Predicting Historical Peanut Yields for Anantapur Region in India with Three Crop Models: Calibration, Aggregation, and Bias Correction

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Two relevant scales and appropriate methodologies

Crop model calibration against *site-specific* experimental data sets.
But is this representative of region?

Regional yield estimates must account for *uncertain* distribution of weather, soils, cultivars, sowing dates, fertility for region

From the point to the region

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Scaling up Crop Model Simulations for Anantapur District of India

- **Objective:** To predict district-level peanut pod yields with multiple crop models for Anantapur, accounting for weather, soils, cultivars, sowing date, & management of the region.
- **General Methods** –Use published experiments, variety trials, & historical regional yields *within regions.* ***STEPS!***
  1. ***Calibrate cultivars:*** Site-specific experiments with known soils and management (time-series data, Platinum) (end-of-season data – variety trials, etc., Silver)
  2. ***Aggregate up to Regional District-level yields***, which lack site-specific information. Do multiple simulations accounting for areal probability of weather, soils, irrigation, sowing date, sowing density, & cultivar. Aggregate in proportion to areal probability, to predict District-level yields.
  3. ***Bias-Adjustment for Regional district-level yields***. Plot observed versus simulated yields over multiple historic years (n=20-30). Ratio is the bias. Account for technology trend?
- **Future** – Predict impact of baseline & climate change scenarios on agricultural production for regions.

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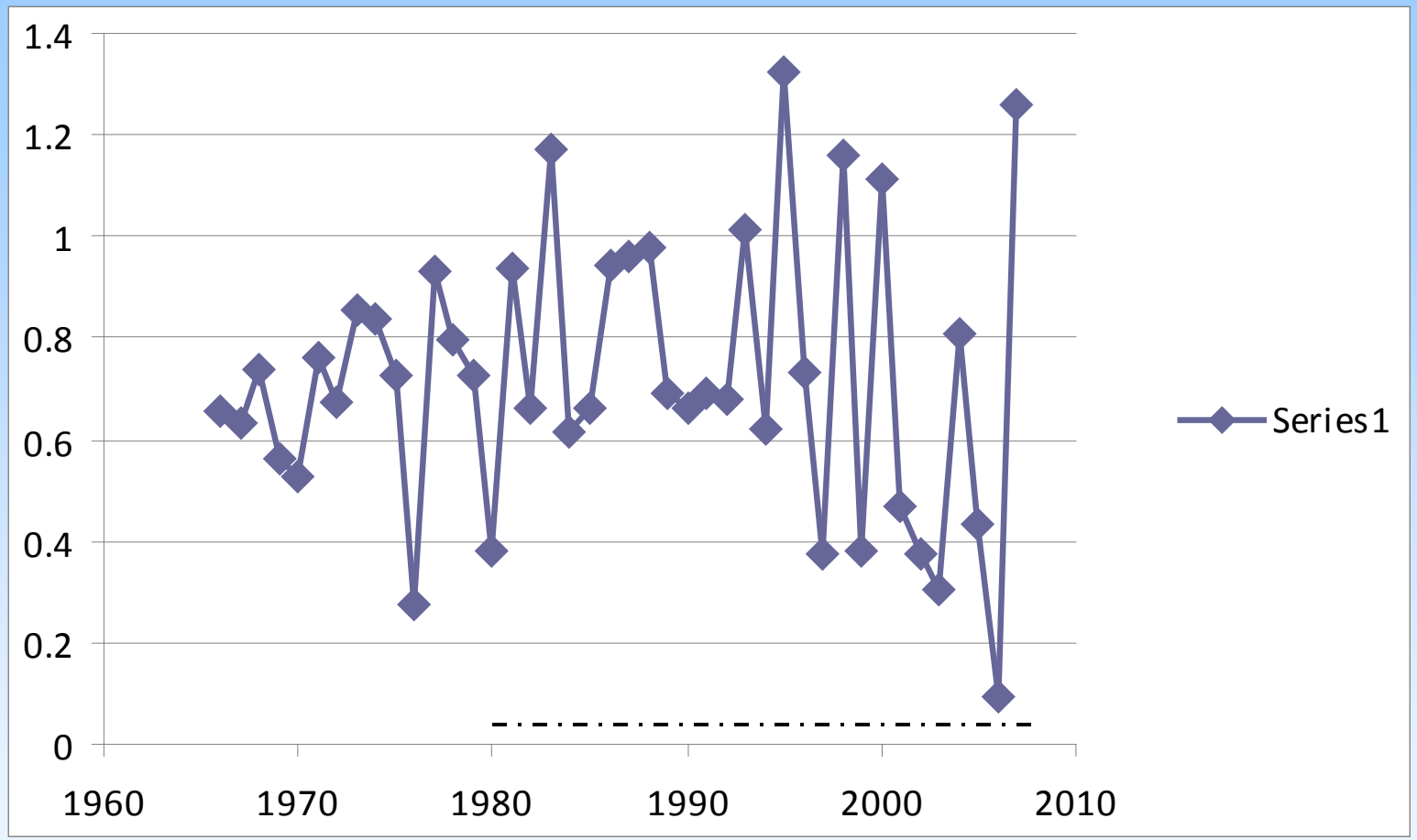
Scaling up Crop Model Simulations for Anantapur District of India

Data Available: Lacked "on-farm" surveys. Had one sentinel experiment station site. 28 years of aggregated groundnut yield for Anantapur District from 1980 to 2007.

