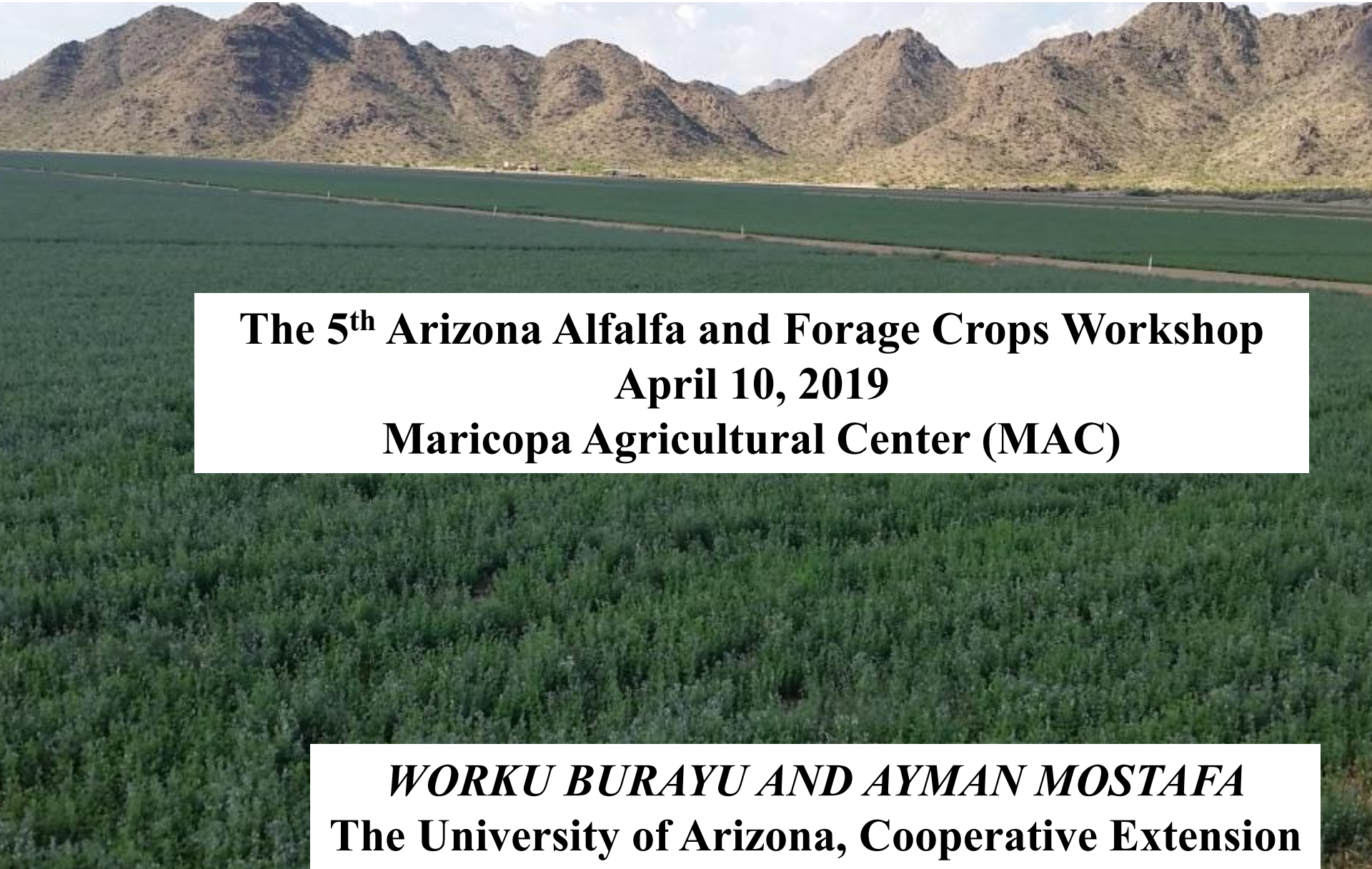
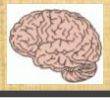
Irrigated Alfalfa Response to Phosphorus and Potassium Fertilizers in a Calcareous Soil of Arizona



The 5th Arizona Alfalfa and Forage Crops Workshop
April 10, 2019
Maricopa Agricultural Center (MAC)

WORKU BURAYU AND AYMAN MOSTAFA
The University of Arizona, Cooperative Extension

To refresh your memory: 

- Main variety, non-dormant in fall,
- High productivity & Multiple harvests per year,
- Cutting cycle & Alfalfa stand life
- The more the stand stay and aging associated problems,
- Require replacement,
- Intensive production system

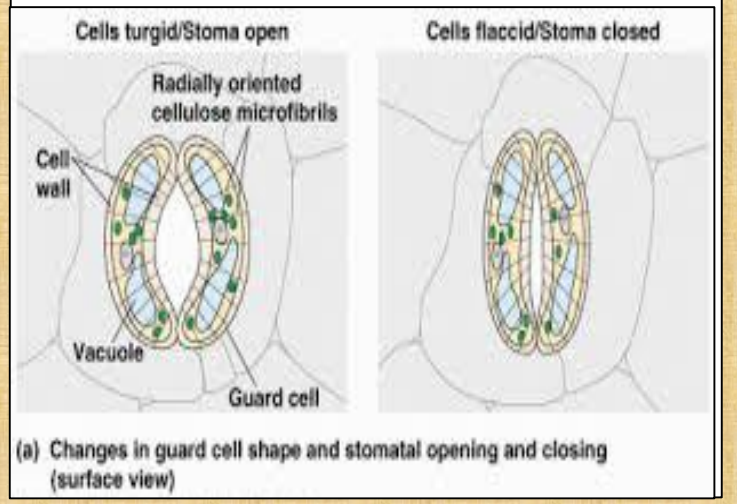
- production continuity, high resource need,
- Average of 8.4 tons/A, 8 to 10 cuttings a year, the more nutrient depletion
- Majority, 28-32 day schedule & > 3 years

yield often decreases, can alter forage quality, chemical medicarpins increases

- High establishment cost
- Remove large amount of P and K

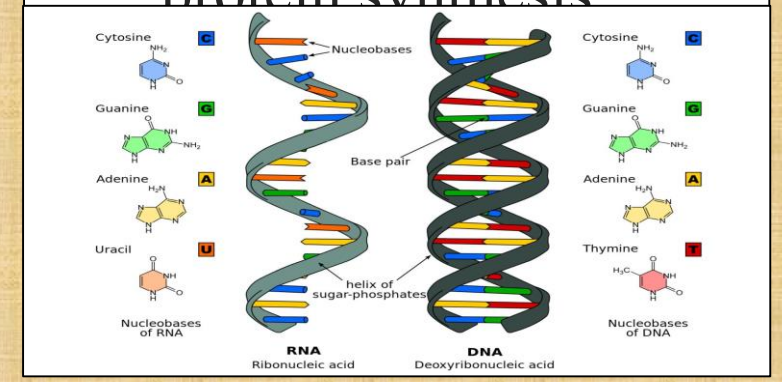
P and K importance in plants

- Potassium:
  - Enzymes activation,
  - Carbohydrates degradation,
  - Protein synthesis,
  - Stomata regulating,



