Experimental evidence on the impact of DT Maize and index insurance on small-holder maize farmers in Mozambique and Tanzania

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From Field Trials to the "Real World"

Laura showed that, on average, DT maize effectively protects yields against midseason drought in farmer field trials in SSA.

We now move to the next link in the "evidence chain".

Do these gains hold up when DT varieties are introduced in real-world context that we most care about?

- Vulnerable, small-holder maize farmers in Mozambique and Tanzania;
- Thin input and output markets.

From Field Trials to the "Real World"

Both farmers in the field trials and "real world" farmers face significant weather-related production risk.

But there are important differences.

Farmers in Fields Trials are not randomly picked off the street!

- Relatively good access to complementary inputs
- Can afford complementary inputs
- The alternative to which DT varieties are compared are commercially available ***improved maize*** varieties

The average "Real-World" small-holder farmer in Tanz & Moz:

- Minimal access to complementary inputs
- Lack liquidity/credit to purchase complementary inputs (if available)
- Low yielding, ***local maize*** varieties are the norm against which we will compare DT varieties.

Primary Research Questions

Among the population of small-holder maize farmers in SSA, what are the impacts of DT seeds by themselves and DT seeds bundled with insurance on maize yields?

- Do DT seeds offer any yield advantage in "normal" years? If so, how much?
- How well do DT seeds protect against yield in seasons characterized by mid-season drought?
- How well do DT seeds and Index Insurance protect against de-capitalization and yield loss in the season following a significant covariate yield shock?

Inter-seasonal impact mechanisms

- How well do DT seeds and Index Insurance protect against de-capitalization and yield loss ***in the season following*** a significant covariate yield shock?

- How might DT & Index Insurance strengthen farmers' resilience & ability to recover from shock?
  - Liquidity 1: If DT trait effectively protects yields against drought, farmers may have sufficient liquidity to re-invest in good seeds and fertilizer next season;
  - Liquidity 2: If yields are low because of catastrophic covariate weather shock, insured farmers receive payout that allows them to maintain "seed capital" and re-plant next season.
  - Learning: Having seen benefits of insurance, farmers may substitute toward DT/improved varieties and away from low-yielding local varieties next season.

Secondary Research Question

Do the impacts of DT and Insurance on yields translate into improvements in food security?

- Secondary in the sense that we're not quite prepared to share full results!
- Time permitting, will share initial insights.

Research Design: RCT with 2 Treatment Arms

- Treatment 1 (DT): Marketing of DT seeds
  - Village-level information meetings about DT seeds
  - Make seeds available for purchase in the village

- Treatment 2 (DTII): Marketing of DT seeds bundled with index insurance
  - Village-level information meetings about DT seeds & Index Insurance
  - Make insured seeds available for purchase in the village
  - Insured seeds marked up 20% for insurance premium
  - Stand-along index insurance NOT available

The Index Insurance Contract

- Insurance payout in the form of seed replacement next season
- Two triggers designed to complement biological insurance of DT maize
- Insurance pays out if either:
  - Establishment rainfall (40 days after planting) < 70 mm or;
  - Predicted end-of-season average yield in village < 65% of historical mean.
    - Prediction based on NDVI and full-season rainfall in the village

Implementation Partners

- Seed Company Partners
  - 2 Local seed companies in Mozambique (hybrids and OPV)
  - 3 Local seed companies in Tanzania (hybrids only)
  - All grow CIMMYT-developed DT Maize varieties

- Insurance Company Partners
  - Mozambique: Hollard
  - Tanzania: UAP

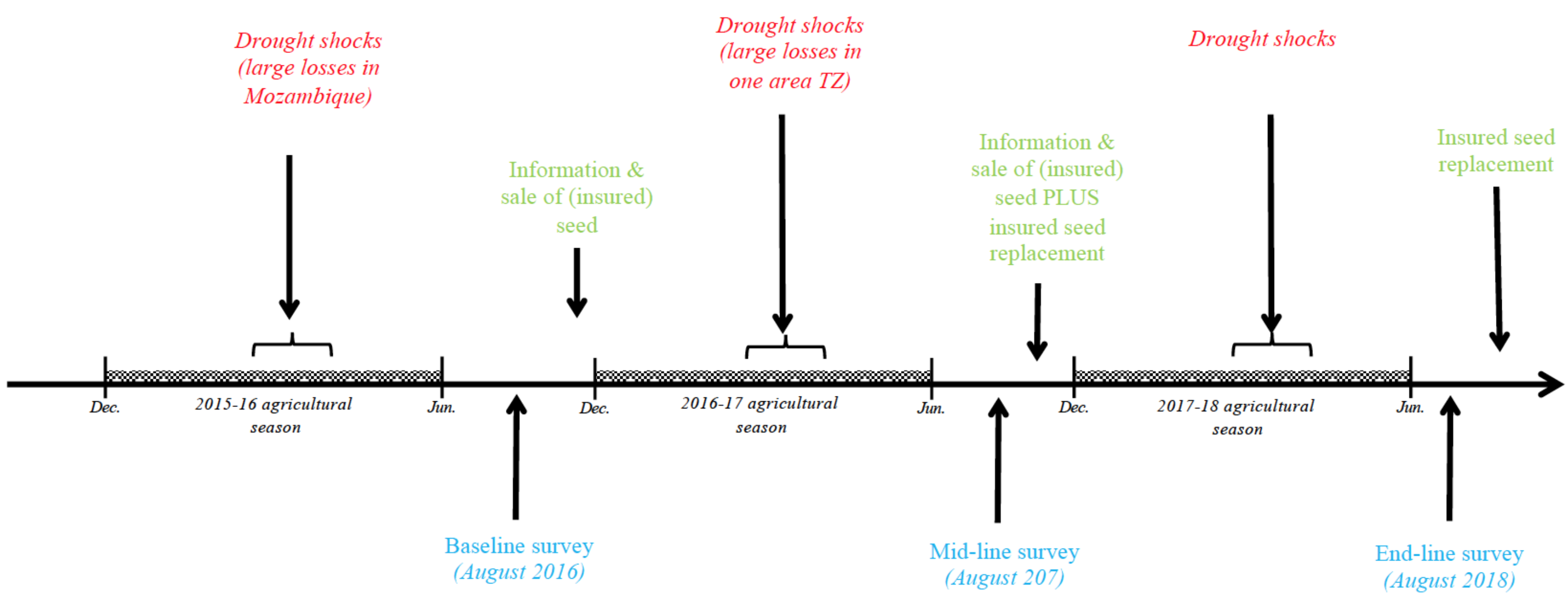
Assignment to Treatments and Sample Selection

- Population of interest: Small scale, rainfed maize producers exposed to moderate to high drought risk in Tanz. and Moz.
- Create strata of 3 agronomically similar communities
- Within each strata:
  - 1 community assigned to Control
  - 1 community assigned to Treatment 1 (DT only)
  - 1 community assigned to Treatment 2 (DT bundled w/insurance)
- Approx. 20 hhlds randomly selected from each community

Country	# Strata	# Communities	# Hhlds
Mozambique	18	64	1,237
Tanzania	30	90	1,767
Total	**48**	**154**	**3,004**

