Phosphorus Fertilizer Sources and Rates Effect on Irrigated Alfalfa in Arizona

Worku Burayu[1], Mike Ottman[2], and Ayman Mostafa[3]

[1] Research Specialist, University of Arizona, Maricopa County Cooperative Extension, Phoenix, AZ
[2] Extension Agronomist, University of Arizona, College of Agriculture and Life Sciences, Tucson, AZ
[3] Area Agent, University of Arizona, Maricopa Cooperative Extension, Phoenix, AZ
Corresponding author's E-mail: workuburayu@email.arizona.edu

THE UNIVERSITY OF ARIZONA College of Agriculture & Life Sciences Cooperative Extension

UID: 99961

Background

Alfalfa is the largest acreage crop in Arizona and the southwest. Because most of the above ground material is removed several times during the growing season, nutrient depletion from alfalfa production is high. Phosphorus (P) fertilization is an essential component and are required in large quantities for alfalfa production. Many sources of phosphorus fertilizers are used for high-yield and high-quality alfalfa production in Arizona. Questions are often asked about the effectiveness and availability of various P fertilizer sources for the plant.

Objective

The objective of this study was to compare monoammonium phosphate (MAP, 11-52-0), phosphoric acid (PA, 0-52-0) and superphos (SP, 0-50-0) at equivalent application rates (0.71, 1.42, 2.13 g P_2O_5 m^{-2}) plus two higher rates for MAP (5.60 and 11.2 g P_2O_5 m^{-2}) on alfalfa yield, soil test and plant P levels.

Materials and Methods

An experiment was conducted in 2015 at the University of Arizona, Maricopa Agricultural Center (MAC). Three sources of P fertilizer: monoammonium phosphate, MAP (11-52-0), phosphoric acid, PA (0-52-0) and superphos, SP (0-50-0) at equivalent application rates (0.71, 1.42, 2.13 g P_2O_5 m^{-2}) plus two higher rates for MAP (5.60 and 11.2 g P_2O_5 m^{-2}) were compared with untreated check (0.0 g P_2O_5 m^{-2}). Corresponding equivalent nitrogen ratio was maintained in all the three sources (Table 1). A randomized complete block design (RCBD) with 12 treatments and 4 replications on 4.60 meter wide and 9.00 m long plots was used. Soil samples were taken to a depth of 15 cm with a soil probe two times during the research period and samples were analyzed for $NaHCO_3$-extractable P (Olsen P). For plant tissue test, 50 stems were randomly collected and Analyzed for phosphorus (PO_4-P). Hay yield data was obtained by harvesting an area of 7 square meter of each plot with a small plot forage harvester for five consecutive cuttings. Data were analyzed using JMP 11 Statistical software and Student's t test used in comparisons for each pair.

Table 1. Sources and rates of P fertilizer used for the study conducted at MAC in 2015

Sources of Fertilizer	Analysis	P Relative rates	P rates g P_2O_5 m^{-2}	N rates g N m^{-2}
UTC	N/A	0.00	0.00	0.00
MAP**	11-52-0	0.50	0.71	0.112
MAP	11-52-0	1.0	1.42	0.336
MAP	11-52-0	1.50	2.13	0.448
MAP	11-52-0	3.94	5.60	1.233
MAP	11-52-0	7.88	11.20	2.354
PA + urea	0-52-0	0.50	0.71	0.112
PA+ urea	0-52-0	1.0	1.42	0.336
PA + urea	0-52-0	1.50	2.13	0.448
SP + urea	0-50-0	0.50	0.71	0.112
SP + urea	0-50-0	1.0	1.42	0.336
SP + urea	0-50-0	1.50	2.13	0.448

**Sources of fertilizer as MAP-monoammonium phosphate, PA-Phosphoric acid, SP-superphos.

Results and Discussion

Our findings showed numerical higher alfalfa yield with increased rate within the same source of P fertilizer. Only the highest rate of MAP gave significantly higher cumulative yield (2765 g m^{-2}) than the untreated check (2214 g m^{-2}). There were no significant differences in alfalfa yields, soil P test and plant tissue P among sources of P fertilizer when fertilized at equivalent application rates. When averaged over the three equivalent application rates, we found relatively higher cumulative yield of 2463 g m^{-2} for SP as compared to 2387 g m^{-2} for PA and 2310 g m^{-2} for MAP (Figure 5). In this particular findings P application rates had little effect on soil P (Table 3) and plant P (Table 4).

