Development and Deployment of Drought Resilient and Insect-resistant Maize

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Presentation at Annual Biosafety Forum, Kampala Serena Hotel June 21 -23rd 2022

Maize Research and Development in Uganda

- Maize is a strategic commodity in NDP III for agro-industrialization
- A key export commodity – top five including gold, coffee, fish, oil and **maize**
- Maize exports have grown to $106.81m (Shs389b) (BoU, 2019)
- Maize value-addition –research areas

Flour
Feeds (animal, fish)
Snacks
Corn flakes
Starch
Ethanol
Nutritious maize-based products

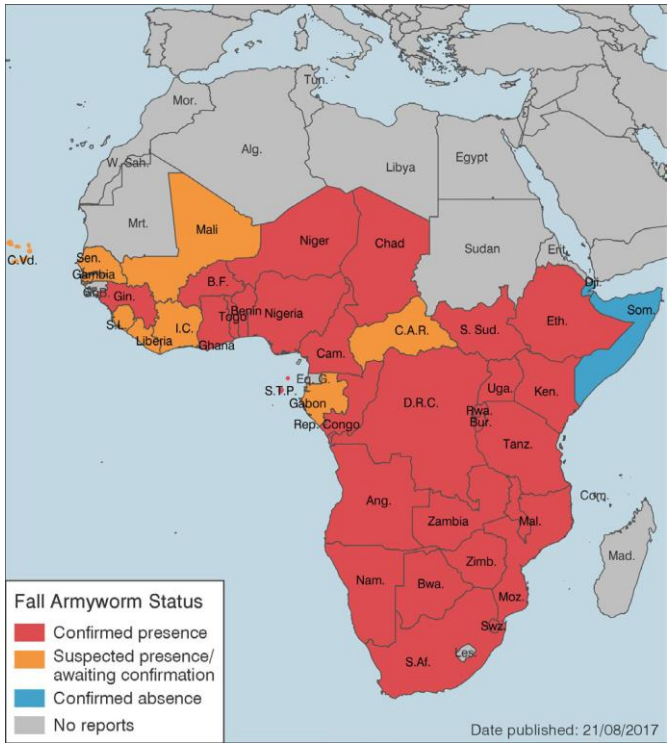
Period	Yield gains (Kg/ha /year)	Intercept	Prob	r^2	Mean (T/ha/year)
1961-2020	26	-50.9	<0.0001	0.729	1.603
1999-2020	62	-122.4	<0.0001	0.766	2.172
2008-2020	37	-72.7	<0.0001	0.815	2.525

Impact of drought on maize and people

2009 drought that caused famine in Eastern Uganda

- About 4.5 million households depend on maize
- Frequent droughts lead to reduced production, loss of investments and food and nutrition insecurity

