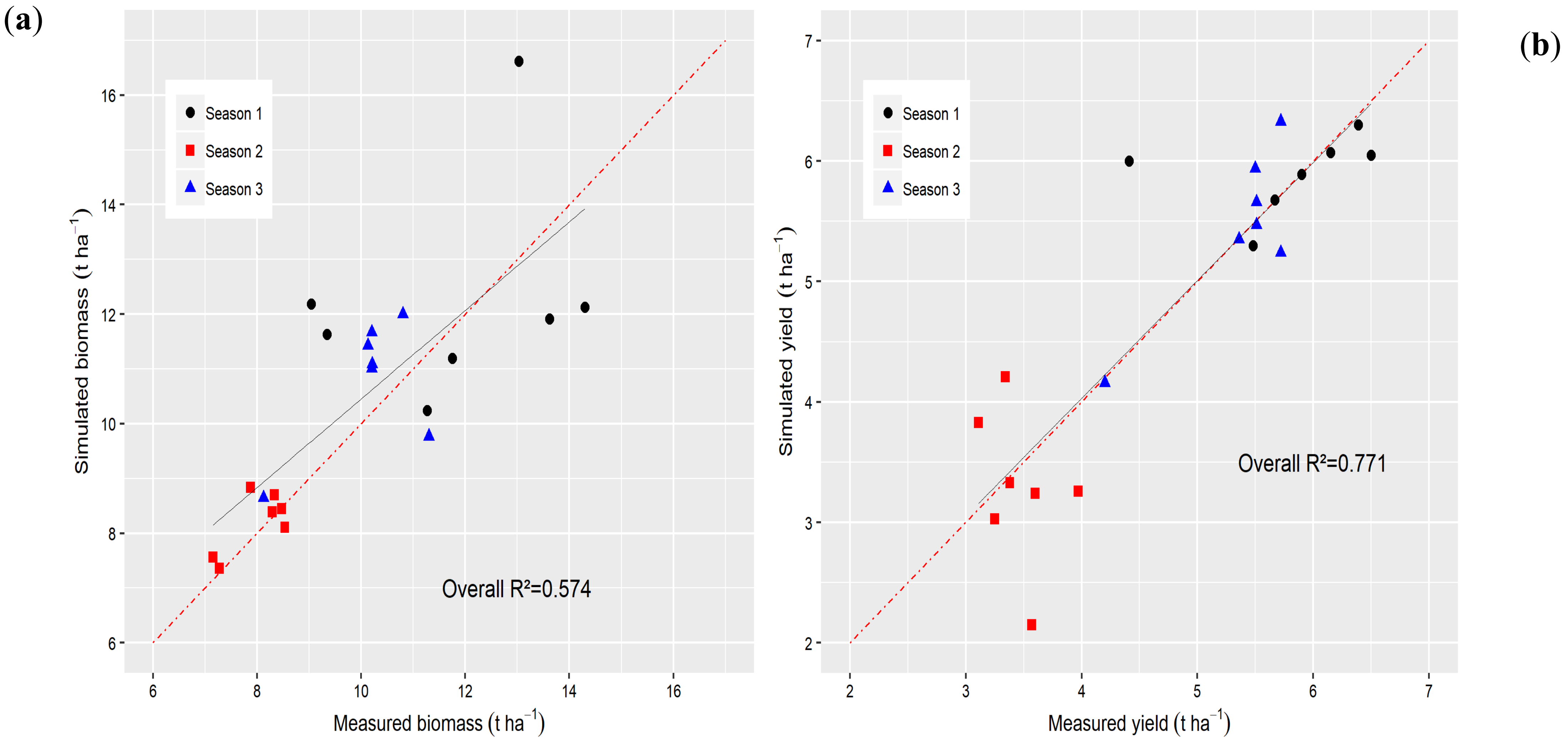


Fig 13. Relationship between measured and simulated maize biomass

GCM Models downscaled representing regional integrated climate change impacts on agriculture……AgMIP procedures

