Research Report
Phosphorus Fertilizer Rate Effect on Alfalfa Yield and Soil Test P, Buckeye, 2014

AZ1672 June 2015

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Summary

Phosphorus is the primary fertilizer nutrient needed by alfalfa in Arizona. The objective of this study is to determine the effect of P fertilizer rate on alfalfa yield and soil test P. A phosphorus fertilizer rate study was conducted with alfalfa in Buckeye, AZ where 11-52-0 was applied at 0, 200, 400, and 800 lb fertilizer/acre in February, 2014 after the first cutting. Alfalfa hay yield was increased by phosphorus fertilizer application up to the cutting on July 30, but not thereafter. No differences in yield were found among the fertilizer rates of 200,400, and 800 lb 11-52-0/acre. Soil test phosphorus increased directly proportional to fertilizer rate, but eventually decreased close to deficient levels 3-5 months after fertilizer application. It is not known if additional fertilizer applications throughout the season would increase yield. Fertilizer rates higher than 200 lb 11-52-0/acre were not beneficial under the conditions of this study.

Introduction

Phosphorus is the primary fertilizer nutrient needed by alfalfa in Arizona. Previous recommendations for phosphorus fertilizer in alfalfa were to apply all phosphorus fertilizer before planting and to incorporate the fertilizer into the soil (Dennis et al., 1966). As much as 300 lb P_2O_5/acre were recommended to be applied at planting. Research in Yuma, AZ supported the idea that a single application of P at planting was just as effective as annual applications (Stanberry et al., 1955).

In more recent years, liquid formulations of P fertilizer such as ammonium polyphosphate (10-34-0) and phosphoric acid (0-52-0) have become more prevalent. Annual applications of P fertilizer top-dressed to existing alfalfa stands has become a more common practice, in addition to multiple applications of liquid fertilizer in the irrigation water during each growing season.

Certain soils tie up P fertilizer, particularly highly alkaline soils common in Arizona. In addition to banding P fertilizer, more frequent applications of P fertilizer may be needed in certain soils so that this nutrient is available to the crop.

The objective of this study is to determine the effect of P fertilizer rate on alfalfa yield and soil test P.

Procedure

The alfalfa variety WL 656HQ was seeded on 23 January 2012 on a Coolidge sandy loam in Buckeye, AZ on a field of about 75 acres (Field 15) at the Rovey Farming Company. The crop was grown according to typical practices for the Rovey Farming Company (Table 1). The chemical composition of the untreated check is presented in Table 2 and the soil test P level of 4 ppm is considered deficient and likely to respond to P fertilizer. Fertilizer was not applied the first year, but was applied at the beginning of the second year on 25 January 2013 at a rate of 24 lb N, 120 lbs P_2O_5, and 75 lb S per acre in the form of 300 lb/acre 8-40-0-25S, a mix of 75% 11-52-0 and 25% Tiger 90 Elemental Sulfur (0-0-0-90S). At the beginning of the third season, nine borders in the center portion of the field were selected to receive variable rates of P fertilizer. The border dimensions not including the headlands were 62 ft x 820 ft, or 1.167 acres each. Mono-ammonium phosphate (11-52-0) was applied with a fertilizer spreader at 0, 200, 400, and 800 lb fertilizer/acre for P rates of 0, 104, 208, and 416 lb P_2O_5/acre on 9 February 2014. The number of replications was 2, 3, 3, and 1 for the fertilizer rates of 0, 200, 400, and 800 lb/acre, respectively.

Alfalfa was cut and bales counted and weighed 8 times during the season not including a clipping at the beginning of the year on 2 February 2014 to clean up the field due to frost damage. Bale weights were obtained by dividing the net weight of a load from a harrow bed (bale wagon) by the number of bales. Bale weights were kept consistent by making adjustments as necessary from a weight monitor on the baler. No attempt was made to distinguish hay in the chamber of the baler that may be from a previous border since the bale numbers were high enough (31 bales/border on average) that this error would be minimal. Yields reported in the trial were above field average. The trial did not include headlands and did not count headland bales. Area was calculated for the trial borders without headland area.

Discussion

Phosphorus fertilizer increased alfalfa hay yield 8.7% over the course of the 2014 growing season, from 9.95 to 10.82 tons/acre (Table 2). In a study conducted at Maricopa, the average increase in hay yield over 3 years of annual applications of 11-52-0 was also 8.7%, coincidentally (Ottman et al. 2006). The benefit of phosphorus fertilizer was realized in all cuttings after the time of application in February until the July 30 cutting, with the exception of the April 22 cutting. No difference was detected among the fertilizer rates of 200, 400, and 800 lb 11-52-0/acre, so these treatments were pooled and compared to the untreated check. When all treatments were compared with each other, differences between the untreated check and the fertilized treatments were detected at the March 12 and May 22 cuttings only and the seasonal total, thus pooling the treated plots allowed us to detect differences at a few other dates. The graphed data illustrates how yields plateaued at the 200 lb 11-52-0/acre rate for various cuttings throughout the year (Fig. 1) and for the seasonal total (Fig. 2).

The yield increase of 0.87 tons/acre more than paid for the cost of the fertilizer. The 11-52-0 fertilizer cost $590/ton, the value of the alfalfa was $230/ton, and the cost to bale and stack is $1.50/bale or $29/ton assuming an average bale weight of 102 pounds The cost to cut and rake is $17/acre but this cost does not change with any yield increase. A 200 lb 11-52-0/acre fertilizer application cost $59/acre and the breakeven yield increase of 0.29 tons/acre was achieved after the third cutting. The breakeven price of a 200 lb 11-52-0/acre application was $1749/ton of 11-52-0.

Phosphorus fertilizer application increased soil test P proportionately to the amount of P fertilizer applied, and we were able to detect differences statistically four of the five dates sampled (Table 3). The increase in soil P with phosphorus fertilizer application was linear, although a quadratic (sloping upward) trend was also detected for the highest rate at the first sampling time on March 27 (Fig 3). We would expect higher rates of P fertilizer to eventually overcome the ability of the soil minerals to fix fertilizer P. Soil P decreased gradually over time since the fertilizer application in February through the date of the October 29 soil sampling (Fig. 4).

The soil test P levels were correlated with hay yield for the first three soil samplings on March 27, May 7, and July 16 where the untreated check was at or near the deficient level of 5 ppm soil P, the treated plots were above the deficient level and a difference between the control and treated was detected. For soil samples taken on August 20

and on October 29, there were no differences in yield near these time periods even though the treated plots were at or above the critical level. These apparent discrepancies can be explained by the fact that the so-called critical level is approximate and can vary depending on the time of the year. In the summer, for example, the soil is warmer allowing phosphorus to diffuse more easily to plant roots, and crops are not as affected by soil P levels or P fertilizer applications compared to cooler times of the year. Nevertheless, the question remains whether or not an application of P fertilizer in the summer would have increased yield in this study.

Acknowledgments

The foresight and diligence of Jason Rovey in initiating and executing this work is greatly appreciated.

References

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Table 1. Farming practices for a phosphorus fertilizer rate study at the Rovey Farming Company in 2014.

1/23/2012	Plant WL Research 656HQ and irrigate
1/25/2013	Spread 300 lb/acre 8-40-0-25 fertilizer
10/28/2013	Last cutting in 2013
11/6/2013	Last irrigation in 2013
2/2/2014	1st cutting early due to frost damage (get dead foliage out of field). Avg field yield 0.63 tons/acre and not included in this data.
2/7/2014	Bale 0.62 tons/acre
2/9/2014	Spread 200 lb/acre 11-52 fertilizer except P trial borders different rates
2/11/2014	1st irrigation in 2014
2/23/2014	Spray Steward EC insecticide for Alfalfa Weevils
3/12/2014	2nd cutting (heavy aphid pressure)
3/16/2014	Bale 0.76 tons/acre
3/16/2014	Spray Raptor herbicide on borders (weed pressure from weevil damage)
3/21/2014	Irrigate
4/5/2014	Irrigate
4/22/2014	3rd cutting
4/24/2014	Bale 1.33 tons/acre
4/28/2014	Spray Prowl H20 herbicide
4/29/2014	Irrigate
5/12/2014	Irrigate
5/22/2014	4th cutting
5/27/2014	Bale 1.68 tons/acre
5/31/2014	Irrigate
6/13/2014	Spray Clethodim 2E herbicide for grass around field edges
6/17/2014	Irrigate
6/29/2014	5th cutting
7/3/2014	Bale with rain damage 2.31 tons/acre
7/7/2014	Irrigate
7/17/2014	Spray Steward EC insecticide for Alfalfa Caterpillars and Potato Leafhoppers
7/20/2014	Irrigate
7/30/2014	6th cutting
8/6/2014	Bale with heavy rain damage 1.68 tons/acre
8/15/2014	Spray Clethodim 2E herbicide and Steward EC insecticide
8/16/2014	Irrigate
8/30/2014	7th cutting (only one irrigation this cutting)
9/3/2014	Bale 0.94 tons/acre
9/4/2014	Irrigate
9/20/2014	Spray Baythroid XL 2.8 oz/acre for Potato Leafhoppers
9/29/2014	Irrigate
10/15/2014	8th cutting
10/17/2014	Bale 0.72 tons/acre
10/22/2014	Irrigate
11/20/2014	9th cutting
11/26/2014	Bale 0.61 tons/acre
12/4/2014	Spread 100 lb/acre 11-52 fertilizer
12/5/2014	Irrigate

Table 2. Soil chemical characteristics for a phosphorus fertilizer rate study at the Rovey Farming Company in 2014.

Sample Location	COMPOSITE
Sample Description #1	Rovey FIELD 15
Sample Description #2	0 P plots 8/27/14
Lab Number	0240-1
Total Exchange Capacity (meq/100 g)	17.97
pH	8.5
Organic Matter (%)	0.51
Estimated Nitrogen Release (#'s N/acre)	20
S* (mg/kg)	20
Olsen P (mg/kg)	4
Ca* (mg/kg)	2685
Mg* (mg/kg)	361
K* (mg/kg)	152
Na* (mg/kg)	145
Ca** (%)	74.71
Mg** (%)	16.74
K** (%)	2.17
Na** (%)	3.51
Other Bases** (%)	2.9
H** (%)	0
Fe*** (mg/kg)	2
Mn*** (mg/kg)	4
Cu*** (mg/kg)	0.6
Zn*** (mg/kg)	< 0.4
* Ammonium Acetate Extractable (pH of 8.1)	
** This value represents the percent of a given element found on the soils total exchange capacity. Values should add to 100 for a given sample.	
*** DTPA Extractable	

Table 3. Alfalfa hay yield as affected by phosphorus rate for each cutting date for a study conducted at the Rovey Farming Company in 2014. The yields do not include the first cutting yield of 0.62 tons/acre of frost-damaged alfalfa on 2 February 2014.

		Alfalfa hay yield								
Fertilizer	P	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	9th cut	
rate	rate	12-Mar	22-Apr	22-May	29-Jun	30-Jul	30-Aug	15-Oct	20-Nov	Total
lb 11-52-0/A	lb P_2O_5/A	tons/acre								
0	0	0.62	1.46	1.73	2.08	1.72	0.93	0.79	0.62	9.95
200	104	0.75	1.58	1.92	2.36	1.83	0.95	0.81	0.62	10.82
400	208	0.79	1.58	1.88	2.36	1.82	0.92	0.83	0.64	10.82
800	416	0.73	1.44	1.85	2.38	1.82	0.95	0.81	0.67	10.64
$LSD_{.05}$		0.06	ns	0.11	ns	ns	ns	ns	ns	0.44
Linear		ns	ns	ns	ns	ns	ns	ns	ns	ns
Quadratic		*	ns	*	ns	ns	ns	ns	ns	*
Control vs treated		*	ns	*	*	*	ns	ns	ns	**

ns, *, **: Not significant at the 5% probability level, significant at the 5% probability level, and significant at the 1% probability level, respectively.

Table 4. Soil test phosphorus (Olsen P) as affected by phosphorus rate for various sampling times for a phosphorus fertilizer rate study conducted at the Rovey Farming Company in 2014.

Fertilizer	P	Soil test phosphorus				
rate	rate	Soil P (3/27/14)	Soil P (5/7/14)	Soil P (7/16/14)	Soil P (8/27/14)	Soil P (10/29/14)
lb 11-52-0/A	lb P_2O_5/A	ppm P				
0	0	5.5	4.5	3.5	3.0	3.5
200	104	8.0	6.7	5.3	4.7	5.0
400	208	11.3	9.3	7.3	6.3	5.3
800	416	23.0	12.0	11.0	12.0	9.0
$LSD_{.05}$		1.9	1.4	2.9	1.9	ns
Linear		*	*	**	*	ns
Quadratic		*	ns	ns	ns	ns
Control vs treated		**	**	*	**	ns

ns, *, **: Not significant at the 5% probability level, significant at the 5% probability level, and significant at the 1% probability level, respectively.

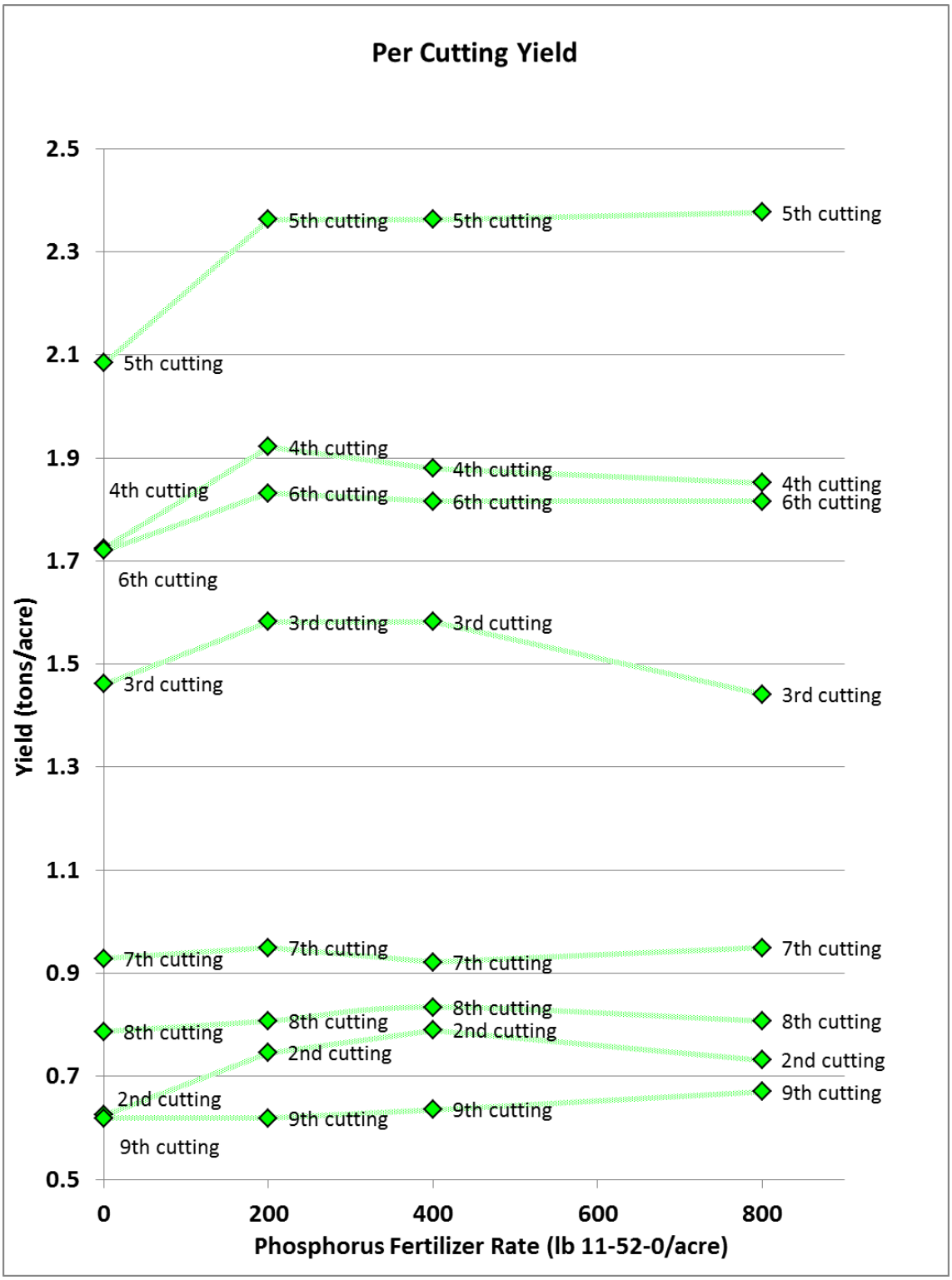

Fig. 1. Alfalfa yield as affected by phosphorus fertilizer rate for each cutting during the year (except the first cutting before fertilizer was applied) for a phosphorus fertilizer rate study conducted at the Rovey Farming Company in 2014.

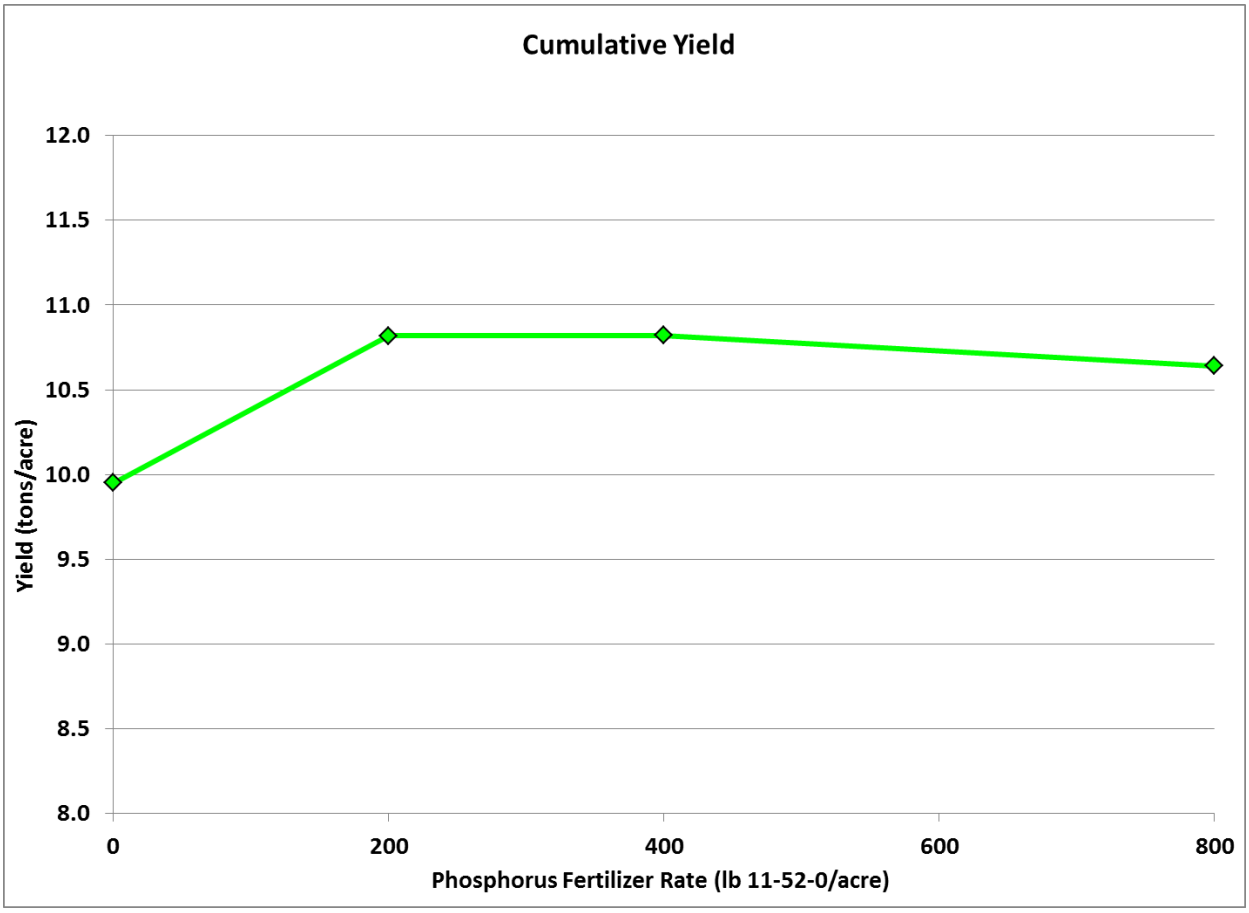

Fig. 2. Alfalfa yield summed over the growing season (except the first cutting before fertilizer was applied) as affected by phosphorus fertilizer rate for a phosphorus fertilizer rate study conducted at the Rovey Farming Company in 2014.

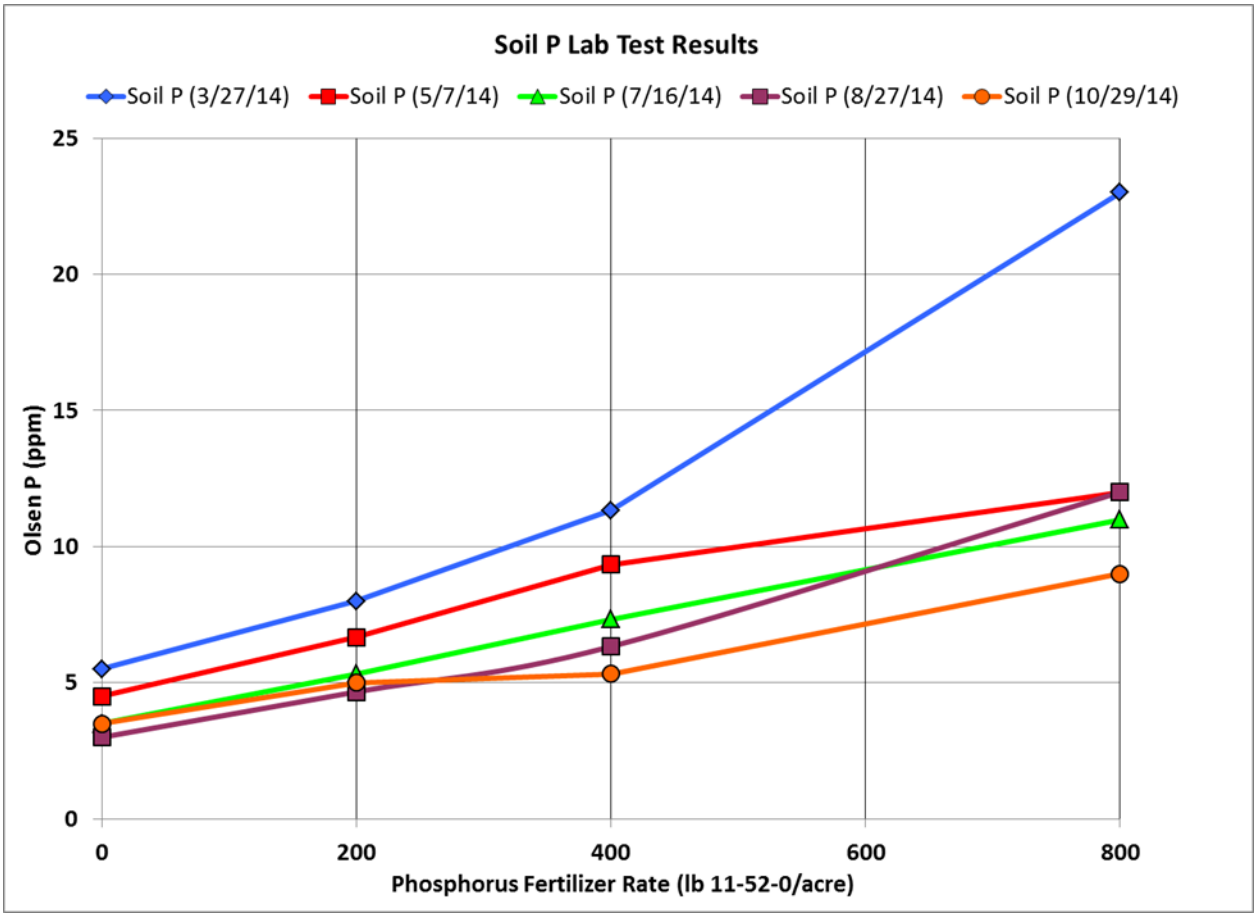

Fig. 3. Soil test P (Olsen method) as affected by phosphorus fertilizer rate at five sampling times for a phosphorus fertilizer rate study conducted at the Rovey Farming Company in 2014.

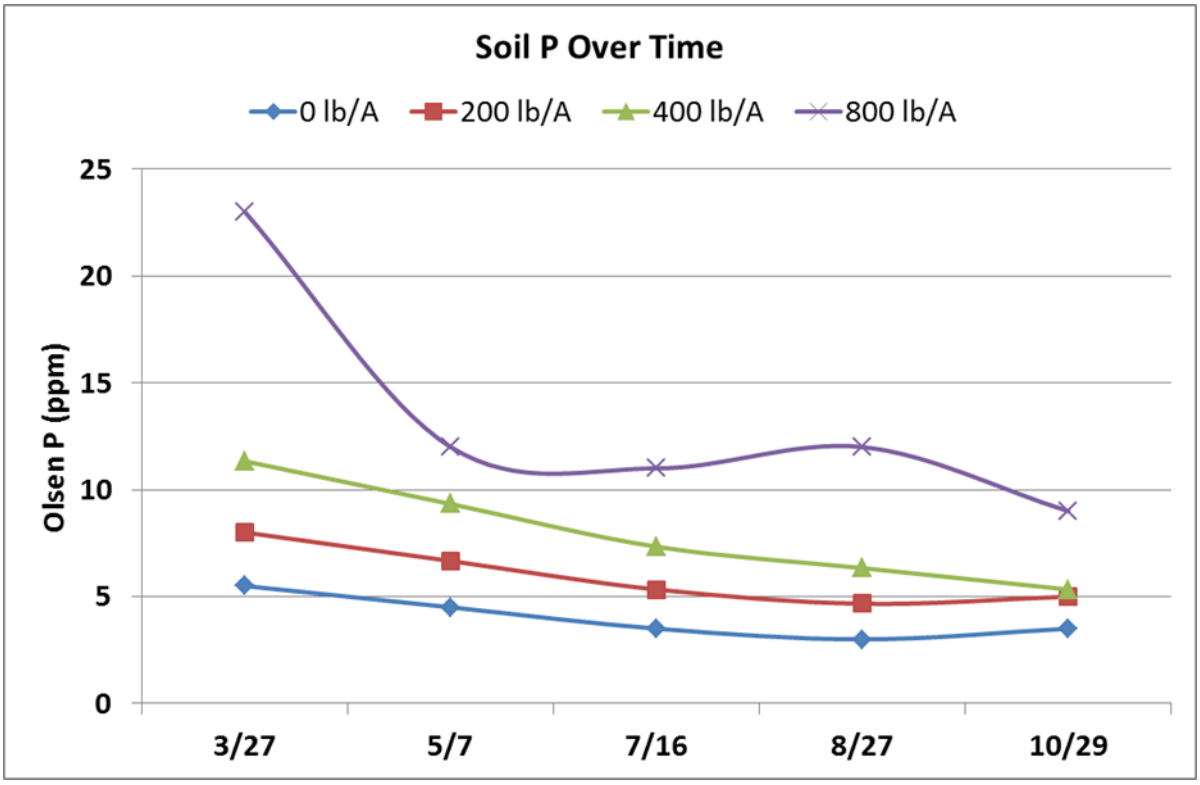

Fig. 4. Soil test P (Olsen method) as affected by sampling time for various phosphorus fertilizer rates for a phosphorus fertilizer rate study conducted at the Rovey Farming Company in 2014.