2023 ANNUAL REVIEW MEETING

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GENMIL

Genetic Enhancement of Pearl Millet for Yield, Biotic and Abiotic Stress Tolerance in Niger and Senegal

Kane Ndjido A. (PI)
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General Objective: Using new genomic-assisted breeding approaches to accelerate the development of a PM combination options for coping against drought, insects and diseases stresses.

ToC: Going beyond the use of traditional landraces/practices and harnessing the genetic diversity of PM:
- Shift of paradigm and developing MVP based on farmers and market needs/preferences: co-development and co-testing of varieties and hybrids for larger scale adoption
- Modernizing NARIs breeding programs using new tools and building on partnership with farmers and private
High-throughput phenotyping pipeline

1. Image analysis and treatment pipeline

2. In dry condition impact of VPD on the NDVI values
High-throughput phenotyping

A Densely Connected Neural Network for Morphological Traits on Sorghum and Millet

Computer Vision on Morphological traits on Sorghum

Thermal Camera for drought stress

Fig 1: example of LAI calibration on millet

Fig 2: example of Sorghum Panicle count

Fig 3: example of drought stress assessment on millet

Data and Methodologies shared on GitHub (open source)
Use of the model to identify root traits that could be targeted to improve pearl millet tolerance to low P conditions
Development of elite gene pools

- Development and use of elite gene pools based on genetic homogeneity (cis-elite) versus genetic heterogeneity (trans-elite) of parental lines.
- Accelerate genetic gain using both phenotypic and genotypic selection.
- Ongoing:
  - Crossing of elite lines using half diallel scheme.
  - Simulation studies using different genetic architecture and population size scenarios.
    - Which lines to cross for acquired Vs desired traits?
    - How many crosses are needed?
Understanding genetic basis of drought escape

- **Phylogenetic analysis and protein motifs analysis**
  - Conserved genomic regions, protein structure for most of candidate genes (GIGANTAE).
  - Some pearl millet specificity for CO protein structure (missing B2 box).

- **Expression analysis of candidate flowering time genes in leaf tissues.**
  - Conserved expression dynamic for Gi->CO->FTs.
  - FTs highly expressed during flowering stage with different dynamics for Hd3a and FT5:
  - Hd3a and FT4 triggers early flower transition and FT5 acts during later stages.
  - Early phenotypes showed higher expression of photoreceptors.

Figure: Our proposed model for flowering time regulatory pathway in pearl millet
Heterotic groups

- Heterotic groups identified in the Senegalese pearl millet core collection
- The F1s performed on average up to about 250% of the parent's yield
More than 1000 crosses (Full sib (Intra and inter), Half Sib & S1) made from 6 populations sourced from Senegal, Burkina, Mali and Niger;

From these crosses, 200 experimental populations were selected based on resistance to downy mildew, flowering time and agronomic appreciation and will be tested in a preliminary yield trial

More than 90 fertile hybrids obtained from evaluation of about 200 F1s crosses as testcrosses for panicle fertility and other agronomic traits

Multi-parental population being developed using 10 inbred lines (Drought tolerance stay green, Fe and Zn, DM resistance, compact heads and high GCA & SCA)
Generation advancement

- 5 single cross hybrids (Long panicle, high grain yield and resistant to downy mildew) developed and ready for registration: High yields and adapted to the different pearl millet growing areas in Senegal.

- A new dual purpose (high biomass and stey green and OPV variety SALAM) ready for registration:
Generation advancement

- Best promoted crossing between Chakti (Mil de Siaka, ICMV89305 and Maradi local) were screened and evaluated for yield, DM, grain quality and Fe and Zn.

- 55 genotypes from crosses have less than 20% of DM, and resistant to drought with high grain yield.

- 440 S6/F5 were developed from local populations and will be genotyping by CIMMYT.
Training PhD and MSc and ECR

Sokhatil Ndoye
PhD candidate
Co-supervision IRD, UCAD

Root traits genes
discovery and
colorization

Safiatou Fall
PhD candidate
Co-supervision CSU, CERAAS

Undercover the
genomic basis of
drought-adaptive
traits

Training of technicians from pearl millet breeding, ISRA Senegal at ICRISAT, Sadore, Niger

Visiting scientist of ECR at ICRISAT, Sadore, Niger

Collaborative Research on Sorghum and Millet
Empowering Farmers and seed producers

- Up to 3 trainings on seed production and good agronomic practices
Irrigation facilities

- Capacity of irrigation 3ha

Maradi, Niger
So what?

- Shift of paradigm and developing MVP from BPP based on farmers needs
- Development first hybrids with high yield in some NARIs programs
- More modernized NARIs breeding programs using new tools and advanced technologies
GenMil

Seed Delivery & Scaling in Senegal

Ndjido Kane, Lamine Diatta, Ghislain Kanfany, Oumar Diack, Khady Nani Dramé
Pearl Millet Multiservice Hubs (Poles Multiservice Paysans - PMP)

18 across Kaolack, Fatick and Kaffrine regions.

Established as part of the USDA|PSEM – Millet Business Services Project led by NCBA/CLUSA (2014-2019).

A platform for exchange, business and services across the pearl millet value chain.

In total – 7,911 members including 22.5% women.
18 PMP + 2 “umbrella organizations” (UGAD, Diourbel and Norayni Federation, Kaolack) mobilized, strongly committed to the dissemination of improved pearl millet varieties.