(a) Changes in guard cell shape and stomatal opening and closing (surface view)

- Phosphorus:
  - Nucleic acids (DNA, RNA),
  - Energy transfer (ATP, ADP)
  - Photosynthesis,
  - Carbohydrate and protein synthesis



Importance of K

- Alfalfa stands receiving K maintained a denser stand after 10 years when compared with plots provided P alone
- Increased alfalfa stand persistence with increased K application
- Shoots per area and forage yield are maintained at higher levels across time if proper P and K fertility is provided (Minnesota, Wisconson)

Why PK important (Literature)

Balanced fertility

- Balance between P and K nutrients have positive effect on yield in a soil where K is not lacking
- P and K improves yield, persistence and stand longevity
- Alfalfa stand fertilized with 50 to 150 lbs P_2O_5/A/yr and 200 to 400 lbs K_2O/A/yr) had higher yields than unfertilized stands (Purdue U)

UNIVERSITY OF ARIZONA STUDY:

Study:

- Phosphorus fertilizer rate effect on alfalfa yield and soil & plant test P, Buckeye, AZ 2014 (Ottman *et al*., 2015)

- Phosphorus Fertilizer Source and Rate Effect on Irrigated Alfalfa in Arizona (Burayu *et al*., 2016)

- Prior Study

Findings:

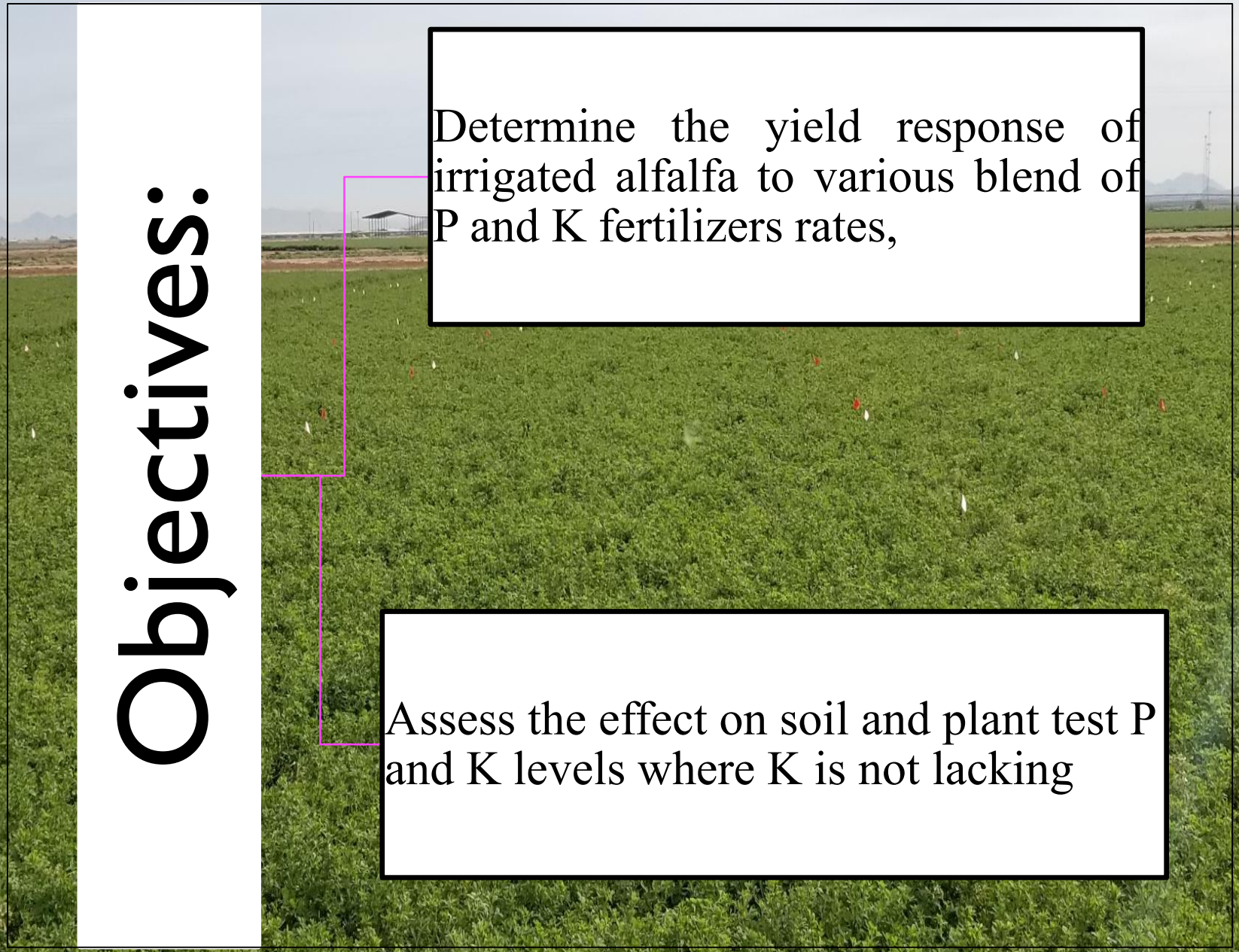
1. Increased yield by phosphorus fertilizer
2. No statistical differences in yield of 200,400, and 800 lb 11-52-0/acre.

1. Yield increased at higher rate,
2. MAP, PA, & Superphos equally effective

- No differences among sources of P

Nutrient management- calcareous soil

✓ Calcareous soil is usually high in Cations & in pH,	• K is rarely recommended, • Information on K from high soil K levels is limited,
✓ Balanced fertility (PK)	• No information on P & K interaction
✓ Our interest	• Profitable and long term productivity
✓ How?	• Nutrient Management is one of the many factors for long term productivity of alfalfa



Objectives:

Determine the yield response of irrigated alfalfa to various blend of P and K fertilizers rates,

Assess the effect on soil and plant test P and K levels where K is not lacking

Materials and Methods (MAC)

Sources of Fertilizers:

- MAP (11-52-0),
- KCL (0-0-60)

