CIMMYT Eastern Africa Maize Breeding Pipeline Updates

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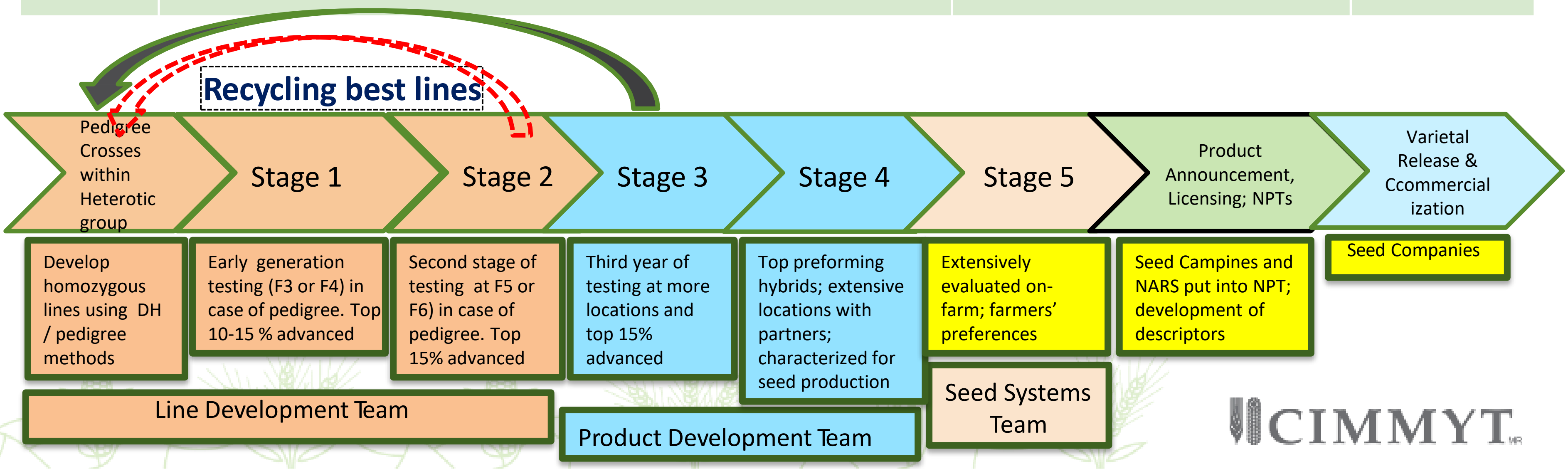
Outline

- Introduction
- Breeding Pipeline updates for 2020
- Implementation of new tools and technologies
  - Use of DH
  - Molecular assisted breeding
- Progress on Breeding Schemes
  - Reducing cycle time
  - Identifying appropriate number of selection environments

- Elite lines available for sharing

CIMMYT Maize Product Profiles in Eastern Africa

Pipeline Code	Short description	Target Countries	Est. Area (M ha)
EA-PP1	**Early/intermediate-maturing, white maize** varieties with **drought-tolerance, NUE** and resistance to GLS, TLB, Ear rots, MSV and **MLN**, and suitable for food use in Eastern African **tropical rainfed dry/wet mid-altitude areas.**	Ethiopia, Kenya, Uganda, Tanzania (Northern)	3.17
EA-PP2	**Late-maturing**, **white maize** varieties with **drought tolerance, NUE,** and resistance to GLS, TLB, MSV, common rust, and ear rots, adapted to **Eastern African tropical rainfed wet, upper mid-altitude areas**, and used mainly for food purposes.	Ethiopia, Kenya, Uganda, Tanzania (Southern)	3.38
EA-PP3	**Late-maturing**, **multiple stress-tolerant white maize** varieties for the **Eastern African tropical rainfed highlands** and used mainly for food purposes.	Ethiopia, Kenya, Uganda, Tanzania (Southern)	1.75



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CIMMYT Eastern Africa Maize Breeding Pipelines

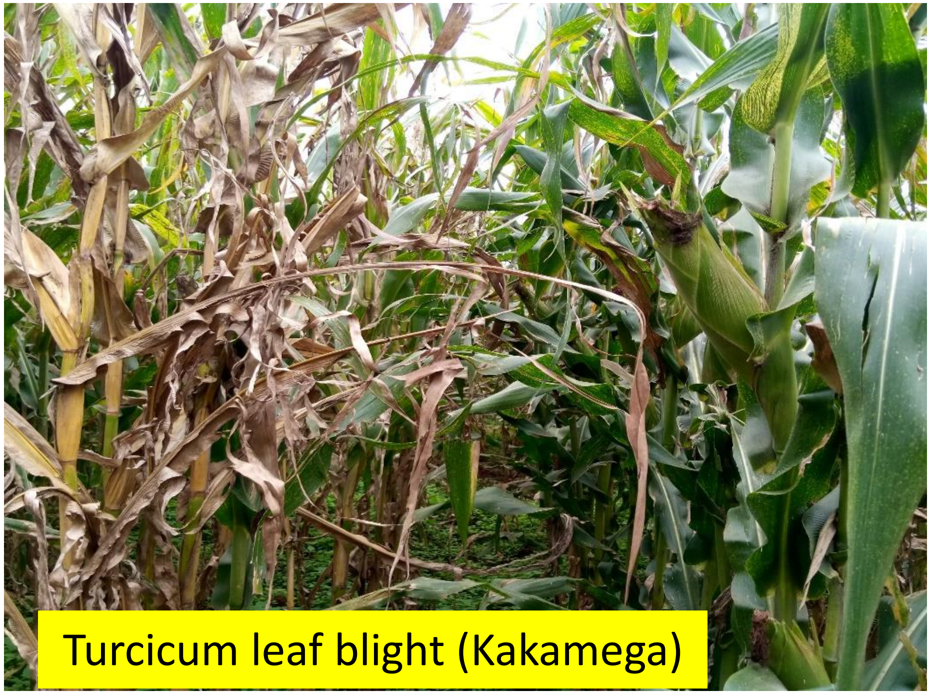
- **An extensive field network to screen for various "must have" and "good-to-have traits" within the Target Population of Environments (TPE).**
- The network is managed between CIMMYT, NARS and private sector – in Eastern Africa, NARS accounts for **~80%** of network,