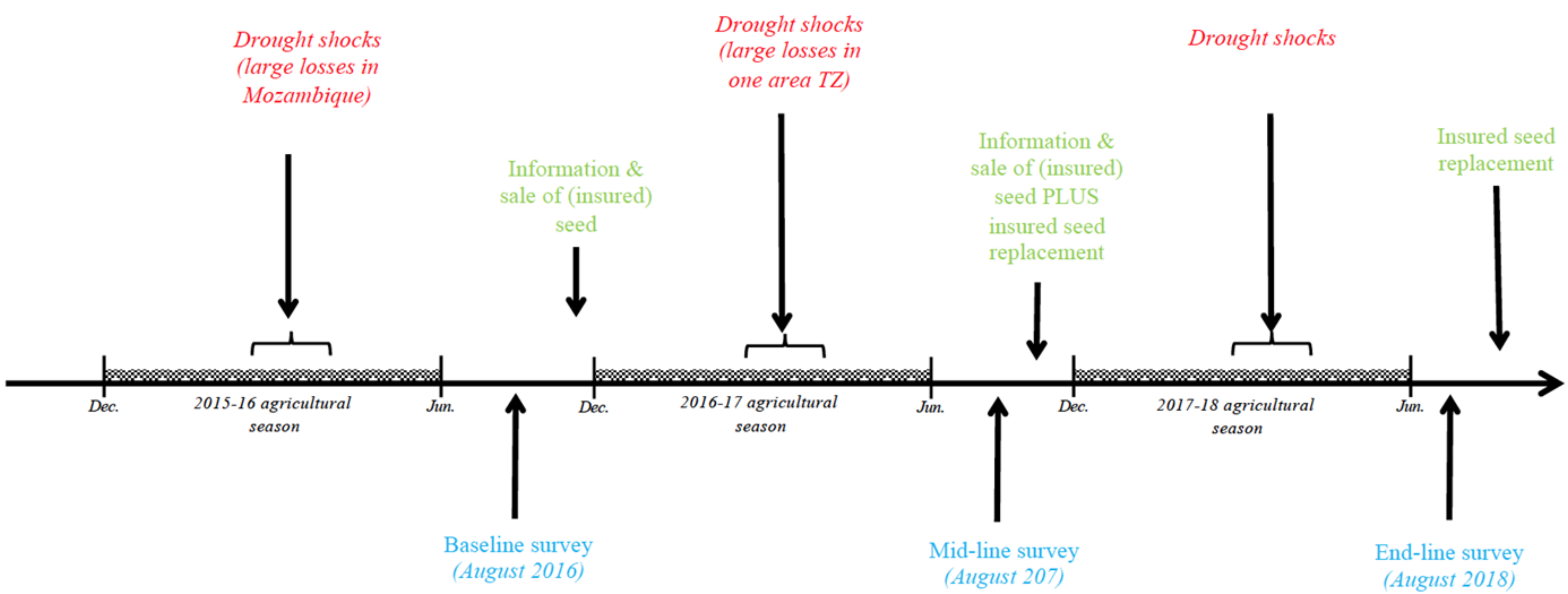
Timing

- Maize season runs from December through June.
- Three survey rounds implemented after harvests of:
  - 2015-16 season (Baseline); 2016-17 season (Midline); 2017-18 season (End-line)
- Marketing interventions occurred in Oct-Nov prior to planting for midline and end-line seasons.



Three year panel allows us to estimate:

- How large are within-season yield losses due to weather shocks using all 3 years?
- How effective are DT seeds at mitigating these losses at midline and end-line?
- How large are yield losses in the year *following* a severe weather shock (shock transmission from baseline to midline and midline to end-line)?;
- How effective are DT seeds and Index Insurance at mitigating these inter-seasonal losses (midline to end-line)?



Definitions & Frequencies of Weather Shocks

- <u>Midseason Drought</u>: Rainfall during the second 40 days after planting (pollination) was less than 200 mm.

- <u>Covariate Yield Shock</u>: Average yields in the community were less than 65% of historic mean.
  - Result of significant adverse weather shock (typically severe drought);
  - Index Insurance would be triggered

	Mozambique			Tanzania		
% Hhlds affected by	2016	2017	2018	2016	2017	2018
Midseason Drought	100%	11%	62%	61%	69%	50%
Covariate Yield Shock	91%	0%	0%	0%	15%	11%

Descriptive Statistics of Sample: Baseline

	Mozambique		Tanzania	
	Plant only local seed	Plant some improved seed	Plant only local seed	Plant some improved seed
% Farmers	79%	21%	29%	71%
Maize Area (ha)	2.6	3.1	1.7	1.6
Seed Use (kg/ha)				
-Local	13.9	9.7	19.3	14.4
-Improved	0	1.8	0	8.1
-Total	13.9	11.5	19.3	22.5
Use fertilizer	1.0%	4.3%	1.5%	7.2%
Had loan	1.5%	2.2%	3.3%	3.2%

Take-up Rates by Treatment Group

	Mozambique		Tanzania	
	Midline	Endline	Midline	Endline
Seed Only Treatment				
% purchased DT	44.3%	43.9%	53.4%	46.9%
Amt purchased (kg)	6.6	3.3	12.2	19.5
DT as % of total seed	21.8%	19.1%	66.9%	75.8%
Insured Seed Treatment				
% purchased DT	38.2%	34.2%	48.6%	40.6%
Amt purchased (kg)	2.6	2.9	13.8	15.1
DT as % of total seed	15.2%	19.2%	67.0%	76.7%

Econometric Approach

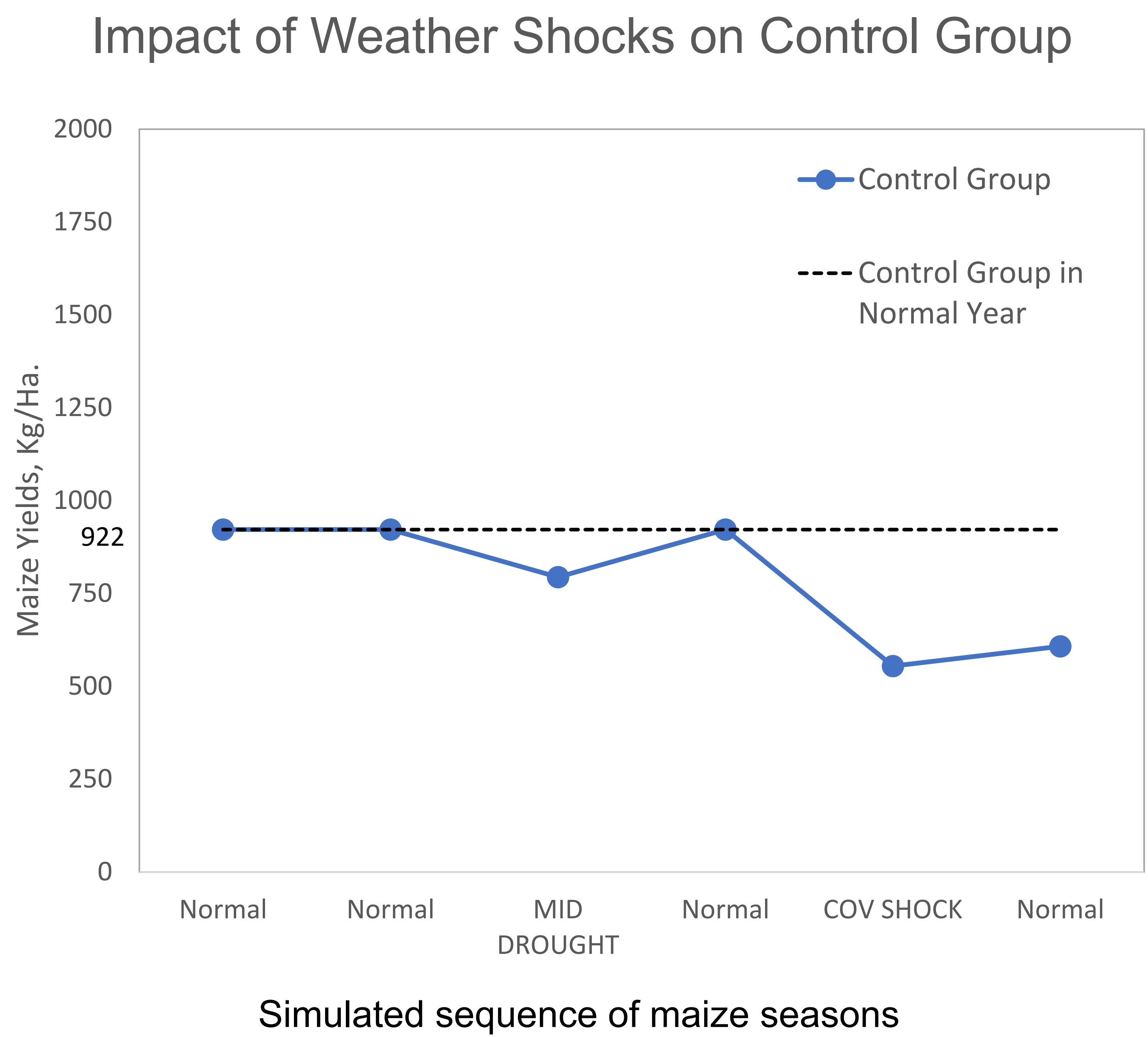
- Goal: Estimate the impact of adoption of DT seeds and Index Insurance on yields.

- Method: Regression analysis
  - Dependent variable: Maize yields
  - Independent variables:
    - Current & Lagged weather shocks
    - Adoption of each treatment: 1) Purchased DT seeds, 2) Purchased Insured Seeds
    - Interaction of the adoption of treatment variables with current and lagged weather shocks.

