Does Potassium Balance Explain the Change in Mehlich-3 Extractable K in Arkansas Soils?
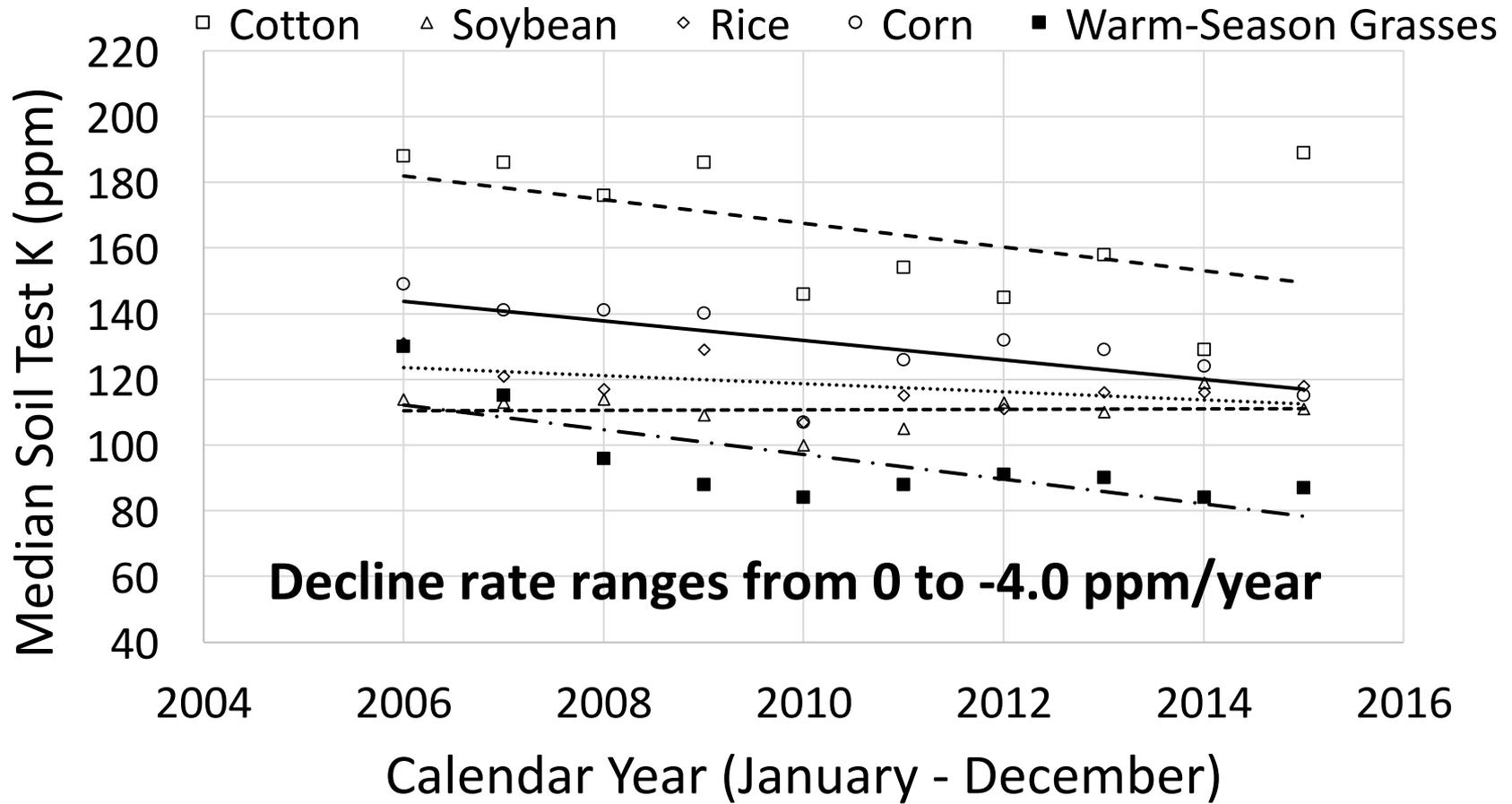
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Frontiers of Potassium
Rome, Italy
25-27 January 2017

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Arkansas Soil-Test K Trends

Legend: □ Cotton △ Soybean ◇ Rice ○ Corn ■ Warm-Season Grasses

Y-axis: Median Soil Test K (ppm) — 40, 60, 80, 100, 120, 140, 160, 180, 200, 220

X-axis: Calendar Year (January - December) — 2004, 2006, 2008, 2010, 2012, 2014, 2016

Decline rate ranges from 0 to -4.0 ppm/year

Slaton unpublished data (2017)

