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Collaborative Research on Sorghum and Millet
FEED THE FUTURE INNOVATION LAB

2022 ANNUAL REVIEW MEETING

March 21-25, 2022

Virtual

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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)

Kassari Ango Issoufou, Gangashetty Prakash, Riyazaddin Mohammed, Kanfany Ghislain

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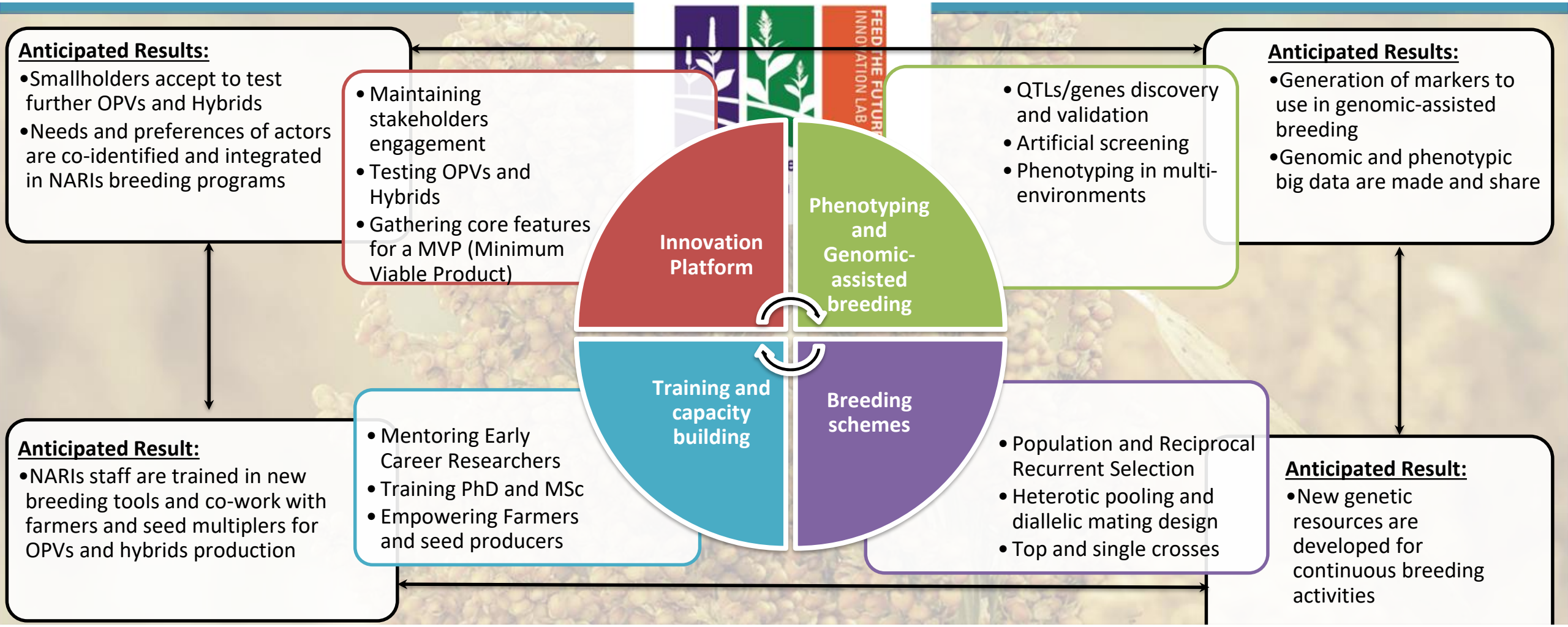
General Objective: Using new genomic-assisted breeding approaches to accelerate the development of a PM combination options for coping against drought, insects and diseases stresses.



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

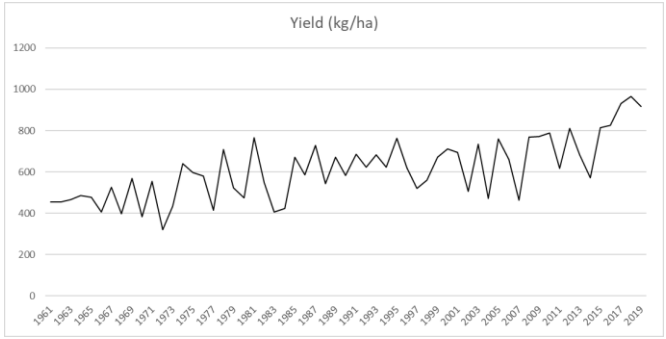
Seed increase

- Seed multiplication of different varieties during the off-season 2021 & 2022 (1,2 tonnes)
- Varieties: SL 423, SL 28, SL 169, Chakti, SOSAT C 88, Thialack 2

Evaluation of available varieties

- Evaluation of 4 OPVs and a hybrid under farmers' field during the rainy season of 2022

- A total of 85 fields established and average grain calculated on a sample of 15 plots showed a grain yield of 1550 kg/ha which is higher than the national average grain yield



- Additional farmers have expressed interest for the new varieties and seeds will be shared with them

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Participatory evaluation

Exposure of pearl millet hybrid seed production plots to the farmer organizations and seed producers in Niger