Key Testing Locations

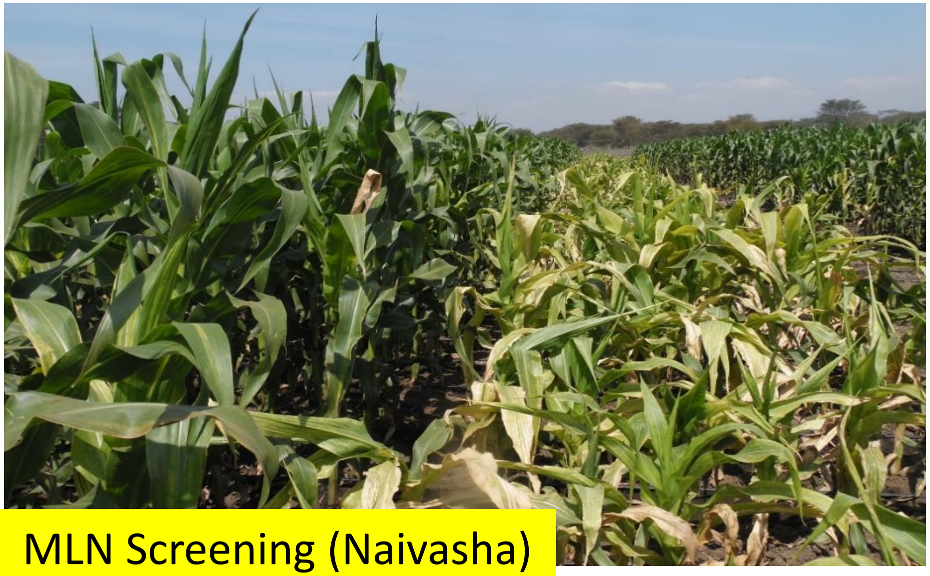
Location	Key Traits
Kiboko (KE)	Yield under drought, low N, Optimal, FAW, stem borers
Kakamega (KE)	Yield, GLS, TLB, common rust, Fusarium ear rot
Elgon downs (KE)	Yield, GLS, TLB, common rust, Fusarium ear rot
Bako (ET)	Yield under optimal and low N, GLS, TLB
Karatu (TZ)	Yield, common rust
Uyole (TZ)	Yield, GLS, TLB
Bulindi (UG)	Yield, TLB
Bulegeni (UG)	Yield, GLS
Embu (KE)	Yield under optimal, low N
Alupe, Kibos (KE)	Striga (artificial infestation)
Naivasha (KE)	MLN (artificial inoculation)

Phenotyping for “Must-have” and “Value-added” Traits

Managed drought (Kiboko)



Turcicum leaf blight (Kakamega)



MLN Screening (Naivasha)

Number of Hybrids and Lines Tested at Different Stages in 2020

Category	EA-PP1	EA-PP2	EA-PP3	Total
Stage 1 Hybrids	2,339	2,223	437	4,999
Stage 2 Hybrids	900	880	280	2,060
Stage 3 Hybrids	210	114	55	379
Stage 4 Hybrids	61	19	30	110
Stage 5 Hybrids	22	7		29
Line evaluated for foliar diseases	3,993	3,020	917	7,930
Line Increase and preliminary evaluation	13,515	10,143	1,970	25,628

Performance of highland maize

41,135 Lines and hybrids were evaluated in 2020

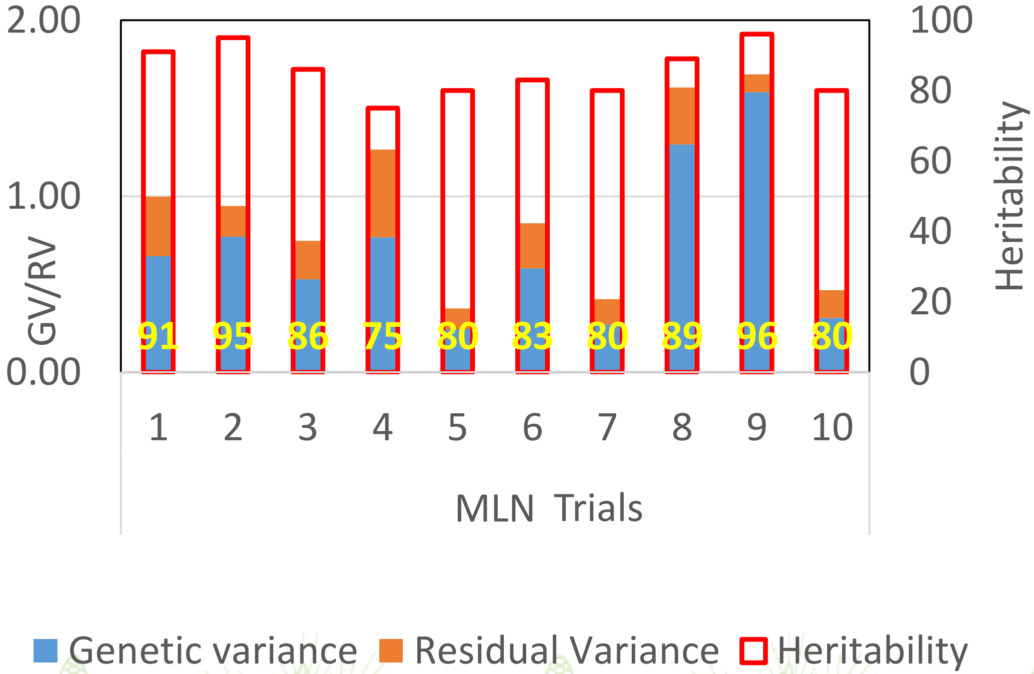
Performance and Combining Ability of Selected Lines under artificial Striga infestation

		Striga Count BLUP			Striga 8WAP		Striga 10WAP		Striga 12WAP	
Line	Name	8WAP	10WAP	12WAP	GCA_f	GCA_m	GCA_f	GCA_m	GCA_f	GCA_m
1	DL171564	9	35	63	3.6*	6.2**	10.2*	18.9**	15.01*	27.7**
2	**DL17535**	3	13	33	**-3.9***	**-3.8***	**-8.1***	-12.7	-8.3	**-16.6***
3	DL17571	5	20	41	1.1	-0.1	6.6	0.0	8.3	3.8
4	DL17604	3	12	29	-0.2	-1.3	-1.7	-0.8	-2.7	-2.6
5	DL17611	3	16	36	-0.7	-0.9	-7.0	-5.6	**-12.4***	-12.4
6	DL17888	5	20	52	2.5	2.2	5.7	10.3*	11.2*	18.7*
7	DL17961	4	21	45	-1.9	3.4*	-4.3	3.7	-5.0	1.9
8	**DL171092**	3	14	33	-0.9	-3.6	-2.9	**-8.9***	-6.6	**-11.5***
9	DL171119	3	14	33	0.1	-0.3	1.7	2.0	2.2	3.1
10	**DL171162**	3	17	43	0.3	-1.7	-0.2	**-7.1***	-1.9	**-12.2***
11	*TEISTR1156*	4	14	34	1.6	-0.2	3.3	-1.2	7.4	0.4
12	*TEISTR1157*	3	12	31	-0.3	0.7	-2.9	1.5	-5.1	0.5
13	*TEISTR1158*	4	18	40	0.6	0.0	-1.0	0.6	-2.4	-1.2
14	*TEISTR1159*	2	10	28	-1.1	-1.6	1.2	-4.5	-0.6	-5.2
15	*TZSTR189*	4	16	39	-0.8	1.1	-0.6	3.7	0.7	5.5
16	DL171267	2	15	42	2.8	-2.7	3.3	-3.9	5.9	-2.0
17	DL171357	5	21	44	-0.5	2.7	-1.8	5.0	-2.7	4.5
18	DL171514	4	17	39	-2.5	-0.3	-2.4	3.2	-1.0	3.9
19	DL171520	5	19	50	3.7	3.1*	8.4*	3.0	10.1*	5.4
20	**DL171527**	2	11	29	**-3.5***	-2.9	**-7.6***	**-7.2***	**-12.3***	**-11.8***
21	DL17508	3	14	31	-0.4	0.1	-3.2	2.3	-3.3	0.9
22	DL17513	11	33	59	3.7*	0.7	10.8*	-1.5	17.5*	1.0
23	**DL17517**	5	16	35	-1.1	-1.7	**-8.1***	-3.5	**-12.3***	**-9.3***
24	**DL17531**	2	11	32	**-4.8***	-2.1	**-10.2***	-3.9	**-14.2***	-5.8
25	DL17650	5	21	49	2.6	2.9	10.6*	6.6	12.4*	13.2*
26	**DL17719**	3	22	65	-4.8	**-3.3***	**-15.7****	**-9.1***	**-21.1****	**-11.6***
27	DL14549	17	37	59	1.7	6.3**	8.6*	9.9*	9.6	7.5
28	DL12128	4	22	51	-0.6	-0.3	-0.8	-2.3	-0.6	0.2
29	**CML543**	4	15	38	**-5.1***	-2.7	**-10.6***	-1.2	**-11.1***	-2.7
30	CML312	15	49	82	8.8**	0.0	18.5**	2.7	23.2**	6.6
	Heritability	**0.69**	**0.64**	**0.48**						
	Grand Mean	5	19	43						
	LSD	7	19	40						
	n Environments	3	3	2						