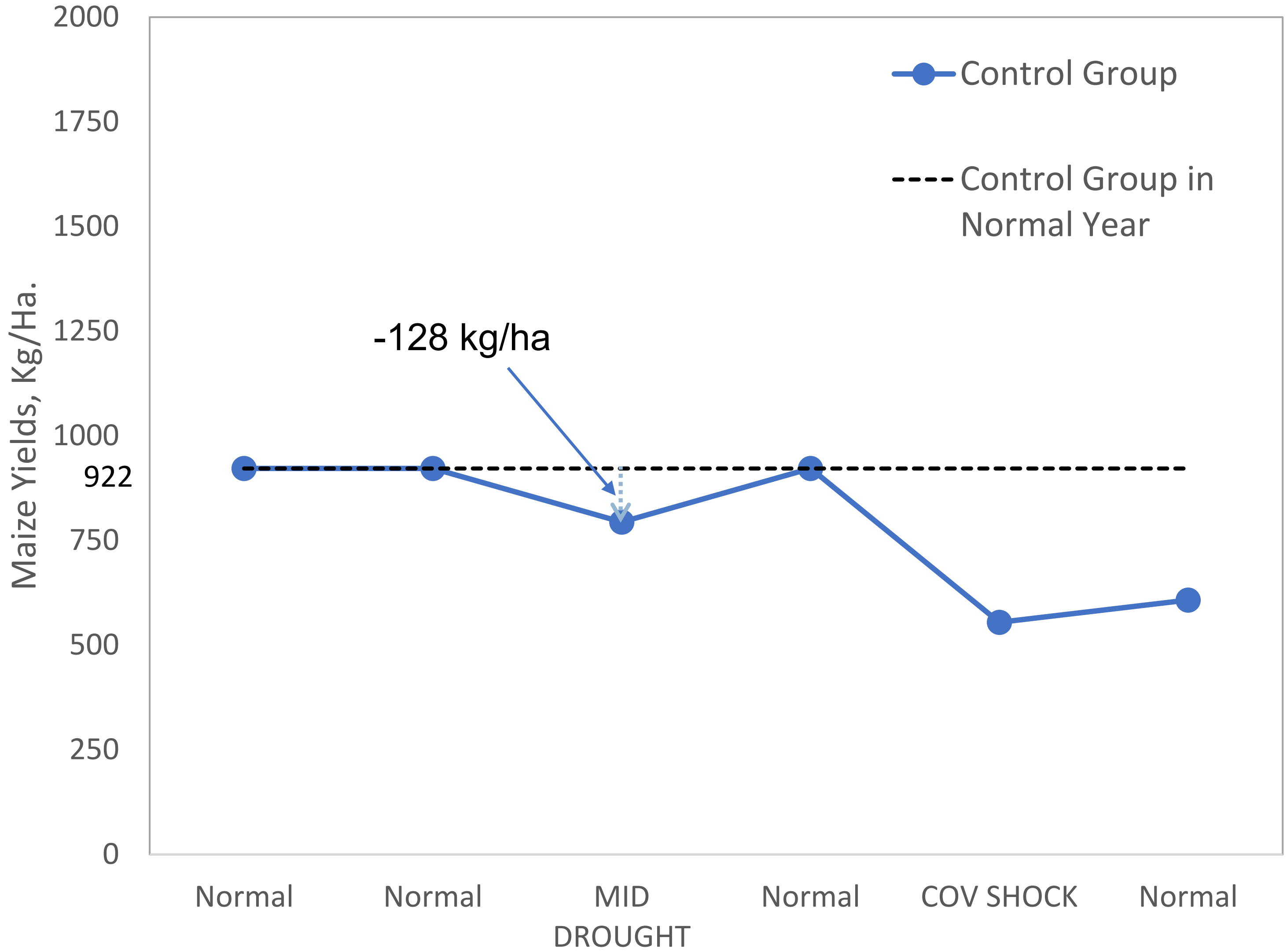
- Technical Details in Appendix slides

Presentation of Results

- Use results from regressions to simulate a sequence of 6 years with different weather outcomes: Normal, Normal, Midseason Drought, Normal, Covariate Yield Shock, Normal.
  - First show predictions for control group;
  - Then show how adoption of DT seeds impacts yields;
  - Then show how index insurance (in addition to DT seeds) affects yields.
- Keep in mind "path dependence"
  - Yields under "Normal" weather may depend on the weather in the previous year!

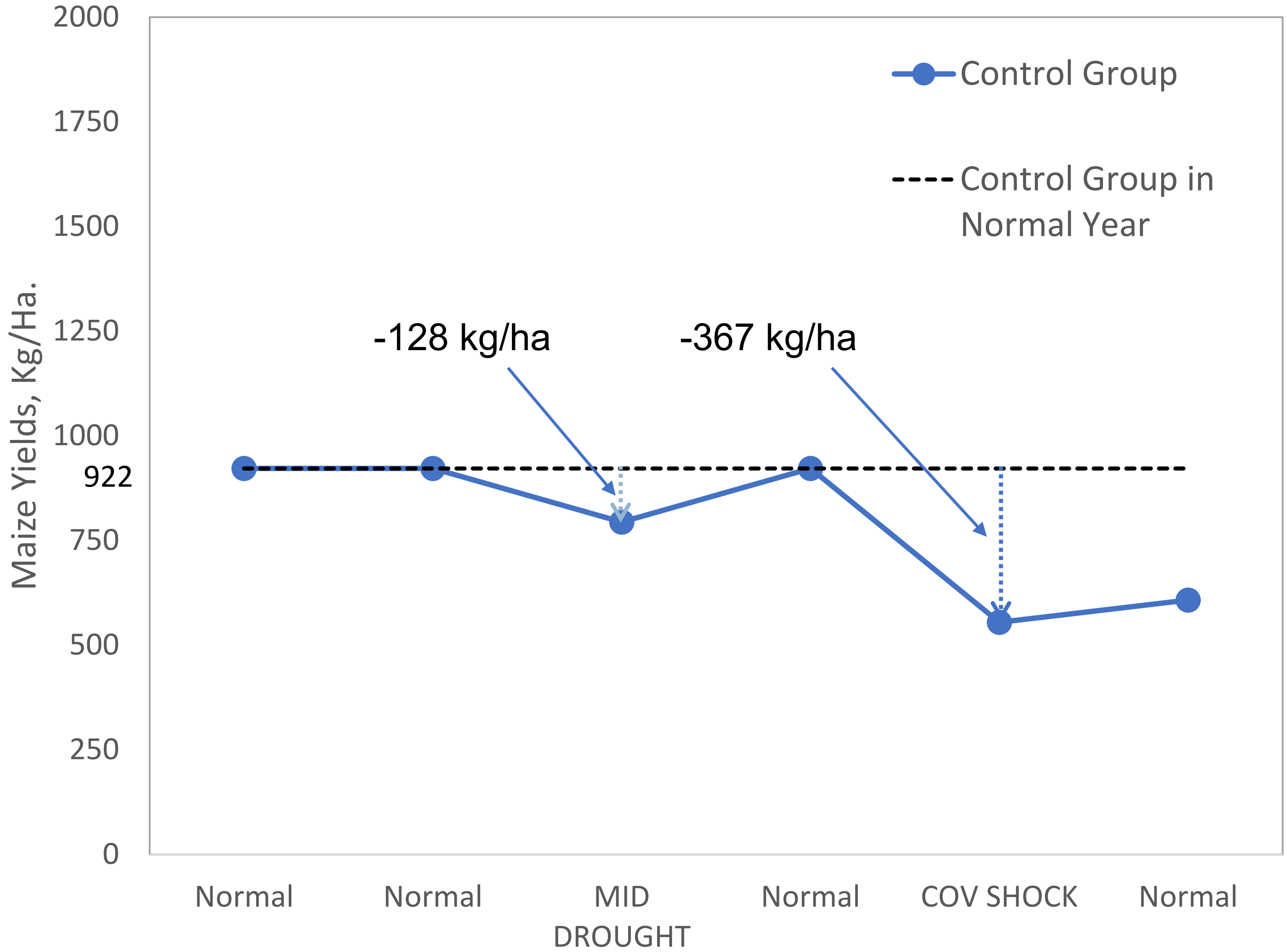

Impact of Weather Shocks on Control Group
2000
1750
1500
1250
1000
922
750
500
250
0
Maize Yields, Kg/Ha.
Control Group
Control Group in Normal Year
Normal
Normal
MID DROUGHT
Normal
COV SHOCK
Normal
Simulated sequence of maize seasons