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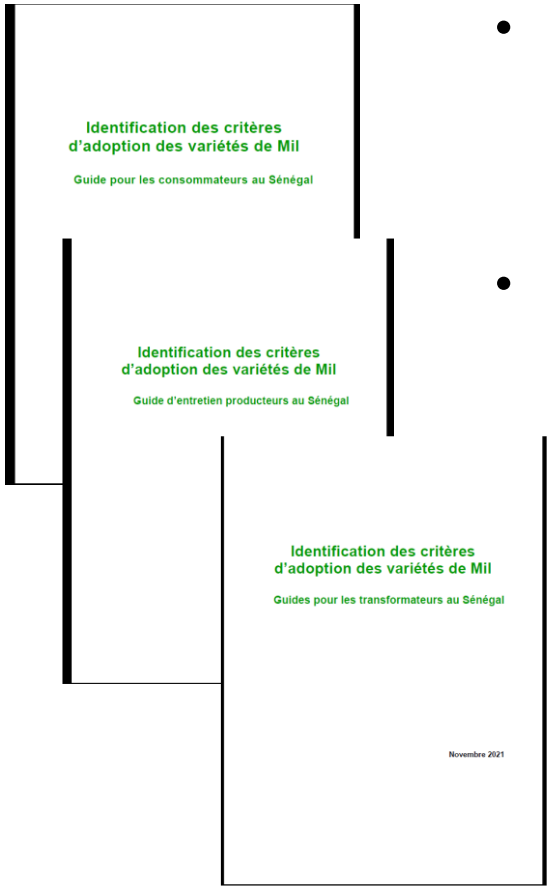
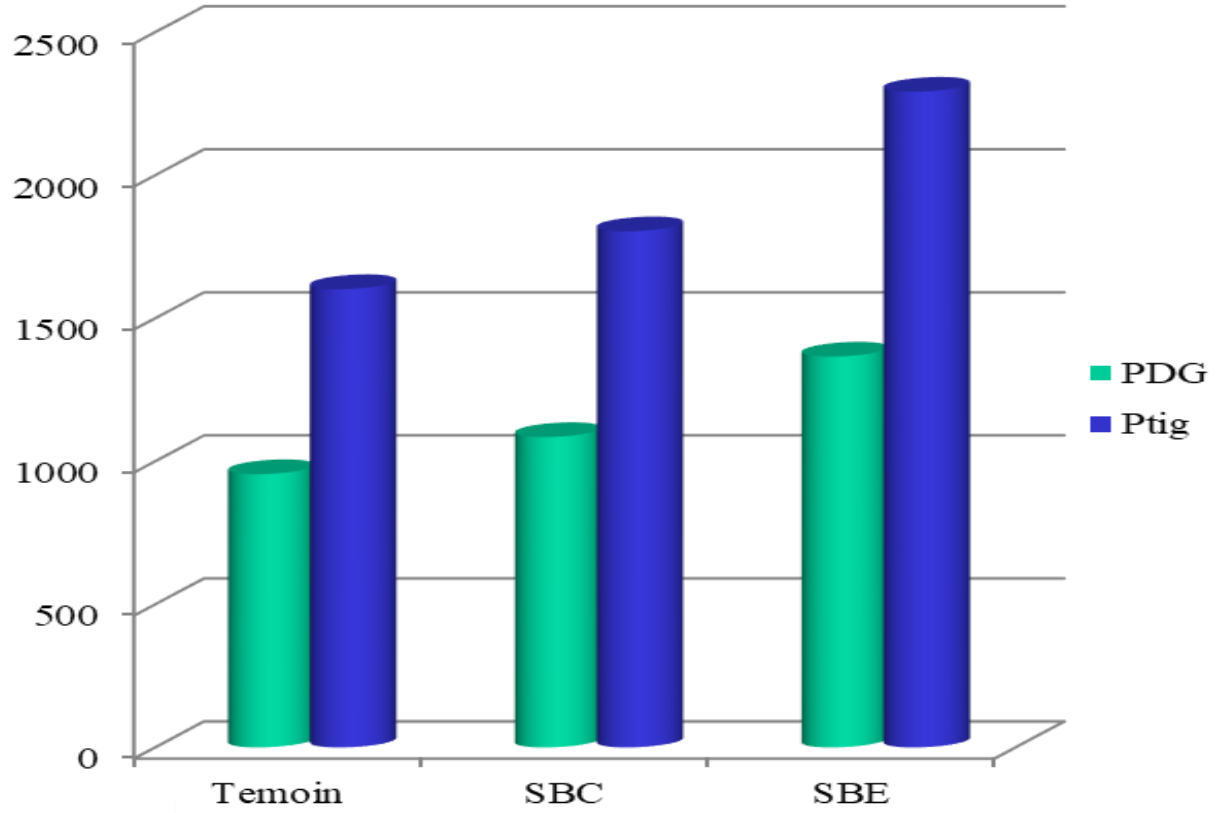
Identify preferences of key selected actors



- 3 interview sheets produced and administered to different stakeholders to collect data on preferences and priority (MVP: minimum viable product for adoption and market)
- 16 FGDs organized

Co-development of innovations

- Evaluation of varieties (4 hybrids and 4 OPVs) under two fertilization levels
- Seed ball technologies with mineral fertilizer, woody or ash



Phenotyping for biotic stress – Downy mildew

- Screening of 5 F2 populations.
- Parents when crossed with CMS lines showed fertile panicle and have a good combining ability

Dénomination	Male	Female
ISMR 14	ICML 08666	ICML 197187
ISMR 16	ICML 197 252	ICML 197187
ISMR 30	ICML 08666	ICML 197 189
ISMR 60	ICML 197189	ICML 08888
ISMR 64	ICML 197 252	ICML 08888