MLN Screening in 2020

Partners type	April Planting (Rows)	November Planting (Rows)	Total
CIMMYT	7330	2806	10136
NARS	0	3604	3604
Private	3194	1035	4229
Total	**10,524**	**7,445**	**17,969**

Field evaluation – Regional trials



Data quality representation

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Development of Multiple Stress Tolerant Hybrids

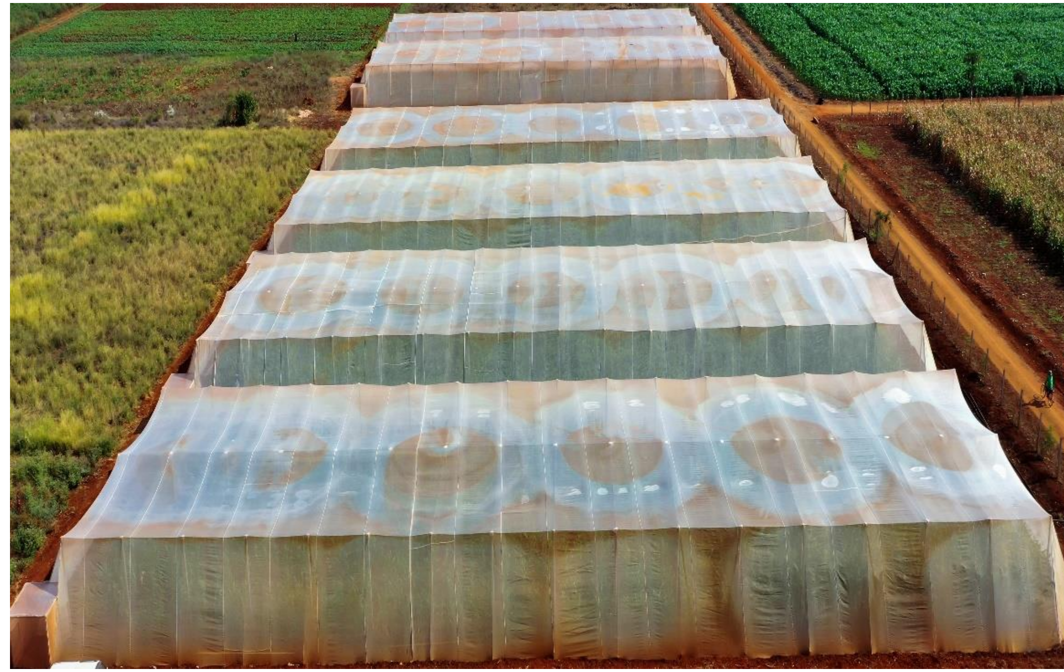
Entry	Pedigree		BLUP_GY (MLN)	BLUP_GY (Opt)	BLUP_GY (Drt)	BLUP_AD	BLUP_Eturc1	BLUP_MOI	BLUP_MLN4
18	(CKDL0323LNT22/CKL05017LNT21)//CKDHL1800829	((CML442/KS23-6)-B)-DH-38-B	8.44	8.74	1.63	75.8	2.0	16.0	3.6
3	(CML444LNT21/CML442LNT21)//CKDHL1800637	((CKDHL0186/KS23-6)-B)-DH-32-B	8.14	7.15	1.57	75.7	2.5	17.5	3.1
9	(CML444LNT21/CML442LNT21)//CKDHL1800937	((CML537/KS523-5)-B)-DH-10-B	7.31	5.89	1.46	77.0	4.9	17.2	3.1
4	(CML569LNT23/CML442LNT21)//CKDHL1800637	((CKDHL0186/KS23-6)-B)-DH-32-B	7.29	7.17	1.92	73.0	2.7	16.5	3.1
5	(CML444LNT21/CML442LNT21)//CKDHL1800651	((CKDHL0186/KS23-6)-B)-DH-46-B	6.98	7.22	1.98	74.9	2.9	17.4	3.6
26	(CKDL0323LNT22/CKL05017LNT21)//CKDHL1800890	((CML442/KS23-6)-B)-DH-99-B	6.89	8.40	1.53	76.1	1.2	17.1	4.0
13	(CML444LNT21/CML442LNT21)//CKDHL1801056	((CML537/KS523-5)-B)-DH-129-B	6.69	5.63	1.79	75.2	4.5	17.6	3.6
20	(CKDL0323LNT22/CKL05017LNT21)//CKDHL1800851	((CML442/KS23-6)-B)-DH-60-B	6.55	8.62	1.77	77.5	1.6	17.1	3.1
12	(CML569LNT23/CML442LNT21)//CKDHL1800974	((CML537/KS523-5)-B)-DH-47-B	6.41	7.14	2.12	74.6	4.2	17.2	3.1
7	(CML444LNT21/CML442LNT21)//CKDHL1800741	((CKDHL0221/KS23-6)-B)-DH-13-B	6.38	8.32	1.97	76.6	2.5	18.3	4.0
1	(CML444LNT21/CML442LNT21)//CKDHL164166	((CKDHL120184/CKDHL120312).%DHH3D030108)-B	3.45	7.35	2.29	72.7	4.2	16.7	4.9
2	(CML569LNT23/CML442LNT21)//CKDHL164166	((CKDHL120184/CKDHL120312).%DHH3D030108)-B	2.53	8.18	2.22	72.7	3.4	17.3	5.4
31	WE7118		4.40	7.11	2.01	70.0	4.1	15.4	4.9
33	DK777		2.92	7.58	1.91	75.7	3.7	17.6	4.9
34	PHB30G19		0.96	7.81	1.48	74.9	1.3	17.7	7.7
	Heritability		0.900	0.660	0.410	0.892	0.957	0.575	0.911
	Grand Mean		5.09	7.38	1.74	75.4	2.9	16.8	4.4
	LSD		1.481	1.207	0.651	2.138	0.568	1.386	0.789
	n Environments		1	2	1	3	1	2	