Impact of Weather Shocks on Control Group



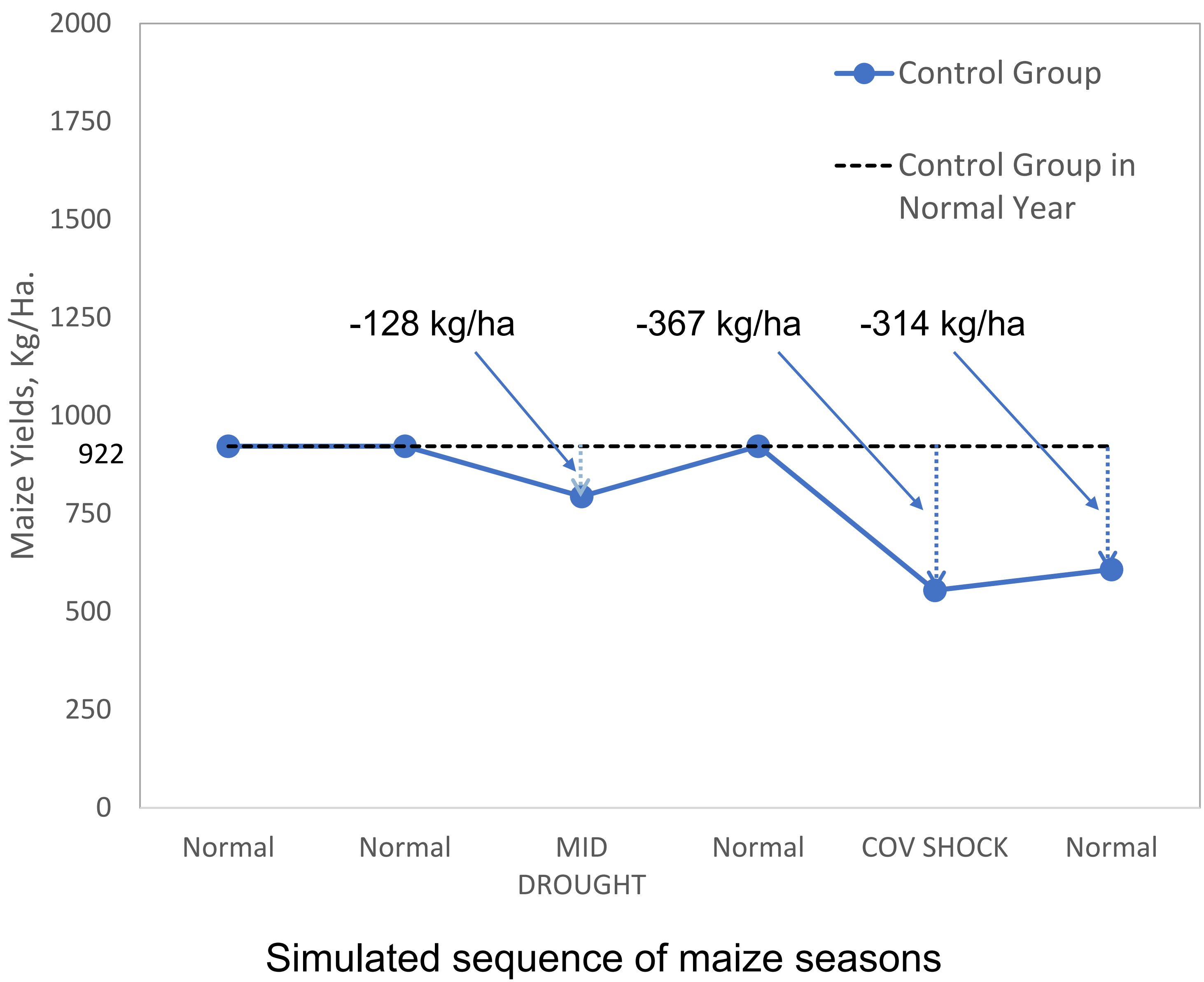
Simulated sequence of maize seasons

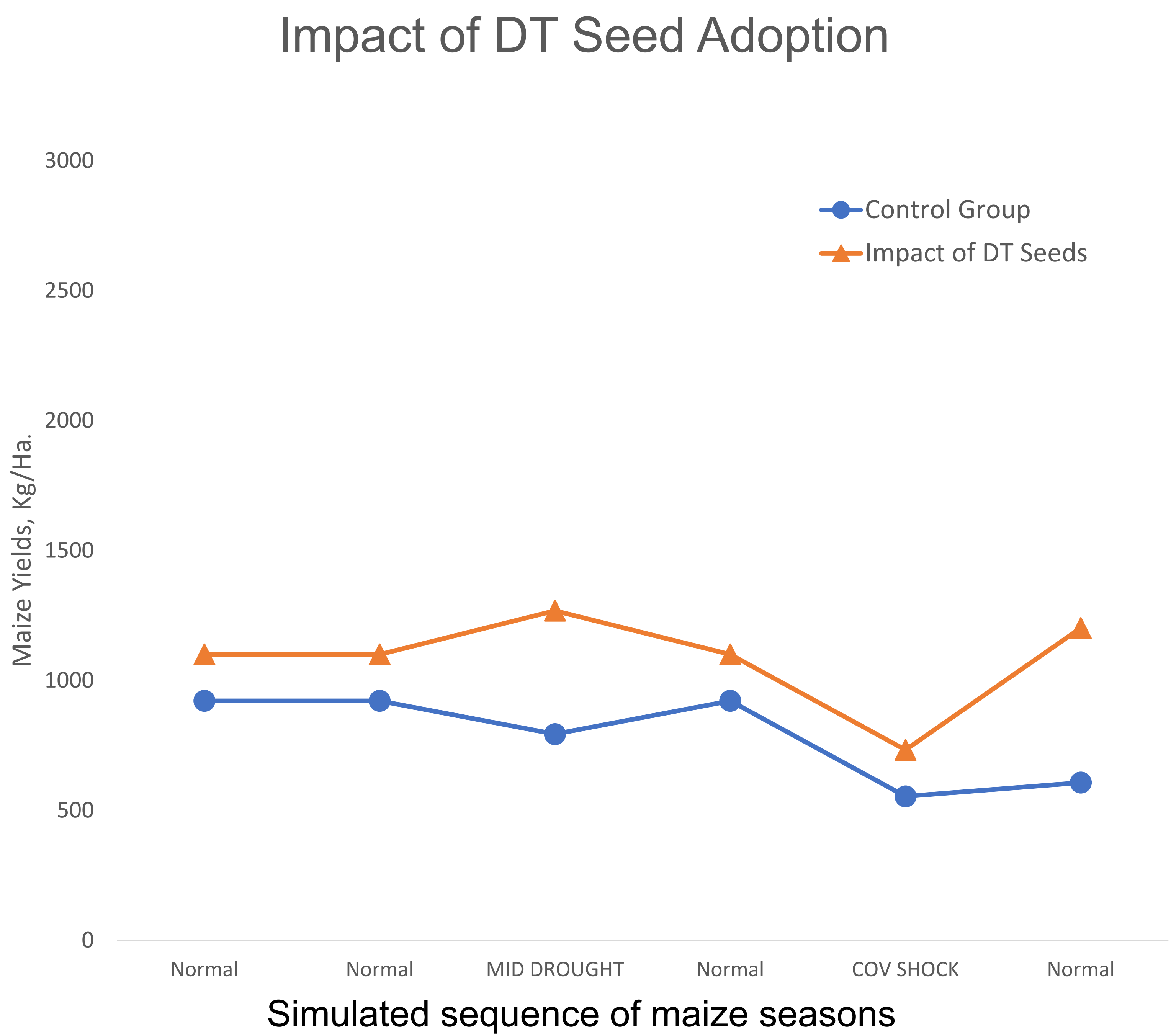
Impact of Weather Shocks on Control Group