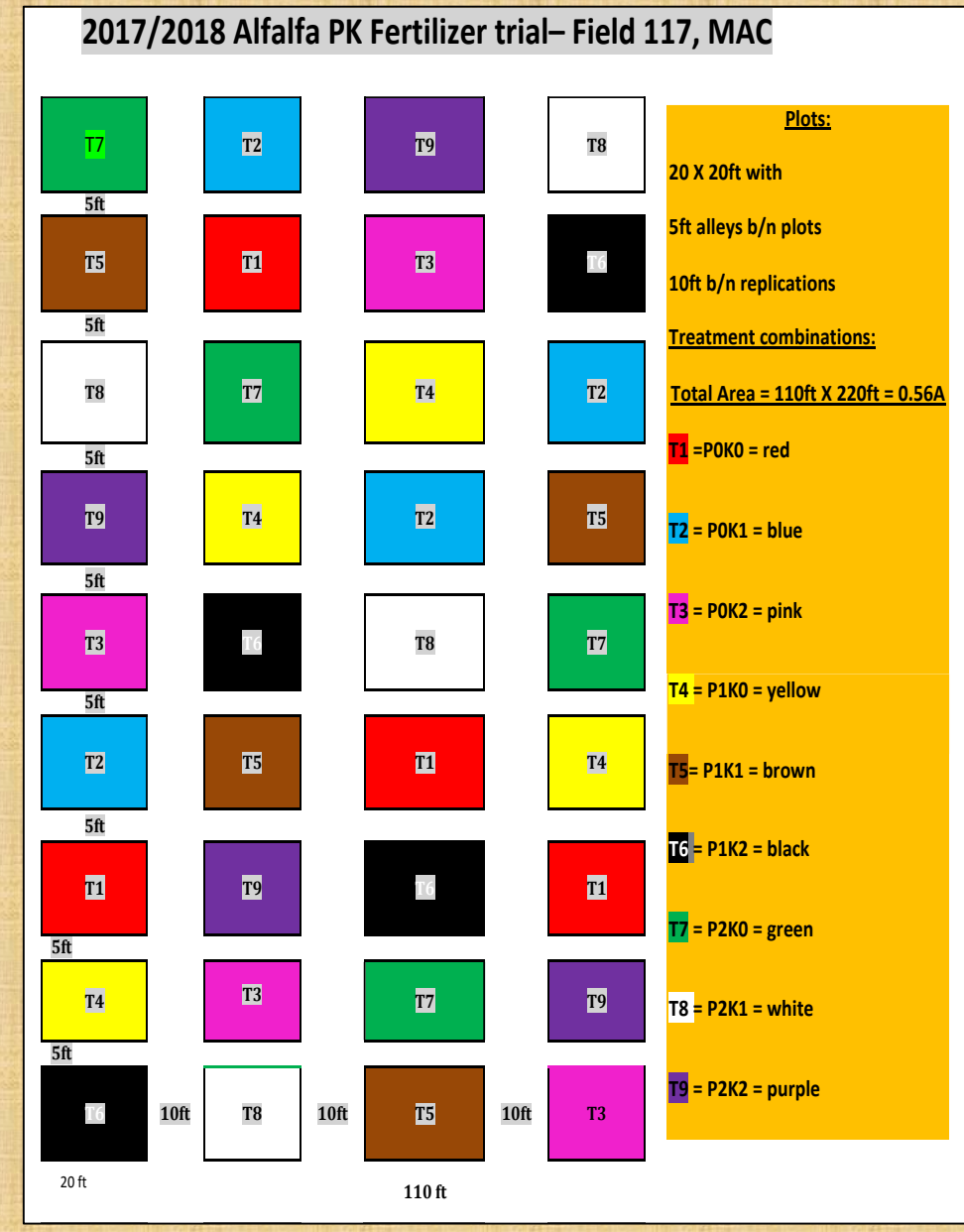
Rates (lbs. acre^{-1})

- P (0,192, 240 MAP)
- K (0, 167, 500 KCL).

Design: RCBD, 4 replication.

Texture:

• Sandy Clay loam	(58% sand)
• K (ppm):	320
• Na (ppm):	250
• Olsen-p (ppm):	6.6
• Nitrate-N (ppm):	1.1
• pH:	8.2



Procedures:

Fertilizers applied, November 2017,

Eight harvests occurred in 2018,

Hay Yield adjusted to 12% moisture,

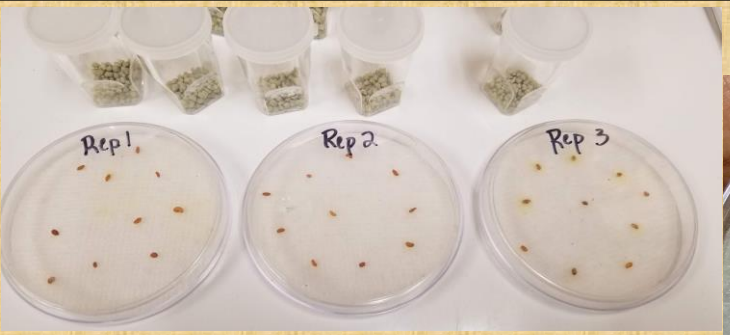
Soil samples at 6 inches collected

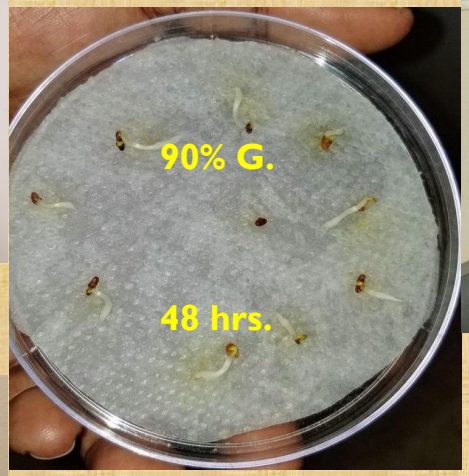
Olsen P & K determined

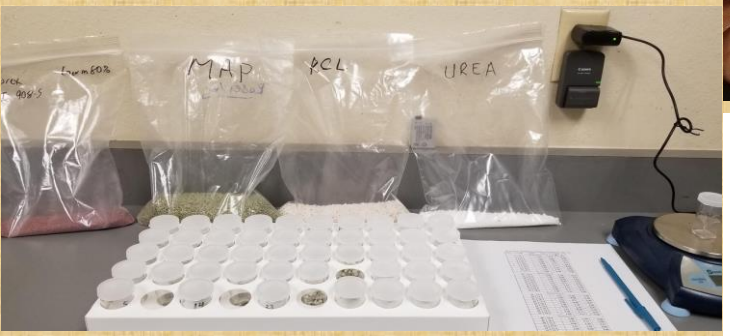
A subsample of 48 shoots each plot,

Plant P & K concentration determined

Tube Trial







Texture: Sandy loam	(72% sand)
K (ppm):	250
Na (ppm):	210
Olsen-p (ppm):	7.8
Nitrate-N (ppm):	3.9
pH:	9.0

Hay Yield (ton. acre^{-1})

Note: The results being presented are:

MAC, 8 cuttings in 2018, one cutting in 2019,

- Tube Trial, 2 cuttings of the first year,
- Nature of the study-long term research,
- Detail economic analysis required,
- Final conclusions cannot be drawn until the completion of the study.

P Fertilizer increased yield (MAC)

Table 1. Alfalfa yield under the influence of three P fertilization rates at MAC, Arizona in 2018.

