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2022 ANNUAL REVIEW MEETING

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Virtual

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Genetic Enhancement of Sorghum to Promote Commercial Seed Supply and Grain Market Development

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Objectives

1) To evaluate Ethiopian sorghum landraces for drought tolerance and *Striga* resistance to produce phenotypic data for these traits to associate with the sequence data generated in Phase I

2) To establish heterotic pools among Ethiopian sorghum landraces

3) To develop elite parental lines for a sorghum hybrid program from Ethiopian landraces

4) To establish a stepwise synthesis and testing of experimental sorghum hybrids from introduced germplasm and Ethiopian landraces improved for multiple agronomic traits

5) To promote and support the development of a hybrid seed production system in Ethiopia

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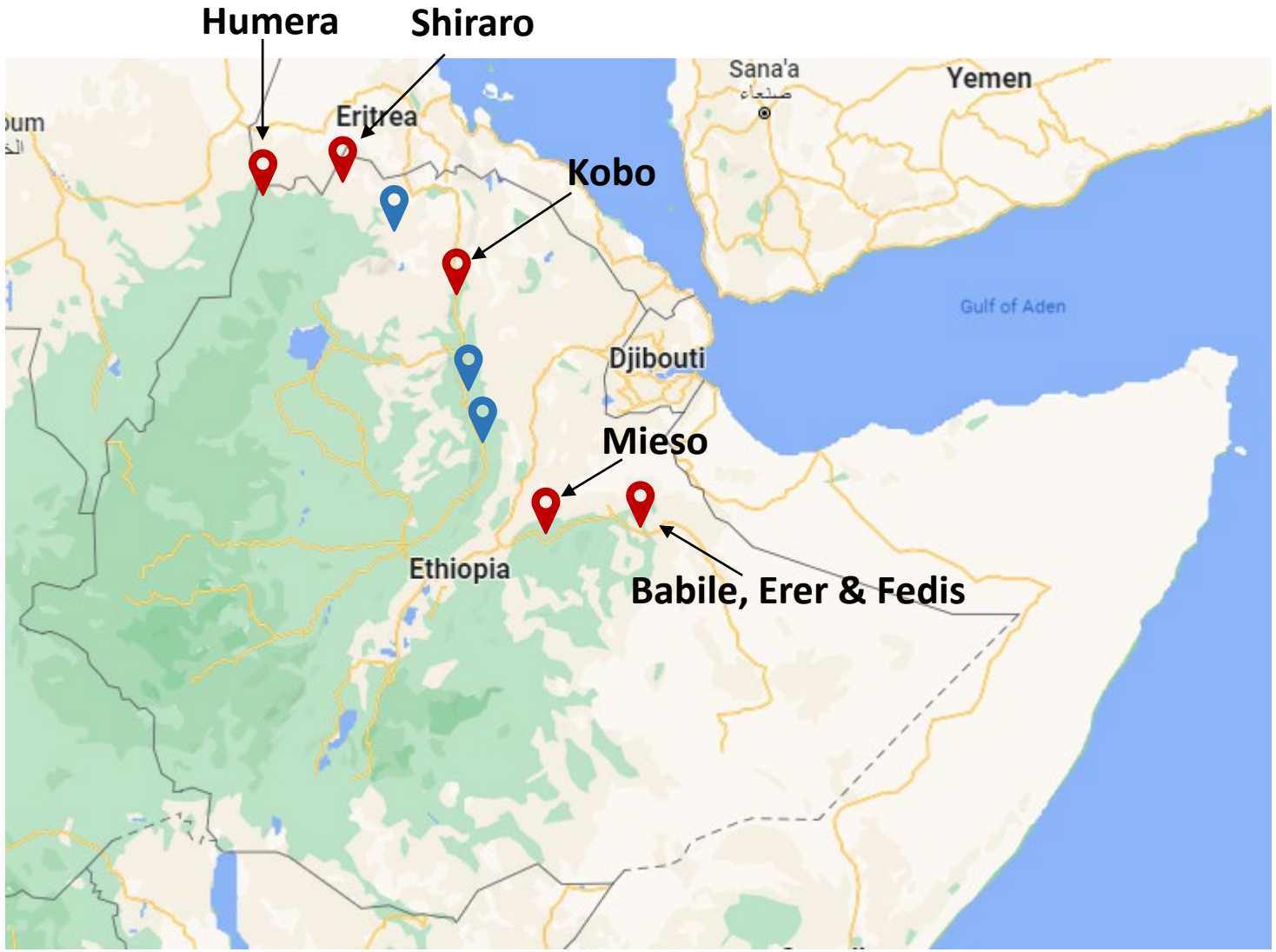
Testing locations