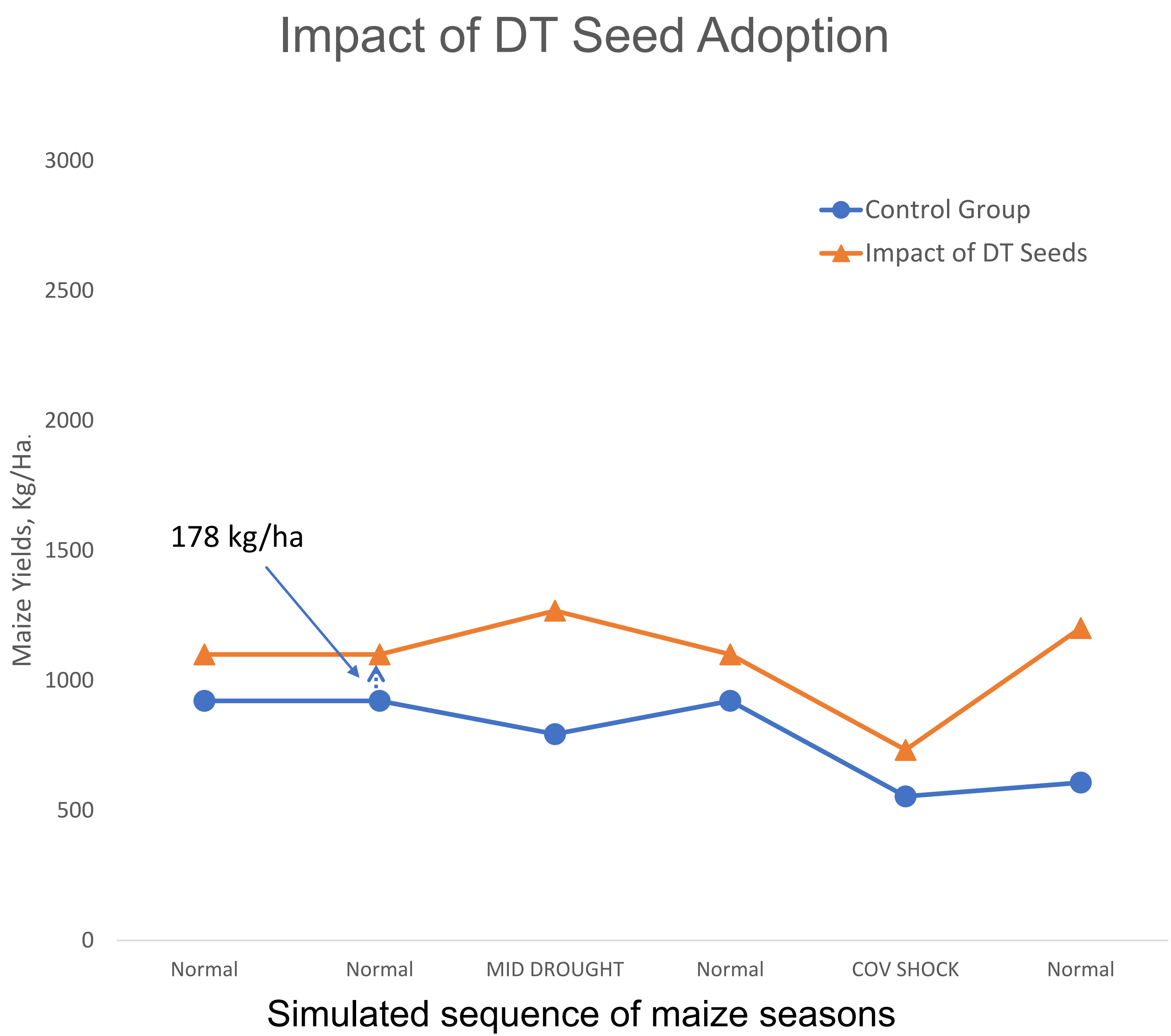


Simulated sequence of maize seasons

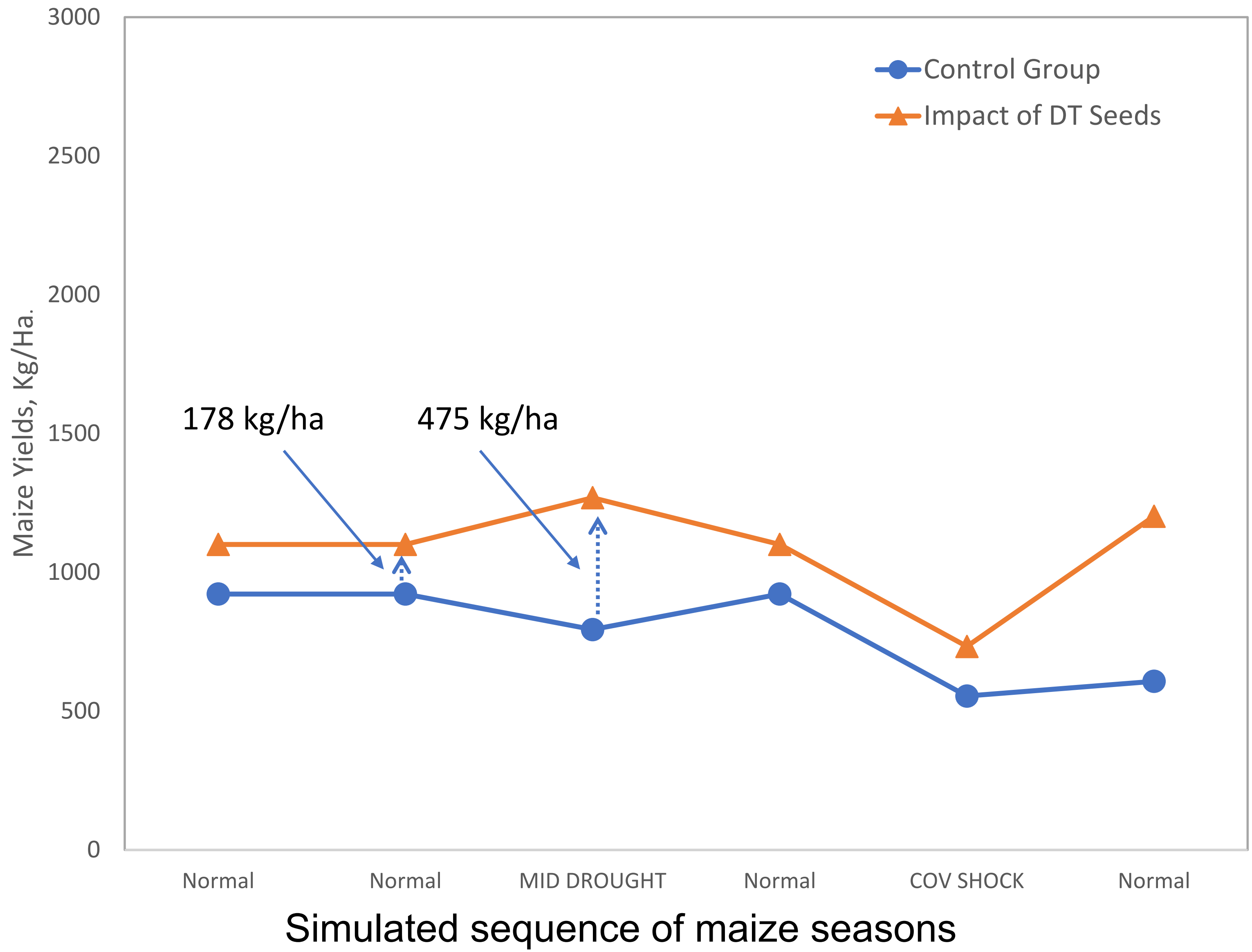
Impact of Weather Shocks on Control Group