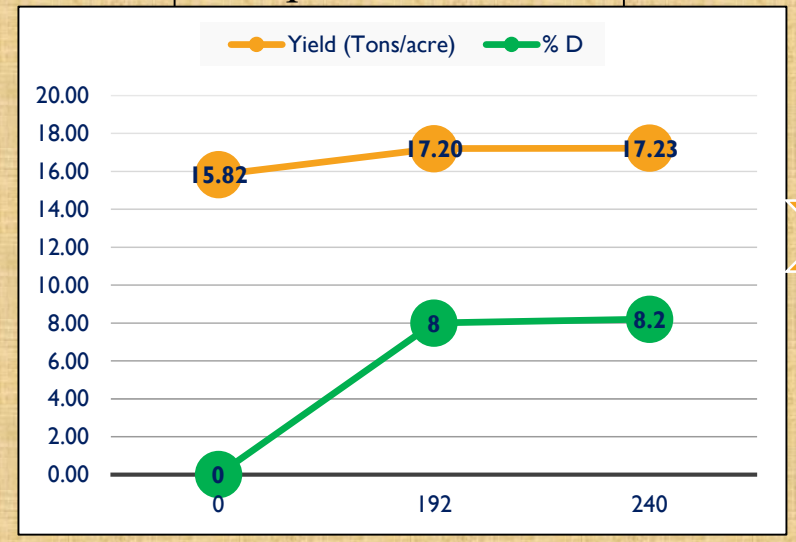
MAP†	January	March	April	May	June	July	August	September	Total
Lbs. acre^{-1}	Hay Yield, tons acre^{-1}								
0	1.24B††	1.62B	1.94B	2.36B	2.69A	1.63B	2.15A	2.19B	15.82B
192	1.31B	1.85A	2.08A	2.49A	2.97A	1.93A	2.24A	2.33A	17.20A
240	1.46A	1.88A	2.10A	2.50A	2.88A	1.76AB	2.33A	2.31A	17.22A

†Sources of fertilizer: MAP-monoammonium phosphate (11-52-0).
†† Within a column, values followed by the same letters are not significantly different at 0.05 level of probability.

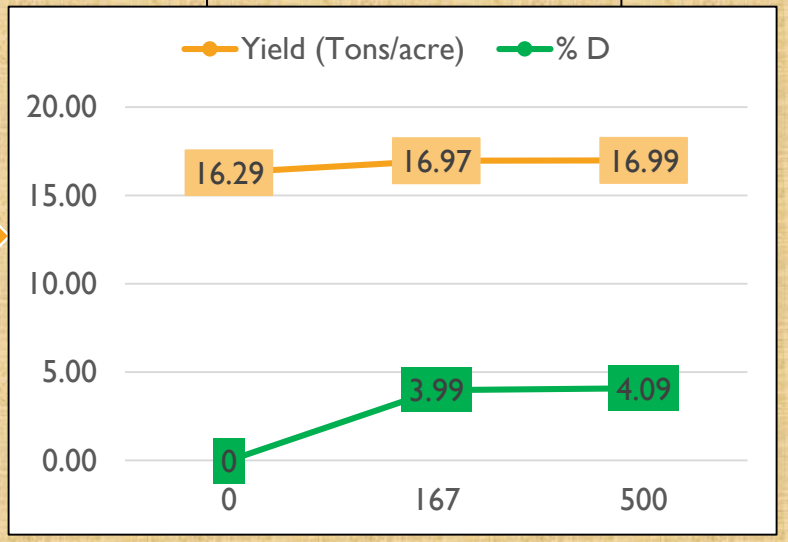
- The benefit of phosphorus fertilizer was realized in all cuttings after the time of application in November until the Sept 26 cutting, with the exception of the June and August cuttings.
- No difference was detected between the fertilizer rates of 192 and 240 lb 11- 52-0 /acre, after the first January cuttings.

Individual P& K effect on yield (MAC)

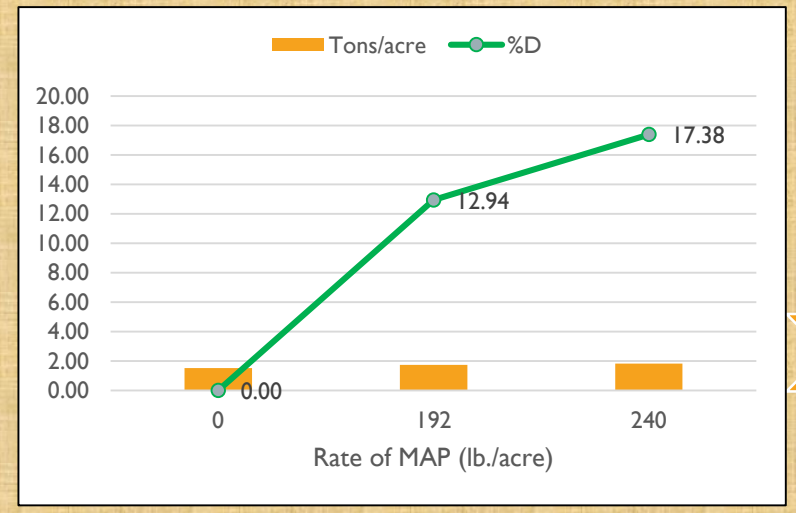
Phosphorus fertilizer



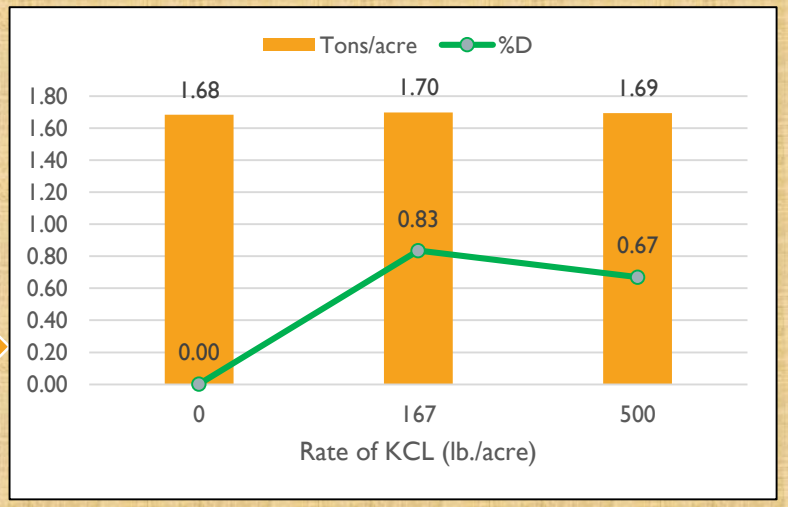
Potassium fertilizer



2018 (8 cuttings)