Combining Ability of Selected Lines under Different Management

	GY_MLN			GY_DRT			GY_OPT			MLN 4		GLS_OPT	
LINE	Line mean	GCA	Rank	Line mean	GCA	Rank	Line mean	GCA	Rank	Line mean	GCA	Line mean	GCA
(CML494/HAIT44)-B-11-1-1-B	7.472	2.868***	1	3.752	0.272	24	7.079	0.369	20	3.031	-1.488***	1.675	-0.222
(CML494/HAIT44)-B-11-1-2-B	6.761	2.157***	2	3.356	-0.124	49	6.794	0.083	37	3.607	-0.912***	1.954	0.058
CKDHL1803570	6.652	2.048***	3	4.444	0.964**	1	6.863	0.152	32	4.198	-0.321	1.972	0.075
CKDHL1803820	6.428	1.824***	4	3.240	-0.24	61	6.649	-0.062	50	4.083	-0.436	1.972	0.076
CKDHL1802085	6.412	1.808***	5	2.889	-0.591*	81	6.698	-0.013	45	3.439	-1.080***	1.566	-0.331*
CKDHL1803230	6.381	1.777***	6	3.500	0.02	37	7.156	0.445	13	4.202	-0.317	1.962	0.065
CKDHL1802265	6.102	1.498**	7	3.006	-0.474	76	6.229	-0.482	74	3.623	-0.897***	1.710	-0.186
CKDHL1803545	6.100	1.496**	8	4.111	0.631*	7	7.439	0.728*	5	4.117	-0.403	1.832	-0.065
CKDHL1702544	6.064	1.460**	9	3.216	-0.264	65	6.016	-0.695*	83	3.782	-0.738**	1.754	-0.143
CKDHL1803517	6.060	1.456**	10	3.264	-0.216	59	7.039	0.328	22	4.191	-0.328	1.923	0.026
CKDHL1803759	5.912	1.308*	11	3.954	0.474	14	6.938	0.227	27	4.012	-0.507	2.319	0.423**
CKDHL1701061	5.871	1.267*	12	3.420	-0.06	43	7.279	0.568	10	4.232	-0.287	1.915	0.019
CKDHL1802075	5.855	1.251*	13	2.906	-0.574	80	6.130	-0.581	77	3.058	-1.462***	1.751	-0.146
CKDHL1802148	5.729	1.125*	14	3.235	-0.245	62	5.919	-0.791	86	3.510	-1.009***	1.474	-0.422*
CKDHL1803913	5.700	1.096*	15	4.344	0.864**	2	6.565	-0.146	53	4.223	-0.296	2.008	0.112
CKDHL1701317	5.662	1.058*	16	3.208	-0.272	66	6.932	0.222	28	4.359	-0.16	1.653	-0.244
CKDHL1803704	5.641	1.037*	17	3.927	0.447	16	6.755	0.044	40	4.075	-0.444	1.897	0.001
CKDHL1701313	5.587	0.983*	18	3.357	-0.123	48	6.963	0.252	25	4.204	-0.316	1.876	-0.02

Breeding for Native Genetic Resistance to FAW

- Optimization of screening protocols
- Screened 2, 700 lines and hybrids under artificial infestation



Tolerant and susceptible lines under FAW under artificial infestation

	FAW	*C. partellus*	*B. fusca*	*S. calam*
Production (adults)	12000	10,000	4,500	1,300
Supplied (neonates)	1,300,000	240,000	240, 000	

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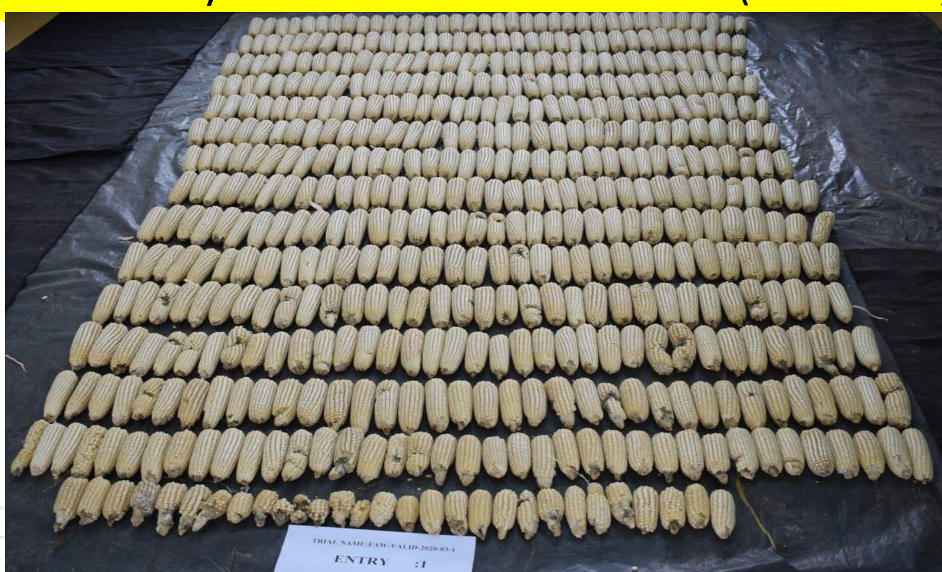
FAW Validation Trials

Tolerant hybrid under art. infestation (no choice)

Susc. hybrid under art. infestation (no choice)



TELA Maize National Performance Trials (NPTs) in Kenya under stalk borer artificial infestation

DH Line Production and Distribution of Tropical Inducer Lines in 2020

	# of populations	# of DH lines
CIMMYT breeders	101	12,228
NARS partners	41	4,523
SMEs	12	1,161
	154	17, 912

- ~ 20, 000 DH lines are expected from the second cycle of 2020 (to be delivered by Feb 2021)
- Second generation tropical inducers were distributed to 7 organizations (4 private sector and 3 public sector organizations)

Developing Improved Method of Chromosome Doubling

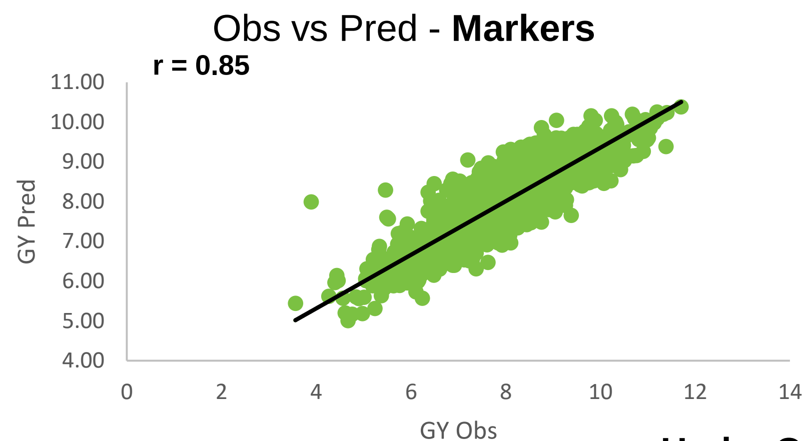
Population	N	Overall success rate	
		Method II (root and crown region immersion at 10-12 days)	Method I (seedling dip of 3-4 old seedlings)
(((CL106653/PHK29)-B/P501SYN))	3000	30.9a	7.5b
(((CL106726/LH185)-B/CL420801//P502SYN2))	3000	33.5a	8.7b
(((CML321/PHK56//CLWN247)/P502SYN1))	3000	32.4a	4.8b
(((CML373/PHHB9)-B/CLHP0005)-B)	3000	32.8a	2.7b
(((CML373/PHP38//CML311)/P501SYN))	3000	32.5a	9.0b
(((CML384/LH185)-B/CL420801)-B)	3000	23.5a	4.4b
(((CML384/PHJ89//CLWN247)/P502SYN1))	3000	37.1a	3.1b
(((CML545/LH194)-B/CLHP0049)-B)	3000	26.9a	3.9b
(((DTPYC9F46 x LPSC7F64DH:48) x CML551)/((DTMA-103 x LPSC7F64DH:37) x CLWN247))	3000	47.1a	7.9b
(((LaPostaSeqC7F711212BBBBCL04934)DH57 x CML551)/((LaPostaSeqC7F711212BBBBCL04934)DH46 x CLWN247))	3000	52.3a	5.3b
((CML78/PHP38//CML311/P501SYN))	3000	30.5a	10.5b
(LPSC7F64/DTPWC9F115)	3000	58.5a	9.9b
Means		**36.5a**	**6.4b**