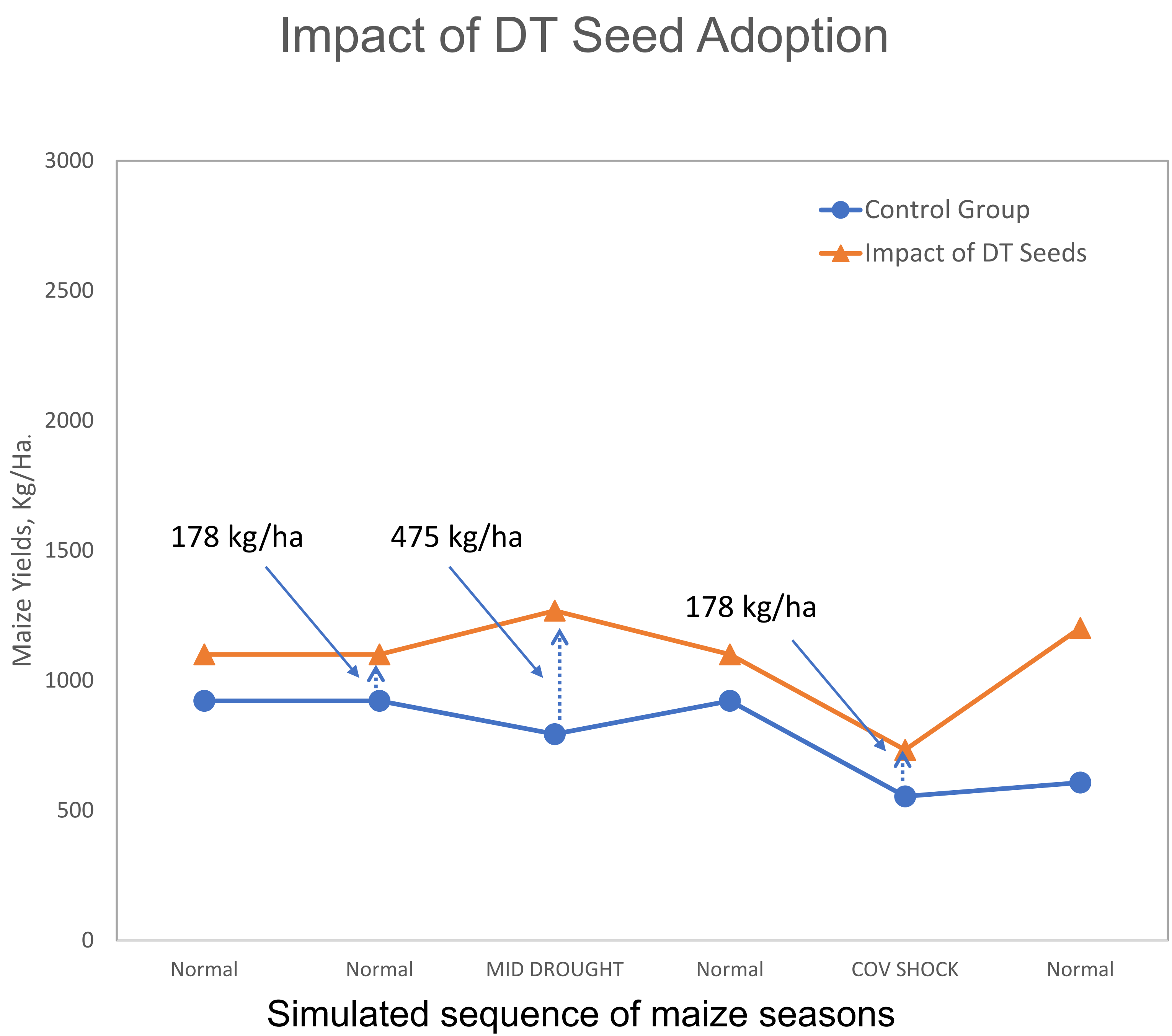


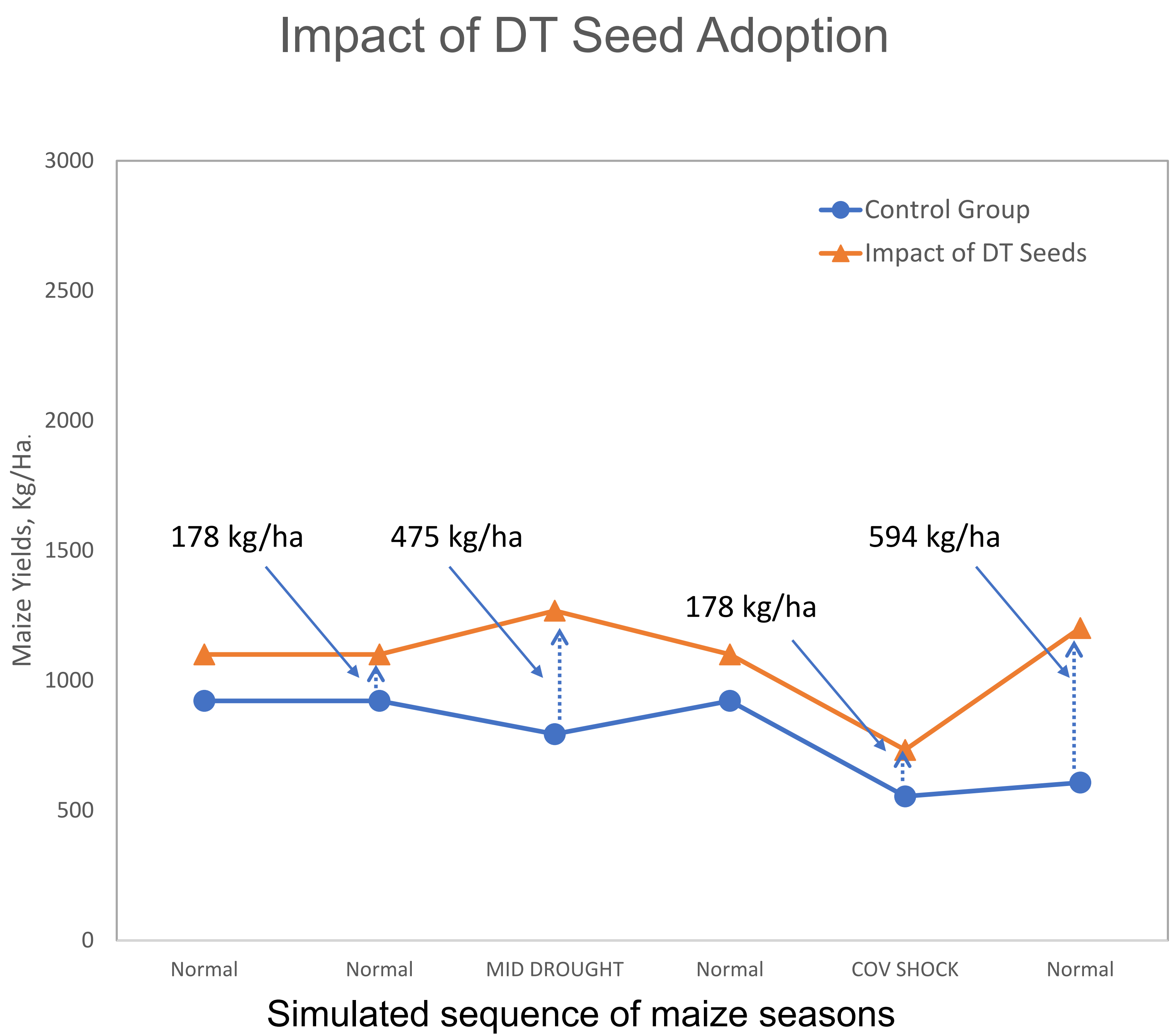

Impact of DT Seed Adoption
3000
2500
2000
1500
1000
500
0
Maize Yields, Kg/Ha.
Control Group
Impact of DT Seeds
Normal
Normal
MID DROUGHT
Normal
COV SHOCK
Normal
Simulated sequence of maize seasons