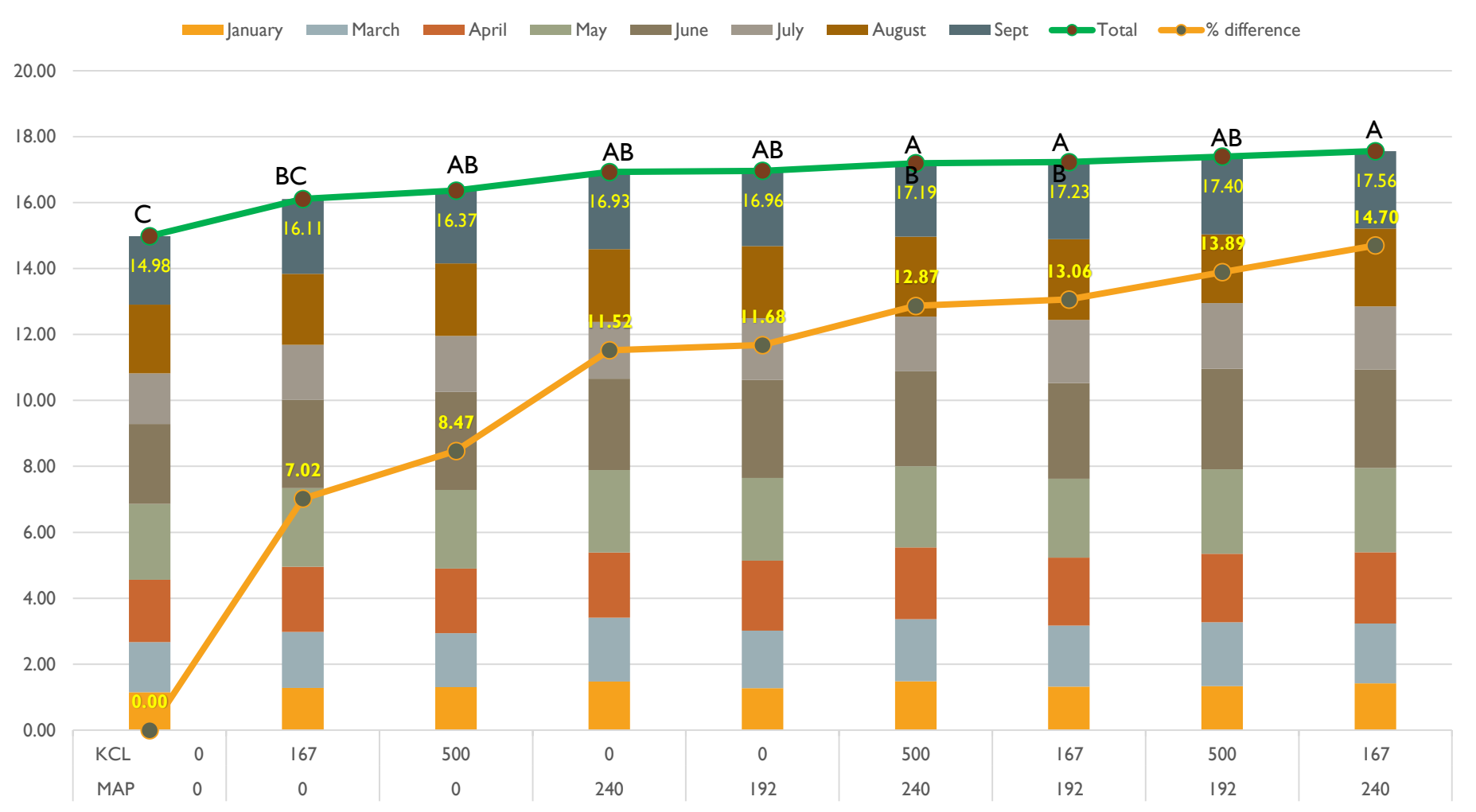
2019 (1 cutting)



Individually percent increase of yield ranged from 8 to 8.2% for Phosphorus, and 3.99 to 4.09% for potassium in 2018 (8 cuttings); 12.94 to 17.38% for Phosphorus, and 0.83 to 0.67% for potassium in 2019 (one cutting).

A P-K interaction effect on yield (2018)

MAC

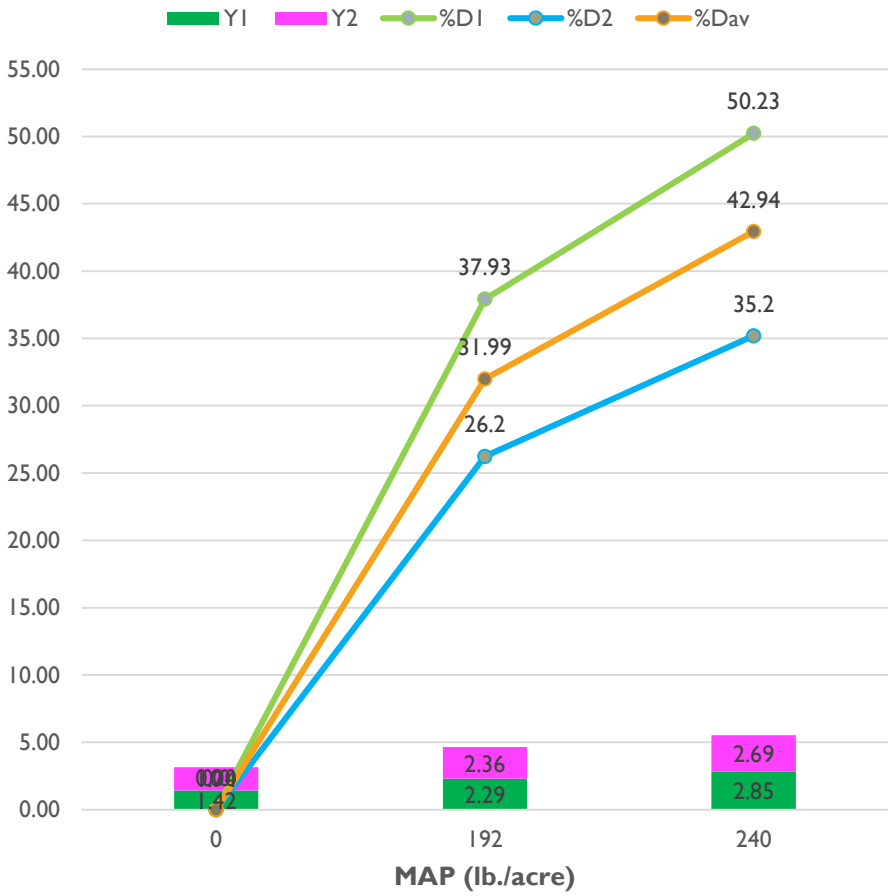


Percent increase of yield due to blend of P & K treatments over untreated control ranged from **7.02 to 14.70 % at MAC (eight cuttings).**