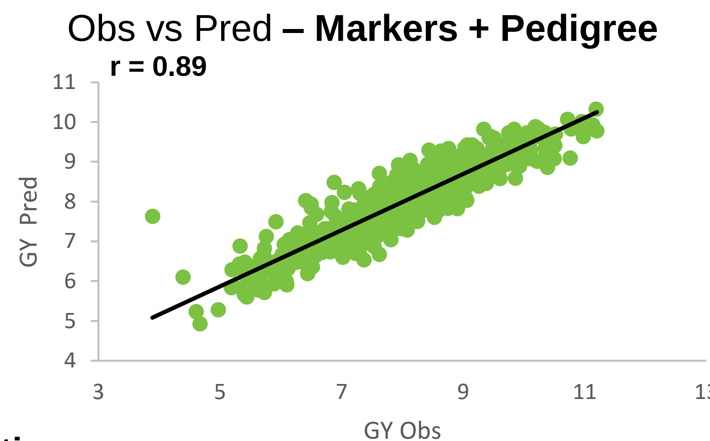
Chromosomal doubling increased by 5-6 times and results in higher seed quantity per DH line

Chaikam et al, Plants(2020)

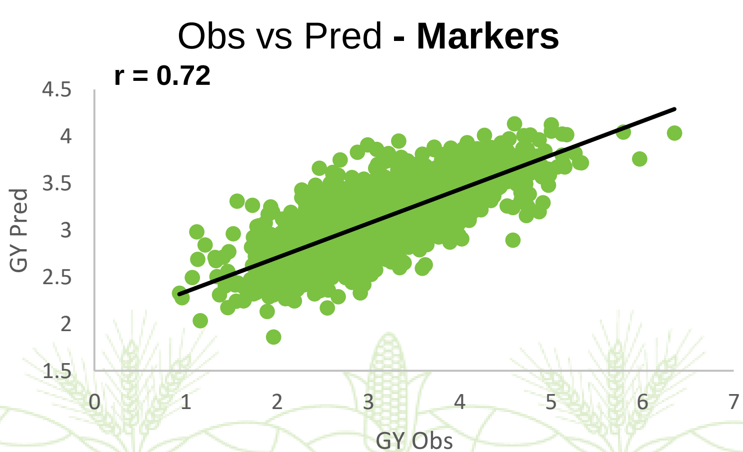
Implementation of GS in stage I trials in EA-PP1 and PP2

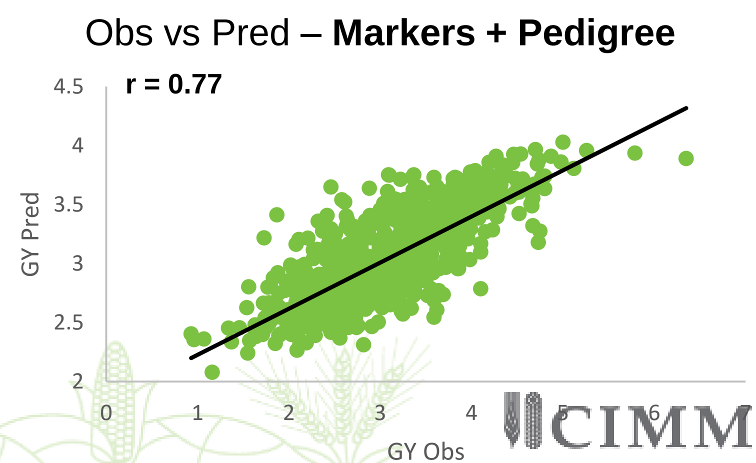
- Phenotyping half and predict half strategy implemented in the last 4 years





Under Optimum





Under drought stress

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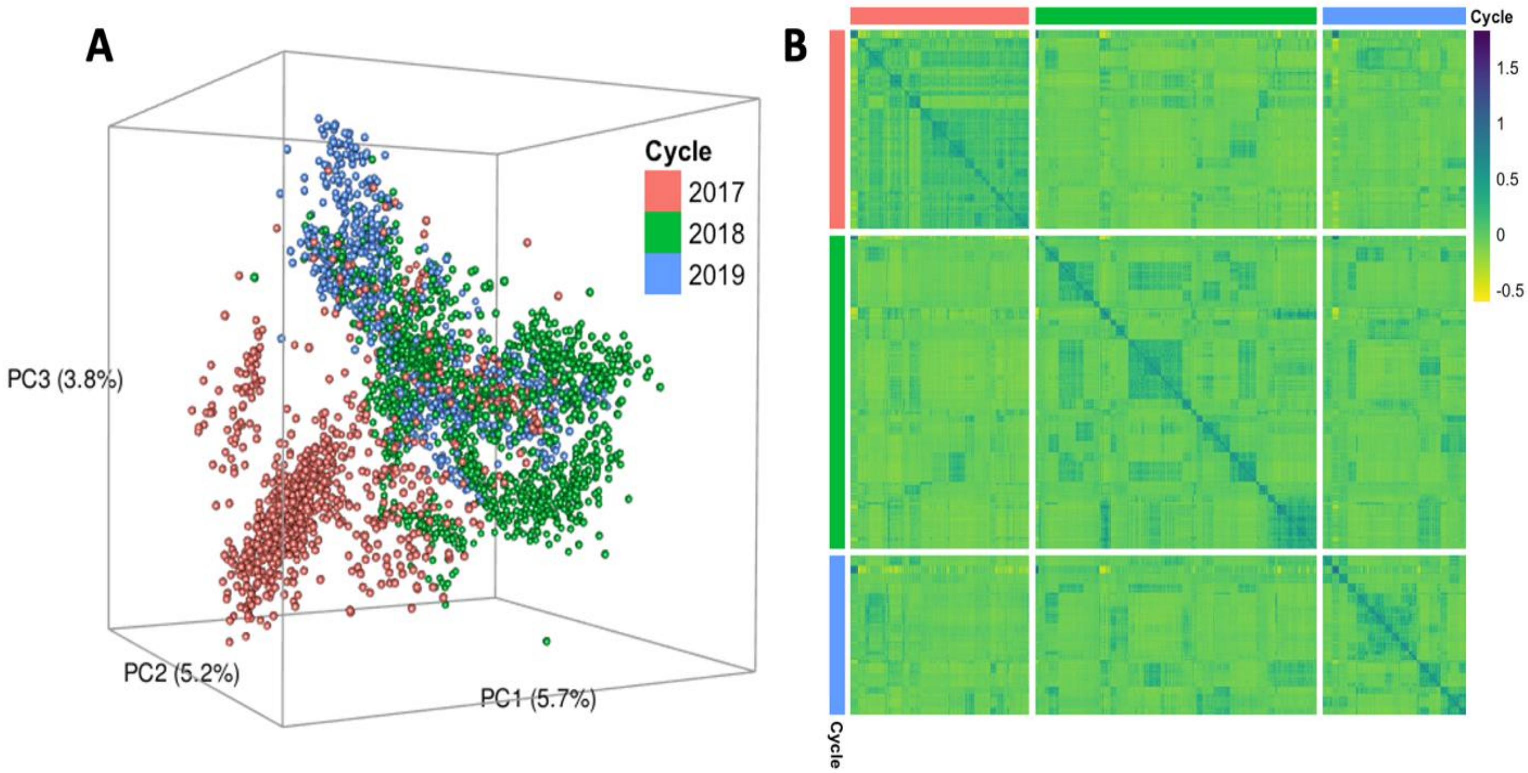
Implementation of GS in Stage 1 for Striga