Alfalfa Hay Yield

Table 2. Phosphorus fertilizer sources and rates effect on alfalfa yield at each cutting time for the study conducted at MAC in 2015

Source	Analysis	P Rate g P_2O_5 m^{-2}	N Rate g N m^{-2}	Hay Yield (tons ha^{-1}) 16-Apr	27-May	24-Jun^{ns}	25-Sep^{ns}	9-Nov
UTC	N/A	0.00	0.00	4.35B	4.67C	5.92	3.66	3.55BC
MAP	11-52-0	0.71	0.112	4.50B	5.00BC	5.86	3.80	3.22C
MAP	11-52-0	1.42	0.336	4.66B	5.08BC	5.79	3.83	3.37BC
MAP	11-52-0	2.13	0.448	5.00AB	5.37BC	6.35	3.84	3.65ABC
MAP	11-52-0	5.60	1.233	4.53B	5.98AB	6.37	4.29	3.57ABC
MAP	11-52-0	11.20	2.354	5.93A	6.57A	6.80	4.37	3.97A
PA + urea	0-52-0	0.71	0.112	4.74B	5.18BC	6.02	4.34	3.35BC
PA + urea	0-52-0	1.42	0.336	4.45B	5.47ABC	5.85	3.69	3.60ABC
PA + urea	0-52-0	2.13	0.448	5.26AB	5.70ABC	6.49	3.77	3.70ABC
SP + urea	0-50-0	0.71	0.112	4.92AB	5.12BC	6.22	3.71	4.03A
SP + urea	0-50-0	1.42	0.336	5.00AB	5.52ABC	6.29	4.08	3.83AB
SP + urea	0-50-0	2.13	0.448	5.00AB	5.76ABC	6.60	4.37	3.45BC

*Levels not connected by same letter in the same column are significantly different using student's test in comparisons for each pair at alpha 0.05, ^{ns} – non significant. Sources of fertilizer as MAP-monoammonium phosphate, PA-Phosphoric acid, SP-superphos.

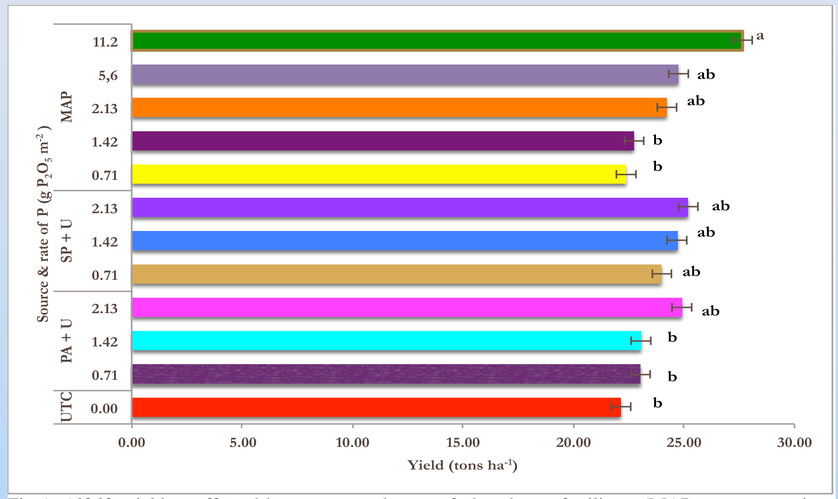

Fig 1. Alfalfa yield as affected by sources and rates of phosphorus fertilizers (MAP-monoammonium phosphate, PA-Phosphoric acid, SP-superphos) summed over the five cuttings during the year conducted at MAC in 2015. U = Urea. Yield bars with the same letter are not significantly different at alpha 0.05.

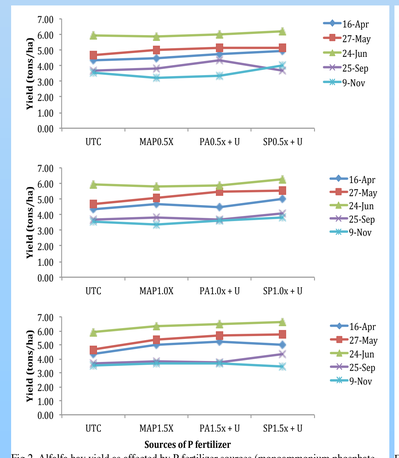

Fig 2. Alfalfa hay yield as affected by P fertilizer sources (monoammonium phosphate-MAP, Phosphoric acid-PA, Superphos-SP) at P relative rate of (0.5x-above, 1.0x-middle, 1.5x-below) for each cutting date during the year conducted at MAC in 2015. U = Urea.

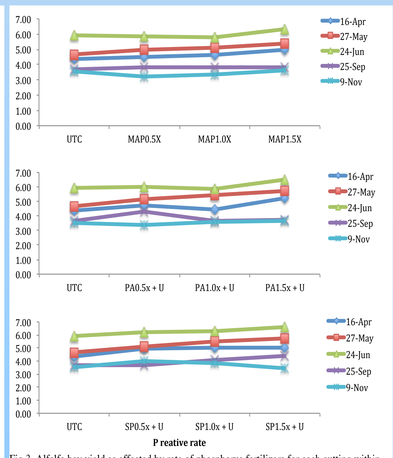

Fig 3. Alfalfa hay yield as affected by rate of phosphorus fertilizers for each cutting within the same source (Monoammonium phosphate-MAP, Phosphoric acid-PA, and Superphos-SP) during the year conducted at MAC in 2015. U = Urea