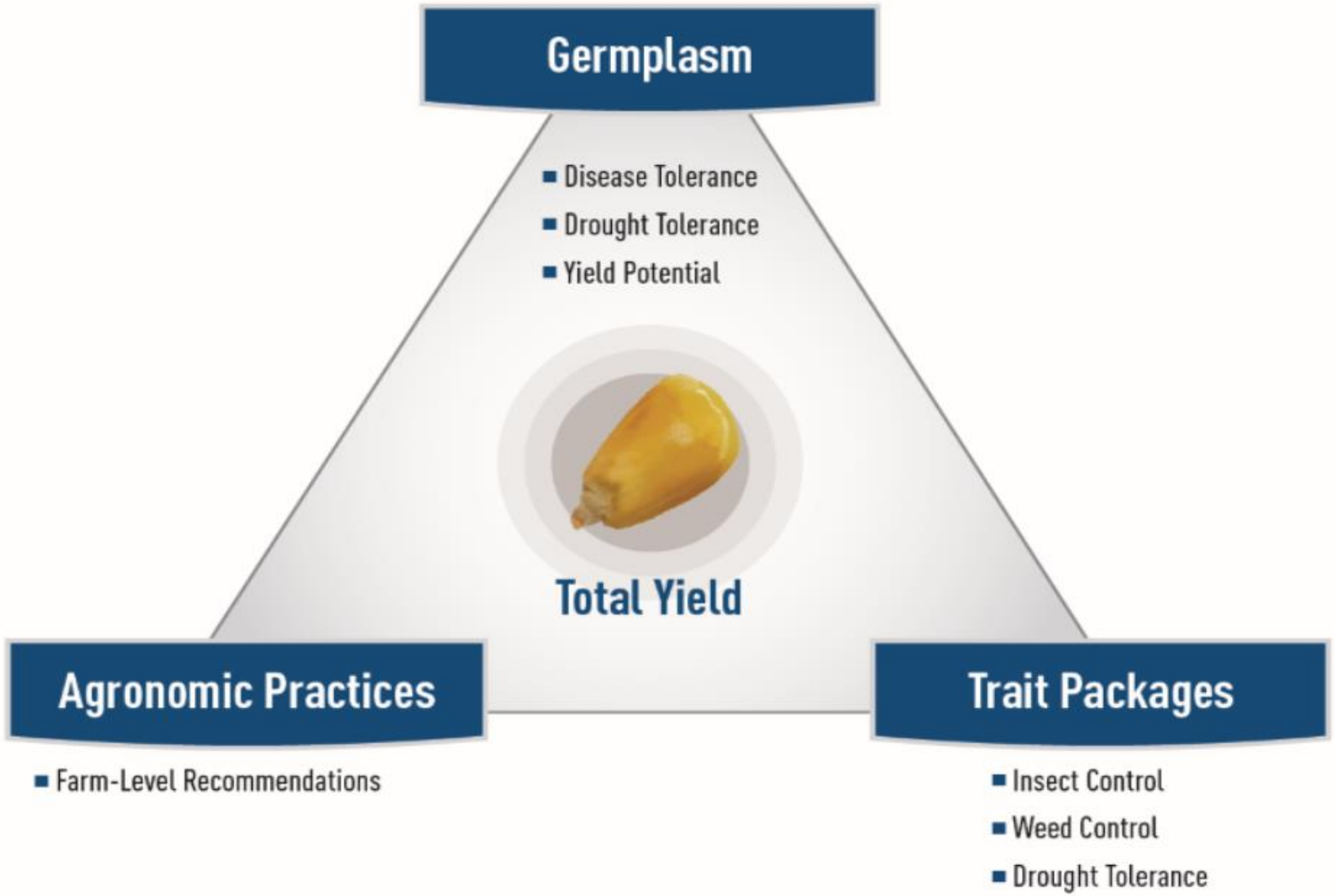
Impact of maize insects: stemborer and fall Armyworm



Countries where Fall Armyworm (FAW) reported (Sept 2017

- Estimated maize annual yield losses by FAW of **8.3–20.6 million tons (USD 2.48 – 6.19 billion) in 12 countries** (CABI, 2017); huge threat to food and nutrition security

A System Helping Farmers Manage Risk



Credit: Bayer

Maize product profile

- **White hybrids (SC or 3-way)**



- **25% yield improvement hybrids under moderate drought conditions using 2008 as a baseline**
  - Target 15% from breeding over 10 years
  - Additional 8-10% from DT transgene
  - Insect protection from *Bt* transgene

- **General product requirements**
  - Drought tolerance
  - Agronomic traits: root lodging, prolificacy, maturity
    Disease resistance: GLS, TLB, MSV and **MLN**

- **Consumer requirements**
  - Maintain required milling quality
  - Grain Texture : flint to flinty-dent

Product development approach

Introgress ***CspB*** (*DroughtGard*® gene from soil bacteria, *Bacillus subtilis*) and ***Bt*** (from *Bacillus thuringiensis*) transgenes into drought-tolerant germplasm adapted to target countries →

Genetically engineered DT; *Bt*; & Stacked DT + *Bt* white maize

Product options

- Conventional Drought Tolerant (CDT) Hybrids
- CDT + Insect-pest protected (Bt) Hybrids
- CDT + Transgenic Bt + DT Stacked Hybrids