- 678 DH lines genotyped
- Phenotyped 178 DH lines under artificial Striga infestation at 2 locations, optimal, and managed drought
- Predicted performance of 500 DH lines

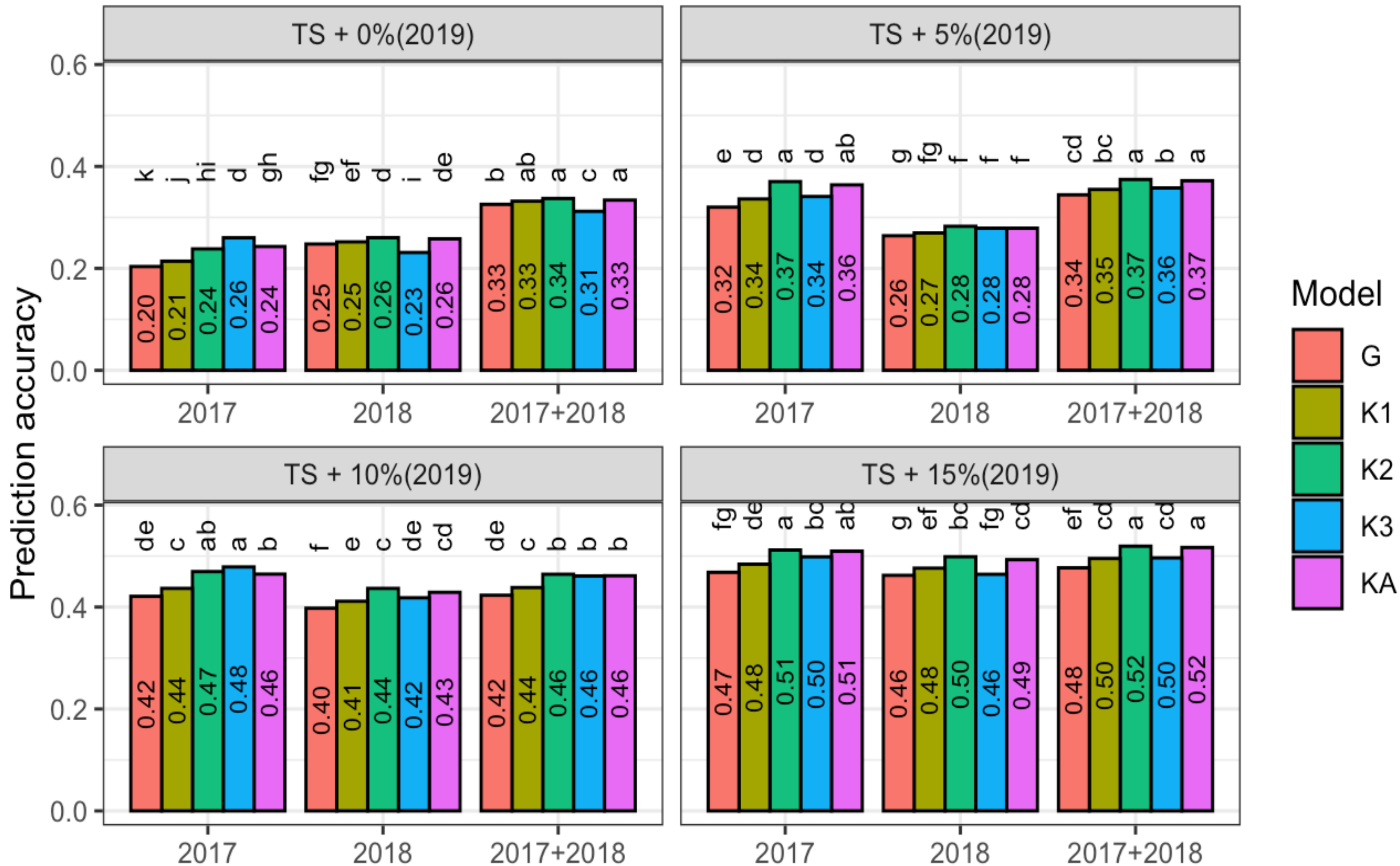
GS_Prediction_Striga	G-BLUP	RKHS model
GY_Optimum	0.66	0.78
BLUE_GY_Striga	0.64	0.72
BLUE_SDR1	0.65	0.75
BLUE_SDR2	0.61	0.71
BLUE_Striga8wks	0.62	0.71
BLUE_Striga10wks	0.72	0.81
BLUE_Striga12wks	0.74	0.82
BLUE_AUSNPC	0.73	0.82

Historical Data – Prediction across Years

Year	Phenotyped	GEBVs	Total
2017	853	639	**1492**
2018	1423	2200	**3623**
2019	724	1852	**2576**
Total	**3000**	**4691**	**7691**