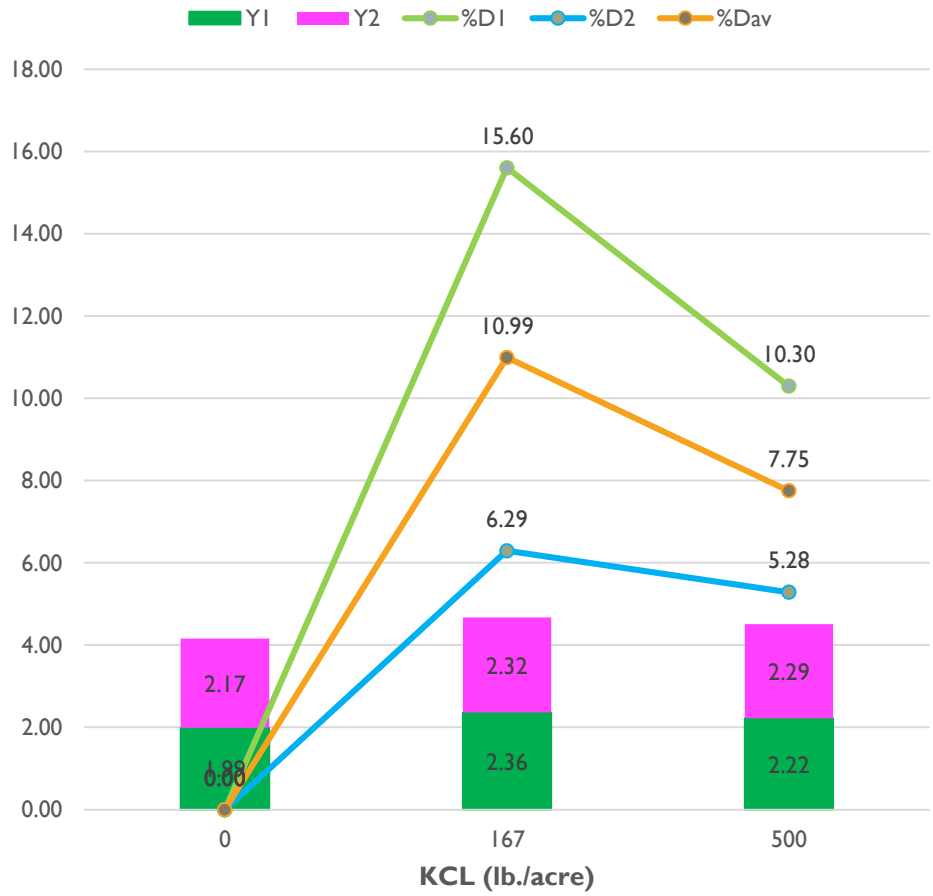
PK impact on performance of alfalfa (Tube, 12 WAP)

Individual PK effect on yield (2019, Tube Trial)

Phosphorus fertilizer



Potassium fertilizer

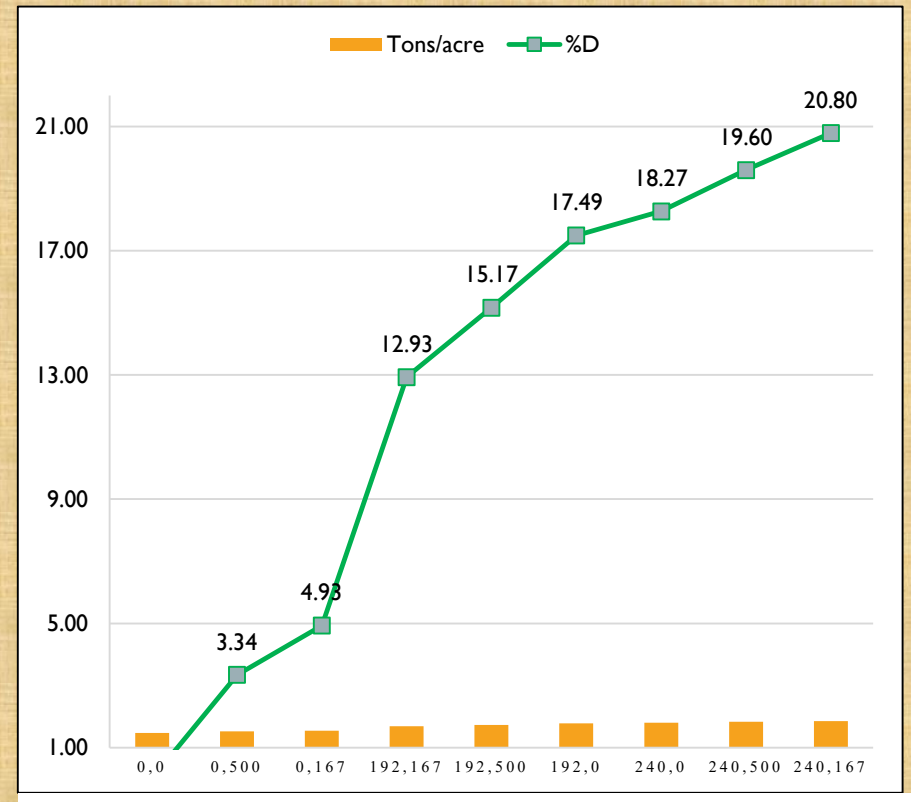


Y1 = The first cutting, Y2 = the second cutting; %D = Percent difference from Control, %Dav = average percent increment from unfertilized plots.(two cuttings).

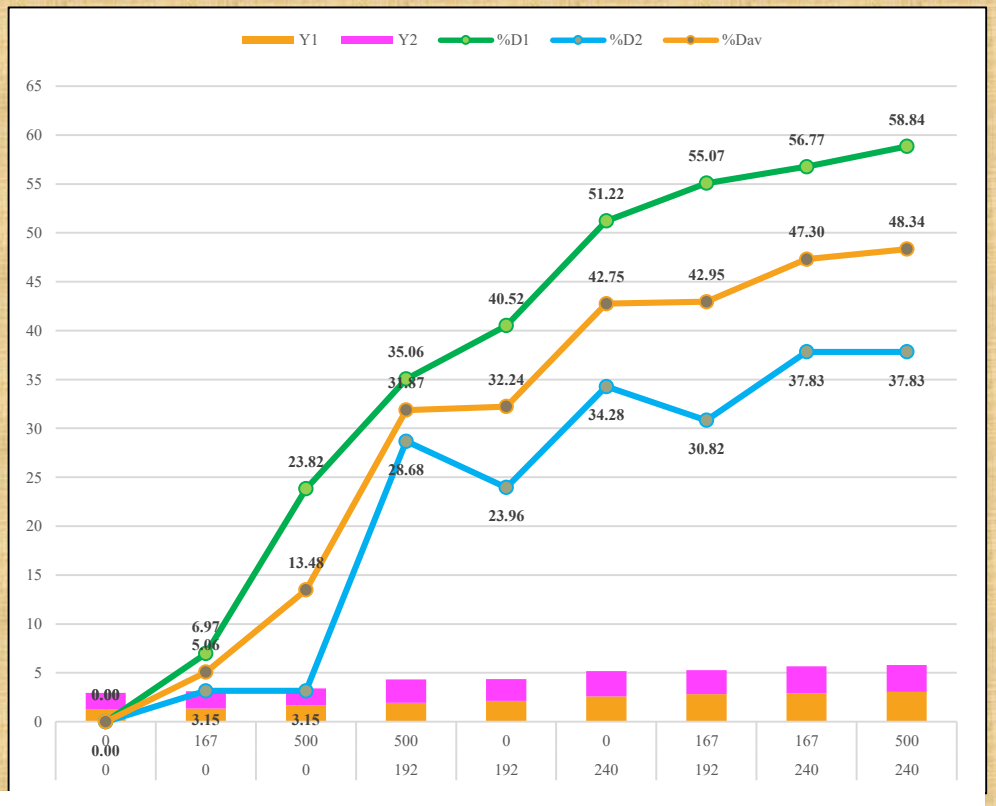
Individually percent increase of yield ranged from 37.93 to 50.23% in first cutting, from 26.2 to 35.2 in the second cuttings, and average of 31.99 to 42.94 for Phosphorus ; and 10.30 to 15.60% in the first cutting and 5.28 to 6.29% in the second cutting, an average being 7.75 to 10.99% for potassium.