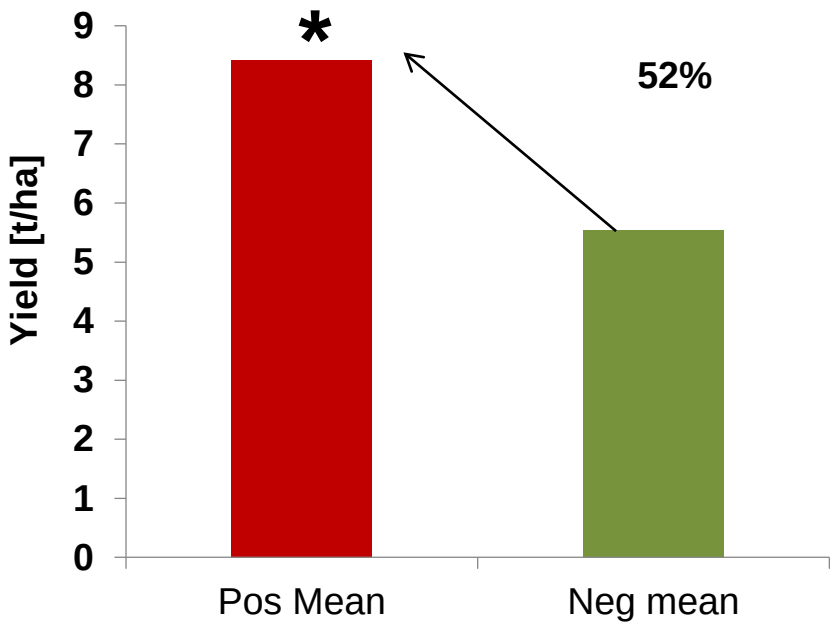
Our expectation

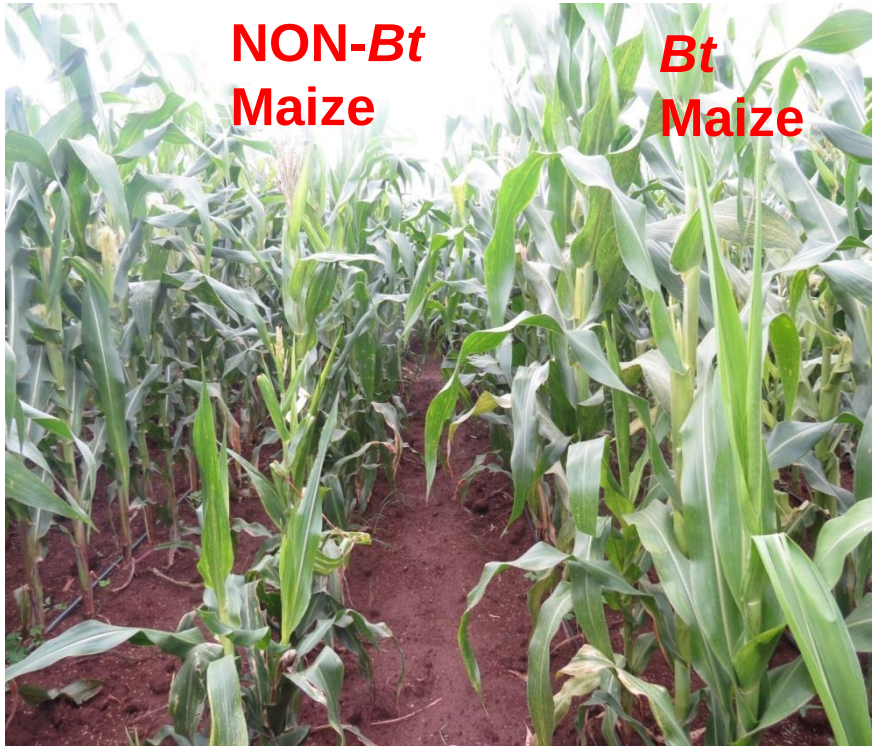
- Under moderate drought, droughtTEGO maize expected to increase yields by 20–35% over year 2008 hybrids
- Translates into additional 0.9 million tons of maize in Uganda during drought years to feed about 10 to 15 million people

MON810 x MON87460 Testing Protocol

- Events: MON810, MON87460
- Test locations: Kasese, Namulonge
- 2 treatments for drought trait: Water optimum and drought stress
- 2 treatments for insect trait: Infested plots and protected plots
- The MON87460 trait is always on the male parent
- Natural Insect infestation was observed on drought trials

Transgenic *Bt* Maize in Uganda Confined Field Trials, Five Seasons





- *Bt* gene (MON810) had positive and significant effect on yield across varieties and trials with **52% yield advantage**

Field performance of CFT infested with stem borers

Relative performance of Bt and non- Bt maize

Comparison of Bt+DT maize for damage parameters

Stacked Hybrid (+VE) (Bt+DT)

Non-Stacked Hybrid (-VE) (Without Bt+DT)