- **Methods:** (*point to region*)
  - FIRST, calibrate cultivar life cycle and yield traits for TMV-2 cultivar with site-specific studies with known soils (measured neutron probe) and management (6 years of time-series and end-of-season data, Platinum/Silver sites).
  - SECOND, simulate district-level yields over 28 years, using 3 sowing dates (auto-plant), 3 representative soils, and 9 weather sites. Gives n=81. Compute simulated mean yield per year.
  - Plot observed district-level yields (per year) versus simulated mean annual yields. Compute bias (ratio or slope with zero intercept). Plot bias-adjusted yields and observed yields over historical time. Evaluate deviations from observed.
  - Use calibrated model for climate impact assessments.



Anantapur district peanut yields (metric ton/ha) over historical time. Used only 1980 to 2007. De-trend? No trend from 1980 to 2007.

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Calibrating Cultivars for Anantapur Exp. Sta (Multi-Model: DSSAT, APSIM, INFOCROP)

Best results if no N and water deficit stresses

- Estimate life cycle-dependent traits first - Most Important
  - Thermal time to anthesis and to maturity.
- Estimate growth, partitioning, and yield traits next.
  - 1. Is final biomass correctly predicted? Is SOC correct? Initial NO3 and NH4? If site has high N fertilization and model over-predicts, then reduce RUE, or reduce SLPF for unknown P, pH, micronutrient deficiencies.
  - 2. Grain yield. Set grain size first. Then grain number. Is HI correct? APSIM: Set rate of HI-increase
- Time-series data: dry weights & leaf area are helpful.
- Use your knowledge. No blind statistical methods.

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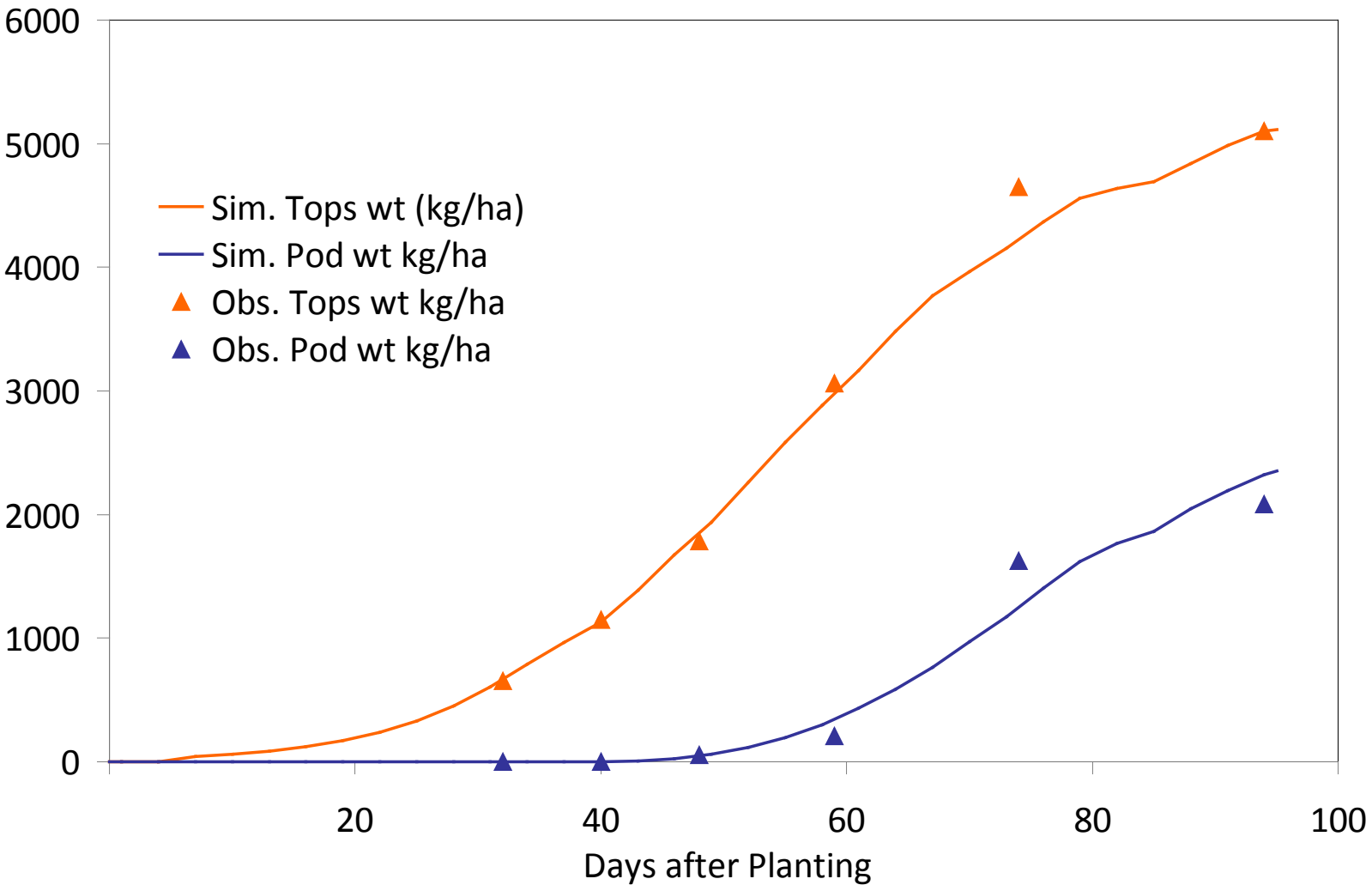
Experimental Data for Anantapur Site