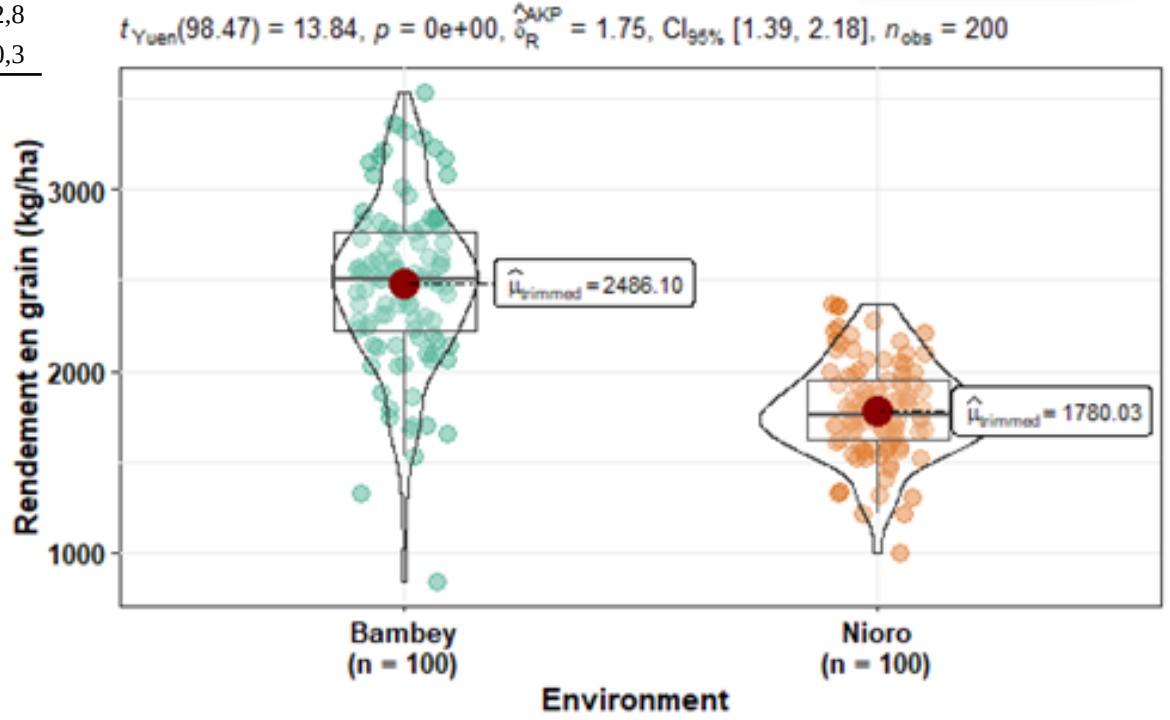
- Cross ISMR 64 was susceptible to DM with 53% of plants showing DM symptoms

Population/Entrée	Incidence		Severity		Number of selected plants for testcross
	DMI_40 jas (%)	DMI_60 jas (%)	Sev_40 jas (%)	Sev_60jas (%)	
ISMR 14	17	23	5	8	72
ISMR 16	14	22	5	7	125
ISMR 30	15	23	6	7	26
ISMR 60	29	32	10	12	55
ISMR 64	49	53	24	30	18

Evaluation of early maturing OPVs

	Moyenne ± SE	Minimum	Maximum	δ^2_g	δ^2_{gxe}	H^2	LSD	CV
Floraison	48±2,6	43	60	11,59***	0,25ns	0,86	3,5	5,3
HP (cm)	235±20,6	203	273	273,36***	57,20ns	0,67	26,6	8,8
LP (cm	31±3,9	25	42	14,53***	0,06ns	0,79	4,9	12,8
RDTG (kg/ha)	2131±435	921	2854	145549,0***	59464,6***	0,65	635,7	20,3

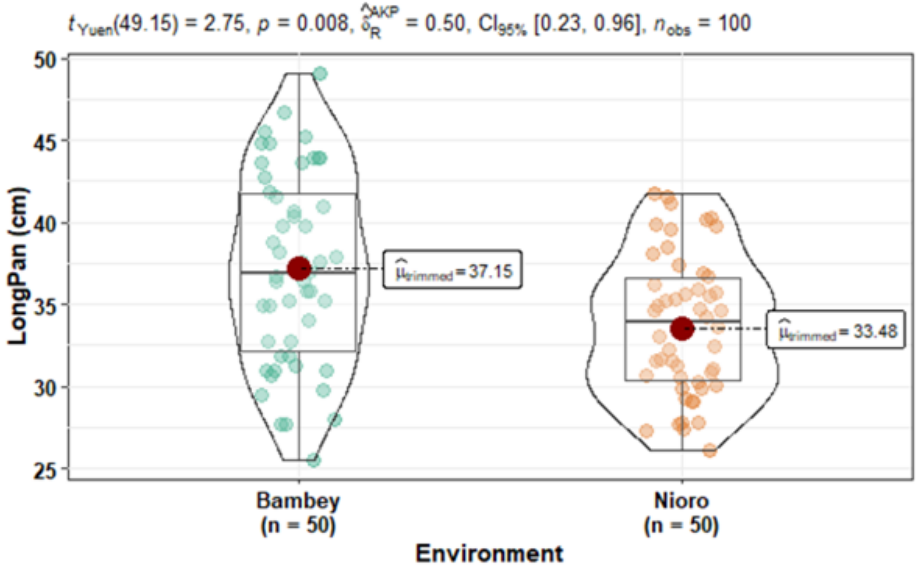
Nom_ Entrée	Numéro Entrée	Floraison	HP (cm)	LP (cm)	RDTG (kg/ha)	RDTE (kg/ha)
ICMP 217042	42	49	239	36	2841	4004
ICMP 217035	35	52	259	37	2806	4076
ICMP 217023	23	49	237	37	2718	3866
ICMP 217014	14	46	233	33	2605	3661
ICMP 217093	93	51	266	34	2588	3700
ICMP 217075	75	49	243	31	2564	3674
ICMP 217027	27	48	232	29	2563	3622
ICMP 217073	73	45	243	34	2550	3539
ICMP 217013	13	50	253	32	2543	3710
ICMP 217031	31	48	248	32	2542	3664
ICMP 217003	3	46	232	33	2527	3611
ICMP 217028	28	48	233	34	2526	3538
ICMP 217018	18	50	247	34	2520	3612
ICMP 217015	15	47	235	31	2511	3500
ICMP 217083	83	46	239	27	2451	3360
ICMP 217090	90	48	247	29	2446	3404
ICMP 217007	7	47	232	38	2445	3440
ICMP 217077	77	48	230	29	2443	3353
ICMP 217030	30	50	243	44	2414	3509
ICMP 217040	40	50	252	29	2411	3310