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1. Evaluate Ethiopian sorghum landraces for drought tolerance and Striga resistance

1.1 Drought

- A core subset of 358 landraces evaluated at Mieso (dryland) in partially replicated plots
- Data on drought and agronomic scores collected

A Core Subset of SMIL landraces, Mieso 2021

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1. Evaluate Ethiopian sorghum landraces for drought tolerance and Striga resistance

1.1 Drought

- Association analysis conducted for drought related traits collected in 2021

- Selection of landraces for drought breeding
  - 40 landraces showed excellent ratings for drought and agronomic traits
  - 75 landraces rated as moderate

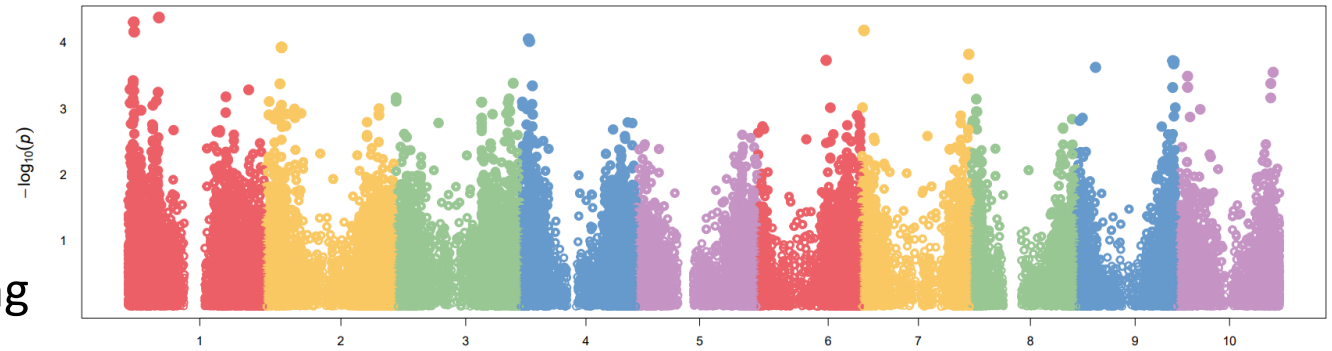

Fig. GWAS for leaf senescence rating, Mieso 2021

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1. Evaluate Ethiopian sorghum landraces for drought tolerance and Striga resistance

- Due to the security situation and extreme drought, successful field testes for drought could not be conducted

Plan for 2022 drought study

- Controlled experiments for drought traits: TE and root system architecture (RSA)
- A PhD student is engaged to conduct TE and RSA

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1. Evaluate Ethiopian sorghum landraces for drought tolerance and Striga resistance

1.2 Striga resistance

- This has been affected by the conflict in Northern Ethiopia

Efforts:

- 2020 - the activity was initiated as a PhD thesis (Hailegebriel Kinfe)
  - 200 landraces were screened for field Striga resistance at three locations in Tigray
  - On November 2020 major conflict broke out in the region
- 2021 – we tried to do the study in Amhara region (MSc and PhD students were engaged)
  - Disrupted by the conflict that expanded to Amhara region starting July 2021

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1. Evaluate Ethiopian sorghum landraces for drought tolerance and Striga resistance

1.2 Striga resistance

- **New plan for 2022** – to do the screening in a controlled and high throughput facility at Holeta
- A PhD student is ready to conduct the screening
- Pilot study on 15 sorghum lines from Purdue

Pilot study at Holeta – PhD students and research staff being trained

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1. Evaluate Ethiopian sorghum landraces for drought tolerance and Striga resistance

1.2 Striga resistance

- Result of the pilot study indicated that the approach is pretty accurate and fast

Striga Reaction at 7th week, Pilot study at Holeta

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2. Establish heterotic pools among Ethiopian sorghum landraces

Background

- Sorghum germplasm generally classified into two major parental groups
  - Seed parents (A/B)
  - Pollinator parent (R)
- Currently the two groups serve as defacto heterotic groups for sorghum
- The heterotic responses among germplasm within each of these two parental gene pools have not been investigated
- This activity will give us evidence if greater heterosis can be achieved within each parental pool and will facilitate selection of landraces for conversion

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2. Establish heterotic pools among Ethiopian sorghum landraces

- Newly generated 309 hybrids of Ethiopian landraces evaluated in two replications at Mieso (Part of Amare's graduate study)
- The hybrids were formed by crossing about 50 landraces and 10 elite lines by 6 testers
- Data: Yield, drought scores, staygreen, phenology and others

Off-season crossing block 2021

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Yield potential of hybrid combinations

Possible hybrid combinations

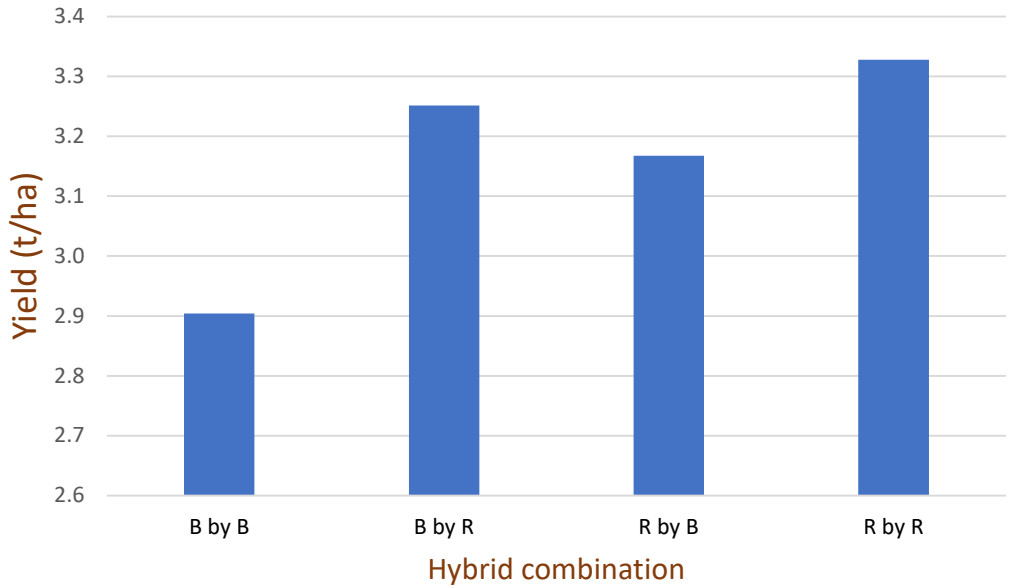
x	B	R
B	B x B	B x R
R	R x B	R x R

B = non restorer; R = restorer of sterility

Note

- R x B and B x R are reciprocals; sterility group written first indicates usage as female
- The unconventional hybrid combinations (R x B) and R x R were generated through the use of genetic male sterility technique

Yield by hybrid combinations



- B by R is the conventional combination used in hybrid breeding

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Combining ability of landraces and elite lines – partial list

- Some popular landraces ranked top in GCA
- Important result for selection of landraces for conversion

Rank	Genotypes	Local names	Sterility group	Yield (t/ha) average of all hybrids	GCA
1	ETSL101865	Wetet begunchie	B	4.8	1.5
2	ETSL100313	Hodem-1-3	R	4.4	1.1
3	ETSL101852	Jeru	B	4.2	1.0
4	ETSL100282	69249	R	4.0	0.8
5	ETSL100311	GendaETU#5	R	3.9	0.7
6	ETSL101851	Jamiyu	R	3.8	0.6
7	ETSL101869	Goronjo	R	3.8	0.6
8	ETSL101842	Amajigta	R	3.8	0.5
9	ETSL101866	Wediaker	R	3.7	0.5
10	IS38341	IS 38341	B	3.7	0.5
11	ETSL100020	H035	R	3.7	0.4
12	ETSL100392	15908	B	3.6	0.4
13	AL-70	AL-70	R	3.6	0.4
14	ETSL101844	Bobe white	R	3.6	0.3
15	ETSL100016	H028	R	3.6	0.3
16	ETSL101367	211883	R	3.5	0.3
17	ETSL101853	Jigurti	R	3.5	0.3
18	ETSL100007	Ag061	R	3.5	0.3
19	ETSL101292	201319	R	3.5	0.2
20	Meko		R	3.5	0.2
21	ETSL100302	2003WolloColl#322	R	3.5	0.2
22	ETSL101857	Masugi Red	R	3.4	0.2

Table 1

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Combining ability of landraces and elite lines – partial list

- Improved (introduced) lines show moderate to low heterosis
- Landraces could enhance diversity and boost gain from heterosis under such dry environment

Table 1. Contd.

Rank	Genotypes	Local names	Sterility group	Yield (t/ha) average of all hybrids	GCA
23	ETSL100541	19636	R	3.4	0.2
24	Misikir		R	3.4	0.2
25	ETSL100301	2003WolloColl#96	R	3.4	0.2
26	ETSL100026	K013	R	3.4	0.1
27	ETSL101399	216827	R	3.3	0.0
28	Gambella 1107		R	3.3	0.0
29	Tilahun		R	3.3	0.0
30	E36-1	E36-1	R	3.3	0.0
31	ETSL100316	Meminay-4	R	3.3	0.0
32	IS38393	IS 38393	R	3.2	0.0
33	Argiti		R	3.2	0.0
34	Melkam		R	3.2	-0.1
35	ETSL101848	DegalitYellow	R	3.2	-0.1
36	ETSL101845	Debir	R	3.2	-0.1
37	ETSL100312	Gorade-2	R	3.1	-0.1
38	ETSL100308	Baduqane	B	3.1	-0.1
39	ETSL101843	Bobe red	R	3.1	-0.2
40	ETSL100303	2003WolloColl#328	B	3.0	-0.2
41	ETSL101855	Kodem	R	3.0	-0.2
42	Teshale		R	3.0	-0.2
43	ETSL101456	228920	R	3.0	-0.3
44	ETSL100286	215525	R	3.0	-0.3
45	ETSL100202	ACC#15	B	2.9	-0.4
46	ETSL101858	Masugi Yellow	R	2.9	-0.4
47	ICSR 14		R	2.8	-0.4

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Combining ability of tester lines

Tester	Yield (t/ha)	GCA
PP290R	3.6	0.3
P732R	3.4	0.1
P9511A	3.3	0.1
PU216A	3.1	-0.1
TX623A	3.1	-0.1
P9401R	3.0	-0.3

Table 2

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3. Parental lines development for hybrid program

B by B crossing of elite landrace B lines

- 39 F1 crosses of B landraces were planted in the off-season and advanced into F2
- 18 F2 B by B cross populations evaluated at Mieso
  - 176 head selections made to be grown as F3 families for conversion starting this off-season
- New B by B crossings will be made based on results of combining ability/heterotic pool study

Table 3. Number of B by B F2 selections

Genotype	Pedigree	#Head Selected
ETSH21600	PU216B/Wetetbegunchie	6
ETSH21601	PU216B/IS38341	11
ETSH21609	PU216B/204632	6
ETSH21612	PU216B/2003Wollocoll#328	9
ETSH21613	PU216B/15908	10
ETSH21614	PU216B/IS38429	14
ETSH21615	PU216B/242410	8
ETSH21616	PU216B/jeru	11
ETSH21618	PU216B/204631	9
ETSH21623	PU216B/16476	5
ETSH21629	PU216B/71564	16
ETSH21630	PU216B/69394	9
ETSH21631	PU216B/IS25542	10
ETSH21632	PU216B/IS25555	8
ETSH21633	PU216B/Abamelko	13
ETSH21635	PU216B/Baji	7
ETSH21636	PU216B/IS38428	12
ETSH21638	PU216B/2001PaweColl#047	11
Total		**176**

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3. Parental lines development for hybrid program

- R by R crossing of elite landrace R lines
  - F1 generation advance conducted for
    - 135 R by R cross populations of landraces and elite R lines (Ms3)
    - 25 R by R cross populations of key landraces and Gambella 1103 (manual crossing)
  - The resulted F2s will be grown in main season of 2022 for selection

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Highlights of ongoing off-season crossing blocks, Werer Ethiopia

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4. Stepwise synthesis and testing of experimental hybrids

- Multi-environment hybrid evaluations conducted over the past several years
- Each year best yielding hybrids being advanced to next level of evaluation with new hybrids added

1. Dual purpose hybrids
2. Drought tolerant hybrids

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Dual purpose hybrids

- 5 advanced dual purpose hybrids and checks evaluated at two locations during 2021
  - Mieso and Babile (Previous location: Kobo)
  - 3 replications and 4 row plots (5 m x 0.75m)

- Data available for:
  - Mieso (Oromia): 2019 - 2021
  - Kobo (Amhara): 2017 - 2020
  - Babile (Oromia): 2021

Dual hybrid at Babile, 2021, Photo by Tamirat Beiiga

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Candidate dual purpose hybrids – for release application

Table 4. Summary of yield and injera making quality of candidate dual purpose hybrids

No	Hybrids	Grain yield – all environment (t/ha)	Dry Biomass (t/ha)	Injera consumer preference (1-9 scale)
1	K10538	4.5	9.9	6.5
2	K10541	5.2	8.5	7.0
3	K10544	4.7	8.2	5.0
4	K10550	4.7	9.1	5.0
5	K10552	4.8	8.7	7.0
6	ESH5 (Check)	4.9	7.2	7.5
7	ESH4 (Check)	4.5	7.5	6.5

Consumer preference scale: 1 = poor; 9 = excellent

- Release of at least 1 hybrid is expected

- Injera making quality data provided by Food science team
- Limitation in equipment (mills and others)

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New sets of dual and forage hybrids for 2022

- Increased interest and request from EIAR for forage and dual purpose varieties and hybrids
- Enhancing effort on dual and forage varieties and hybrids breeding
  - Evaluation of newly synthesized dual and forage hybrids

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Drought tolerant hybrids

- 10 advanced hybrids and checks evaluated at two locations during 2021
  - Mieso and Babile (Previous locations: Kobo & Shiraro)
  - 3 replications and 4 row plots (5 m x 0.75m)

Drought tolerant hybrids, Mieso 2021, Photo by Tamirat Bejiga

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Drought tolerant hybrids

Data available for:

Mieso (Oromia): 2017, 2019, 2021 & 2021
Kobo (Amhara): 2017, 2018, 2019 &2020
Shiraro (Tigrai): 2017, 2018 & 2019
Babile (Oromia): 2021

Drought tolerant hybrids, Mieso 2021, Photo by Tamirat Bejiga

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Candidate drought tolerant hybrids for release application

Table 5. Summary of grain yield and injera consumer preference score for candidate hybrids