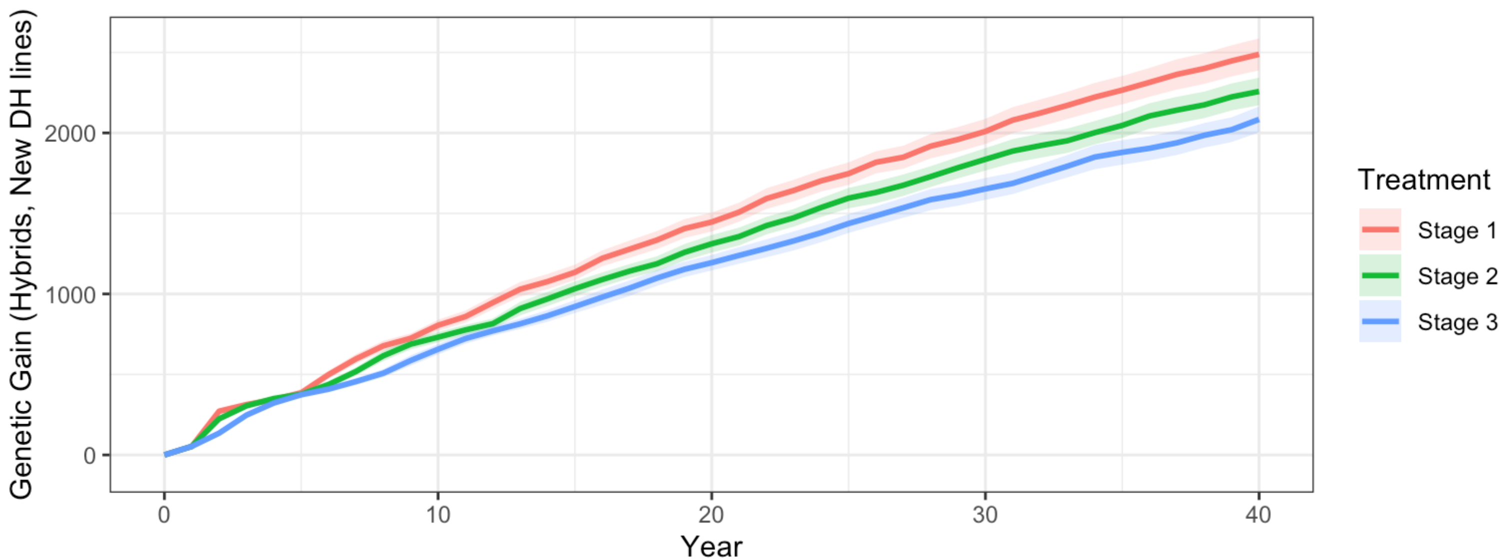


Results of Predication Across Years



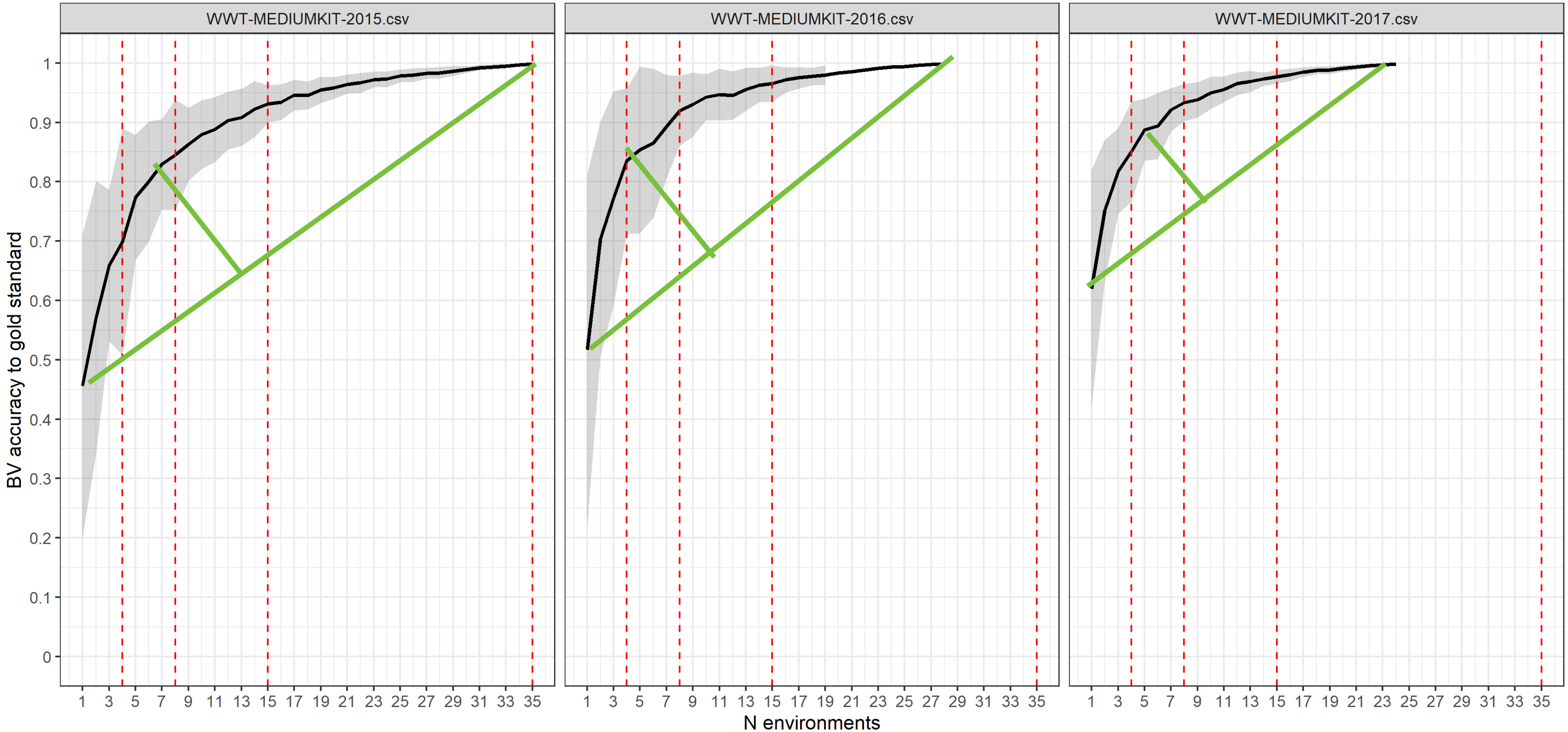
2. Breeding Schemes Optimization in Collaboration with EiB/BSU

2.1. Reducing cycle time: simulation study in collaboration with EiB



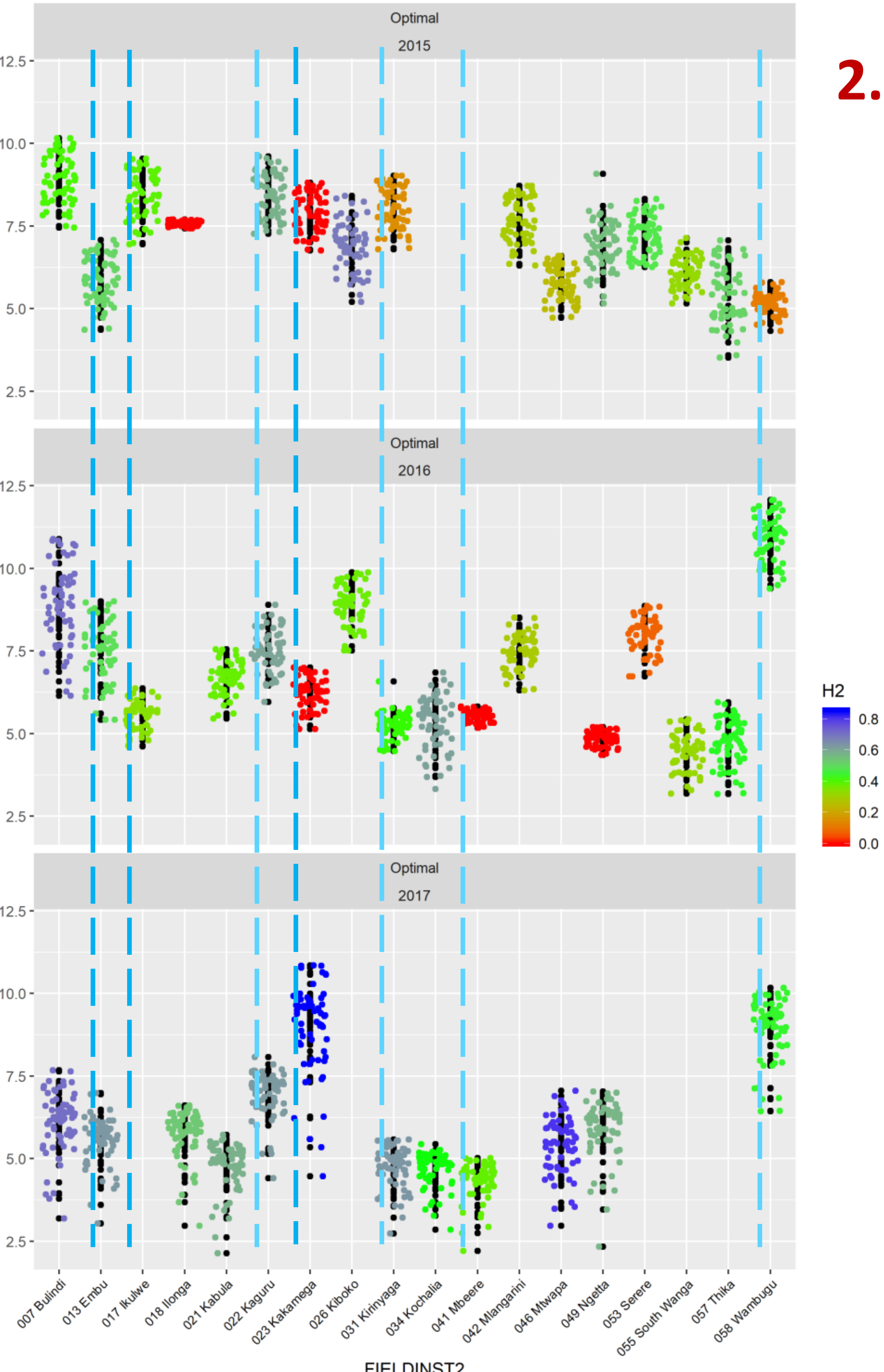
Stage 2 and Stage 1 treatments generated 1.08 and 1.19% times more gain, than the stage 3

2.2. Identifying appropriate number of environments to gain better accuracy for optimal line recycling



Results from cross validation to know the accuracy between real (across the entire TPE) and estimated BV when selecting a given number of environments (we assume the max #of environments represent the real BV).