Evaluation of pearl millet hybrids for better endowed environments

	Moyenne ± SE	Minimum	Maximum	δ^2_g	δ^2_{gxe}	h^2	LSD	CV
HP (cm)	230±16,0	197	277	450,6***	39,6ns	0,88	21,38	6,9
LP (cm	35±3,2	27	43	27,03***	2,25*	0,91	4,55	9,03
TP	4±0,9	3	5	0,25***	0,06 ns	0,61	0,9	23,17
RDTG	2849±647,5	2211	3470	147434,59***	41208,2 ns	0,62	677,52	22,72

Nom_ Entrée	Numéro_Entrée	HP (cm)	LP (cm)	RDTG (kg/ha)
ICMX207246	28	241	39	3470
ICMX207269	43	233	42	3292
ICMX207239	23	249	42	3058
ICMX207260	36	259	43	3053
ICMX207257	34	242	43	2993
ICMX187885	8	247	42	2957
ICMX207272	45	256	40	2944
ICMX207259	35	239	40	2942
ICMX207268	42	244	43	2939
ICMX207236	21	274	43	2870



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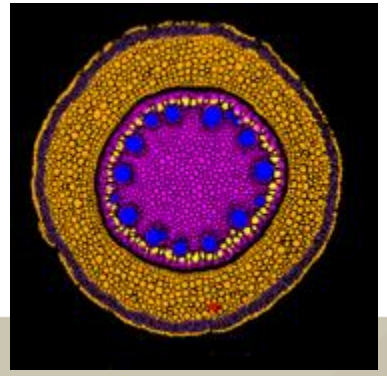
Phenotyping for abiotic stresses – Drought tolerance

- Screening 160 pearl millet genotypes under irrigated and vegetative drought stress (A. FAYE; collaboration with University of Nottingham)