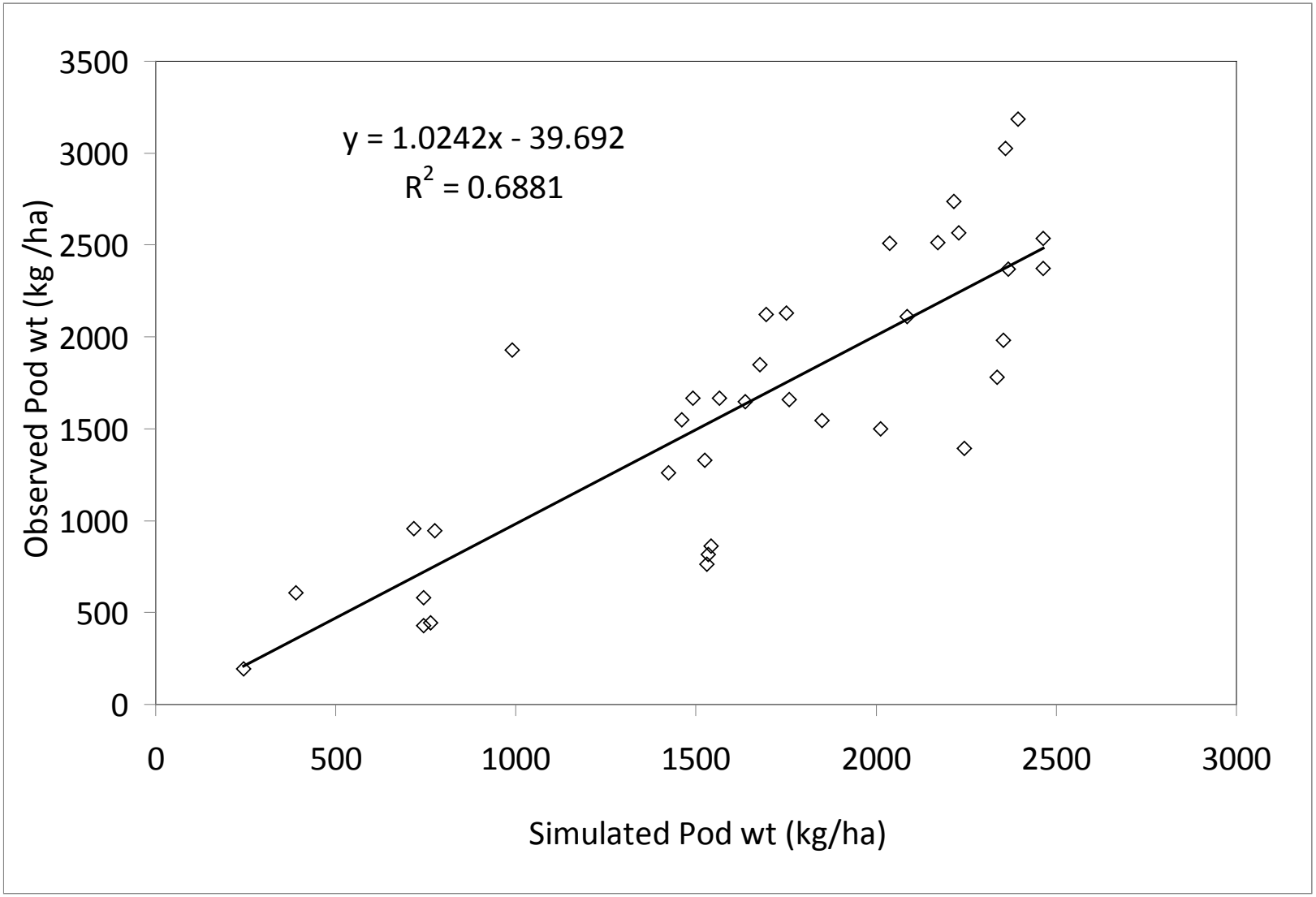
Year	Datasets	Treatments on TMV-2 Cultivar
1986	12	Sowing date X Irr X Plant density
1987	4	Sowing date X irrigation
1988	4	Same
1989	6	Same
1990	6	Same
1993	4	Same