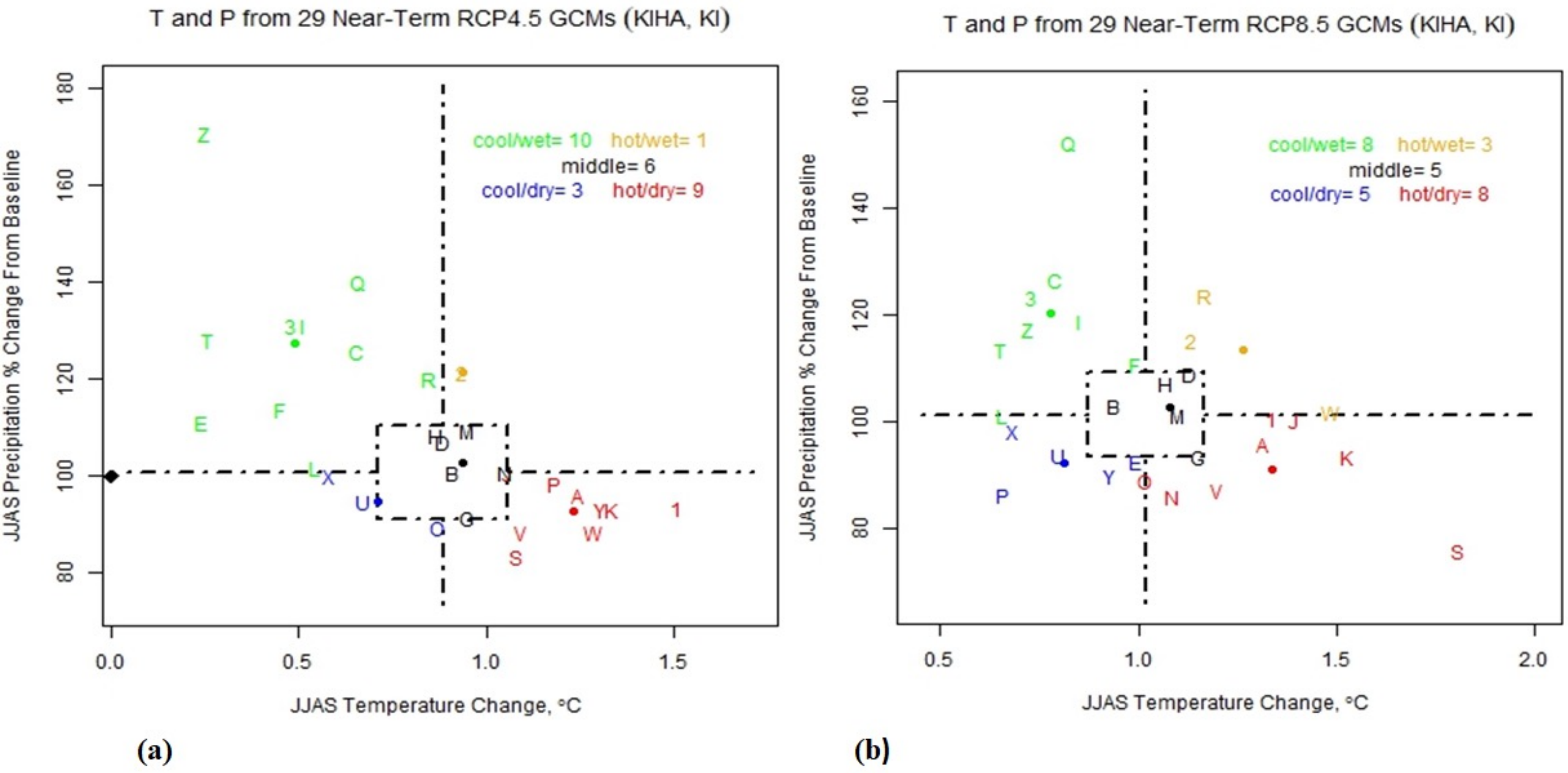


Fig. 14. GCMs model plot

The final selection of a GCM within a quadrant (climate regime) was done by first obtaining the average precipitation and temperature change for all the GCMs within the selected climate regime (marked with a dot).