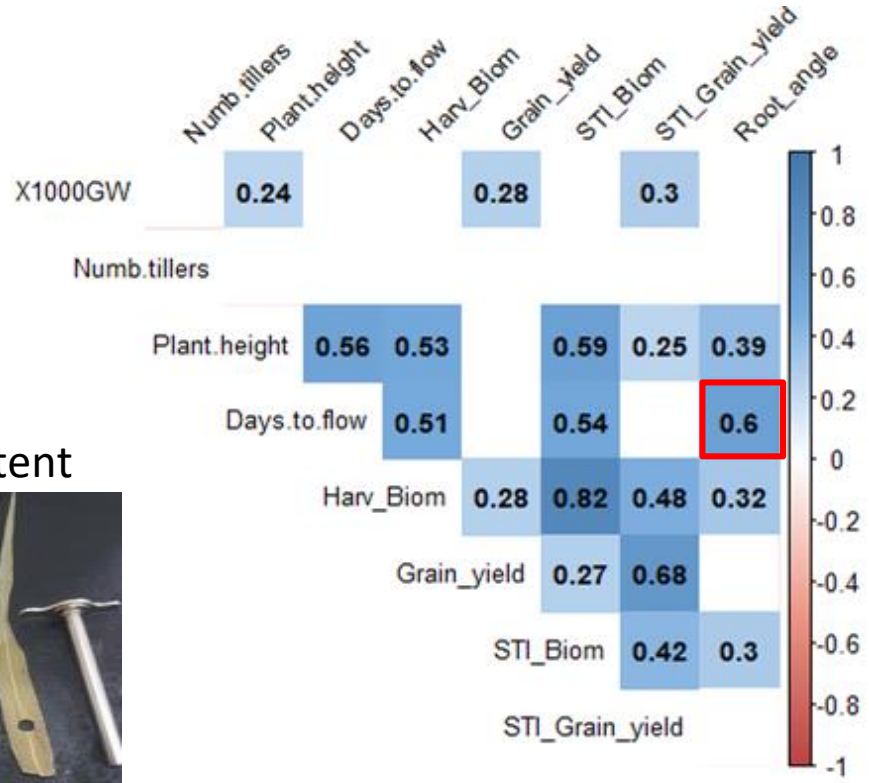
Shovelomics

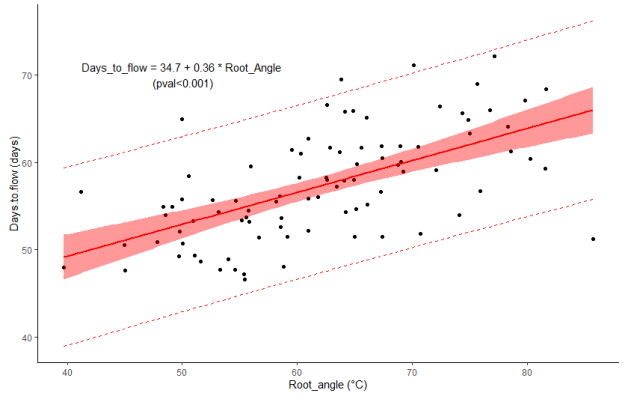
Root angle

Anatomy



Ion content





Genotypes with shallow root systems tend to have longer time to flowering

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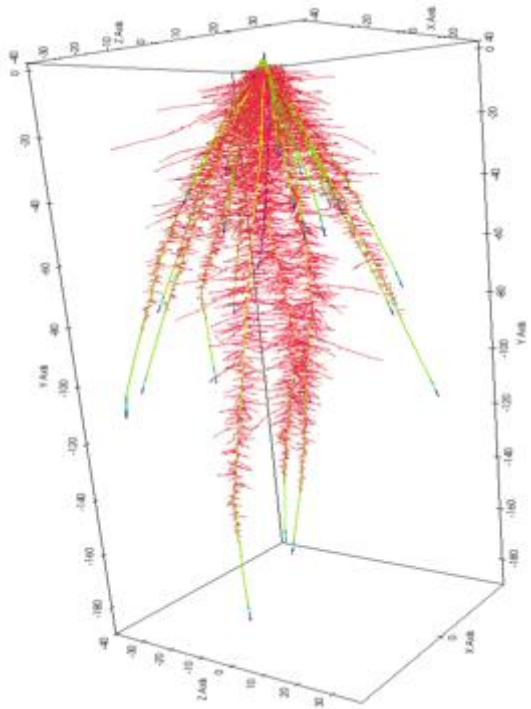
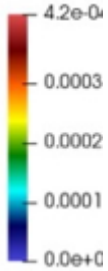
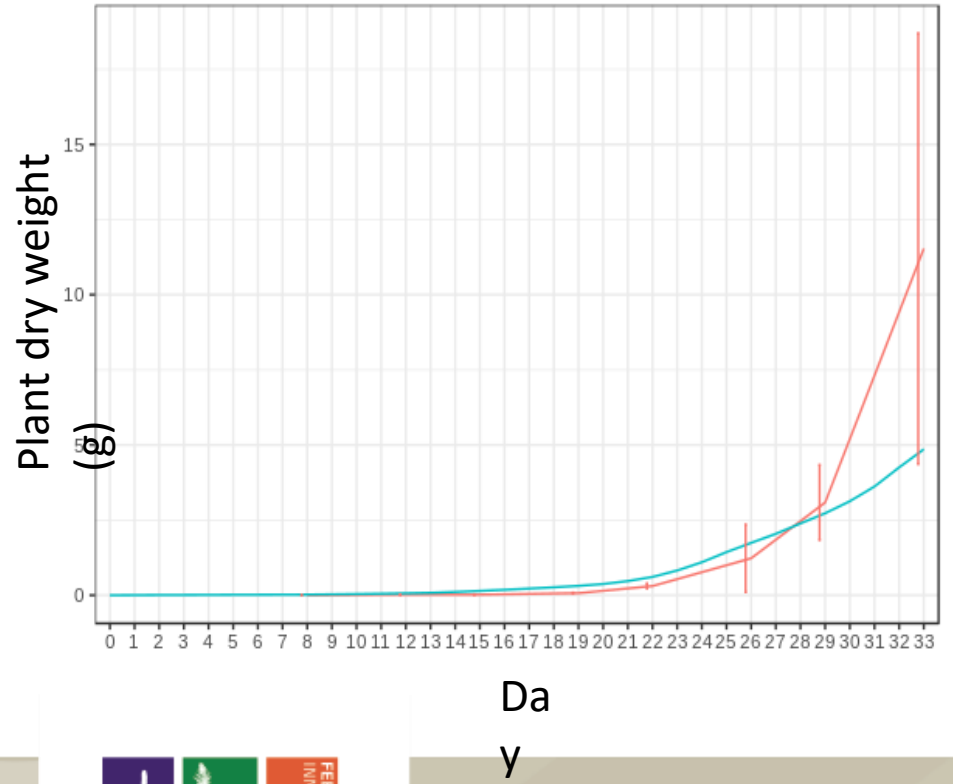
Root model for drought tolerance trait identification

- Parametrization of OpenSimRoot for pearl millet (M. S. NDOYE; collaboration with Penn State University)



Root hydraulic conductivity





Accurate simulation of shoot biomass until 30 days after sowing

Modern Large Scale phenotyping based on Optical sensors combined with Machine Learning

Radar and Optical Satellite VI

- *NDVI*
- *EVI*
- *MSAVI*
- *GNDVI*
- *RVI*
- ……..

Multispectral and thermal VI

- *NDVI*
- *EVI*
- *MSAVI*
- *GNDVI*
- ……..