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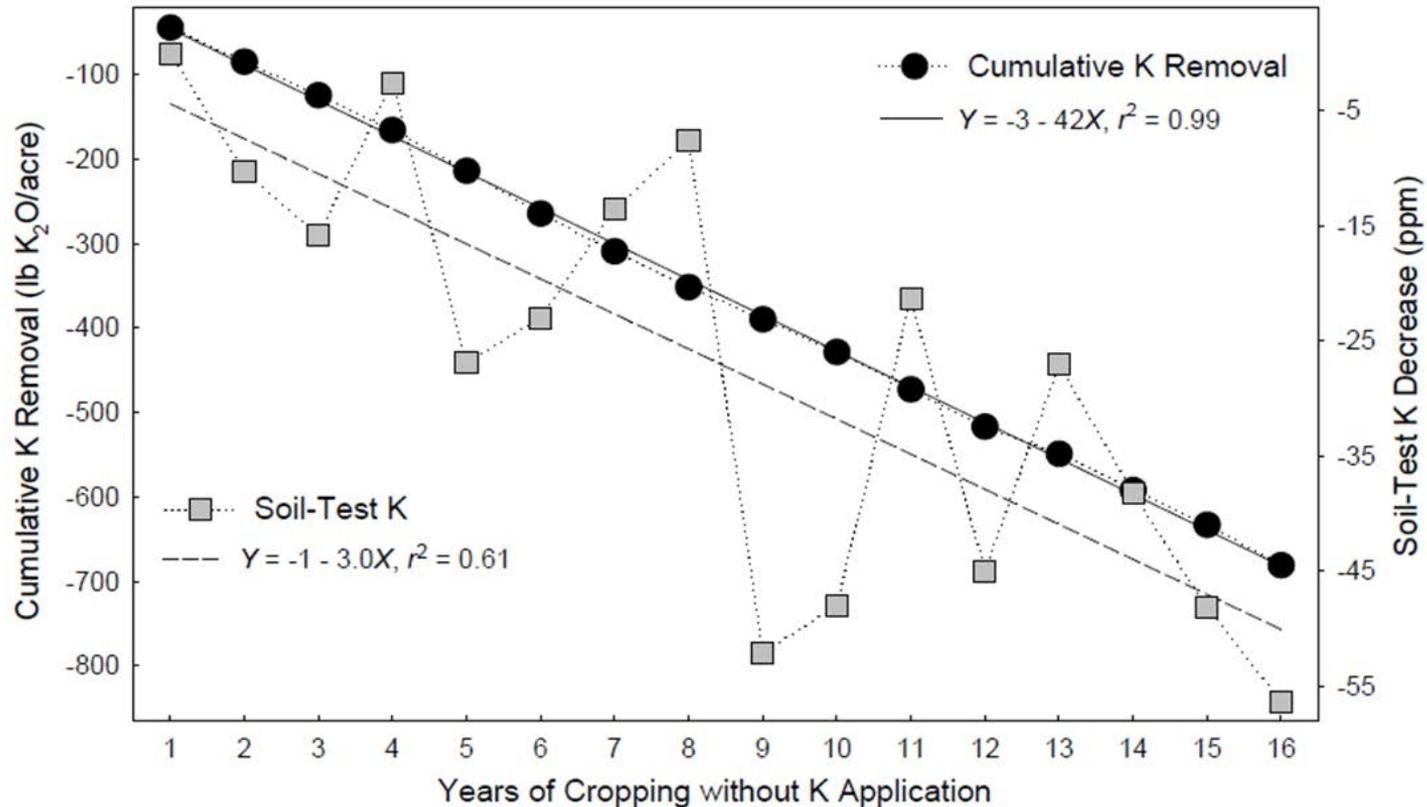
Soil Test K Decline and K Removal

Figure 2. Potassium removal with grain harvest and soil-test K trends over time for corn-soybean rotations across five sites for soils that were not fertilized with K.

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Fertilization Questions

- **Can crop-removal-based fertilizer-K rates maintain soil-test K?**

- *Should fertilizer rates be based on calibration curves or 'build & maintain' equations?*

- *Clients mostly question the accuracy of recommended rates but seldom question the accuracy of the recommendation to fertilize.*

https://en.wikipedia.org/wiki/Calvin_and_Hobbes

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Goal and Objectives

Goal

- Develop better understanding of soil-test K decline and its relationship to crop-K removal and input

Objective

- Examine rate of Mehlich-3 extractable soil K decline and accumulation in the 0-10 cm soil depth of three soils

- Estimate the annual-K rate that maintains Mehlich-3 extractable soil K across time.

Research Sites

Soil	Order	Rotation	Annual-K rates	Duration
			kg K ha^{-1}	
Calhoun	Glossaqualfs	Rice-Soybean	0 – 149	2000 – 2016
Captina	Fragiudults	Bermudagrass	0 – 465	2006 – 2010
Dewitt	Albaqualfs	Rice-Soybean	0 – 149	2007 – 2016
Soil clay content ranges from 10 to 20% clay				

Soil Sampling and Analysis

- Soil sampling
  - 0-10 cm deep samples collected annually from each plot
    - 6 x 2.5 cm i.d. cores/composite
  - Samples collected during winter/dormant season
  - Oven dried at 65°C
    - APHIS Requirement
  - Extracted with Mehlich-3 solution

Data Analysis

- Depletion/build rate
  - Annual soil-test K for soil regressed across time using linear or quadratic model for each annual-K rate

- Net Balance *(Fertilizer-K inputs – Crop removal)*
  - Net change in Mehlich-3 K regressed against net K balance using all years of data for each soil
    - Calhoun, n = 160 (2 means/treatment, 4 reps/mean)
    - Captina, n = 30 (1 mean/treatment, 5 reps/mean)
    - Dewitt, n = 90 (2 means/treatment, 6 reps/mean)

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K Removal Characterization

| Annual-K rates	Captina	Calhoun		Dewitt	
	Bermuda	Rice	Soybean	Rice	Soybean
	- - - - - - - - - - - - - - - - - kg K ha^{-1} - - - - - - - - - - - - - - - - -				
Mean	236	47		48	
0	70	26	52	29	58
1	141	30	62	29	61
2	218	31	65	29	61
3	285	32	68	29	62
4	339	33	70	29	63
5	360	--	--	--	--
Listed values are means calculated across years for each K rate					

Annual-K rates:

0-149 kg K ha^{-1} for Calhoun and Dewitt

0-465 kg K ha^{-1} for Captina
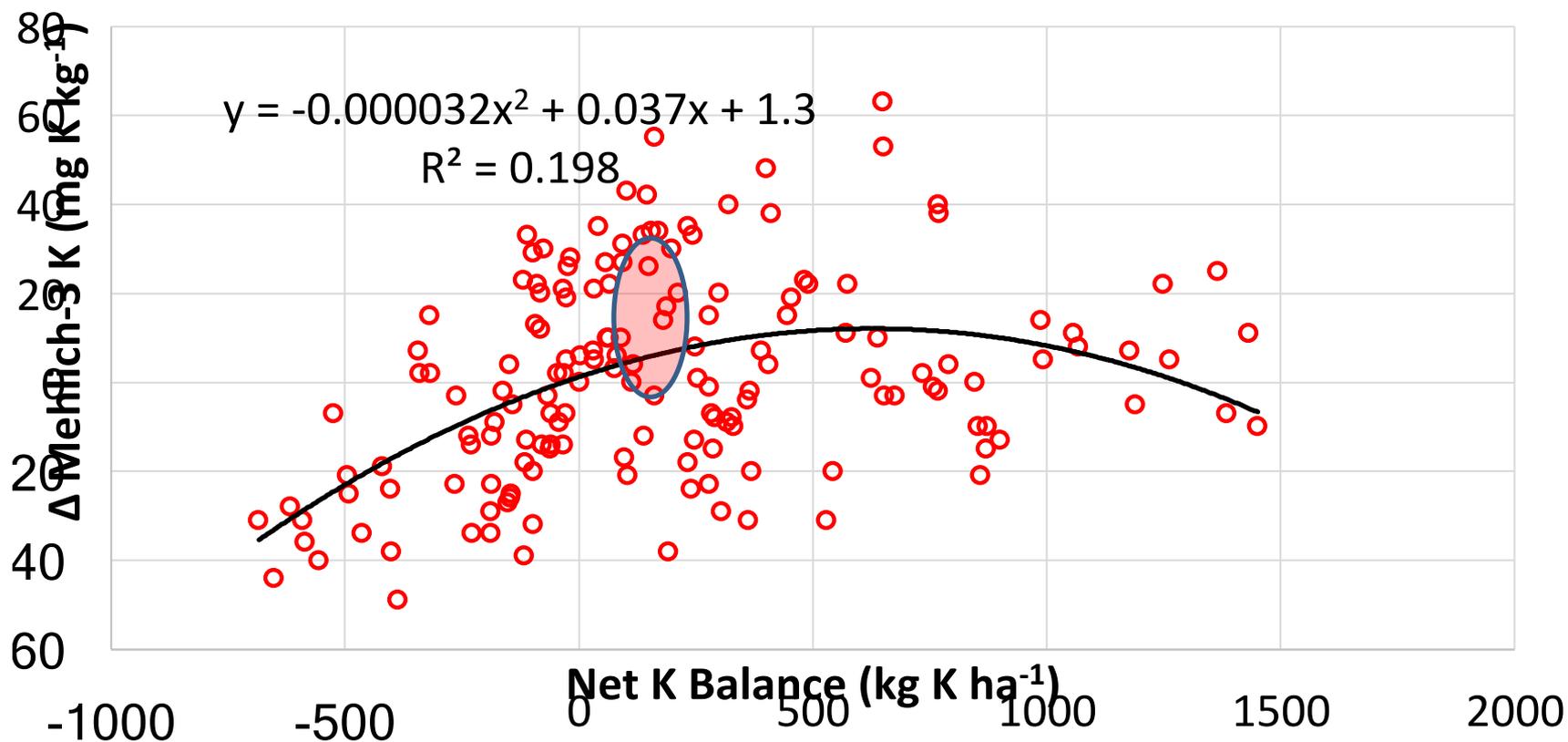
Δ Mehlich-3 Extractable K vs Cumulative Net Balance

Captina Soil

$y = -0.00021x^2 + 0.321x + 34.3$

$R^2 = 0.897$
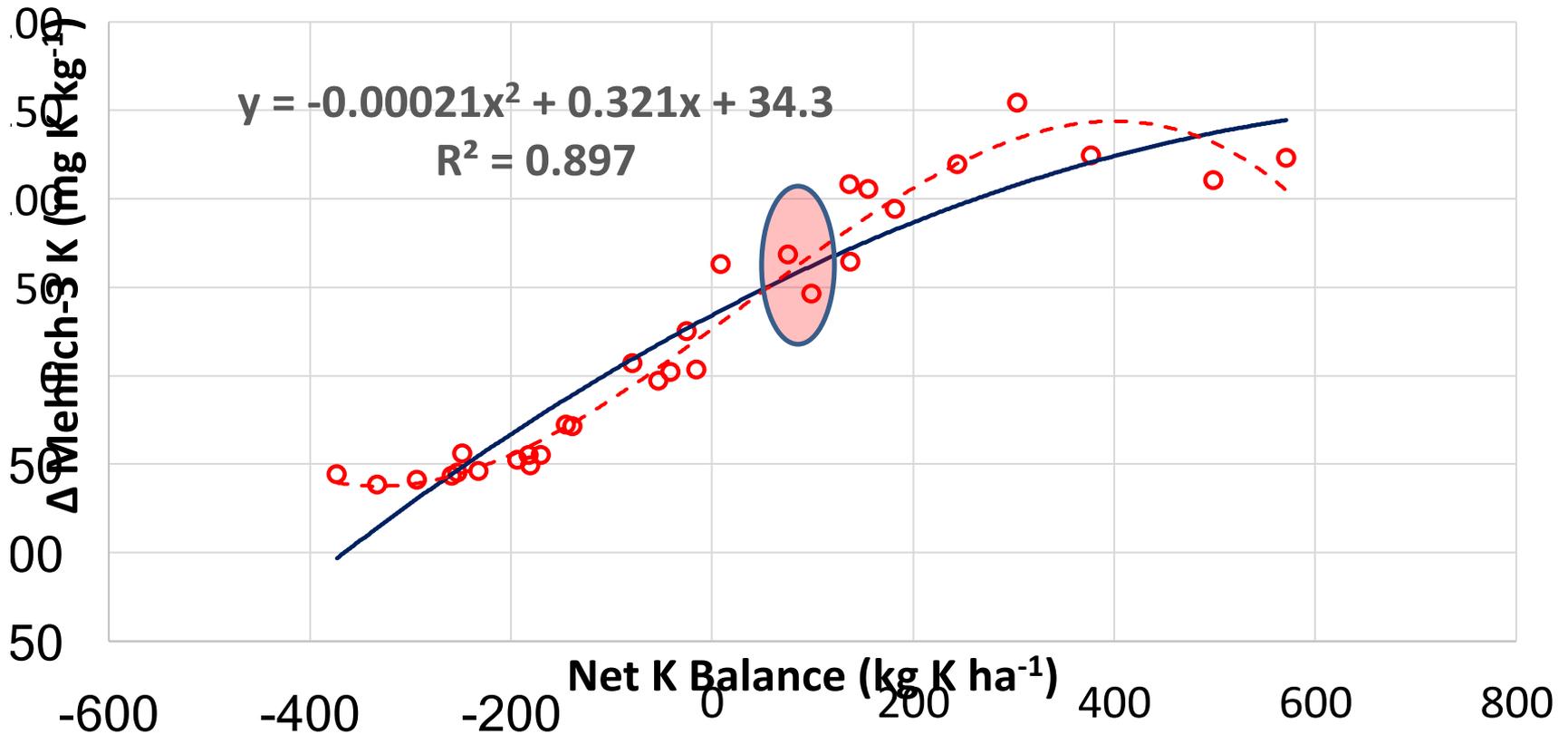
ΔM3-K = +34 ppm when Net-K balance is 0 kg K ha^{-1}

Δ Mehlich-3 Extractable K vs Cumulative Net Balance

Calhoun Soil

$y = -0.000032x^2 + 0.037x + 1.3$

$R^2 = 0.198$

ΔM3-K = +1 when Net-K balance is 0 kg K ha^{-1}

Δ Mehlich-3 Extractable K vs Cumulative Net Balance

Dewitt Soil

Chart: Δ Mehlich-3 K (mg K kg⁻¹) on the y-axis (Δ Mehlich-3 K (mg K kg^{-1})) vs Net K Balance (kg K ha⁻¹) on the x-axis (Net K Balance (kg K ha^{-1})).

$$y = -0.000083x^2 + 0.113x - 12.4$$
$$R^2 = 0.46$$
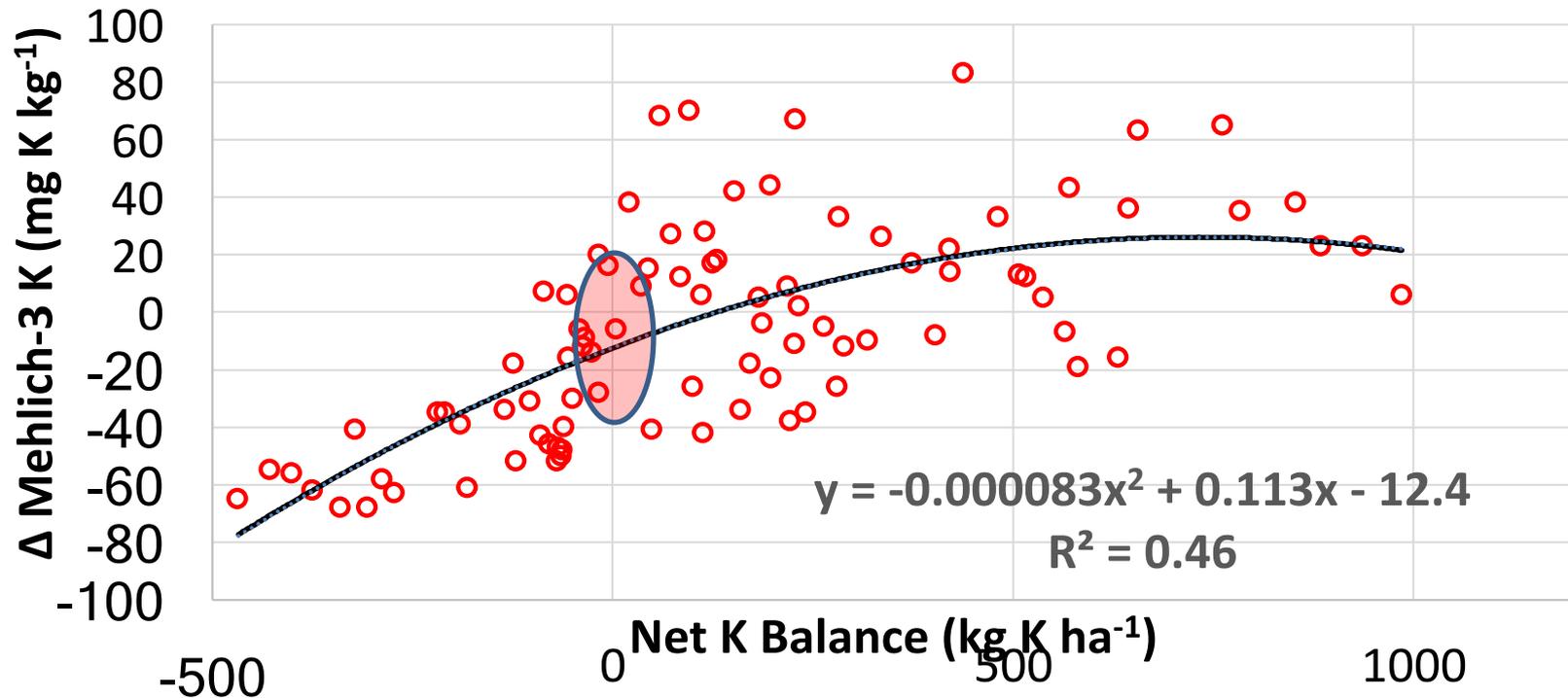
ΔM3-K = -12 ppm when Net-K balance is 0 kg K ha⁻¹ (ΔM3-K = -12 ppm when Net-K balance is 0 kg K ha^{-1})

Calhoun Soil Relationships
by Annual K rate

Annual K	Intercept	Linear	R² Linear	r² Quadratic
kg K ha^{-1}	Intercept (SE)	Slope (SE)		
0	**92 (5)**	**-3.1 (0.5)**	**0.55***	**0.55^{NS}**
37	95 (5)	-2.6 (0.5)	0.42*	0.43^{NS}
75	98 (5)	-2.3 (0.5)	0.32*	0.33^{NS}
112	106 (6)	-1.9 (0.6)	0.22*	0.23^{NS}
149	107 (6)	--1.2 (0.6)	0.08*	0.13*

Mehlich-3 K mg kg^{-1} = Intercept + (Slope × Years)
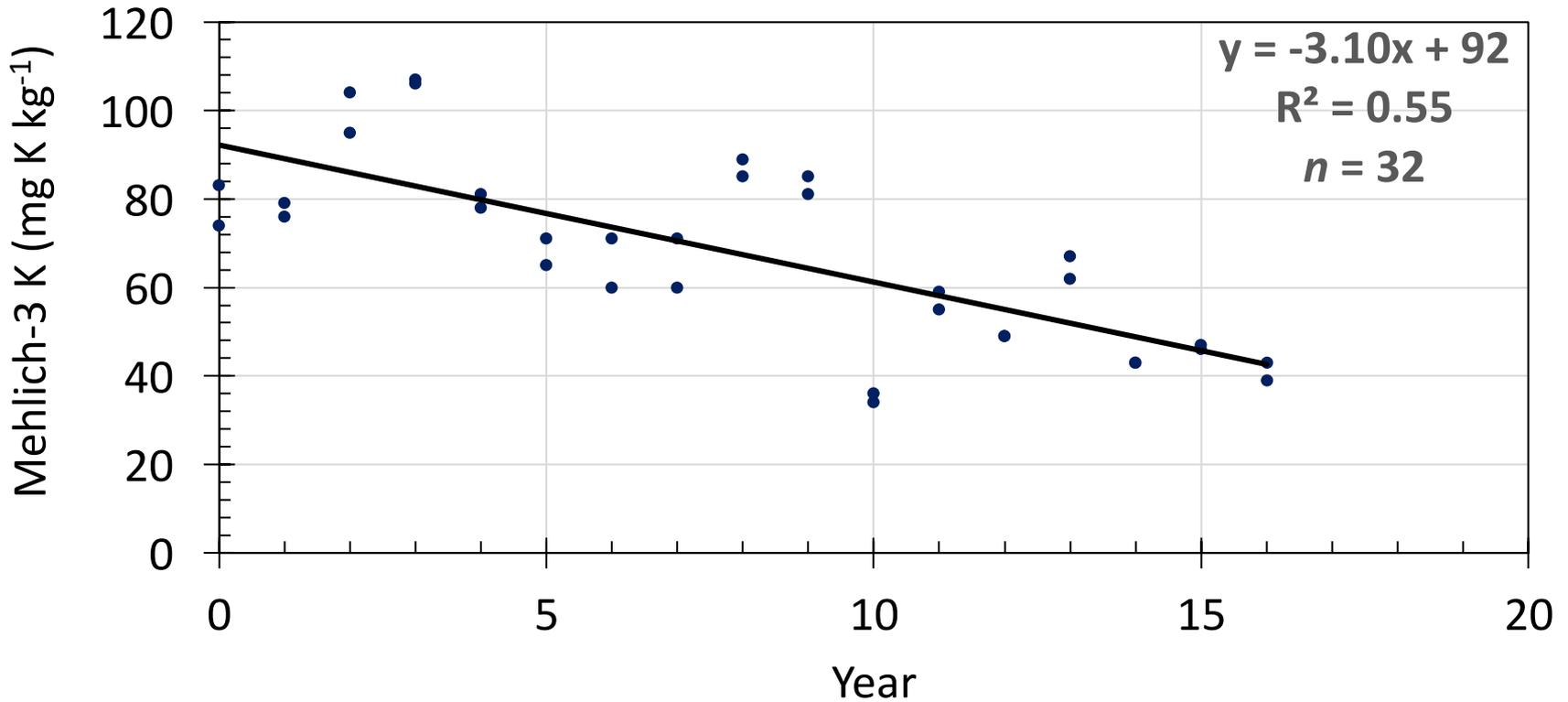* Overall model & coefficients significant at 0.10.

n = 32 for each annual-K rate

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Soil-K Response Across Time To K Rate Calhoun Soil
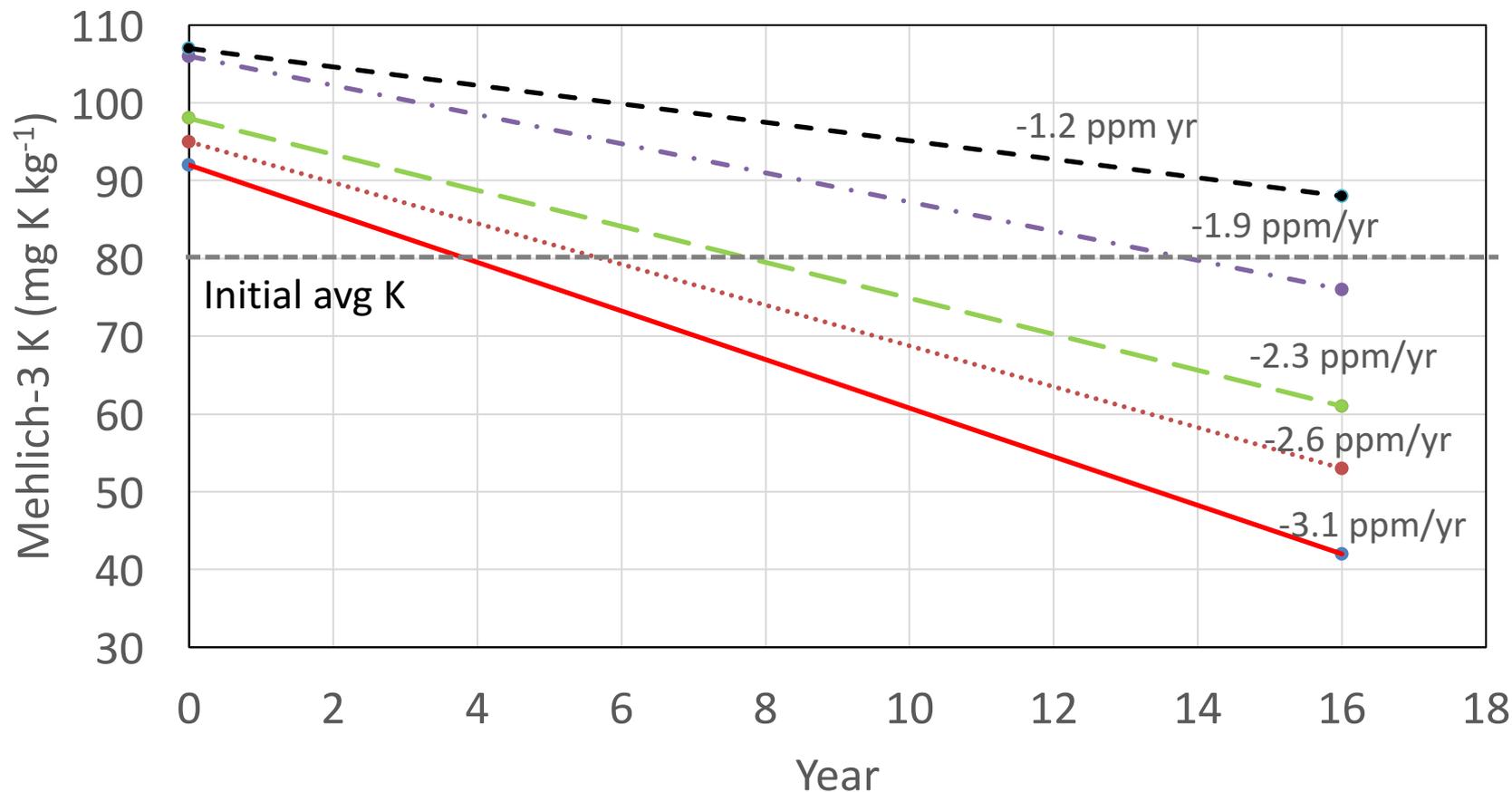
Rice-irrigated soybean system

Soil-K Depletion Rate

Calhoun silt loam

$$y = -3.10x + 92$$
$$R^2 = 0.55$$
$$n = 32$$

Rice-irrigated soybean system

Dewitt Soil Relationships
by Annual K rate

Annual K	Intercept	Linear	R^2 Linear	r^2 Quadratic
kg K ha^{-1}	Intercept (SE)	Slope (SE)		
0	**140**	**-7.6**	**0.73 ***	**0.81 ***
37	147	-5.9	0.64 *	0.65^{NS}
74	158	-4.8	0.45 *	0.42^{NS}
112	167	-2.9	0.12 *	0.12^{NS}
149	175	0.7	0.05^{NS}	0.06^{NS}

Mehlich-3 K mg kg^{-1} = Intercept + Slope × Years
* Overall models & coefficients significant at 0.10.

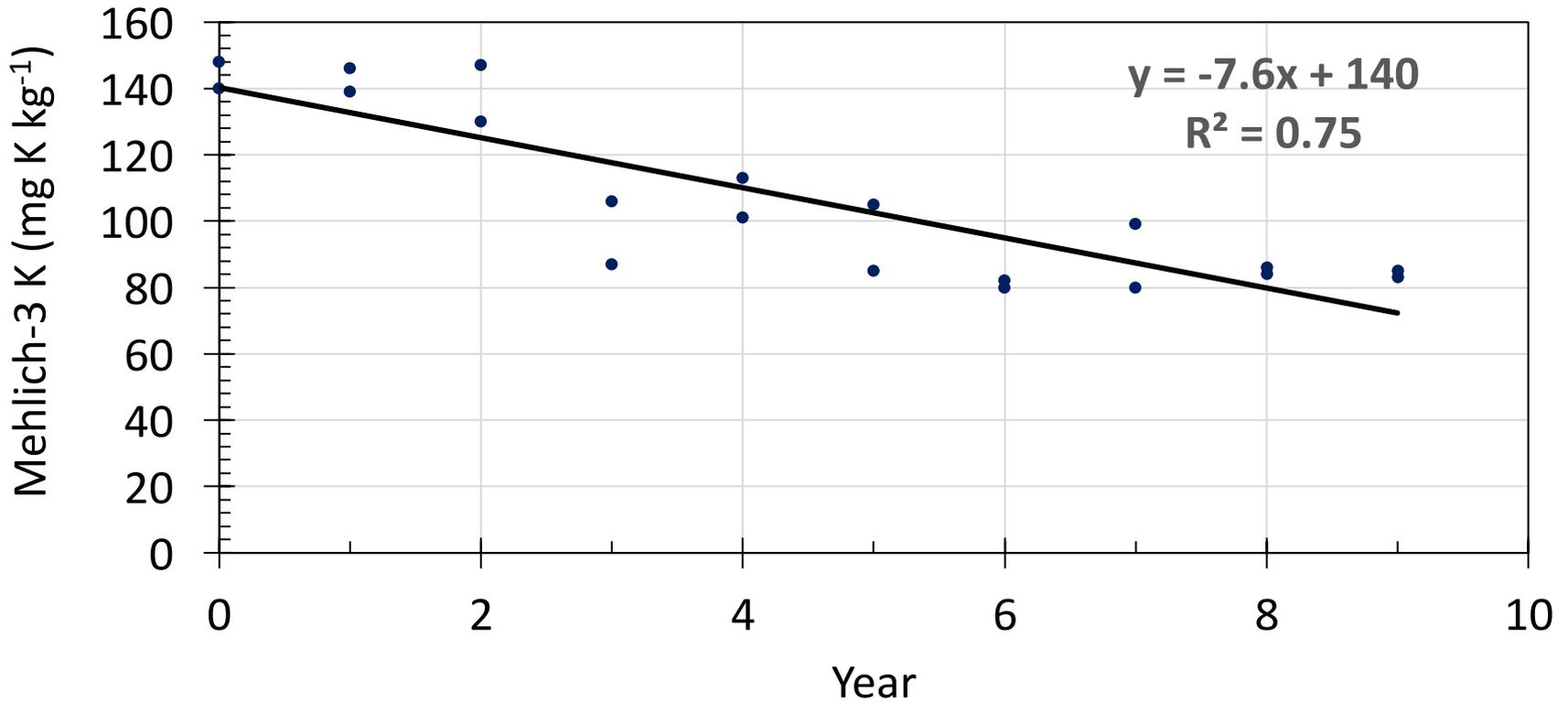*Rice-soybean cropping system*
n = 20 for each annual-K rate

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Soil-K Response Across Time To K Rate Dewitt Soil
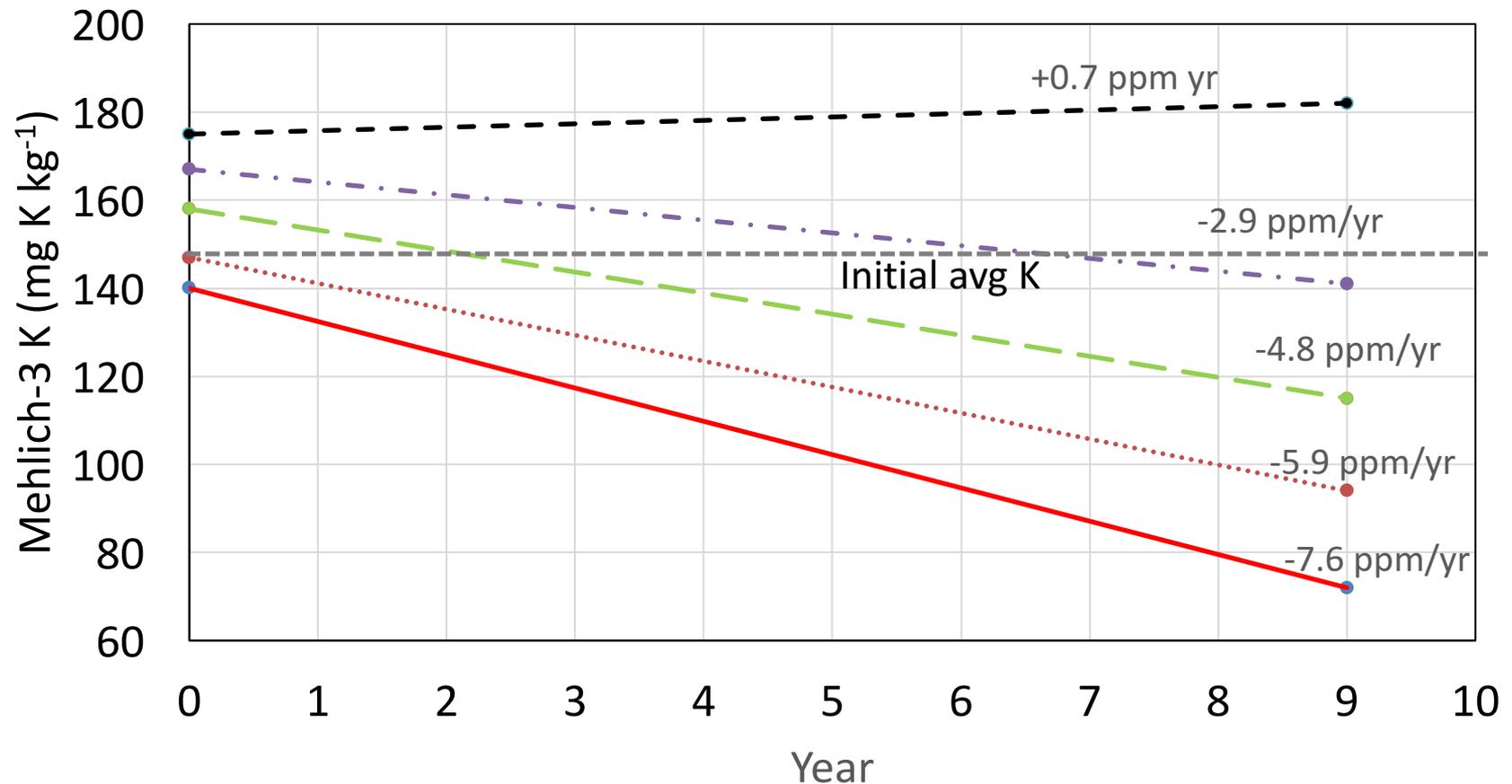
Rice-irrigated soybean system

Soil-K Depletion Rate

Dewitt silt loam

$y = -7.6x + 140$
$R^2 = 0.75$

Rice-irrigated soybean system

Captina Soil Relationships
by Annual K rate

Annual K	Intercept	Linear	R^2 Linear	r^2 Quadratic
kg K ha^{-1}	Intercept (SE)	Slope (SE)		
0	**100**	**-11.3**	**0.74 ***	**0.99 ***
93	118	-13.7	0.70 *	0.72^{NS}
186	126	-11.6	0.74 *	0.77^{NS}
280	144	- 4.0	0.05^{NS}	0.13^{NS}
373	155	8.1	0.13^{NS}	0.22^{NS}
467	186	15.9	0.14^{NS}	0.58 *

Mehlich-3 K mg kg^{-1} = Intercept + Slope ✕ Years
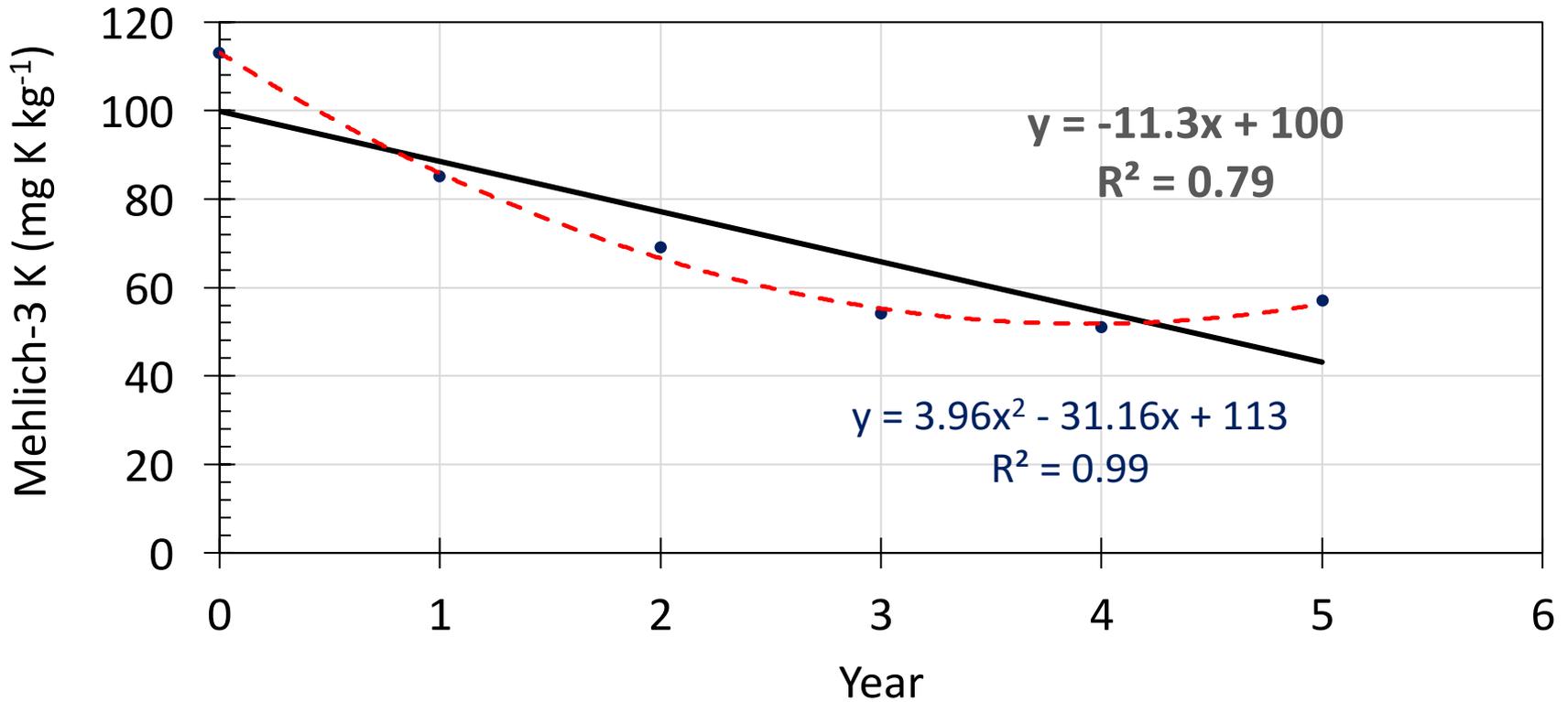* Overall model & coefficients significant at 0.10.

n = 6 for each annual-K rate

Soil-K Response Across Time To K Rate Captina Soil
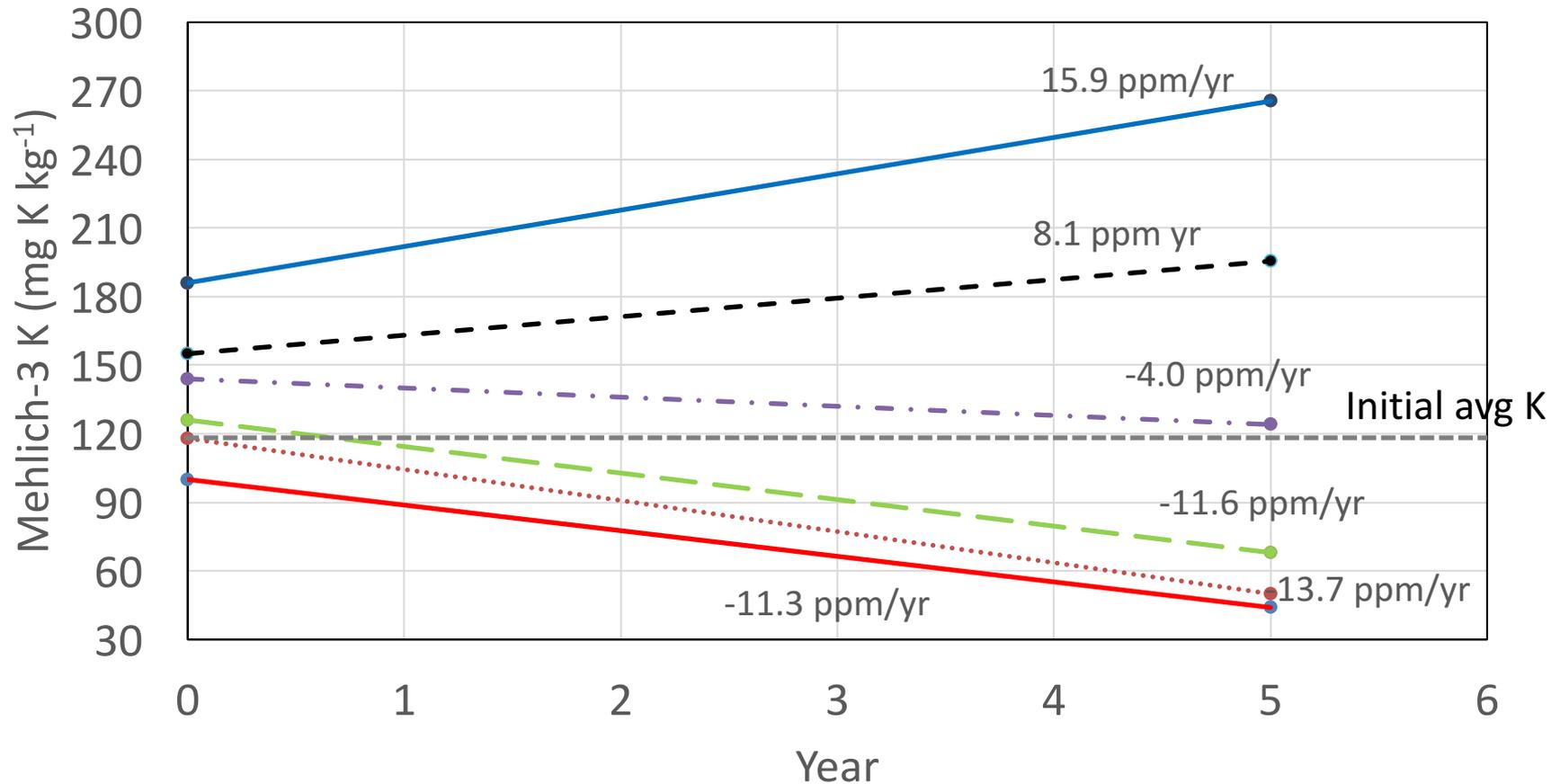
Bermudagrass hay system

Soil-K Depletion Rate

Captina silt loam

y = -11.3x + 100
R² = 0.79

y = 3.96x² - 31.16x + 113
R² = 0.99

Bermudagrass hay system

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Summary

- Net-K balance relationships were significant but provided little or no insight about soil-test K trend across time for two row crop situations.
  - Row crop soils required nearly 3x K rate to maintain soil test at initial value.
- Temporal fluctuation of Mehlich-3 K (and likely other soil-K availability indices) are problematic.
  - Mehlich-3 extractable K is affected by fertilizer-K rate but the effect appears to be relative to soil and cropping system and not an absolute, predictable response in fertilized systems.

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Practical Application

- Fertilizer-K recommendations based on build & replacement equations need further evaluation
  - Fertilizer-K rates should be based on response probability and calibration curves not K replacement and soil nutrient building equations.
  - Alternatively, the end-user expectations of build and maintain programs must change
- Need better understanding of field K losses
- Long-term trend assessment tools needed at the grid or field level to examine impact of nutrient management and crop yield on soil nutrient availability.

THANKS for your Attention

- Contact Information
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  - University of Arkansas System Division of Agriculture
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  - Arkansas Soybean Promotion Board
  - Arkansas Rice Research and Promotion Board