A P-K interaction effect on yield (2019)

MAC



Tube



Y1 = The first yield, Y2 = the second yield; %D = Percent difference from Control, %Dav = average percent increment from unfertilized plots.(two cuttings).

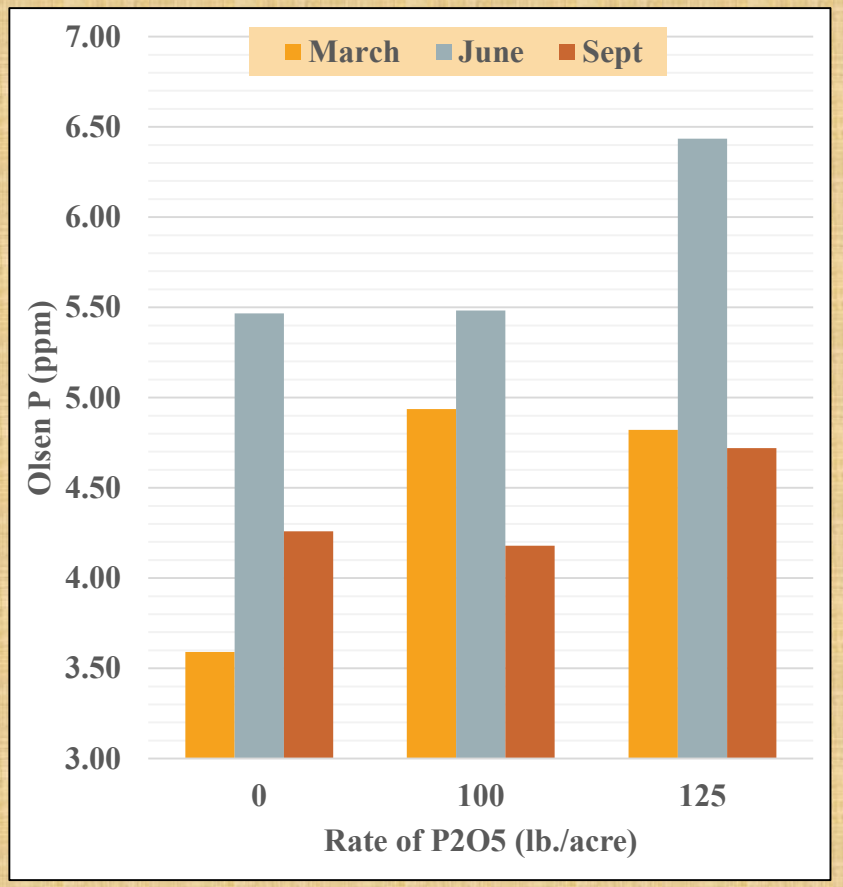
Percent increase of yield due to blend of P & K treatments over untreated control ranged from **3.34 to 20.80 % at MAC (one cutting), and** ranged from 6.97 to 58.84 in first cutting, 3.15 to 37.83 in second cutting, and **5.06 to 48.34 on average, Tube trial (two cuttings).**

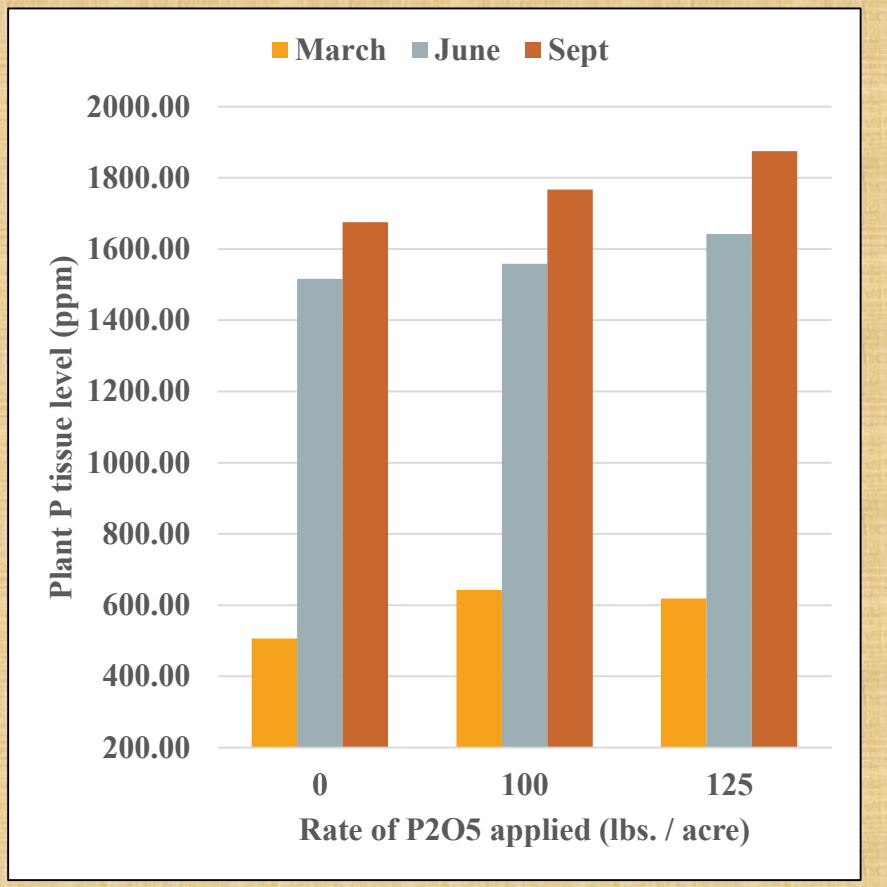
Balanced fertility synergetic effect (MAC)

P2O5 (lb/A)	K2O (lb/A)	Yield (ton/A)	Response
0	0	14.98	--
0	100	16.11	1.13, tons/A
125	0	16.93	1.95, tons/A
125	100	17.56	2.58, tons/A
Average (P + K)		16.52	
Difference {(PK-(P+K)}		1.04	5.92%
Yield Advantage of Interaction (PK) over Individual components (tons/A)			
Together (PK) over P alone		0.63	Synergetic effect of PK Interaction
Together (PK) over K alone		1.45	

- Phosphorus and K each increased hay yields in a study. Together, they increased yield by 2.58 tons/A over unfertilized, and 0.63 to 1.45 tons/A or an average increase of 5.92% more (synergetic effect) than when each was applied alone.