Agro-morphological Measurements

- *Biomass*
- *Plant Height*
- *Chlorophyll*
- *LAI*

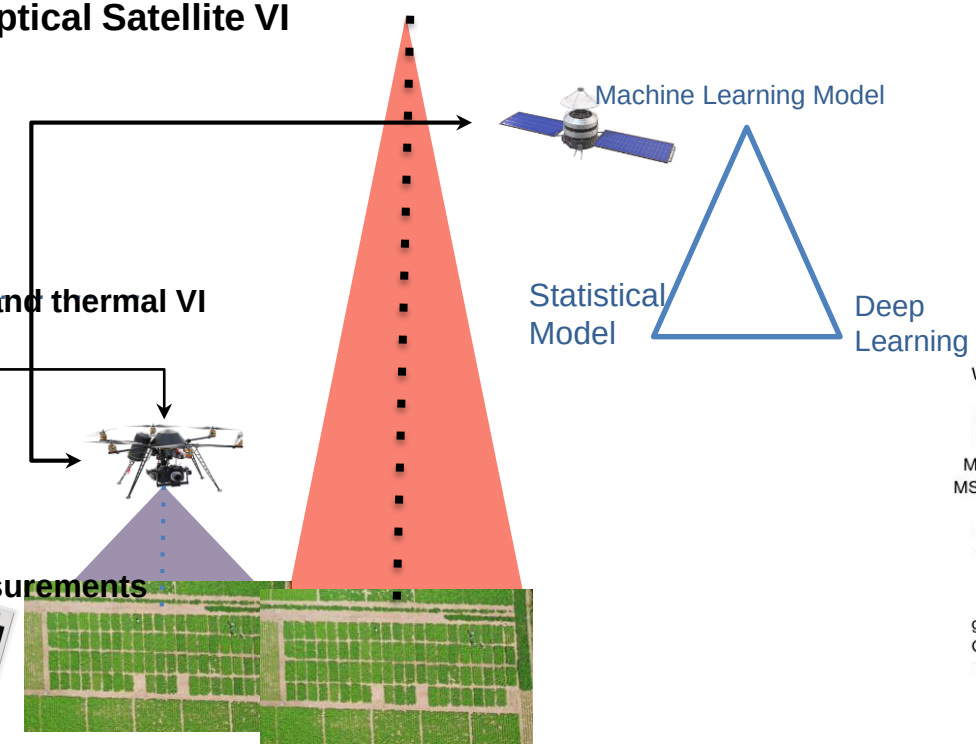


Fig 1 : a methodology for data fusion technique for modern phenotyping

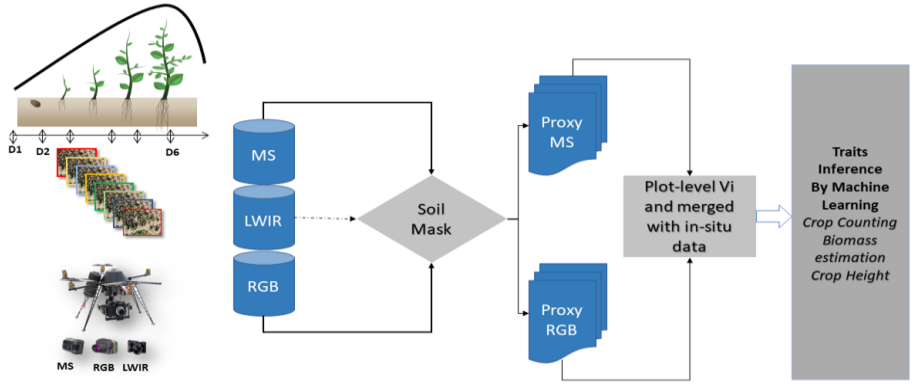


Fig 2 : The pipeline of HTP at CERAAS

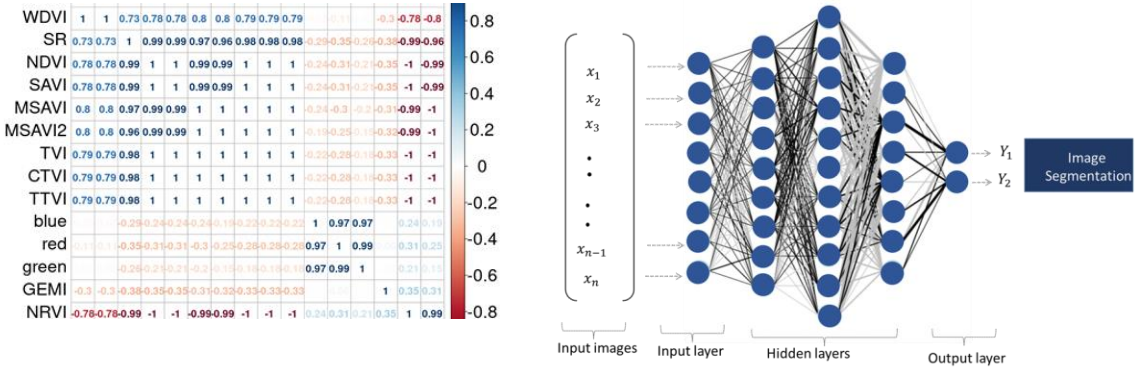


Fig 3 : machine learning segmentation

Deep Learning Approach of LAI estimation

Fig 1: Drone RGB field view

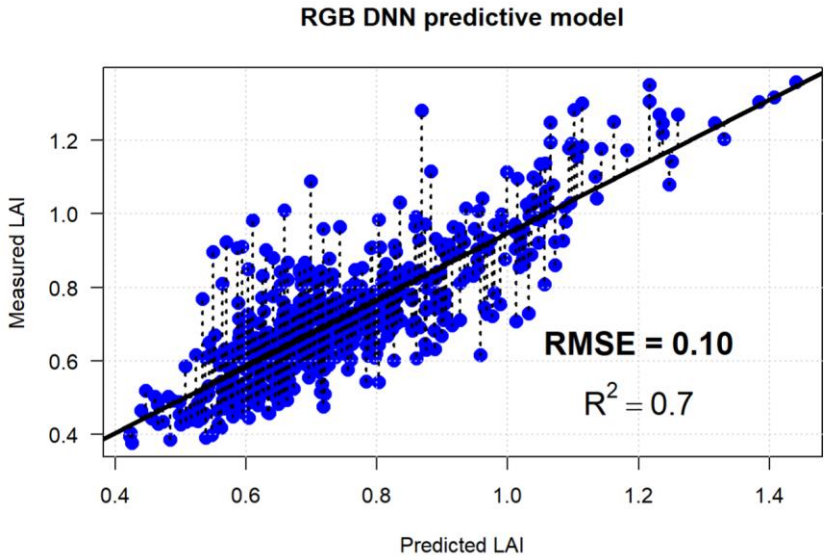


Fig 2 : a DNN calibration based on RGB Band

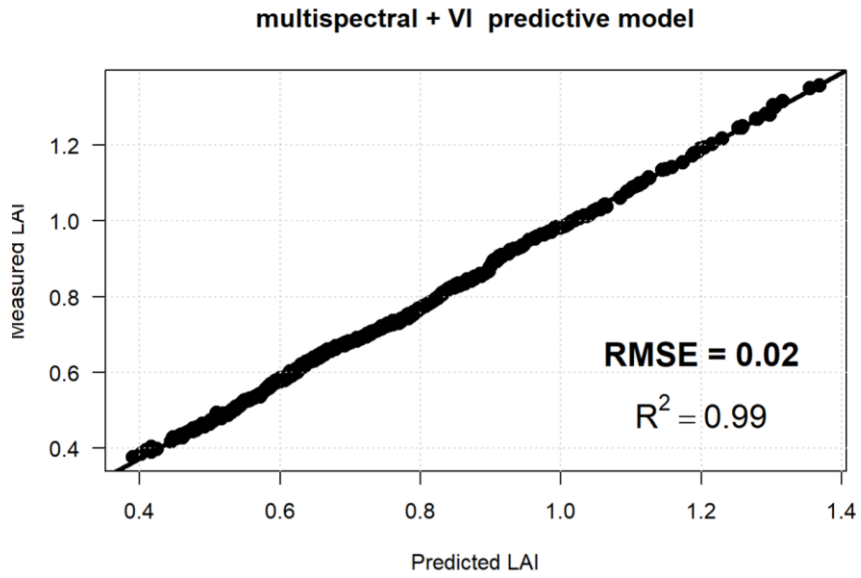


Fig 3: A DNN calibration based on the multispectral band and ndvi VI

Developing new genetic resources

- BC1F1 ⟶ BC1F2 (Being harvested at ICRISAT Sadore and will be advanced to BC1F3)
- Populations- 6, progenies- 5000

Female parents
ICMB 177001
ICMB 177002
ICMB 177003
ICMB 177004
ICMB 177005

Male Parents
HP-WCA 42
HP-WCA 44
HP-WCA 46
HP-WCA- 48
HP-WCA- 50

Female parents selected for :

Adoption

Inbred lines

Downy mildew resistant

Medium maturity

Good combiners for high grain yield

Male parents selected for :

- High Fe
- Extra early maturing
- Drought tolerant
- Striga resistant
- High combining ability for grain yield, bold grains, high grain quality

Developing new genetic resources

Name	Generation	Number	observations
IBV8001	S4/F5	204	Inbred lines derived from local population
Thialack2	S4/F5	47	Inbred lines derived from local population
Salam	S4/F5	141	Inbred lines derived from local population
PMIGAP-WCA	F5	98	Inbred lines derived from local populations of WCA