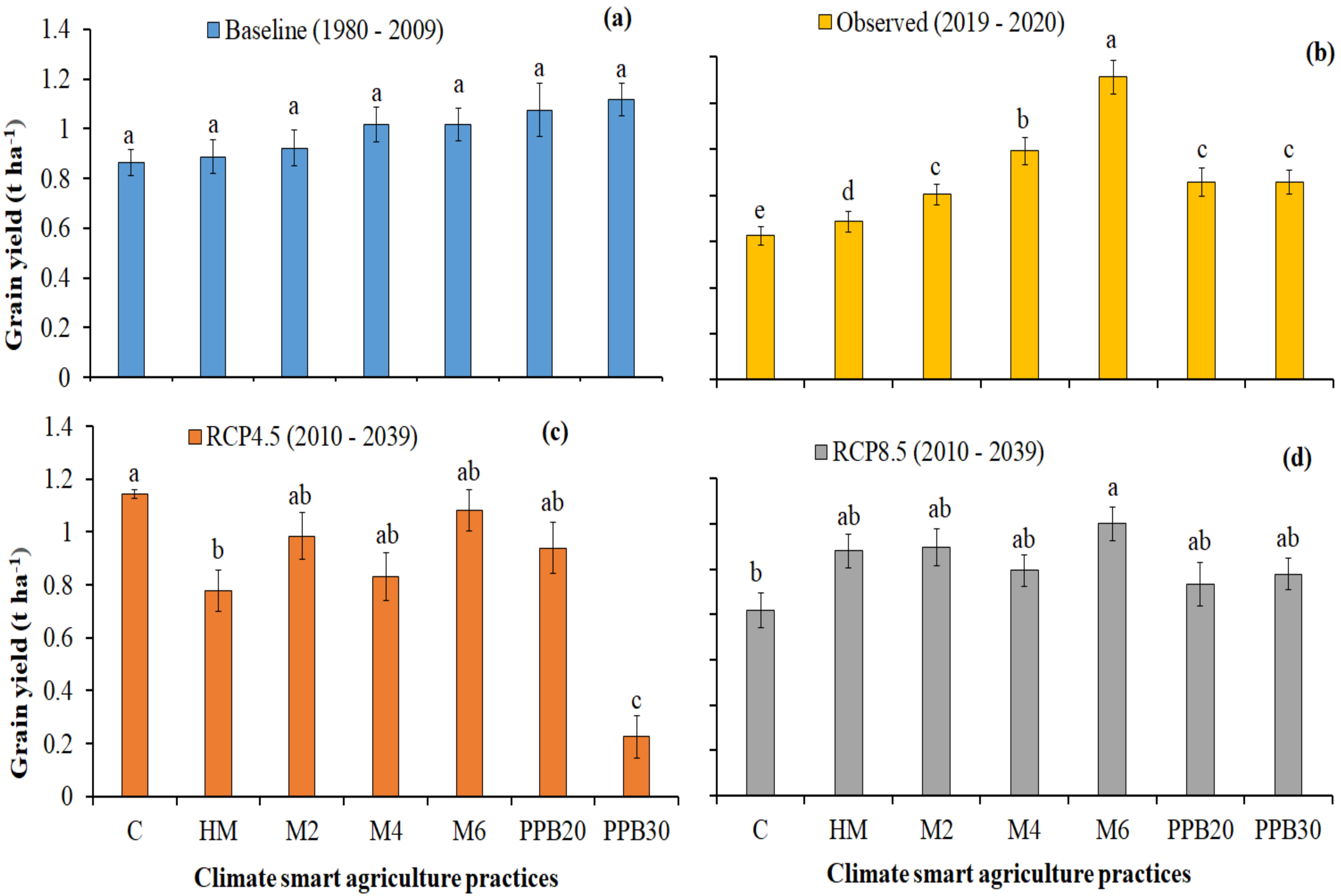
- Plotting relative precipitation and temperature change for the 29 models .
- Clustering the models into 5 classes.
- Climate scenario was obtained by plotting the respective temperature change against the precipitation change for each GCM.
- Subsets were obtained by clustering the GCMs into 4 quadrants (climate regimes) and middle, based on GCM's precipitation and temperature change in relation to the ensemble median.

Hudson & Ruane et al., 2013 ; Ruane et al., 2015

Projected impacts of climate change scenarios on maize grain yield

CSA practices are projected to increase Maize GY under the baseline and observed climate conditions by 3 – 29% and 10–110%, respectively compared to the control treatment:

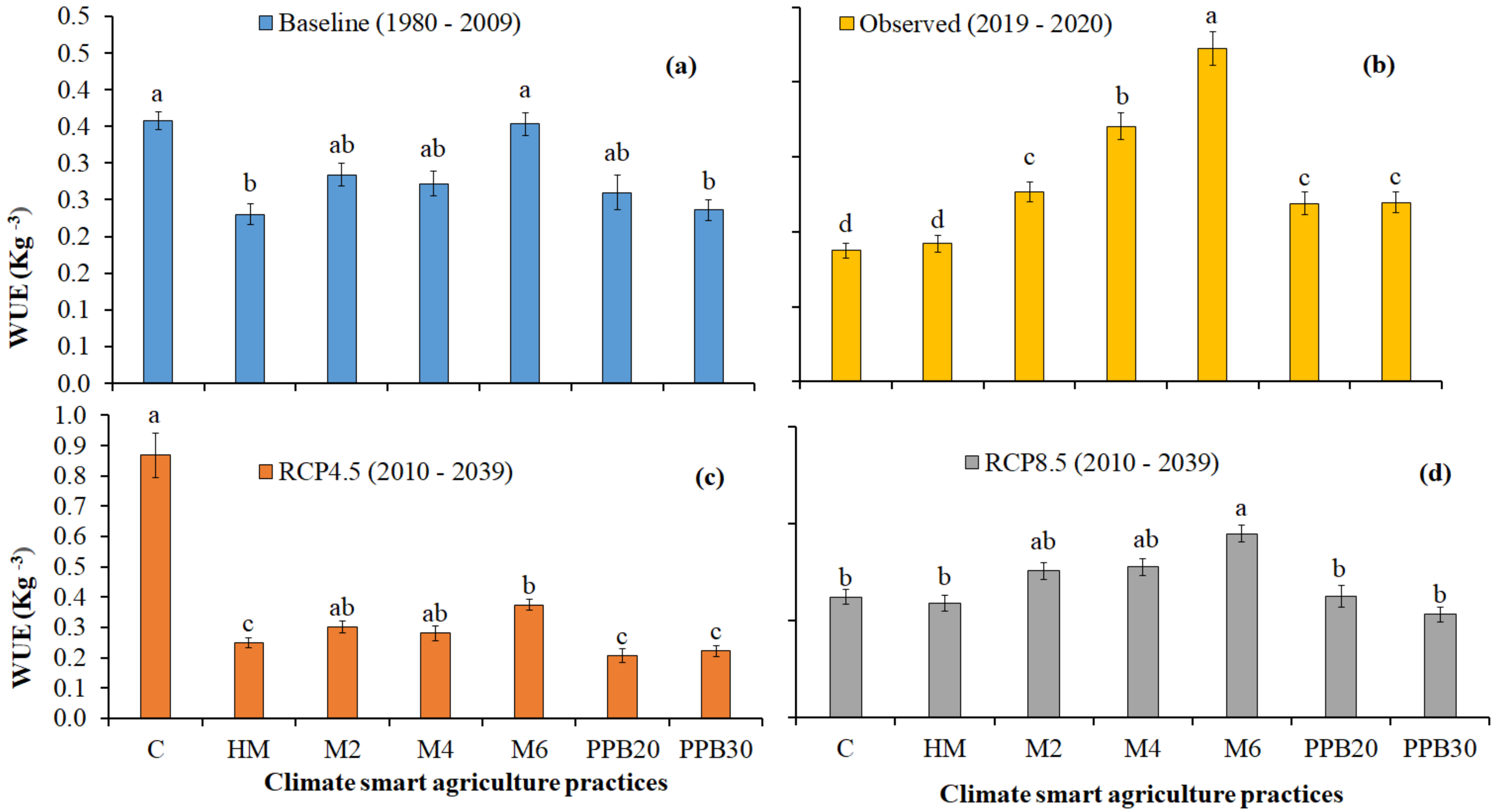
In the future climate of RCP8.5, the CSA practices are projected to increase grain yield by 14 –47% compared to the control treatment



Projected impacts of climate change scenarios on WUE

Under RCP8.5, the CSA practices will increase WUE by 1–53%, with the highest and lowest values achieved using M6 and PPB20, respectively

The M4 and M6 significantly increased WUE under observed conditions compared to other CSA treatments



Zizinga et al., 2022

Summary

- CC is a threat to maize productivity
- Application of CSA is key in adapting to CC impacts for improved maize yield.
- In Uganda, temperatures are projected to increase by 0.5-1.0 °C while rainfall will decrease from 2010-2039.
- AquaCrop model projections indicate that CSA will increase maize grain yield by 14-37%.
- Mulching and permanent planting basins were the most effective for improved maize yield and water use efficiency.

Agricultural Systems 199 (2022) 103407

Contents lists available at ScienceDirect

Agricultural Systems

journal homepage: www.elsevier.com/locate/agsy

ELSEVIER

AGRICULTURAL SYSTEMS

Climate change and maize productivity in Uganda: Simulating the impacts and alleviation with climate smart agriculture practices

Alex Zizinga[a,b,c,*], Jackson-Gilbert Majaliwa Mwanjalolo[a,b], Britta Tietjen[c], Bobe Bedadi[d], Himanshu Pathak[f], Geofrey Gabiri[e], Dennis Beesigamukama[g,h]

Zizinga et al., 2022

Thank you very much for your attention!