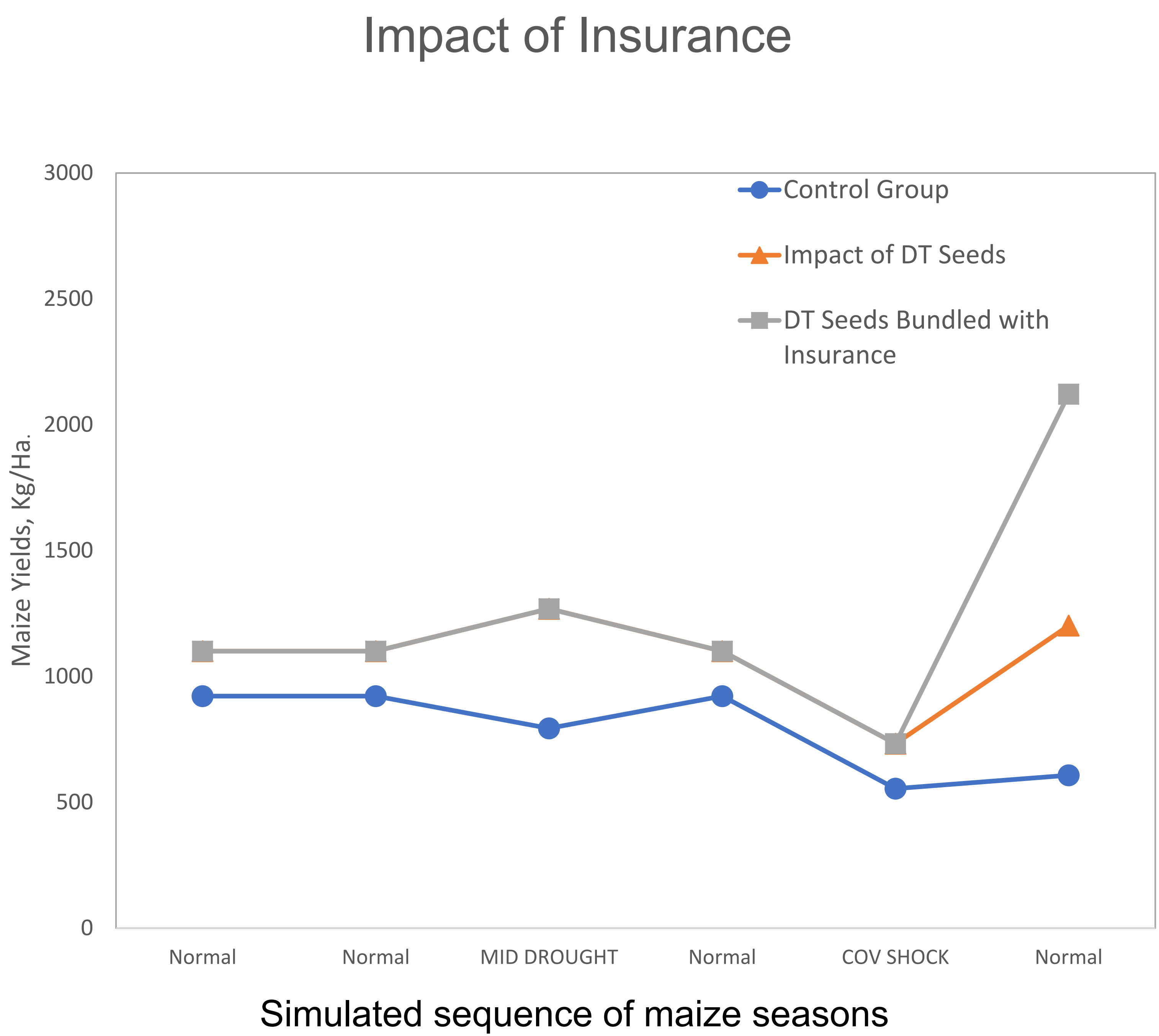

Impact of DT Seed Adoption
3000
2500
2000
1500
1000
500
0
Maize Yields, Kg/Ha.
Control Group
Impact of DT Seeds
178 kg/ha
Normal
Normal
MID DROUGHT
Normal
COV SHOCK
Normal
Simulated sequence of maize seasons

Impact of DT Seed Adoption

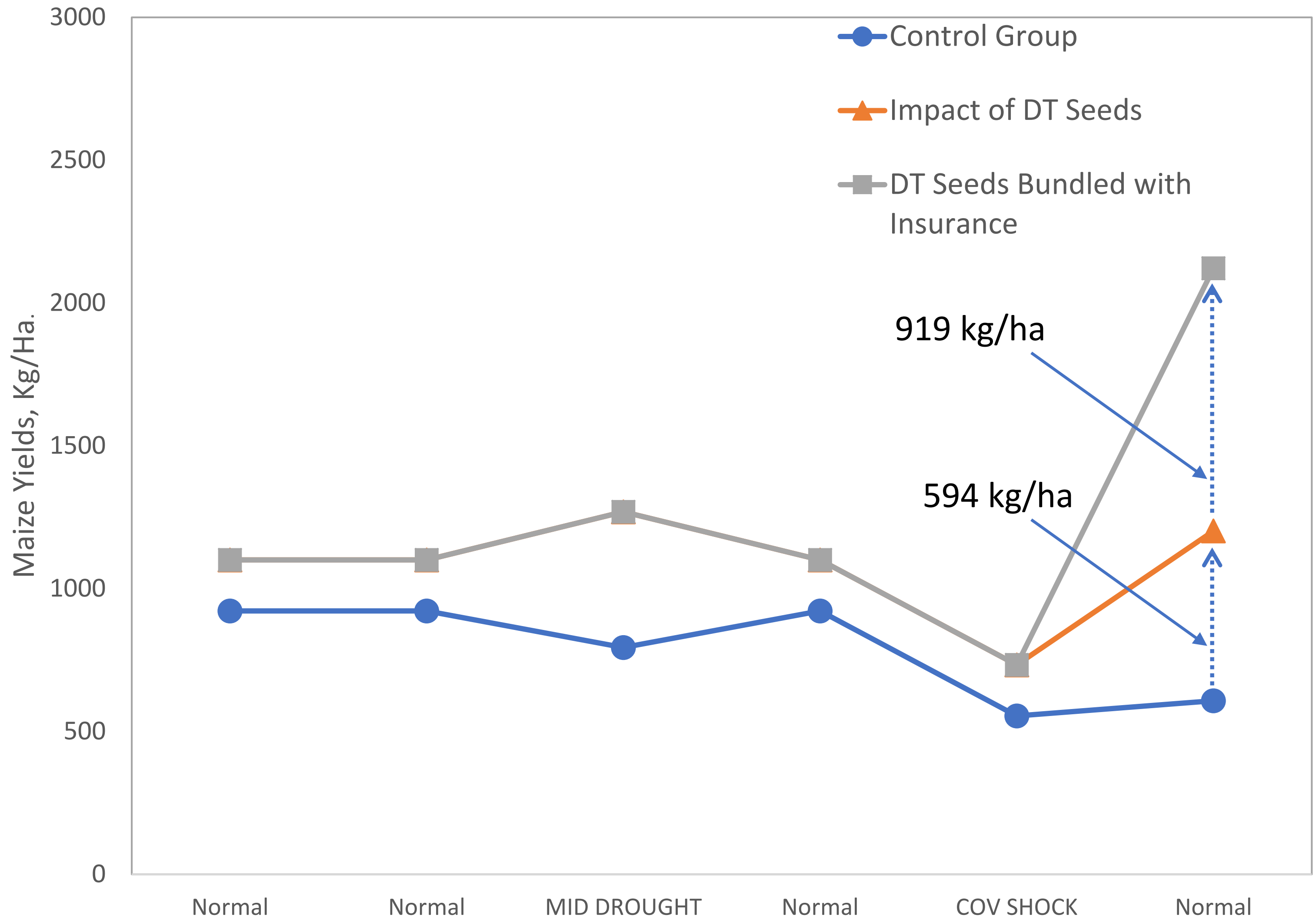



Impact of DT Seed Adoption
3000
2500
2000
1500
1000
500
0
Maize Yields, Kg/Ha.
Control Group
Impact of DT Seeds
178 kg/ha
475 kg/ha
178 kg/ha
Normal
Normal
MID DROUGHT
Normal
COV SHOCK
Normal
Simulated sequence of maize seasons


Impact of DT Seed Adoption
3000
2500
2000
1500
1000
500
0
Maize Yields, Kg/Ha.
Control Group
Impact of DT Seeds
178 kg/ha
475 kg/ha
178 kg/ha
594 kg/ha
Normal
Normal
MID DROUGHT
Normal
COV SHOCK
Normal
Simulated sequence of maize seasons


Impact of Insurance
3000
2500
2000
1500
1000
500
0
Maize Yields, Kg/Ha.
Control Group
Impact of DT Seeds
DT Seeds Bundled with Insurance
Normal
Normal
MID DROUGHT
Normal
COV SHOCK
Normal
Simulated sequence of maize seasons

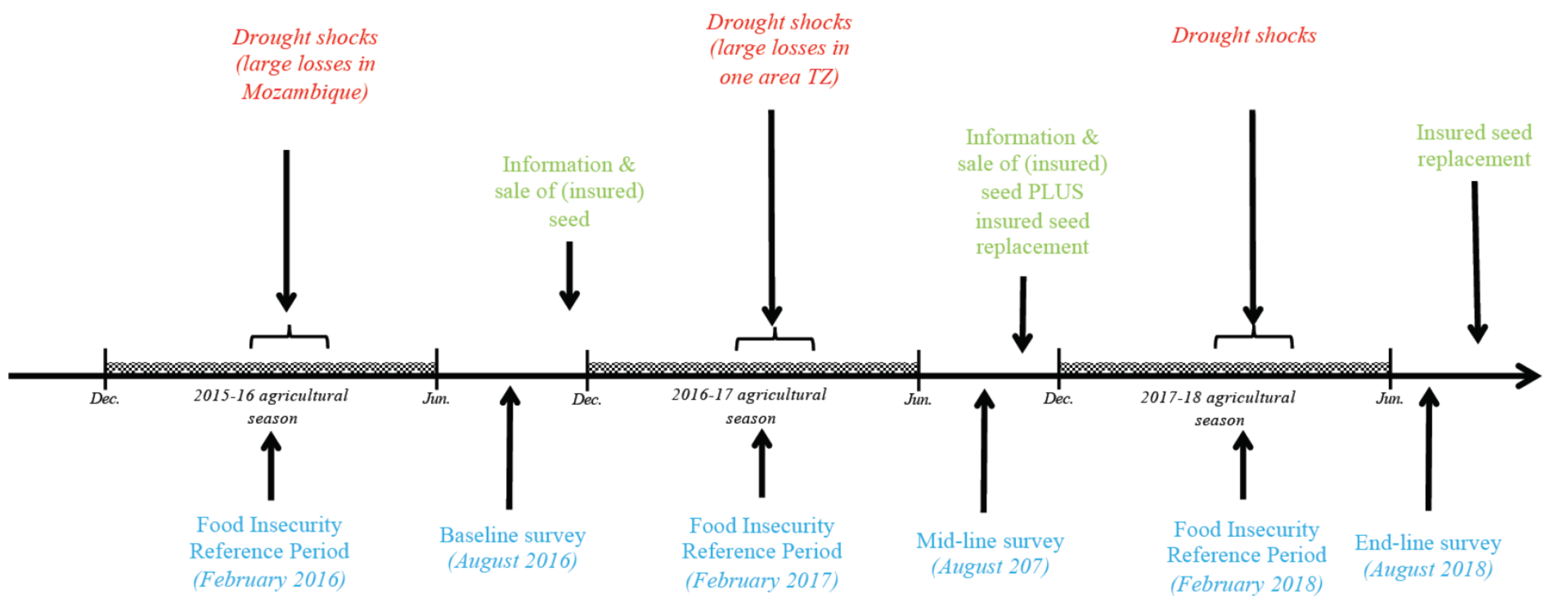
Impact of Insurance



Simulated sequence of maize seasons

Impacts on Food Security

- Food insecurity highest in Feb -- April (stocks depleted, waiting for harvest)
- Quality of previous harvest (May/June) is crucial.
- Specific Questions
  - Q1: What is the impact of weather shocks that occurred last season on this year's food security?
  - Q2: Do the positive inter-seasonal impacts of DT and Insurance translate into reductions in food insecurity?



Impacts on Food Security: Initial Insights

- Dependent variable: Household Food Insecurity Access Scale (HFIAS)
  - Index from 0 to 30
  - Larger values indicate greater *insecurity*
- Mean HFIAS among control group = 18.4
- Preliminary Findings
  - Midseason drought increases food insecurity by 4.4 points (24%)
  - Covariate yield shock increases food insecurity by 6.6 points (35%)
  - See some impacts of DT and Index Insurance in the right directions, but estimates not precise…need additional work.

Summary of Findings

- DT provides significant protection against midseason drought without sacrificing yield during normal seasons
  - During seasons with midseason drought, planting DT seeds raised maize yields by 475 kg (60%) compared to control group.
  - During seasons with normal weather, planting DT seeds raised maize yields by 178 kg (18%) compared to control group.
- DT enhances farmer resilience by avoiding decapitalization.
  - Planting DT seeds during a season with a major covariate yield shock raises maize yields in the following season by 595 kg (95%) compared to control group.
  - Planting DT allows farmers to fully rebound after major covariate shock.

Summary of Findings

- Index insurance significantly strengthens farmer resilience above and beyond the DT seeds ("Resilience Plus")
  - Purchasing insured DT seeds during a season with a major covariate yield shock raises maize yields in the following season by 1,500 kg (250%) compared to control group.

- Are large insurance effects plausible?
  - Could be result of intensification along multiple margins
    - Insured farmers learn that the insurance works and decide to intensify production: Replacing local seed with more DT/improved seed;
    - Uninsured farmers observe payouts received by insured farmers and decide to try insured DT maize.
  - Some descriptive evidence of first two channels, but more work needs to be done.

Summary of Findings

- Food Security (very preliminary findings)
  - Initial evidence that weather shocks have adverse effects on food security.
  - Weaker evidence on effectiveness of DT and Insurance on mitigating these effects.
  - Stay tuned for more results soon!

Thank You!

Additional Slides

Treatment on Treated Econometric Specification

$$
\begin{aligned}
y_{i,t=(1,2)} = {} & \gamma_1 DROUGHT_{it} + \gamma_2 ZSHOCK_{c,t} + \gamma_3 ZSHOCK_{c,t-1} + \gamma_4 ZSHOCK_{c,t-1} I(t=2) \\
& + \beta_1^1 \mathrm{DT}_i + \beta_1^2 \mathrm{II}_i + \beta_2^1 \mathrm{DT}_i \times DROUGHT_{it} \\
& + [\beta_3^1 \mathrm{DT}_i \times ZSHOCK_{c,t-1}] I(t=2) + [\beta_3^2 \mathrm{II}_i \times ZSHOCK_{c,t-1}] I(t=2) \\
& + \theta y_{i,0} + v_s + e_{it}
\end{aligned}
$$

Where the variables are defined as follows:

- $y_{i,t}$: Maize yield in period t (kg/ha)
- $DROUGHT_{it} = 1$ if mid-season rainfall < 200 mm
- $ZSHOCK_{c,t} = 1$ if predicted avg yield in the community $< 65\%$ of historical mean (insurance triggered);
- $DT_i = 1$ if farmer i planted DT maize
- $II_i = 1$ if farmer i purchased insured seed
- $I(t = 2)$: Indicator for end-line
- $y_{i,0}$ = Yields at baseline
- v_s: Triad fixed effect

Definition of Instrumental Variables

$$
\begin{aligned}
y_{i,t=(1,2)} = {} & \gamma_1 DROUGHT_{it} + \gamma_2 ZSHOCK_{c,t} + \gamma_3 ZSHOCK_{c,t-1} + \gamma_4 ZSHOCK_{c,t-1} I(t=2) \\
& + \beta_1^1 \mathrm{DT}_i + \beta_1^2 \mathrm{II}_i + \beta_2^1 \mathrm{DT}_i \times DROUGHT_{it} \\
& + [\beta_3^1 \mathrm{DT}_i \times ZSHOCK_{c,t-1}] I(t=2) + [\beta_3^2 \mathrm{II}_i \times ZSHOCK_{c,t-1}] I(t=2) \\
& + \theta y_{i,0} + v_s + e_{it}
\end{aligned}
$$

Our TOT specification includes 5 endogenous variables (any term that includes either DT_i or II_i). We use the following instruments in our IV estimation:

- T1: Assignment to seed only treatment
- T2: Assignment to seed-with-insurance treatment
- T1*$\mathrm{DROUGHT}_{it}$
- T2*$\mathrm{DROUGHT}_{it}$
- T1*ZSHOCK_{it-1}
- T2*ZSHOCK_{it-1}

Results: Treatment on Treated

	Coefficient	Std Error	Z value	P > Z
$DROUGHT_t$	-128.1	107.2	117.9	0.096
$ZSHOCK_t$	-367.5	77.0	-4.77	0.000
$ZSHOCK_{t-1}$	-101.5	21.7	-4.67	0.000
$ZSHOCK_{t-1}$I(t=2)	-213.0	97.0	-2.20	0.028
DT	178.6	107.2	1.67	0.096
II	-69.7	75.8	-0.92	0.358
DT x $DROUGHT_t$	296.3	105.5	2.81	0.005
(DT x $ZSHOCK_{t-1}$)I(t=2)	416.0	393.1	1.06	0.290
(II x $ZSHOCK_{t-1}$)I(t=2)	919.2	336.9	2.73	0.006
y_0	0.16	0.026	6.16	0.000
Control Mean	539			
Observations	5407			