ICMR 088888 X ICML 197189	F3	72	Develop lines with high GCA
ICML 197189 X ICMR 08666	F3	125	Develop lines with high GCA
ICMR 088888 X ICML 197252	F3	26	Develop lines with high GCA
ICML 197187 X ICMR 08666	F3	55	Develop lines with high GCA
ICML 197187 X ICML197252	F3	116	Develop lines with high GCA
WAAP line	F6	50	Develop lines with long panicle and early maturity
GAWANE	S1	126	Develop Inbred lines derived from local population
IBV8004	S1	98	Develop Inbred lines derived from local population
SOUNA III	S1	140	Develop Inbred lines derived from local population
Souna x Sanio	FS	12	Cross Sanio with Souna types
ICMA 177002 x ICML 197181	BC1F1	1	Develop new A/B lines

- Shared 50 S4/F5 with our colleague in Burkina for Phenotyping/Genotyping

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Developing new genetic resources

		Male									
		1	2	3	4	5	6	7	8	11	12
ICMB 177002	1			X							
ICMB 177003	2	X			X	X		X		X	X
SOSAT C 88	3								X	X	X
29 AW	4	X									
ICMR 088888	5							X	X	X	
ICML 197186	6		X			X				X	
ICML 197243	7	X		X	X				X	X	
ICML 197264	8										
ICML 197253	11		X					X			X
ICML 197246	12	X	X		X		X		X		

Name	Pedigre
ICMB 177002	ICMB 177002
ICMB 177003	ICMB 177003
SOSAT C 88	SOSAT
ICML 197243	PE00735-B-B-1-1-B
ICML 197186	ICMV 96490-S1-15-1-2-1-1
29 AW	29 AW
ICMR 088888	ICMR 088888
ICML 197264	ICTP 8203 S1-84-3-3-1-B

These lines are having a drought tolerance, stay green type, high Fe and Zn, DM resistance, compact heads and also possess high GCA and SCA.