Stacked Hybrid (+VE) (Bt+DT)

Non-Stacked Hybrid (-VE) (Without Bt+DT)

Bt Maize with Potential to Control Fall Army Worm (Confined Field Trials of stacked DT + Bt traited hybrids, Namulonge)

Stacked DT + *Bt*: Performance of *Bt* Maize under Natural Stem-borers and FAW Infestation at Namulonge, 2018

Impact of *Bt* trait in controlling FAW and Stem borers (*Left*) compared with non-*Bt* version (*Right*), March 2018

Six drought CFTs: Yield differences between susceptible and drought-tolerant varieties

CFT -Yield [t/ha]: Efficacy results under optimum-moisture

WEMA Pedigree	Pos N	Neg N	Pos Mean	Neg mean	Delta	PERC	P-value	LSD(.05)
CML395+WMC4103	4	4	16.5	13.1	3.4	25.8	0.00	1.54
CML445+WMB0001	4	4	14.6	9.7	4.9	50.1	0.00	1.54
CML395+WMB0001	4	4	15.3	11.7	3.6	31.2	0.00	1.54
CML395+WMB3309	4	4	15.0	11.8	3.2	27.5	0.00	1.54
CML445+WMC4103	3	4	13.6	12.5	1.1	9.0	0.03	1.54
CML445+WMB3309	4	4	14.4	10.8	3.6	33.4	0.00	1.54
CHECK 1		4		9.2				
CHECK 2		4		7.4				
CHECK 3		4		8.30				
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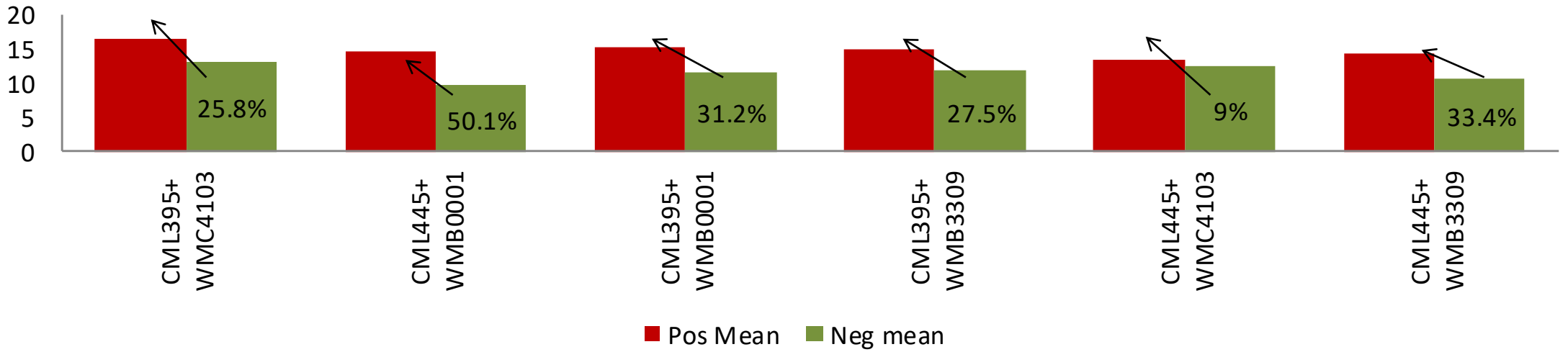
- Significant differences for all hybrids were observed between positive and negative ranging from 1.1 to 5.0 t/ha (9.0% to 50.1%)