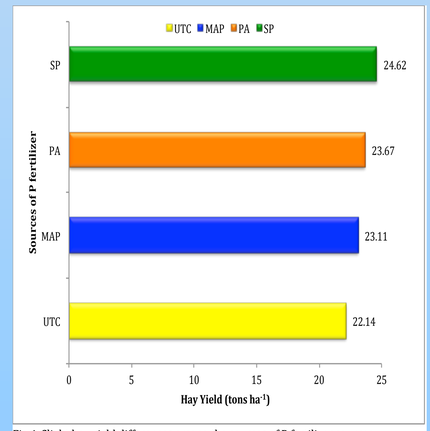

Fig 4. Slight hay yield differences among the sources of P fertilizer sources (Monoammoniumphosphate-MAP, Phosphoric acid-PA, Superphos-SP) summed over the five cuttings when averaged the three rate of application during the year conducted at MAC in 2015.

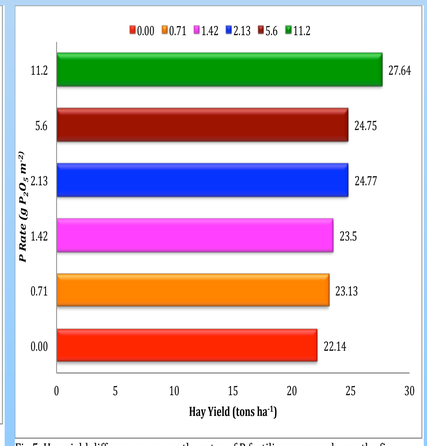

Fig 5. Hay yield differences among the rates of P fertilizer summed over the five cuttings when averaged over the sources of P fertilizer (Monoammoniumphosphate-MAP, Phosphoric acid-PA, Superphos-SP) during the year conducted at MAC in 2015.

Soil test P (Olsen method)

Table 3. Soil test P (Olsen method) levels by source and rate of phosphorus fertilizer at two sampling times and soil values (ppm) for the study conducted at MAC in 2015

Treatment	Analysis	P Rate g P_2O_5 m^{-2}	Soil Phosphorus (ppm) 15-May	19-June
UTC	0	0.00	5.000	4.250
MAP	11-52-0	0.71	3.750	3.250*
MAP	11-52-0	1.42	4.750	4.250
MAP	11-52-0	2.13	3.250	4.000
MAP	11-52-0	5.60	5.500	4.500
MAP	11-52-0	11.20	4.500	4.250
PA + urea	0-52-0	0.71	4.000	3.000
PA + urea	0-52-0	1.42	4.250	4.000
PA + urea	0-52-0	2.13	4.000	4.000
SP + urea	0-50-0	0.71	4.250	4.750
SP + urea	0-50-0	1.42	3.750	4.500
SP + urea	0-50-0	2.13	4.250	4.000

* Almost all soil test values indicate deficient soil phosphorus level (<5.00 ppm). Sources of fertilizer as MAP-monoammonium phosphate, PA-Phosphoric acid, SP-superphos

Total Plant P (ppm)

Table 4. Phosphorus fertilizer source and rate effect on total plant P and P% for the study conducted at MAC in 2015

Treatment	Analysis	P Rate g P_2O_5 m^{-2}	Total Plant P (ppm P) 15-May	19-June	P%
UTC	N/A	0.00	339.500	674.750	0.069*
MAP	11-52-0	0.71	379.225	385.625	0.075
MAP	11-52-0	1.42	384.200	441.825	0.071
MAP	11-52-0	2.13	443.750	378.150	0.080
MAP	11-52-0	5.60	366.600	370.550	0.072
MAP	11-52-0	11.20	522.625	495.650	0.081
PA + urea	0-52-0	0.71	329.250	677.225	0.066
PA + urea	0-52-0	1.42	302.150	637.050	0.065
PA + urea	0-52-0	2.13	363.900	545.075	0.073
SP + urea	0-50-0	0.71	413.975	680.075	0.077
SP + urea	0-50-0	1.42	323.100	577.550	0.064
SP + urea	0-50-0	2.13	295.125	506.300	0.061

* Plant tissue phosphorus concentration (P%) values were at deficient level (<0.20%) for all phosphorus fertilizer sources and at all application rates. Sources of fertilizer as MAP-monoammonium phosphate, PA-Phosphoric acid, SP-superphos

Conclusion

This research demonstrates that the three sources of P fertilizer were equally effective at equivalent rate of application on irrigated alfalfa in low desert Arizona. Considerations other than agronomic performance such as cost per unit of nutrient, ease of application and availability must be taken into account in selection of specific P fertilizer.

Acknowledgement

The authors thank Bio Huma Netics for their resource support and Ahmed Gadelhak for his technical assistance to conduct this study.