10,880 potential beneficiaries (incl. producers and processors).

<table>
<thead>
<tr>
<th>Organization</th>
<th>Members (M)</th>
<th>Members (F)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 PMP</td>
<td>6,128</td>
<td>1,783</td>
<td>7,911</td>
</tr>
<tr>
<td>Norayni Federation</td>
<td>600</td>
<td>870</td>
<td>1,470</td>
</tr>
<tr>
<td>UGAD</td>
<td>588</td>
<td>911</td>
<td>1,499</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7,316</strong></td>
<td><strong>3,564</strong></td>
<td><strong>10,880</strong></td>
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</table>
How we engaged with pearl millet producers for their active participation in seed scaling

- **WS2020**
  - Open day organized to visit the on-station demo plots of improved varieties

- **DS2021**
  - Seed production of the improved varieties for a pilot diffusion in 4 regions

- **WS2021**
  - On farm demonstration by Lead producers from the PMP, UGAD and Fed. Norayni

- **DS2022**
  - Breeder seed production by ISRA

- **WS2022**
  - Foundation seed production by accredited seed producers within the FOs

PMP Taiba Niassene
97% women
Year 1 (2021)
Localizing exposure

- FOs select their lead producers
  18 PMP – 66 (56 Men, 10 Women)
  UGAD – 8 (7 Men, 1 Woman)
  Norayni – 11 (7 Men, 4 Women)

- Each lead producer plants at least ½ ha
- Each lead producer receives seeds and fertilizers
- They show their plots to at least 10 farmers

85 demo plots installed
(17.6% managed by women)

At least 935 farmers exposed

CREATING AWARENESS & DEMAND
**Key Achievements**

**Year 1 (2021) – Localizing exposure**

- 196 kg of seeds, 6,750 kg of NPK and 4,900 kg of Urea distributed to 85 lead producers across the 4 regions.

- 49 ha sown with Gawane (10.5ha), Thialack2 (23ha), Salam (11.5ha), ISMH140 (1.5ha), Souna 3 (2.5ha).

- 6,706 kg of pearl millet collected from the participating FOs at the end of the first campaign as per the agreement.

- Women processors invited to buy the production.
Year 2 (2022)
Spreading Wider

• Where available, FOs select their accredited seed producers.
• ISRA produces breeder seeds for on-farm multiplication.
• FOs’ seed producers produce foundation seeds on ½ ha (and then certified seeds in 2024).
Key Achievements

Year 2 (2022) – Spreading wider (1. Seed Production)

• 90 kg of breeder seeds distributed to accredited seed producers within the FOs.

• 22.5 ha sown for seed multiplication of SL423, SL169, SL28, Gawane and SOSAT-C88.

• Assuming seed yield of 0.7 t/ha \( \Rightarrow \) 15.75 tons of breeders \( \Rightarrow \) potentially 3,937.5 ha can be planted during the WS2023.
Key Achievements

Year 2 (2022) – Spreading wider (2. Further diffusion)

- 790 kg of seeds (SL423, SL169, SL28, Gawane and SOSAT-C88) distributed to participating FOs for further diffusion among their members.

- Each FO received 2 to 5 varieties.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Qty distributed</th>
<th>Area potentially covered</th>
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</thead>
<tbody>
<tr>
<td>Gawane</td>
<td>404 kg</td>
<td>101 ha</td>
</tr>
<tr>
<td>SL169 (Sine)</td>
<td>112 kg</td>
<td>28 ha</td>
</tr>
<tr>
<td>SL423 (Baol)</td>
<td>166 kg</td>
<td>41,5 ha</td>
</tr>
<tr>
<td>SL28 (Saloum)</td>
<td>80 kg</td>
<td>20 ha</td>
</tr>
<tr>
<td>SOSAT</td>
<td>28 kg</td>
<td>7 ha</td>
</tr>
<tr>
<td>Total</td>
<td>790 kg</td>
<td>197,5 ha</td>
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Assuming average GY of 1 t/ha >>> 197.5 tons of pearl millet are expected.
Main Challenges and Mitigation Options

• Irregular follow-up in Year 2 due to the departure of the PMP liaison officer
  
  >> Incentive in the form of occasional service provision while waiting for a more durable solution

• Maintenance of seed purity/quality in producers’ fields
  
  >> Recommendations were given to agree among members of the same PMP to reserve a specific area for a given variety and to surround it with other crops to maintain distancing (1 km).
### What is Next?

**2023**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Period</th>
<th>Potential roadblocks</th>
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<tbody>
<tr>
<td>Monitoring tour to take stock of FO’s grain/seed production during the WS2022</td>
<td>Mid-March</td>
<td>Upgrading of foundation seeds to certified seeds by some seed producers</td>
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<tr>
<td>Hold a joint review and planning meeting with all participating FOs – lessons learnt and way forward</td>
<td>April</td>
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<tr>
<td>Monitor certified seed production and the use of improved varieties (continuity?)</td>
<td>Wet season</td>
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<tr>
<td>Draft an article on this diffusion approach</td>
<td>By year end</td>
<td>Data quality</td>
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Beyond 2023

• Performance analysis of this community-based approach
• Adoption and impact studies – improved varieties penetration in the FOs

Take home message

Building on existing organizations and strengthening them.
Farmer to/for farmer diffusion approach.
Improved varieties appreciated for yield potential, tillering, greenness at maturity, and earliness.
Thank you for your attention

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative