Available Phosphorus by Five Different Soil Testing Methods and Fractionation in Southwest Florida Vegetable Production

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Vegetable Production in Florida

- #2 state in US in fresh market vegetable in acreage and production (34600 acre) in 2009 (#1-CA)
- #1 state in US in fresh-market value of selected crops including squash, sweet pepper, tomatoes, and watermelons
- Tomato is #1 value crop in FL accounting 26% ($520 million) of the state's total value in 2009.

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BMPs and Fertilizer

- Best Management Practices (BMPs) adopted all current UF/IFAS recommendations.
- Adequate fertilizer rates may be achieved by combinations of UF/IFAS recommended base rates and supplemental applications.
- Fertilizer recommendations are determined based on Mehlich-1 (M1) extractable nutrients prior to planting.

Problems

- The majority of soils in FL is sandy soil (>95% sand) and acidic. But many vegetable production in south FL are on soils naturally high in soil pH (>7.0), P (>100 ppm), and Ca (>1000 ppm).
- M1 extractant is best suitable for acidic soils (pH<7.0), and may dissolve insoluble Ca-P precipitates in soil that are not available to plant uptake.
- M1 results to base P recommendations may not be appropriate for alkaline and calcareous soils, while Bray and Olsen extractants are typically used for such soils.
- There is a need to evaluate the best soil P test methods for growers in south FL to base P recommendations particularly in calcareous soils.

Fertilizer Recommendations

Recommendation category by Mehlich-1 extractable nutrients in native (pre-plant) soil

Element	Very Low	Low	Medium	High	Very High
	mg/kg				
P	**<10**	**10-15**	**16-30**	**31-60**	**>60**
K	<20	20-35	36-60	61-125	>125

Soil pH and fertilizer recommendation by UF/IFAS for mineral soils for **TOMATO**

Element	Very Low	Low	Medium	High	Very High
	lb/acre/season				
Target pH	6.5				
N	200				
P_2O_5	**150**	**120**	**100**	**0**	**0**
K_2O	225	150	100	0	0

Field Experiments (3 years)

Growing year	Farm	Period	Crop	P_2O_5 rates (lb/acre)*
2008-2009	1	Oct 08 – Mar 09	Tomato	0, 60, 120
	2	Feb 09 – Jun 09	Tomato	0, 60, 90, 120
2009-2010	1	Oct 09 – Mar 10	Tomato	0, 60, 120
	2	Oct 09 – Jan 10	Tomato	0, 60, 90, 120
2010-2011	1	Nov 10 – Dec 10	Tomato	0, 60, 90, 120
	2	Sep 10 – Feb 11	Tomato	0, 60, 90, 120
* 0, 50, 75, and 100% of IFAS recommended rates determined using "low" category in soil test P index				

- Soil samples at 2 depths (0-15 and 15-30 cm) from center of bed at pre-plant and on about 0, 30, 60, 90, and 120 days after planting.
- 5 different soil P extractants: M1, Mehlich-3 (M3), Bray, Olsen, and AB-DTPA.
- Modified Hedley P fractionation on the samples from the upper depths.

Selected Soil Properties (pre-plant samples)

(mg/kg)

Farm	pH	M-1 P	M-1 Ca	M-1 Mg	M-1 Fe	M-1 Al
Farm 1 (alkaline and non-calcareous)	7.43	99	829	52	18	56
Farm 2 (alkaline and calcareous)	7.08	454	3102	81	44	215

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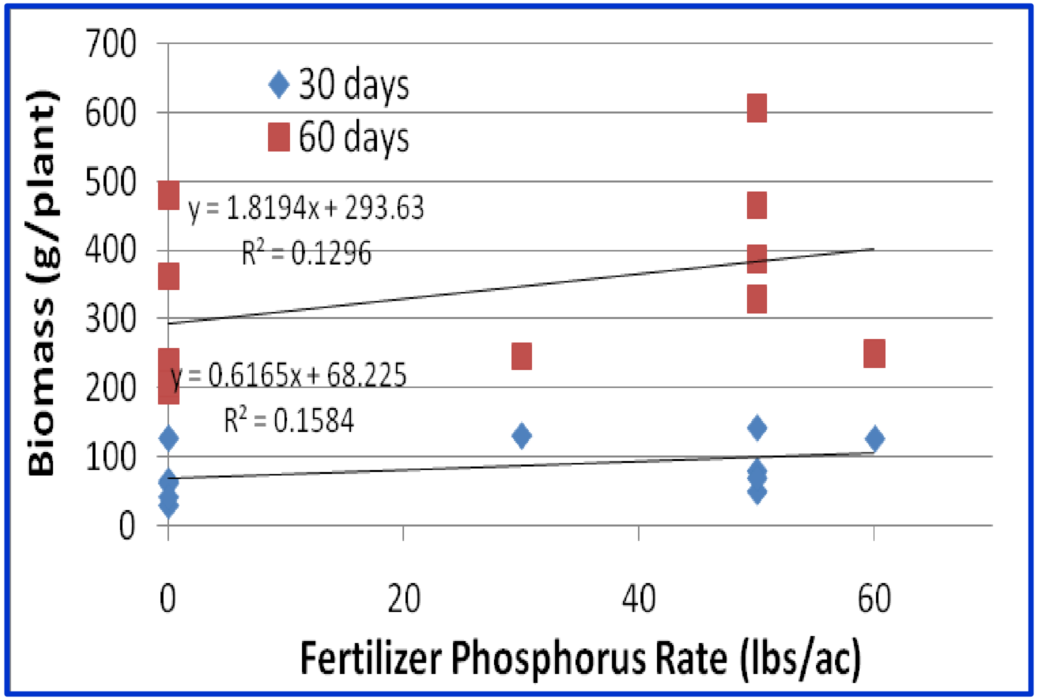
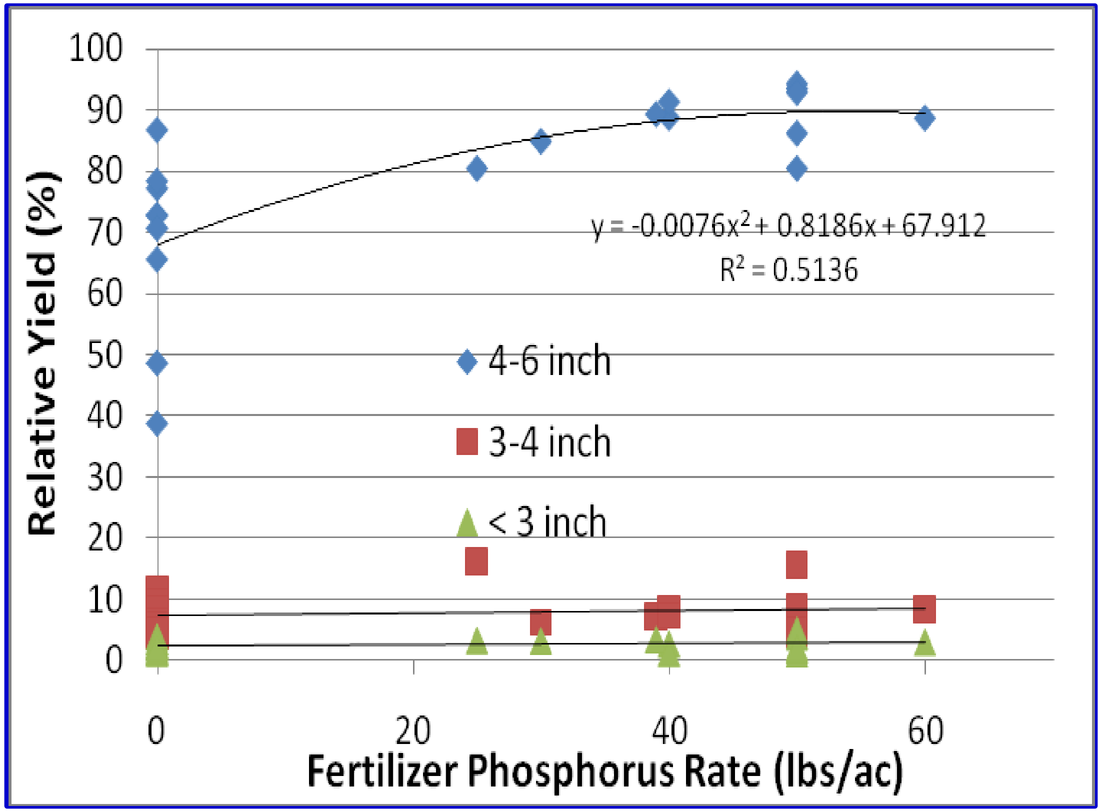
Green Bean – Growth Response to Added P



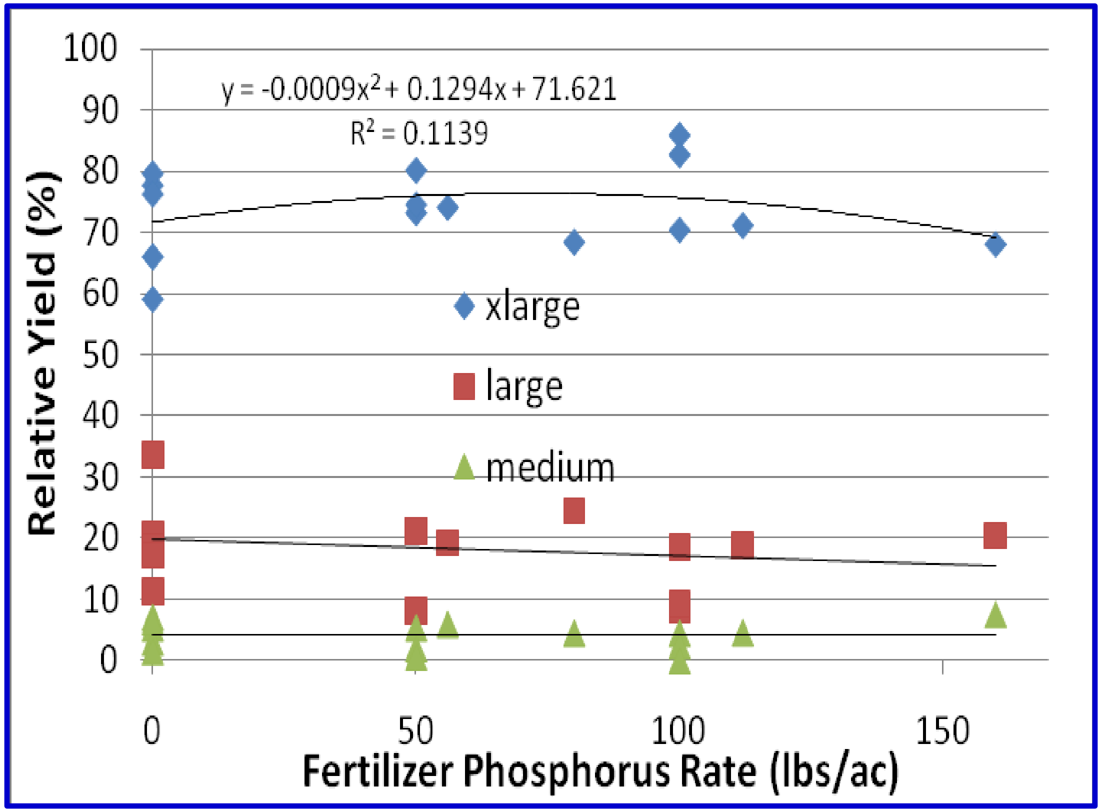
- Leaf P was in optimum range at all sample dates
- 28% leaf P significantly greater in full P rate compared with zero rate
- 44% of sample had significantly greater biomass at 30 and 60 days after planting with increased fertilizer P

Green Bean – Yield Results



- 28% of crops significant increase in pods < 3 inches long with increased fertilizer P
- 78% of crops significant increase in pods > 4 inches long with increased P rate

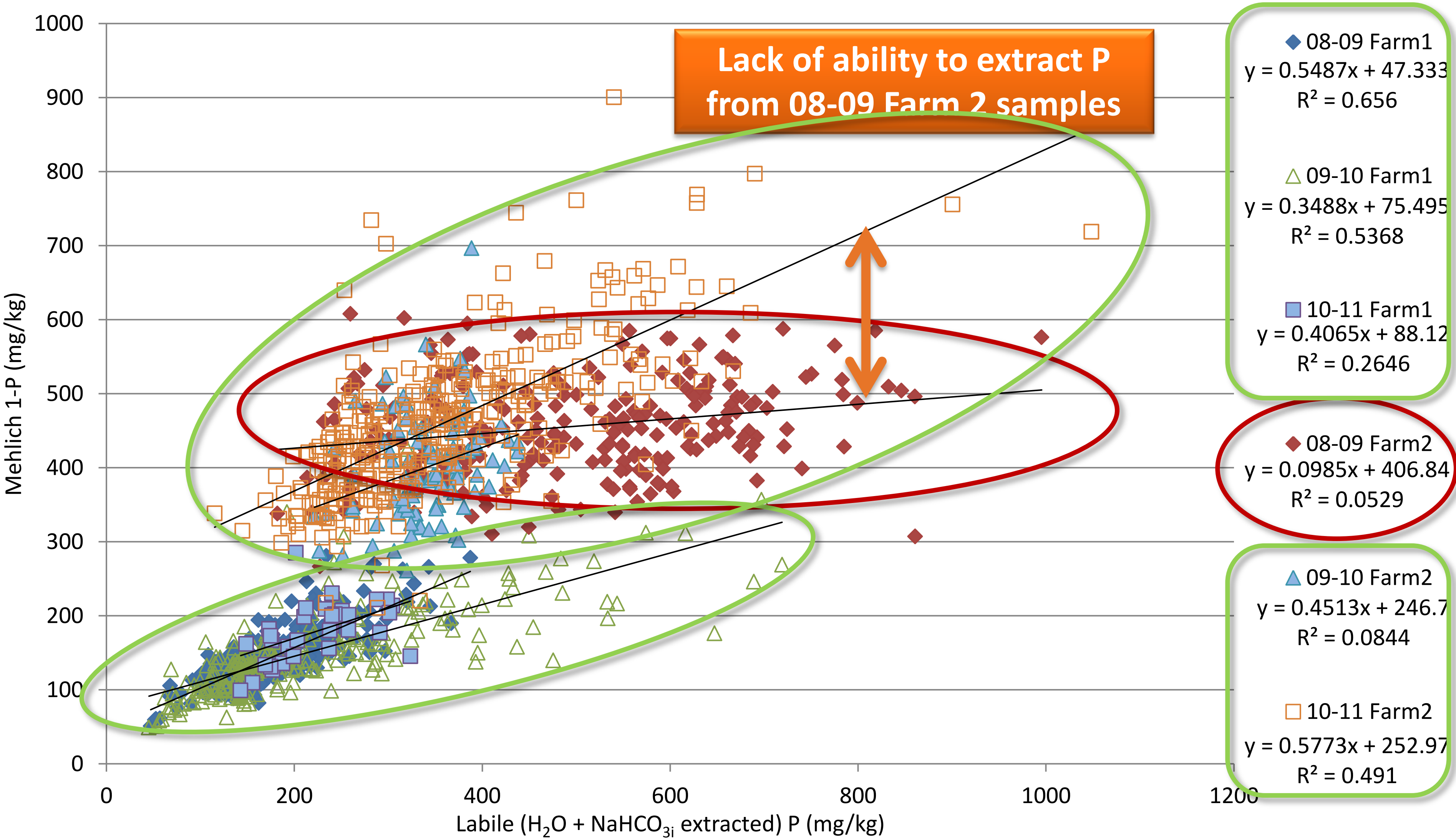
Tomatoes – Yield Results



- Little significant difference in total yields with added P
- Xlarge fruit significantly increased at first harvest <20% of time

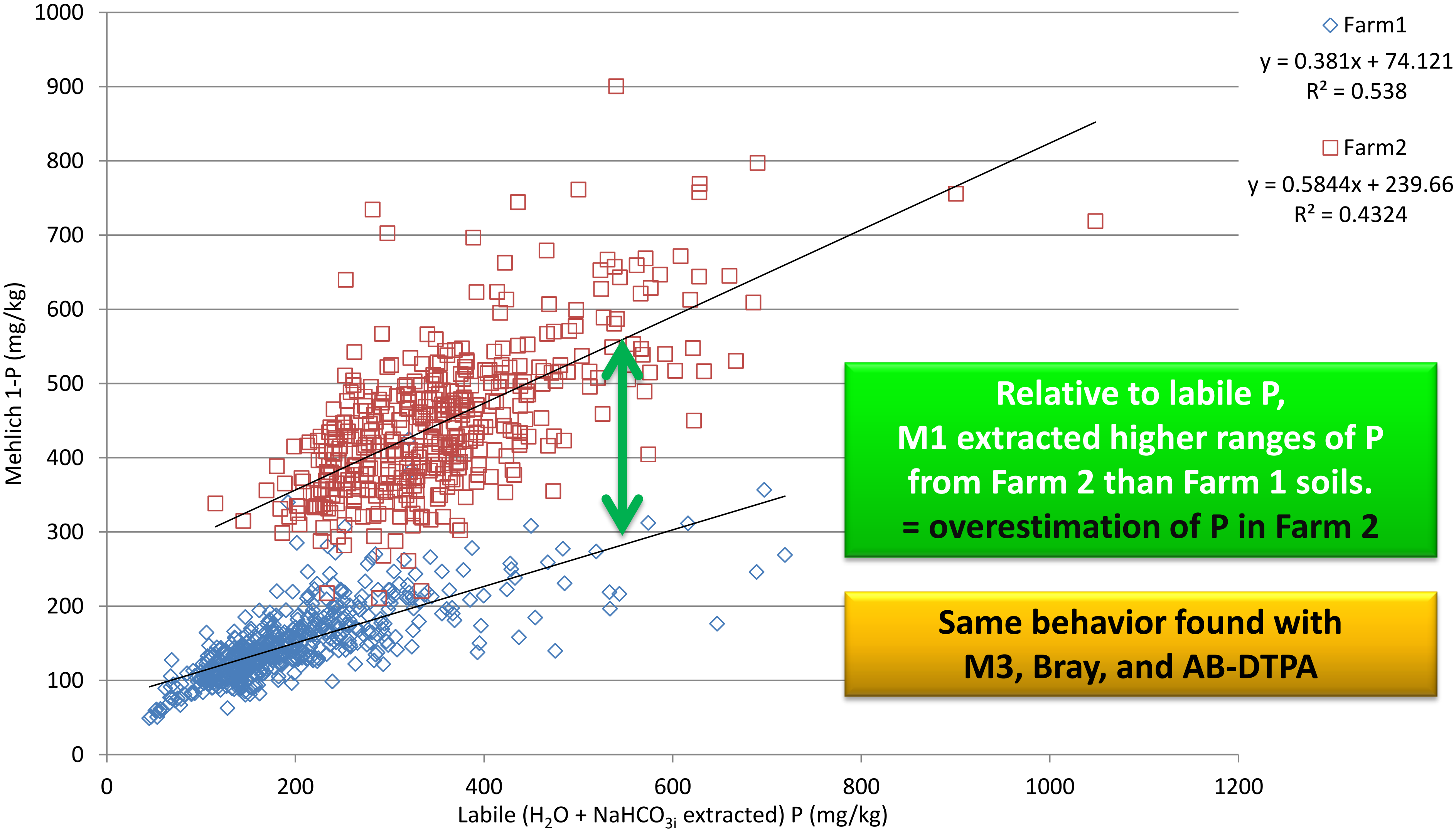
Labile P vs. M1-P by Year/Farm

(H_2O+$NaHCO_{3i}$ extractable)



Labile P vs. M1-P by Farm

(08-09 Farm 2 excluded)

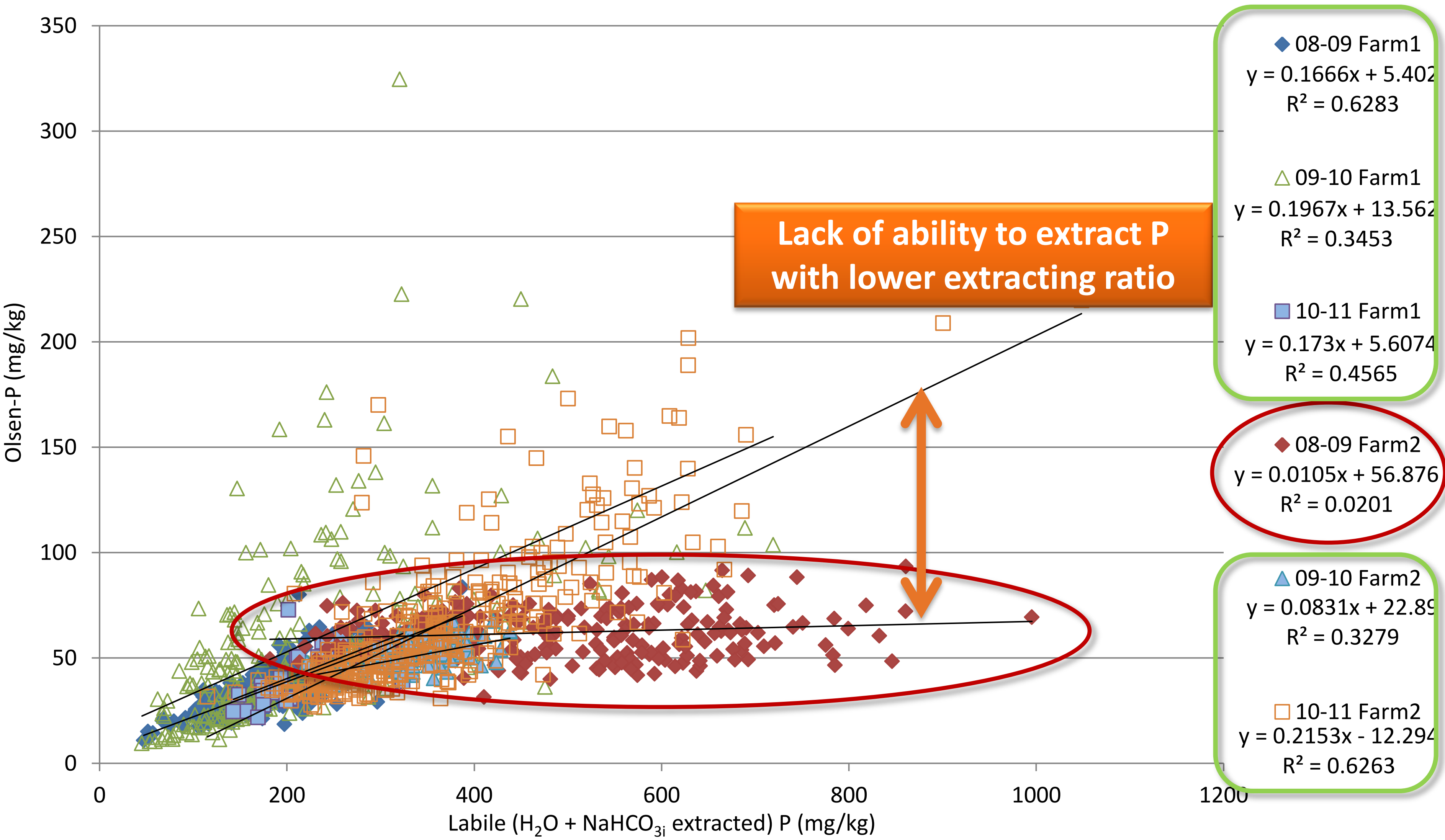


Relative to labile P, M1 extracted higher ranges of P from Farm 2 than Farm 1 soils. = overestimation of P in Farm 2

Same behavior found with M3, Bray, and AB-DTPA

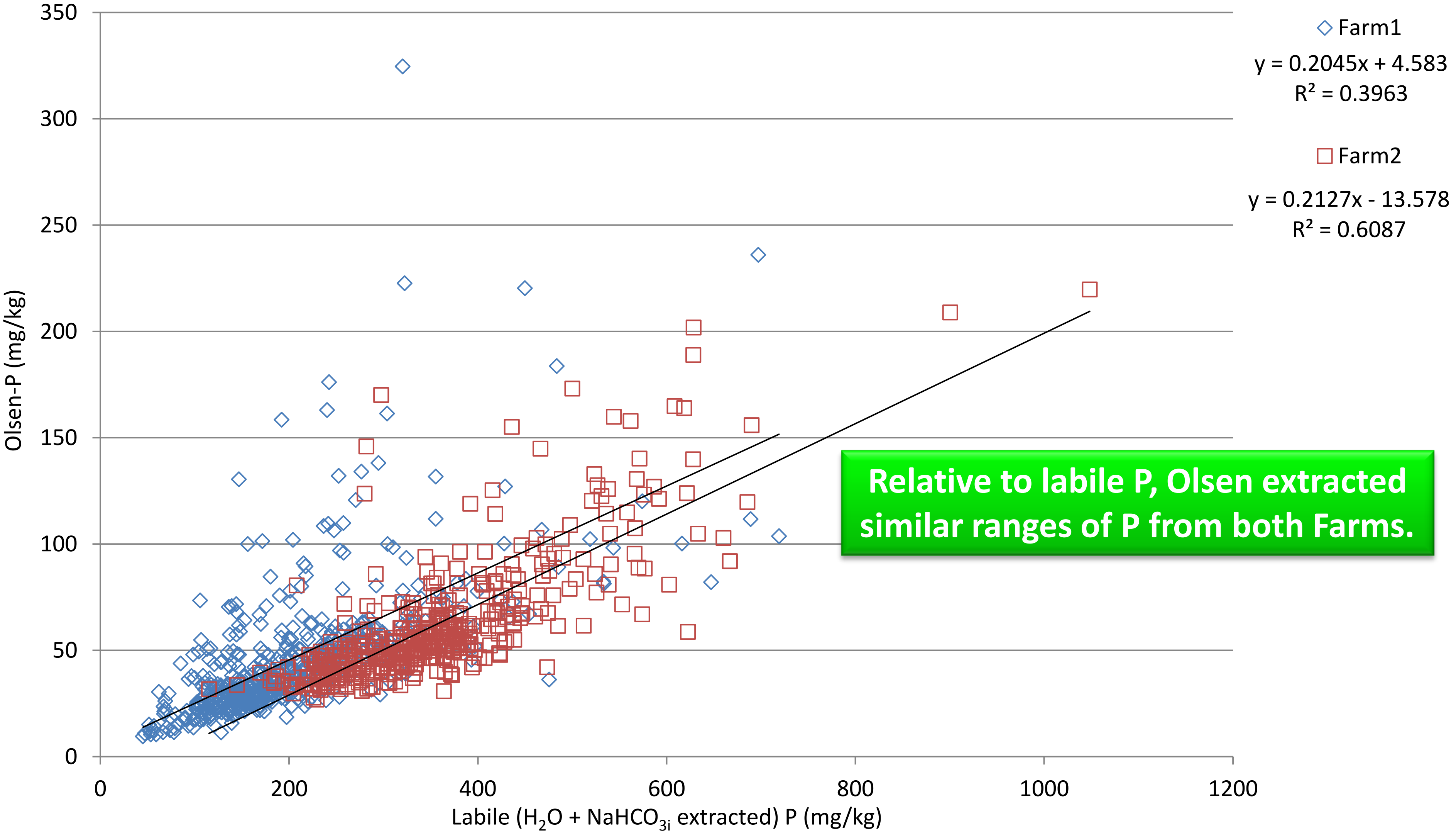
Labile P vs. Olsen-P by Year/Farm

($H_2O+NaHCO_{3i}$ extractable)

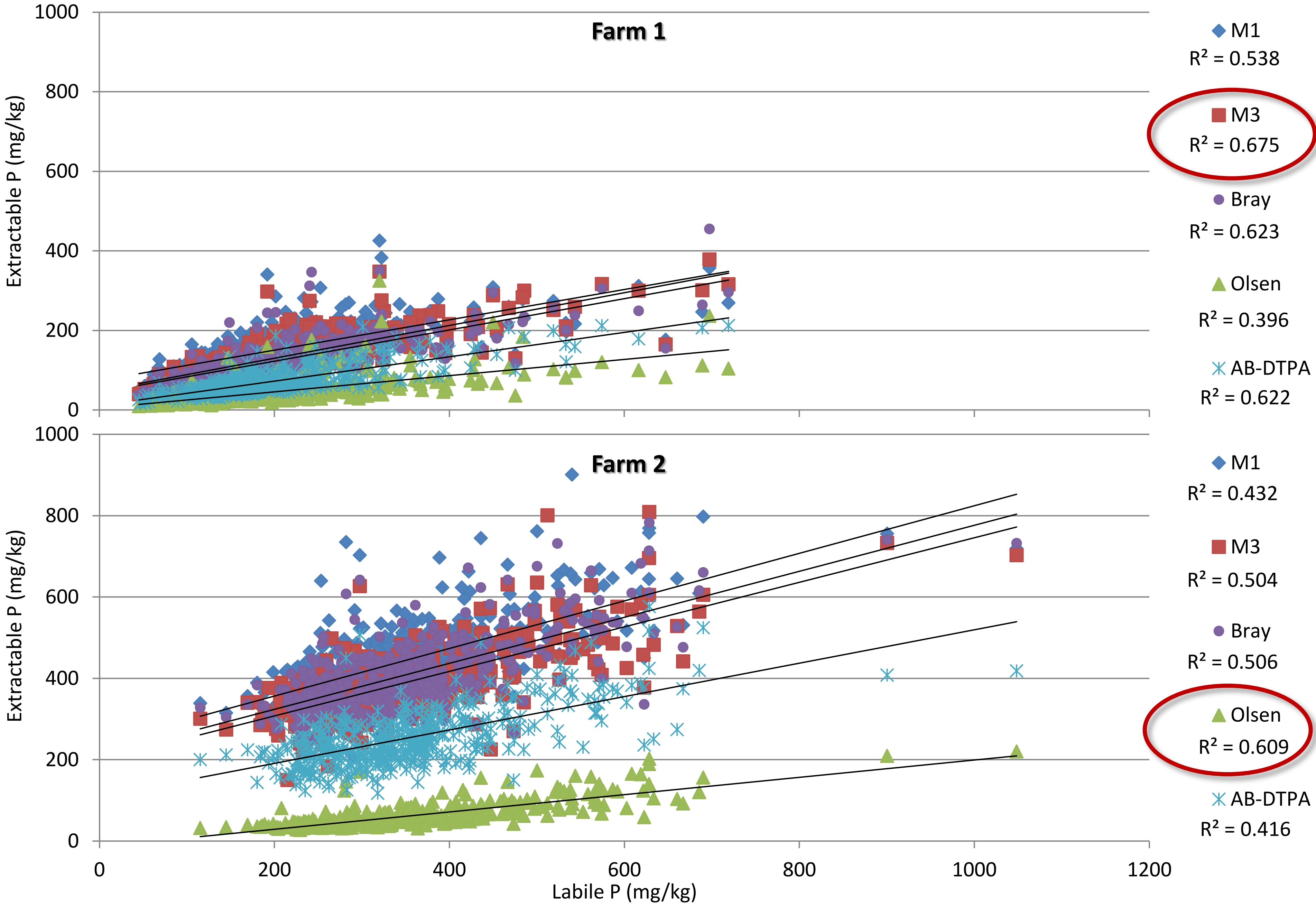


Labile P vs. Olsen-P by Farm

(08-09 Farm 2 excluded)



Labile P vs. Extractable P (08-09 Farm 2 excluded)



Conclusions – Farm 1

(relatively high P but non-calcareous soil)

- M1, M3, Bray, and AB-DTPA extractants were able to extract labile (H_2O + $NaHCO_{3i}$) P with high r^2 values (0.538-0.675). M3 among them was best correlated with labile pool.
- Olsen had the poorest r^2 value (0.396) with labile P among 5 extractants tested.

Conclusions – Farm 2

(extremely high P and calcareous soil)

- M1, M3, Bray, and AB-DTPA had lower r^2 values with labile P (0.416-0.506), compared to those in Farm 1, respectively.
- They may overestimate labile P in calcareous soils. M1 and M3 are better correlated (r^2=) to total P than labile P.
- Olsen had better r^2 than that in Farm 1 and the best r^2 among 5 extractants with labile P (0.609), indicating the superiority of Olsen to others in such soils for soil P test.