Total 36 data sets/treatments

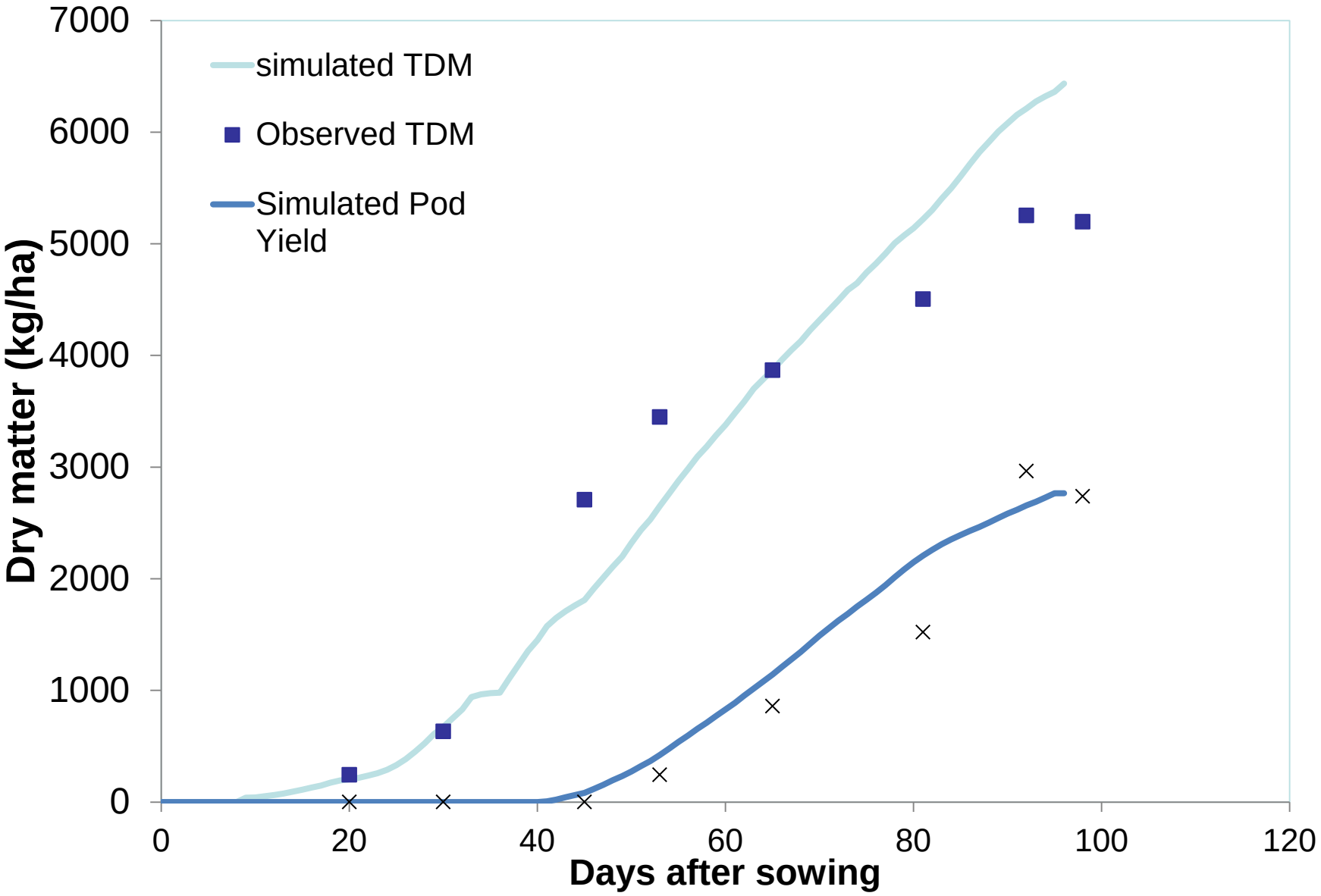
Simulated Total Biomass and Pod over Time in 1987 at Anantapur after calibration of DSSAT-Groundnut model.



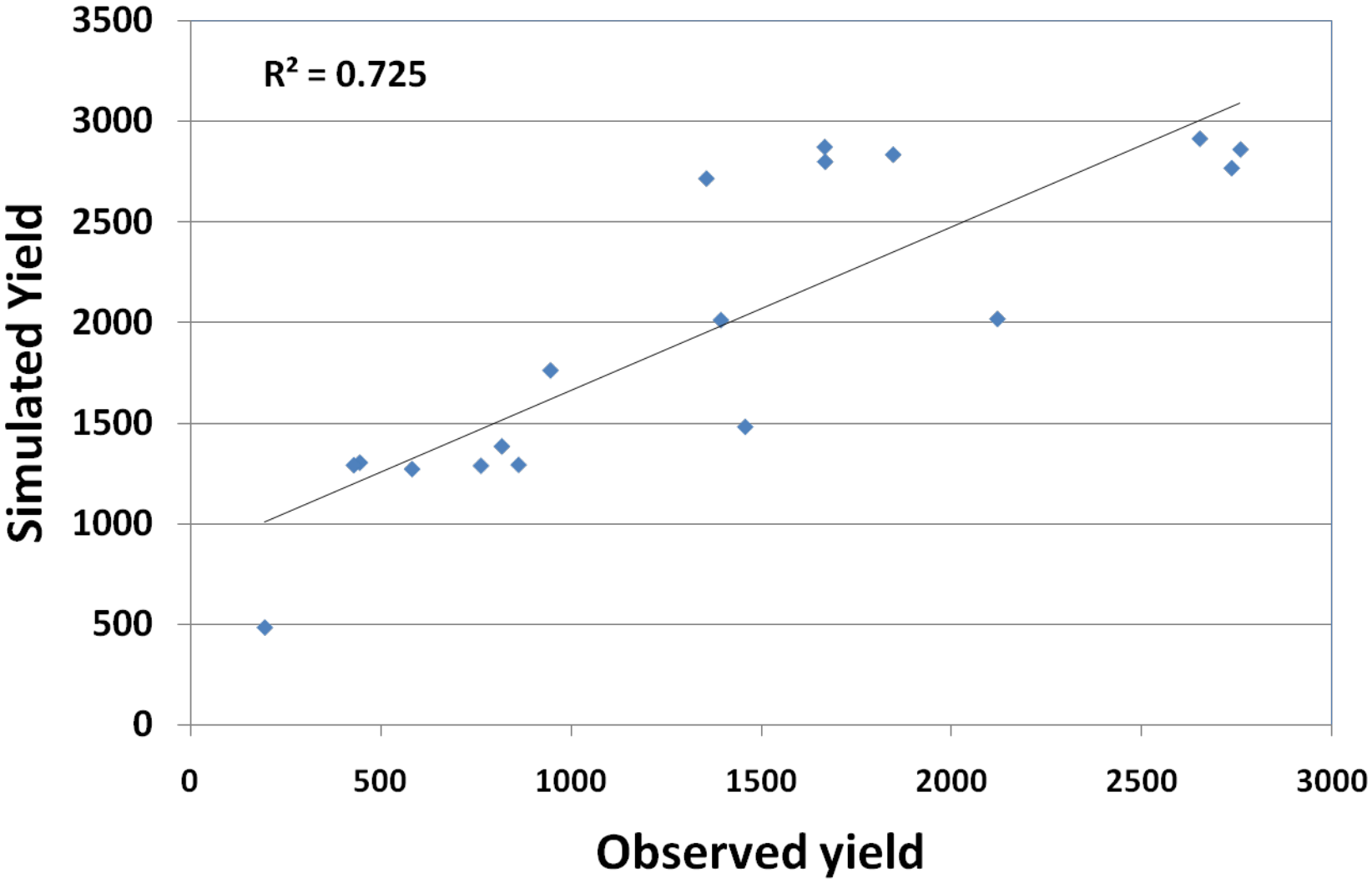
Comparison of observed versus simulated pod yield at Anantapur after calibration of DSSAT-Groundnut model.



Anantapur – Groundnut-1987 Info Crop



Groundnut pod yield (1987-89)-InfoCrop

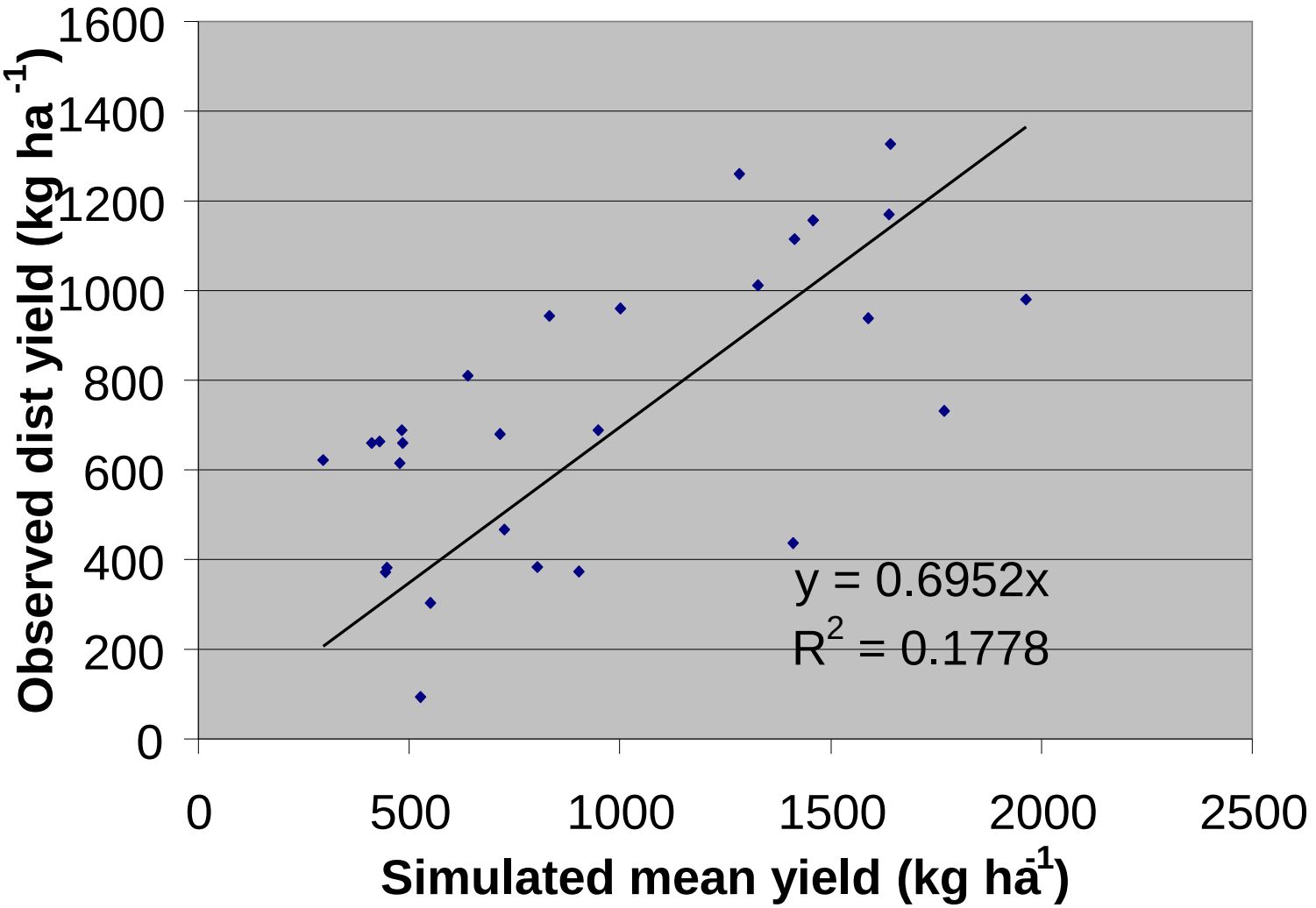


APSIM-Groundnut

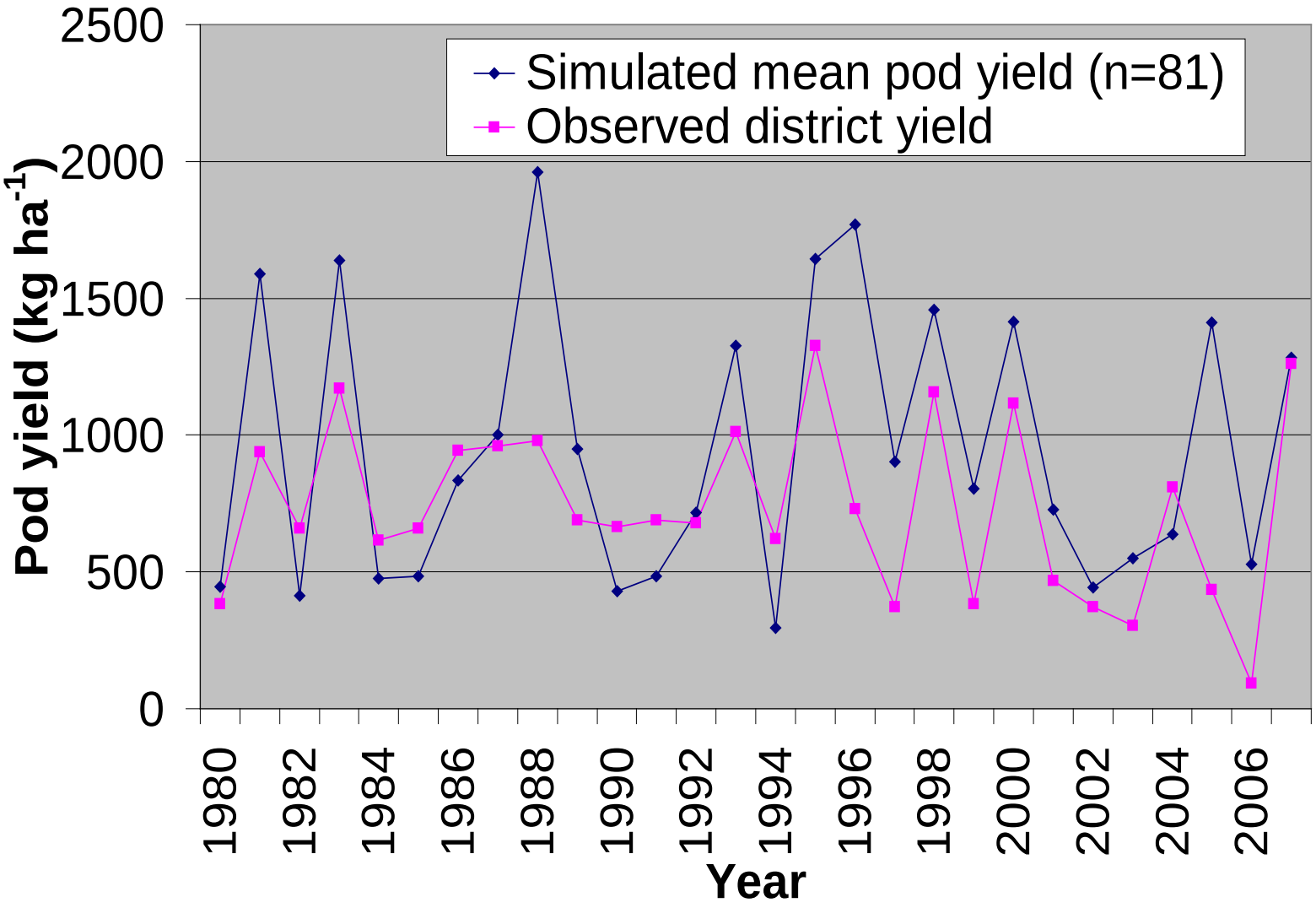
- Calibration completed for TMV 2 cultivar
  - Anthesis and Maturity Phenological stages
  - Pod Yield
  - Total Dry matter
  - Harvest Index (HI)

