Simulation of post-rainy sorghum yield response to N fertilization in India

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Overview:

Way forward

Summary

Experiment findings

Methodology

Sorghum – Indian Context
Sorghum (Great Millet)

Sorghum – Multipurpose cereal crop - Source of food, feed, forage and fuel crop

Staple crop of poverty threatened small holder farmers.

Grown in rainy (*kharif*), post-rainy (*rabi*) seasons & summer seasons

Suitable crop for Climate change scenario in the semi-arid tropics

Nutritional and health benefits
Post rainy sorghum

Post-rainy sorghum – highly valued food grain – marginal growing conditions – changing climate scenario

Farmer’s yields stagnate at ~800kg/ha

Yield potential ~3500kg/ha

Low input agronomic practice, frequent droughts caused by climatic variability.
✓ Bridge this yield gap – by GxExM

✓ Testing GxExM experientially in field – reflects ground reality

✓ Limited by no. of seasons, sites, cultivars & management combinations

✓ Crop simulation models – capture scenarios

✓ Require prediction methods that combine the products of genetic gain & management optimization to close yield gap (Mark Cooper pptn)

✓ Apsim - decision support tool to design suitable crop and management interventions.
In-silico experiment:
Simulation of post-rainy sorghum yield response to N fertilization in India

- **Target system:** India; RABI sorghum major production areas

- **Situation:** Rainfed, marginal land - low input agriculture practice.

**Questions:**

Can increased dose of N enhance the rabi sorghum production; where?

**Tools:**
Sorghum module; APSIM platform (v 7.6)
Rabi sorghum production tract in India

Kholova et al., 2013

Maharashtra, 62%
Karnataka, 28%
Andhra Pradesh, 7%
Gujarat, 1%
Tamil Nadu, 2%

Production (1000 tons)
- 271
- 250-270
- 200-245
- 150-199
- 100-149
- 50-99
- 0-49
- Missing value

North
Central
South
Far South
Drought stress scenarios: Effect on yield

Fig. 1. Trajectories of crop water stress progress (S/D index) through the crop cycle.

Fig. 2. Effect of water stress on yield

Kholova et al., 2013
Methodology

✓ Districts of major rabi production region

✓ Sorghum module in APSIM

✓ Genotype M 35-1 – Parameterized & validated (Ravi Kumar et al., 2009)

✓ Soil database (NBSS-LUP, ISRIC)

✓ 50 years of Marksim meteorological data

✓ Sowing window – 25 Sep to 15 Oct

✓ Plant density – 12 plants m$^{-2}$
Scenarios tested

1) Low Nitrogen (LN): 20kg urea/ha as starter dose and 20kg urea/ha as top dressing

2) High Nitrogen (HN): 150 kg DAP/ha as starter dose and 100 kg urea/ha as top dressing
Question:

Can increased dose of N enhance the rabi sorghum production; where?
Grain yield difference;
Low N practice versus high N practice
Yield difference;
LN practice *versus* HN practice

Yield loss due to HN  Yield gain due to HN

<table>
<thead>
<tr>
<th>Yield difference (kg/ha) between HN and LN practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>-500 - 250.0</td>
</tr>
<tr>
<td>-249.9 - 0.0</td>
</tr>
</tbody>
</table>
Higher loss frequency due to HN

Higher gain frequency due to HN
Crop growth dynamics: farmers practice *versus* on-station N practice

**Severe water stress**

OS-crop fail to yield due to early water depletion
Summary:

• Loss in grain yield due to HN in majority of districts

• Under water stress, larger canopy in HN practice leads to early water depletion and crop failure
Way Forward

Observed Weather data
Synthetic data (MARKSIM / NASA)
100 × 100 km
Towards More granularity...

Synthetic weather data
30 × 30 km
Validation of NASA weather data

Temperature (°C)

- Observed data: $y = 1.0805x$, $R^2 = 0.7427$
- NASA data: $y = 1.0041x + 0.3246$, $R^2 = 0.8812$

Rainfall

- Observed data: $y = x$, $R^2 = 1$
- NASA data: $y = 0.8166x + 0.0997$, $R^2 = 0.8656$
## Parameterisation of rabi sorghum cultivars

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSV 14R</td>
<td>Phule Chitra</td>
</tr>
<tr>
<td>CSV 18</td>
<td>Phule Anuradha</td>
</tr>
<tr>
<td>CSV 22R</td>
<td>Parbhani Moti</td>
</tr>
<tr>
<td>CSV 26R</td>
<td>PKV kranthi</td>
</tr>
<tr>
<td>CSV 29 R</td>
<td>Phule Revathi</td>
</tr>
<tr>
<td>CSV 216 R</td>
<td>Phule Moulee</td>
</tr>
<tr>
<td>M 35-1</td>
<td>Phule Vasudha</td>
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<tr>
<td>Phule Suchitra</td>
<td></td>
</tr>
</tbody>
</table>
Field experiments for parameterisation

Well watered condition

Water stress condition