No	Hybrids	Yield-all environment (2017-2021) (t/ha)	Injera consumer preference (1-9 scale)
1	K19020	5.0	7.0
2	K19021	4.6	6.5
3	K19026	4.5	7.5
4	K7148	4.3	6.5
11	ESH5 (Check)	4.0	7.0
12	ESH4 (Check)	3.1	6.5

Consumer preference scale: 1 = poor; 9 = excellent

- Release of 1-2 hybrids is expected

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Candidate drought hybrids also top yielding at Purdue

Rank	Genotype	Yield (t/ha)	Note
1	K19020	12.6	
2	K19021	12.5	
3	K7150	12.4	
4	K7148	11.9	
5	C.Check1	10.8	Commercial hybrid check
6	K19026	10.6	
7	K19007	10.3	
8	C.Check2	9.9	Commercial hybrid check
9	C.Check3	8.7	Commercial hybrid check
10	K7411	8.6	
11	ESH6	8.2	
12	ESH4	7.9	
13	K6090	7.8	
14	P9401	7.4	
15	K7410	6.8	
16	ESH5	6.5	

Table 6

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New sets of hybrid for drought and yield for 2022

- New hybrids synthesized at Purdue for drought and yield evaluation across environments in Ethiopia

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5. Promote and support the development of a sorghum hybrid seed system in Ethiopia

Aims

- Farmers education on the agronomic and economic merit of hybrids
- Supportive programs for availability of quality hybrid sorghum seed production by both public and private agencies
- Market linkages to supply chains of quality hybrid sorghum seed and grain production and distribution

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5. Promote and support the development of a sorghum hybrid seed system in Ethiopia

- Demonstration of ESH5 hybrid released in phase I

ESH5 hybrid demonstration to farmers, Mieso 2021, Western Hararghe, Ethiopia

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5. Promote and support the development of a sorghum hybrid seed system in Ethiopia

Seed multiplication at public and private seed enterprises

- The 2021 Seed multiplications limited to Oromia region due to conflict in Tigray and Amhara
- Ethio-Agri CEFT (Private seed enterprise) was engaged at large scale multiplication in 2020 – didn't multiply in 2021
  - They are planning to multiply in 2022

Large scale seed multiplication at Ethio-Agri CEFT, 2020

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Institutional capacity development

- To enhance the capacity, 12 additional benches purchased

Striga screening facility at Holeta Biotechnology Research Center, Holeta

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Human capacity development

Technical support to research staff through bi-weekly zoom meetings, free messaging and calling apps (Viber, WhatsApp)

- Topics covered through the various zoom meetings:
  - Techniques of setting up crossing blocks
  - Foundation and certified hybrid seed production techniques
  - Parental line development for hybrid breeding program and
  - Development of mapping populations

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Human capacity development

Technical support and guidance to graduate students

- Technical support and guidance to 6 MSc and 7 PhD students working on various topics in sorghum

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Human capacity development

Training of seed experts at OSE

- In-person training to about 45 staff members of Oromia Seed Enterprise on hybrid seed production techniques and seed quality

Training to seed experts from Oromia Seed Enterprise (OSE), Shashemene 2021, Ethiopia

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Issues or concerns

➢ Conflict in Northern Ethiopia

- The conflict in Northern Ethiopia (Tigrai, Amhara and Afar) caused significant disruption and loss of research capacity in the region
- Research stations affected:
  - **Tigray**: Humera, Shiraro stations and all on-farm activities - 2020 & 2021
  - **Amhara**: Kobo, Sirinka, Sekota, Jari, Chefa stations and all on-farms activities – 2021

➢ Accelerated inflation

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Lessons learned

- The biggest lesson is that peace and stability are essential for a nation at its prime stage of economic development
- Continuous virtual discussions and consultations helped to keep project activities running
- Collaborators showed resilience and grit to do all they could to find new ways of doing things under very difficult situation

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Thank you!

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