What is more important: effect of climate change or effect of improved practices on sorghum yield under current climate in semi-arid regions of West Africa?

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Sorghum in the 21st century Cape Town – South Africa
• Questions to answer
  1) What is the sensitivity of current agricultural production systems to climate change?
  2) What are the benefits of adaptation in current agricultural systems?

• Take home message
  – Importance of effect of management (up to 200%) vs CC (decrease to 10% max)
  – On farm yield gap (M) >> on farm yield potential (G)
Methodology

- Two crop models, Decision Support Systems for Agro-Technological Transfer (DSSAT) and the Agricultural Productions Systems sIMulator (APSIM)
- Fed by weather data from baseline climate (1980-2009) from observed weather and future climate (2040-2069) from 5 Global Circulation Models (GCMs)
- Survey data to evaluate performances of the models for the region (to define initial conditions and settings of the models)
Unimodal rainfall pattern with annual mean rainfall ~ 900mm, from May to October

Daily observations of rainfall and temperature for the 1980-2010 period (AGRHYMET).

**Navrongo, Ghana**

<table>
<thead>
<tr>
<th>Climate Model</th>
<th>Cool/Wet</th>
<th>Hot/Wet</th>
<th>Middle</th>
<th>Cool/Dry</th>
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</tr>
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<tbody>
<tr>
<td>CCSM4</td>
<td>CMCC-CMS</td>
<td>GFDL-ESM2</td>
<td>BNU-ESM</td>
<td>MPI-ESM-MR</td>
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<td>CCSM4</td>
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**Koutiala, Mali**

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An average cropping system

Koutiala, Mali:
A sorghum-millet based system (10.5ha)

Navrongo, Ghana:
A sorghum-based system (2.82ha)

Mixed agro-pastoral systems with cotton as the main cash crop in rotation with cereals (maize, millet and sorghum) and legumes (groundnut and cowpea)
Sorhghum management

Sowing density: 4 pl.m\(^{-2}\)
No fertilization

Navrongo: 3 soil types
Koutiala: 7 soil types

Sorghum cultivar (CSM355) calibrated from dataset from Akinseye et al. (2017)

Koutiala: cotton always the first crop to be sowed (early –mid June), then maize 7 days later, then millet/sorghum/peanut 15 days later.
Results - crop yield of the current system
Results - climate change

RCP8.5 mid-century Temperature scenarios for 29 GCMs (Navrongo, Ghana)

RCP8.5 mid-century Precip scenarios for 29 GCMs (Navrongo, Ghana)

Navrongo
Results - crop yield with climate change

Sorghum, as it is cultivated today, is moderately vulnerable to climate change and could either slightly benefit or suffer from it.

Baseline: 757 to 780 kg ha\(^{-1}\)
DSSAT: 9 to 38% reduction
APSIM: -3 to 8% change

Baseline: 480 to 572 kg ha\(^{-1}\)
DSSAT: 3 to 9% reduction
APSIM: 1 to 10% increase
Sorghum sensitivities to climate variables

Response to $[CO_2]$  

Response to Temperature

Response to Rainfall

Response to Fertilizer
Use of crops with heat tolerance:
- shortened the time from emergence to end of juvenile by 10% and
- lengthened the photo thermal time to flowering to maturity by 10%
- increased the temperature thresholds that affect grain filling rate
- increased the relative proportion of partitioning of assimilates to the panicle by 20%

Management practices
- increasing N/ha fertilizer: + 30 N/ha for sorghum
- increasing plant population from 4 plants m\(^{-2}\) to 5.5 plants m\(^{-2}\)
Results - crop yield with adaptation

- Doubling fertilizer input today with adjusted plant density will more than double yields of maize and sorghum.
- Increasing smallholder use of fertilizers is today more important than improved varieties.

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<th>Location</th>
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<th>Yield Percent Change</th>
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- Improved cultivar has a marginal effect on grain yield, no matter the crop model, while
- Increase in fertilisation simulated an increase in grain yield from 20% to 153% for DSSAT and APSIM respectively.
Conclusion

- **Climate projection:**
  - Mainly increase in temperature, from +1°C to up to 3°C
  - In RCP4.5, no major change in annual rainfall
  - In RCP8.5, from 94 to 115% change compared to the baseline

- **Effect on crop yield:**
  - DSSAT more sensitive than APSIM (more drastic response), mostly due to temperature effect
  - Temperature effect in RCP4.5 and rainfall effect in RCP8.5 simulated with DSSAT
  - Change of 1.5 °C is still having a significant effect on crop yield

- **Effect adaptation vs CC on crop yield:**
  - Importance of effect of management (up to 200%) vs CC (decrease to 10% max)
  - Importance of fertilization vs. improved cultivar
THANKS FOR YOUR ATTENTION

Photos: Rik Schuiling/ TropCrop -TCS