		Anthesis DAS	Maturity DAS	Pod Yield (kg/ha)	Total Dry Matter	HI
Mean	Sim	29	99	1698	3997	0.29
	Obs	28	94	1654	3773	0.29
Median	Sim	27	97	1709	3967	0.27
	Obs	27	93	1663	3722	0.31

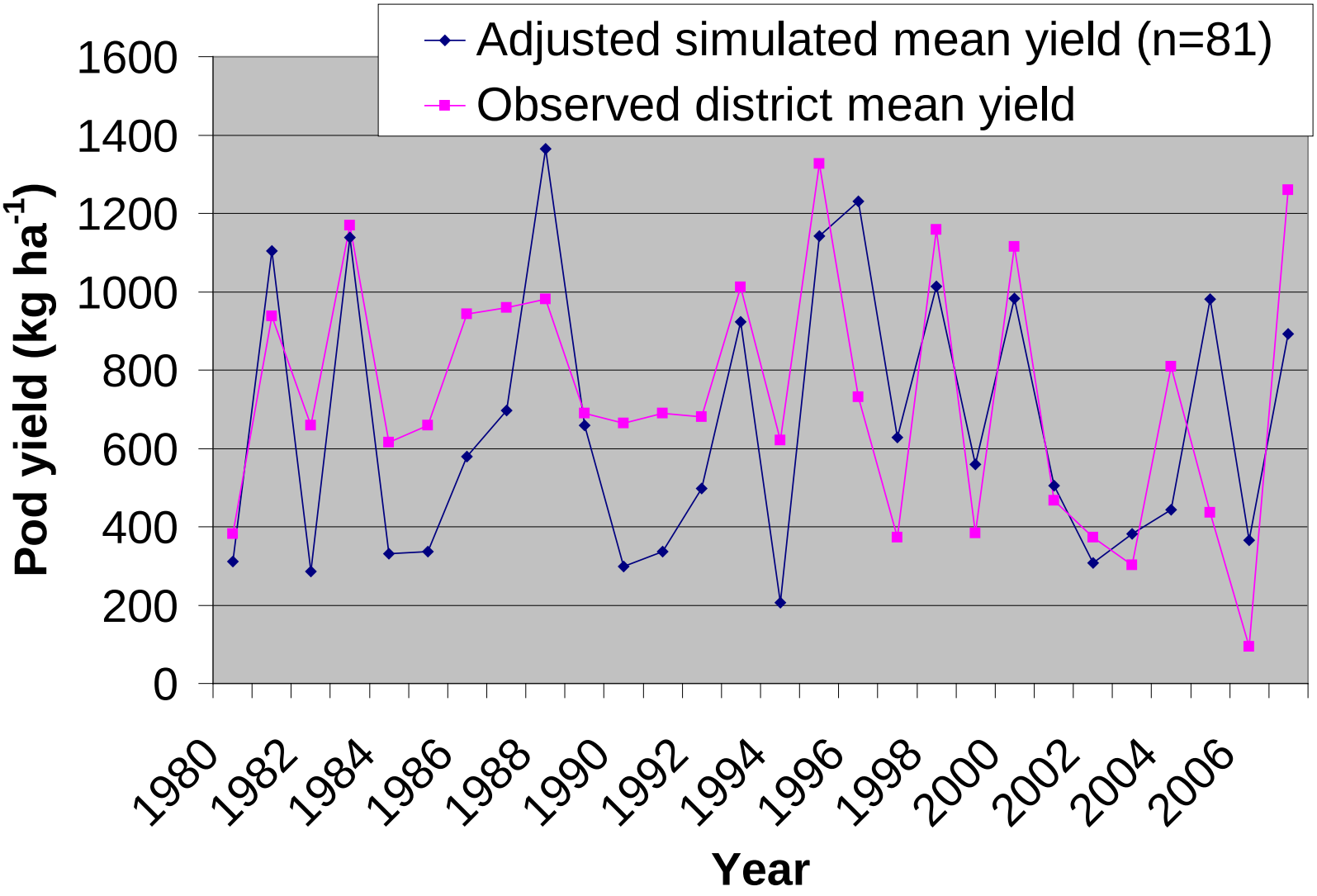
Comparison of observed district yields versus DSSAT-simulated pod yield (aggregated over 9 weather sites, 3 soils, & 3 sowing dates). Slope is *bias-adjustment*.