2.3. Identifying selection environments that permit high heritability and genetic variance estimates



- Results from single environment heritability across three years of data from CIMMYT-Eastern Africa

- Environments with highest H^2 and genetic variance represent the best locations for applying selection: for e.g., Embu, Kiboko, Thika, Kaguru, Kochalia ; Bulindi Kabulia

Source: CIMMYT Breeding Team + Eduardo (EiB)

Elite Lines Available for Sharing

CML candidate	HG	Product profile to which this candidate will primarily used for	Grain yield across locations)	GCA
CKL12128	B	PP1 & PP2 (EA)	3.3	0.51 (overall, 2/18); 0.79 (optimal, 1/18); 0.28 (drought, 8/18)
CKL12136	B	PP1 & PP2 (EA)	2.5	0.66 (overall, 4/18); 0.73 (optimal, 4/18); 0.40 (drought, 2/18)
CKL12139	B	PP1 & PP2 (EA)	2.2	0.09 (overall, 6/18); 0.13 (optimal, 8/18); 0.10 (drought, 7/18)
CKL14546	A	PP1 & PP2 (EA)	3.1	0.62 (overall, 5/28); 0.60 (optimal, 6/28); 0.25 (drought, 7/28)
CKL14549	A	PP1 & PP2 (EA)	3	0.73 (overall, 3/28); 0.85 (optimal, 2/28); 0.13 (drought, 11/28)
CKDHL0221	A	EA-PP1	3.4	0.20 (overall, 2/10); 0.55 (optimal, 1/10); ``-0.268 (drought, 8/10)
CKDHL0282	B	EA-PP1	4.1	0.20 (overall, 5/23); 0.29 (optimal, 5/23); 0.51 (drought, 5/23)
CKDHL0323	B	EA-PP1	3.9	0.41 (overall, 1/14); 0.32 (optimal, 1/14); 0.19 (drought, 2/14)
CKDHL164665	A	EA-PP1	2.1	1.12 (overall, 1/11); 1.8 (optimal, 1/11); 0.96 (drought, 1/11)
CKLMARSI0022	B	EA-PP1	3.1	0.97 (overall, 1/7); 1.2 (optimal, 1/7); 0.41 (drought, 2/7)
CKLMARSI0037	B	EA-PP1	3.1	0.06 (overall, 11/16); 0.19 (optimal, 14/16); 0.22 (drought, 4/16)
CKLTI0028	A	EA-PP1	2.4	0.65 (overall, 1/7); 0.88 (optimal, 1/7); 0.20 (drought, 1/7)
CKLTI0200	A	EA-PP1	2.5	0.26 (overall, 3/9); 0.25 (optimal, 3/9); 0.23 (drought, 2/9)
CKLTI0344	A	EA-PP1	2.1	0.81 (overall, 1/5); 0.99 (optimal, 1/5); 0.26 (drought, 3/5)
CEL08011	B	EA-PP3	4	0.7 (Optimal) and -0.2 (Low LN)
CEL14028	B	EA-PP3	4	0.7 (Optimal)

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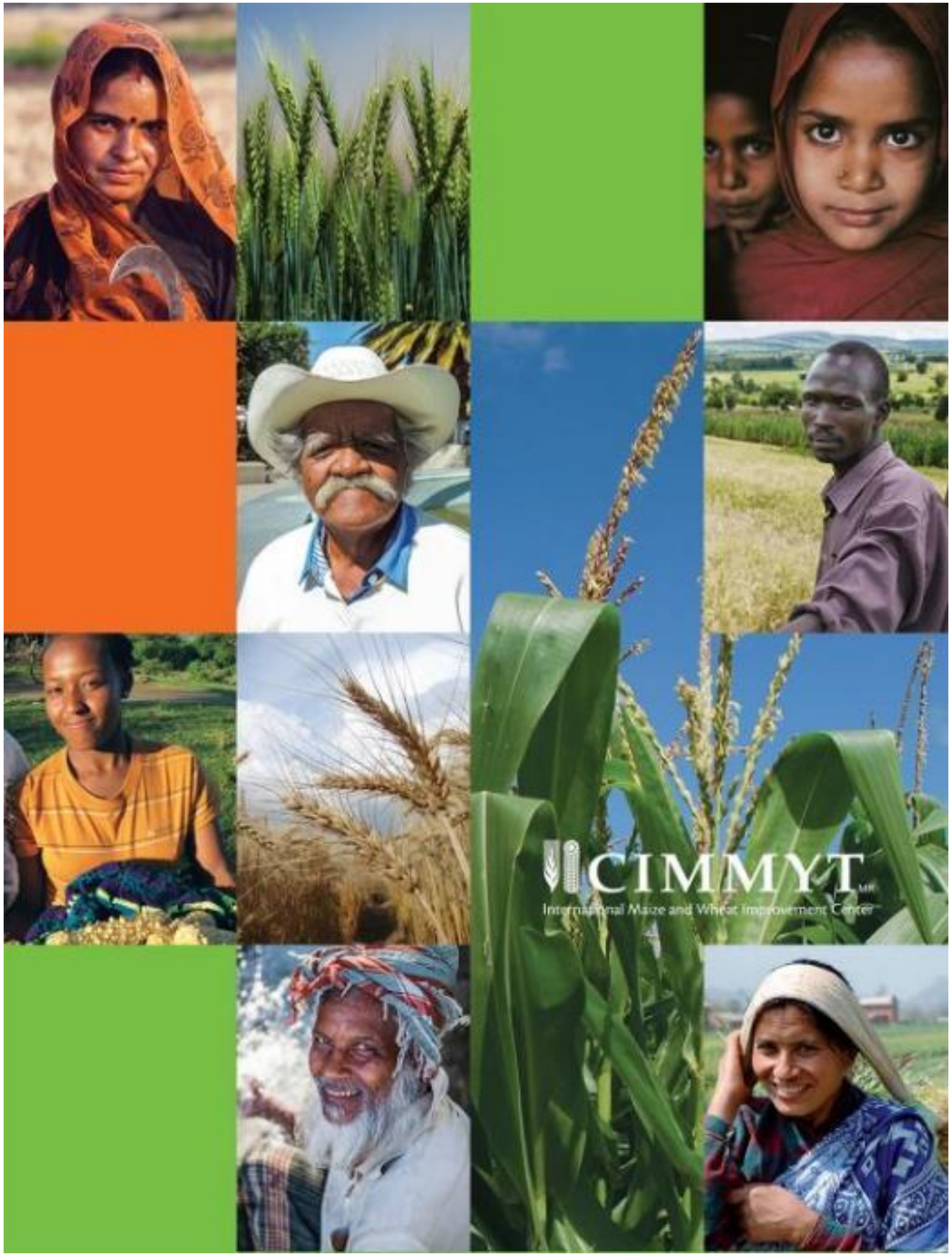

Thank you for your interest!