Mainly ICMB 177001, ICMB 177002 and ICMB 177004 used as females and they are our promising, designated B lines. The donor parents are of diverse origin and they possess different traits.

Interm of relation to Senegalese germplasm, mainly ICMB 177001 and ICMB 177002 have SOUNA 3 as parental background and have wider adaptability to the region and in specific to Senegal.

- In blue are crosses already done and will be completed during the off season 2022.
- Will be evaluated during the rainy season 2022 for GCA and SCA
- Initiate a second round of intercrossing during the rainy season 2022 (MAGIC pop)

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Understanding the genomic basis of flowering time

Hypothesis	**Flowering time is fixed within variety ?**	**Flowering time is fixed among varieties ?**	**Flowering time is a mendelian, oligogenic or polygenic trait ?**
Experiment	Selfing local varieties	Crossing elite x elite lines	Developing biparental population (Souna X Sanio)
Status	S1 → S2	F1 → F2	S1 → S2

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Training of seed producers in hybrid and OPVs pearl millet seed production

Trained 30 participants from NGOs, Farmers' organizations (UNIS, SEDAB, PMP) and Government (DRDR, DISEM, ANCAR)

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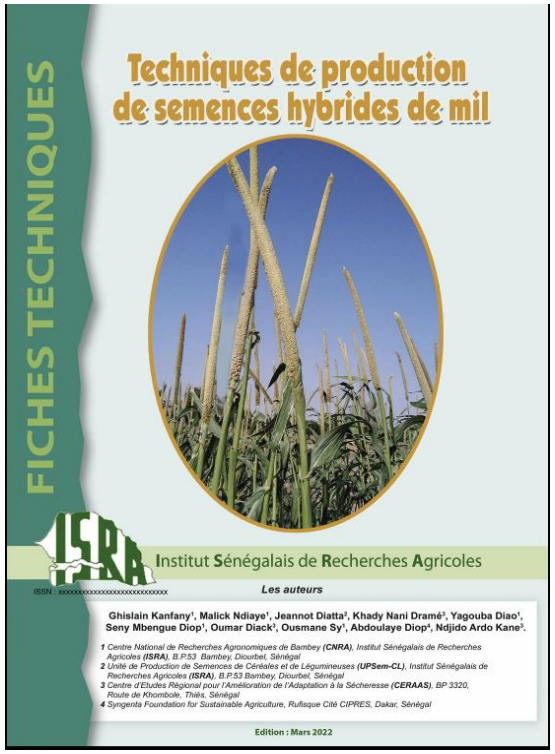
Technical manuals and videos on seed production



- More than 500 Manuals shared with technicians and farmers

Training and capacity building

Training session at Maradi on seed production

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Training and capacity building

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

Visiting scientist of ECR to learn more on pearl millet activities [varietal development strategies (population and hybrid), product profile, seed multiplication and purification] at ICRISAT, Sadore, Niger.

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Training and capacity building (PhD students)

Safiatou Fall
PhD candidate
Co-supervision
CSU, CERAAS

Undercover the genomic basis of drought-adaptive traits

Sokhatil Ndoye
PhD candidate
Co-supervision
IRD, UCAD

Root traits genes discovery and characterization

Some Project's Future Activities (2022 – 2023)

- Create S1, inter and intra FS between these populations
- Full diallel to identify pop with high GCA and SCA
- Cross them with 5 CMS to create Top-cross hybrid
- Cross also inbred lines with the 5 CMS for single cross hybrid
- Have a second round of multi parental crosses initiated during the off season

Numéro	Entrèes	Trait d'intéret	Origine	
1	SOUNA 3	High yield	Sénégal	
2	ICTP 8203	High grain iron and zinc content	Sénégal	
3	ISMI 9507	Early maturity, high yield	Sénégal	
4	**SL 28**	**High yield, dual purpose, Long panicle**	Sénégal	
5	**SL 169**	**High yield, dual purpose, Long panicle**	Sénégal	
6	IBV 8004	Early maturity	Sénégal	
7	THIALACK 2	**Long panicle**	Sénégal	
8	**SL 423**	**High yield, dual purpose, Long panicle**	Sénégal	
9	GAWANE	Early maturity, drought tolerant	Sénégal	
10	SOSAT C 88	Downy mildew resistance	Sénégal	
11	**KONKOSOUGA**	**Early maturity, épis moyen**	**Burkina Faso**	
12	**SOMKIETA**	**Dual purpose, épis moyen**	**Burkina Faso**	
13	**MISARI 2**	**Grain colour (grise laiteux), épis moyen**	**Burkina Faso**	
14	**MORO**	**Long panicle**	**Niger**	
15	**ZATIB**	**Long panicle**	**Niger**	
16	**HKP**	**Long panicle**	**Niger**	
17	**Sanio 1**	**Aristation, grain quality**	**Sénégal**	
18	**Sanio 2**	**Aristation, grain quality**	**Sénégal**	

Some Project future Activities (2022 – 2023)

Scaling improved pearl millet varieties

- 4 OPVs (SOSAT C88, SL 169, SL 423 & SL 28) and 1 hybrid (Taaw)
- Breeder seeds production (~700kg) during the off season 2022.
- Foundation seeds production during the rainy season 2022 by 180 lead producers selected from the 18 Millet Multi-Services Hubs across Kaolack, Kaffrine and Fatick Districts.
- Training lead producers on good agronomic practices for quality grain production and support for seed quality control and certification.
- Distribution of the produced seeds to farmers during seed fairs.

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