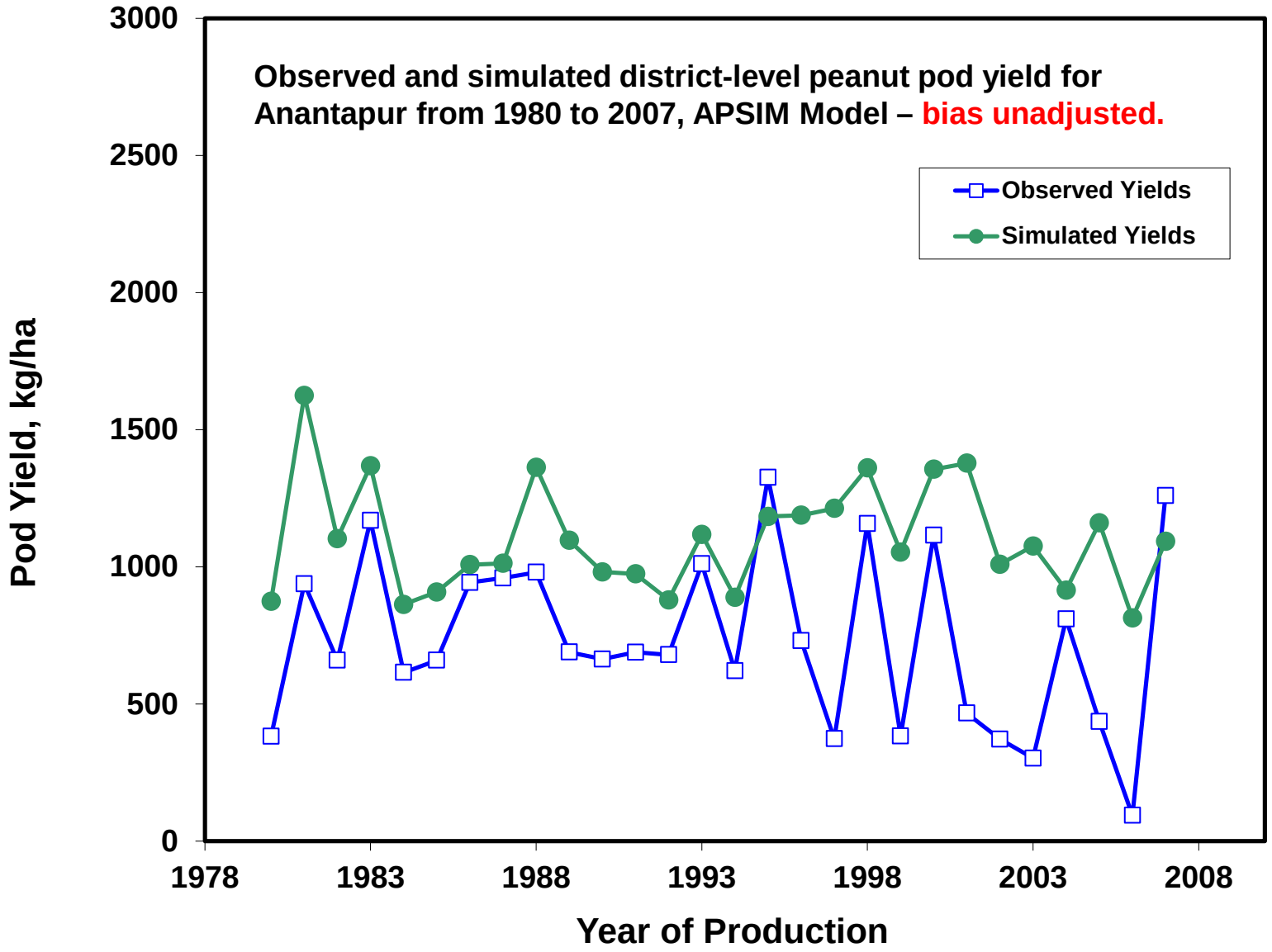


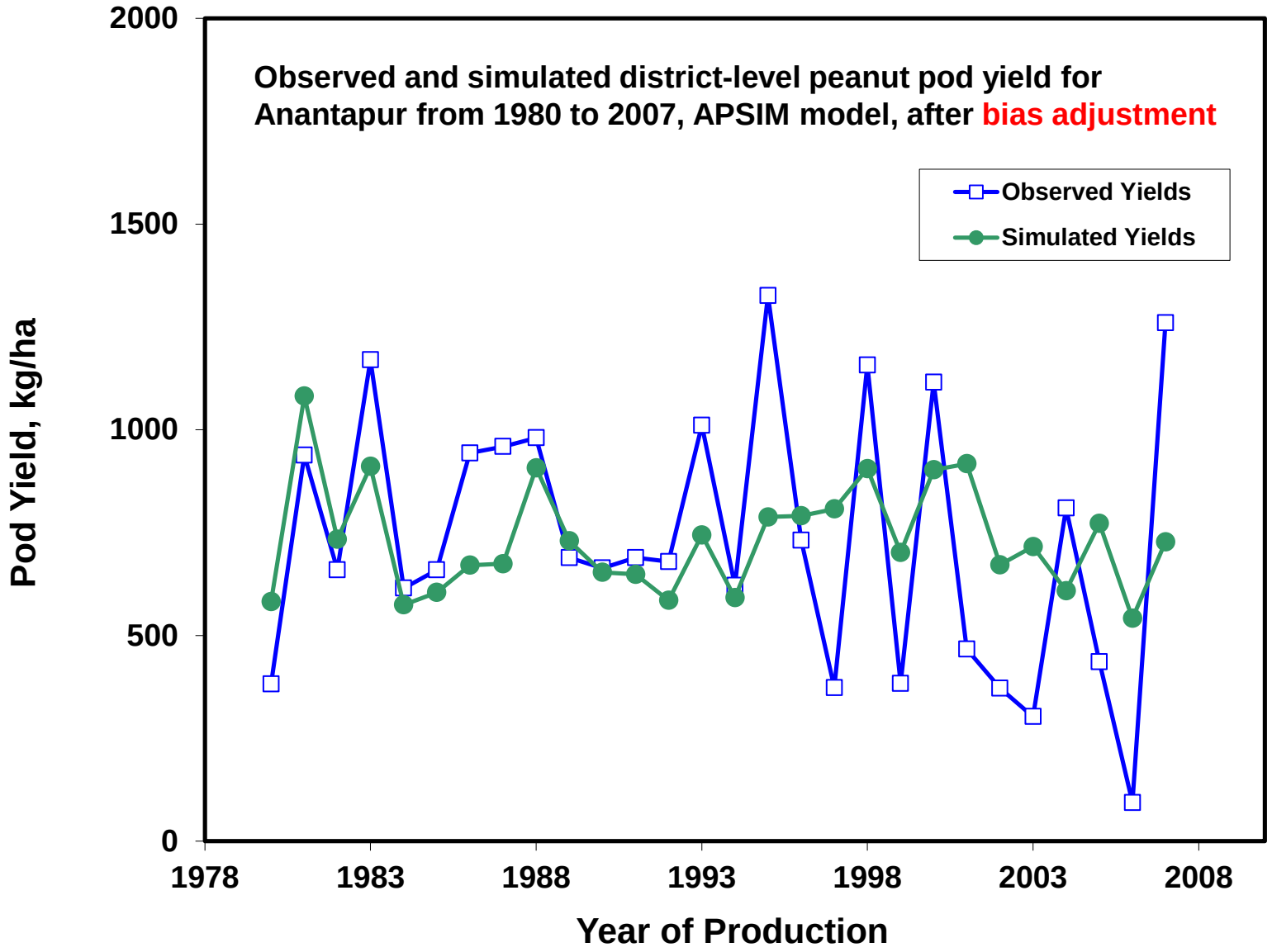
DSSAT-simulated & District yield, unadjusted



Observed historical district yields versus DSSAT-simulated yield (after bias-adjustment and aggregation) at Anantapur.




Observed and simulated district-level peanut pod yield for Anantapur from 1980 to 2007, APSIM Model – bias unadjusted.
Observed Yields
Simulated Yields
Pod Yield, kg/ha
3000
2500
2000
1500
1000
500
0
1978
1983
1988
1993
1998
2003
2008
Year of Production


Observed and simulated district-level peanut pod yield for Anantapur from 1980 to 2007, APSIM model, after bias adjustment
Observed Yields
Simulated Yields
Pod Yield, kg/ha
2000
1500
1000
500
0
1978
1983
1988
1993
1998
2003
2008
Year of Production

Summary: Two-Step Process for Scaling up Crop Model Simulations for Regions

What Data is Available: Do you have "on-farm" surveys? How many sentinel-site experiments? Are they representative of Region? Do you have district yield over historical time? Can you describe the range of distribution of weather, soils, sowing dates, fertilization inputs needed for simulating aggregated yield for the region?

1. **Sentinel Site Experimental Data – Calibrate thermal times for cultivars (time to anthesis and maturity) & partitioning/yield traits**
2. **Predict District-level Yields and do Bias-adjustment**
   - Collect district-level historical yields and de-trend.
   - Determine range of distribution of soils, weather stations, sowing dates, fertilization, soil organic carbon for the region
   - Simulate district-level yields over the range of distributed inputs and compute simulated mean yield per year.
   - Aggregate and plot observed district-level yields (per year) versus simulated mean annual yields. Compute bias (ratio or slope with zero intercept).