CFT : Yield (t/ha)- Efficacy results under optimum-moisture



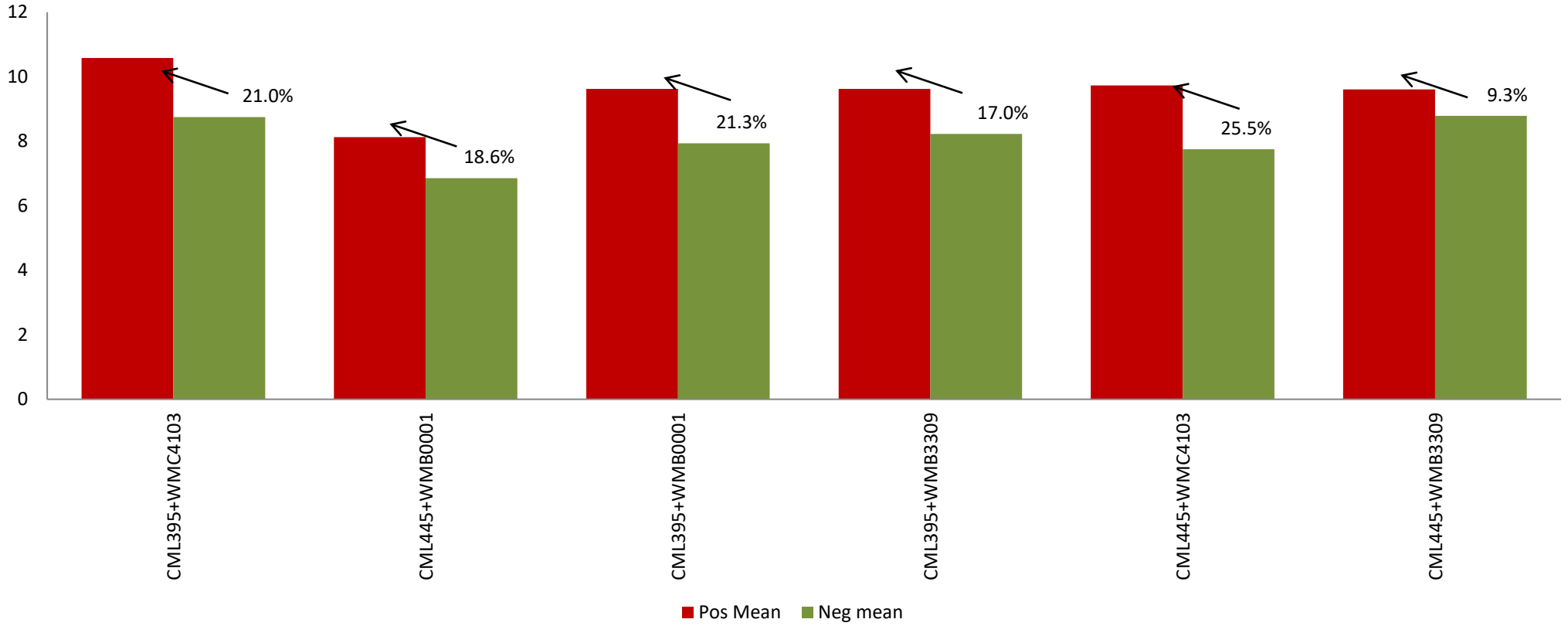
- Differences between positive and negative ranged from 1.1 to 5.0 t/ha (9.0% to 50.1%)
- CV for yield in stressed plots = 26.26%

CFT: Yield [t/ha]: Efficacy results under drought

WEMA Pedigree	Pos N	Neg N	Pos Mean	Neg mean	Delta	PERC	P-value	LSD(.05)
CML395+WMC4103	9	9	10.6	8.7	1.8	21.0	0.0004	1.03
CML445+WMB0001	10	6	8.1	6.9	1.3	18.6	0.0225	1.03
CML395+WMB0001	9	8	9.6	7.9	1.7	21.3	0.0016	1.03
CML395+WMB3309	10	10	9.6	8.2	1.4	17.0	0.0039	1.03
CML445+WMC4103	9	9	9.7	7.8	2.0	25.5	0.0002	1.03
CML445+WMB3309	10	9	9.6	8.8	0.8	9.3	0.0937	1.03
CHECK 1		10		6.1				
CHECK 2		11		5.5				
CHECK 3		9		5.40				
CHECK 4		6		5.50				

- All hybrids had more yield in the positive compared to negative in the drought trials (shown in green)
- Differences between positive and negative range from 0.80 to 2.0 t/ha (9.3% to -25.5%)

Grain yield (t/ha) of Stacked MON87460 + MON810 under managed drought



- All traited hybrids significantly realized 9–26% yield advantage over non-traited isogenic-hybrids

Optimum block

Comparison of cobs of 10 hybrids under optimum and drought stress blocks (odd numbers with drought gene and even number without gene)

Stress block

Performance of local commercial checks under optimum (upper) and stress (lower)

Concluding remarks

- Test results have been consistent over the years indicating the potential benefit of MON810 for control of stem borers and MON87460 for additional drought tolerance in hybrid backgrounds

Thank you