Future BMPs: Some New Uses for Soil Extractants, Based on pH

- **Fe and Al controls on nutrients**
  - Phosphorus Saturation Ratio: predicts when P concentration exceeds Fe and Al and/or Ca to hold P in the soil (saturation)
    - *Nair et al. 2010.* An Indicator for Risk of Phosphorus Loss from Sandy Soils*;*
  - Soil Phosphorus Storage Capacity: Predictions with threshold points work for soil horizons and with several extractants including M1 and M3
    - *Nair et al. 2010.* Understanding Soil Phosphorus Storage Capacity.

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Vegetable Example: Soil Phosphorus Storage Capacity (SPSC)

- >800 soil samples from 5 vegetable farms
  - Same Watershed, seep irrigation
  - Lime additions: ~1 ton ag lime/acre/yr (over-liming)
    - Lime was added for 15 years
  - Soil pH: 6.8 to 8.4 and extractable Ca
  - One farm used Organic Matter annually

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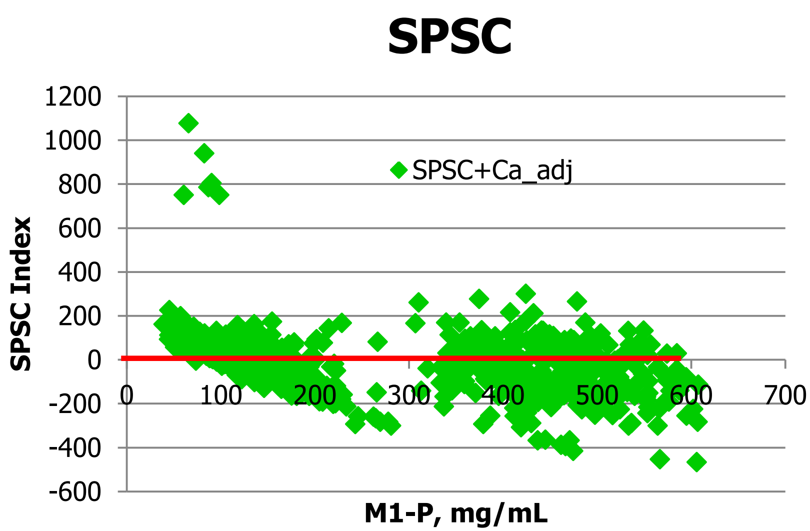
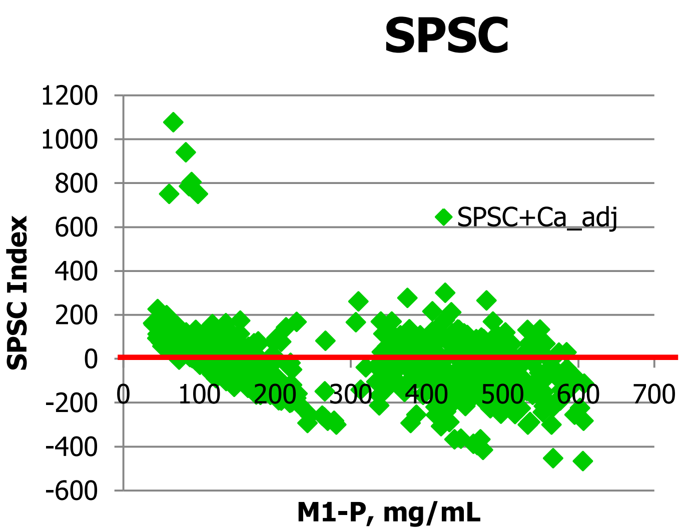
SPSC: Continued



- When SPSC > 0 then P can be held in the soil
- When SPSC < 0 then P can be lost from the soil
- Crop response with proper soil pH is not expected when M1-extractable P is >30 ppm
- Most soils had excessive lime resulting in both high pH and high extractable Ca
    - P response is likely because of excess Ca reacting with P
- In this example, more than 50% of soils are predicted to lose P from the soil (SPSC is negative)

SPSC: Continued



- Preliminary interpretations indicate that:
  - The two data clouds are related to organic matter additions
  - Left side data cloud are mostly farms not adding organic matter (low % OM not contributing to P retention)
  - Right side data cloud are values mostly from the farm adding organic matter, or from farms with elevated %OM naturally (increased % OM also holding more P)
  - Due to high pH and extractable Ca concentrations, the SPSC included an adjustment for Ca

Conclusions

- The SPSC appears to have value when considering P movement and crop response
- Application of the SPSC in our example pointed to the need for improved soil pH management to benefit from P fertilizer additions

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