Soil and Plant phosphorus (MAC):

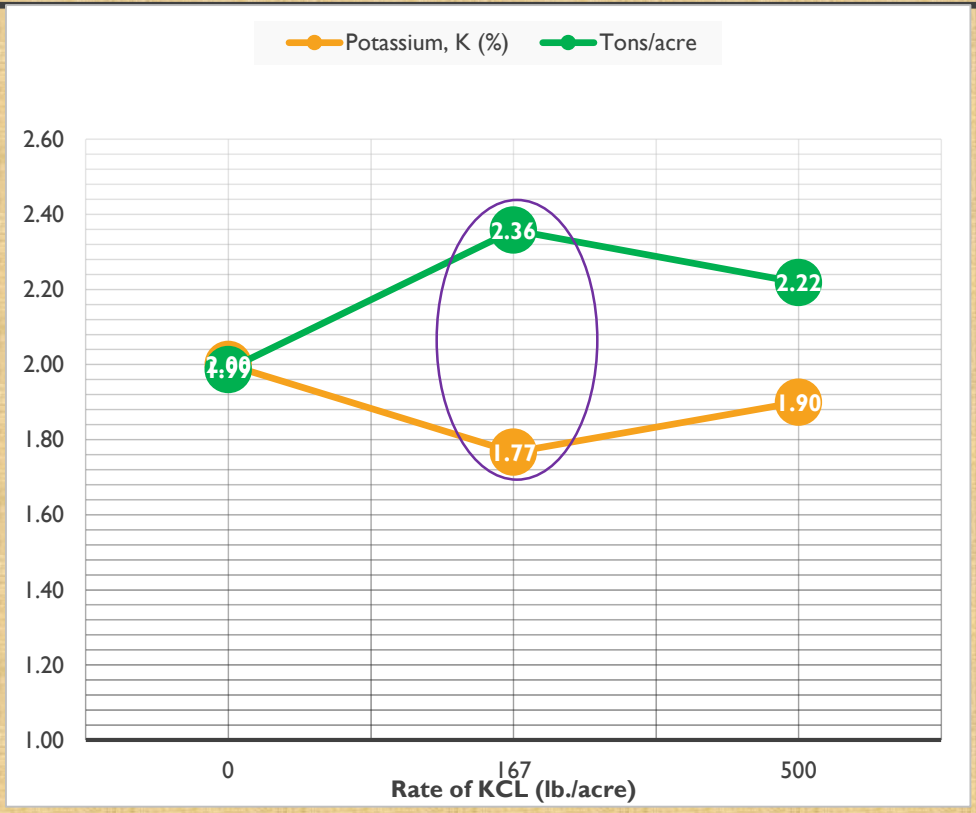


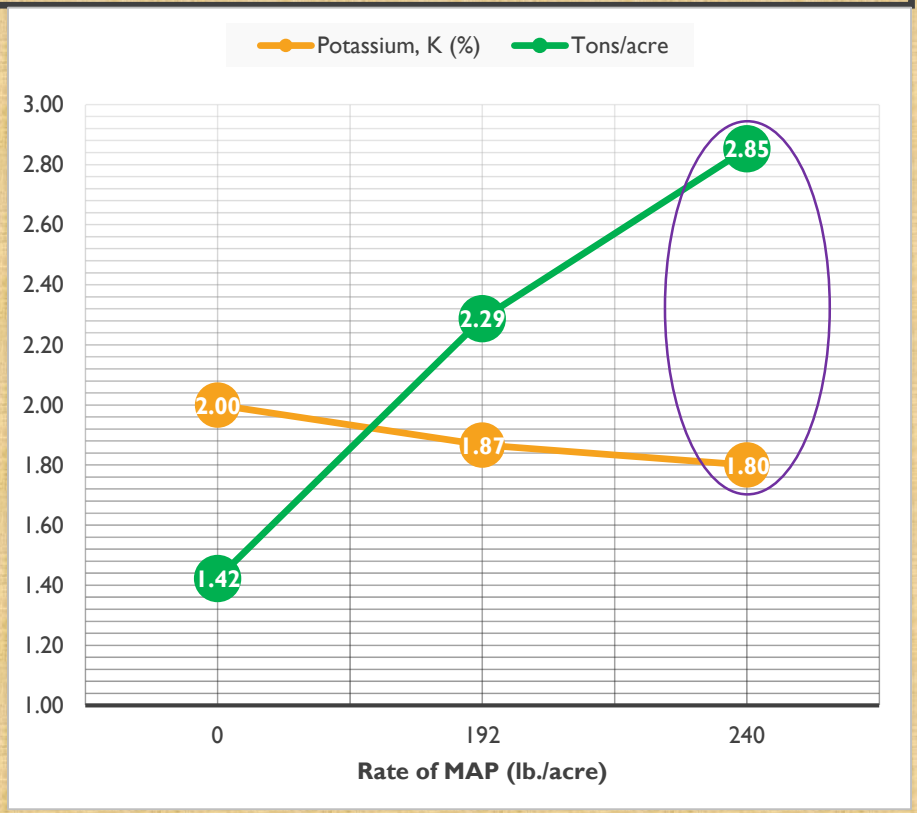


- Olsen P ranges from 3.59 to 4.94 in March, 5.47 to 6.44 in June, and 4.18 to 4.72 ppm in September.

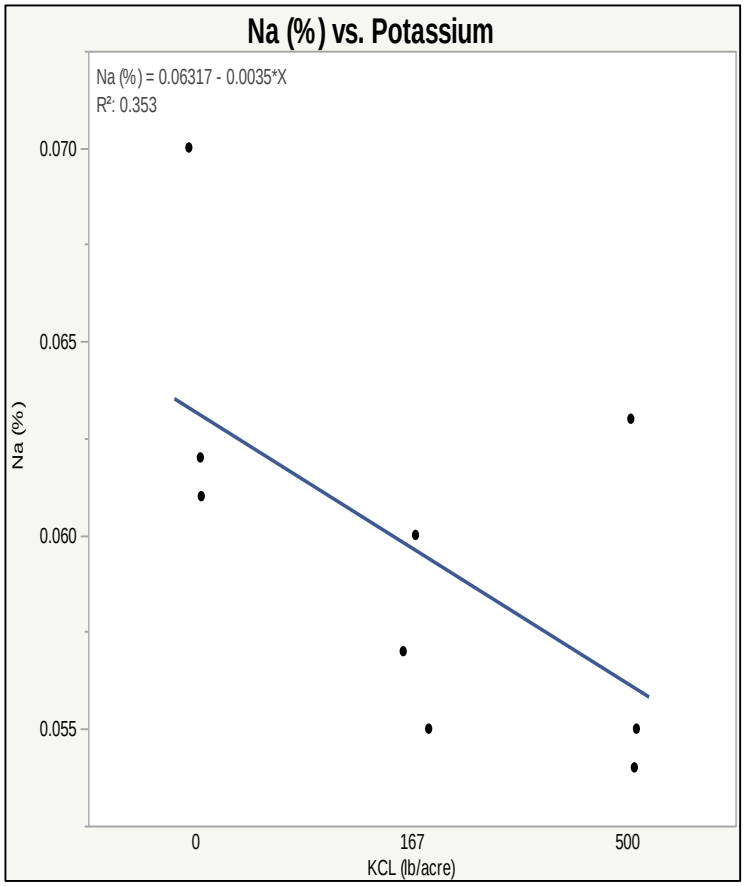
- The PO4-P tissue levels < 700-ppm level in March, 1517 to 1642 ppm in June, and 1675 to 1875 ppm in September.

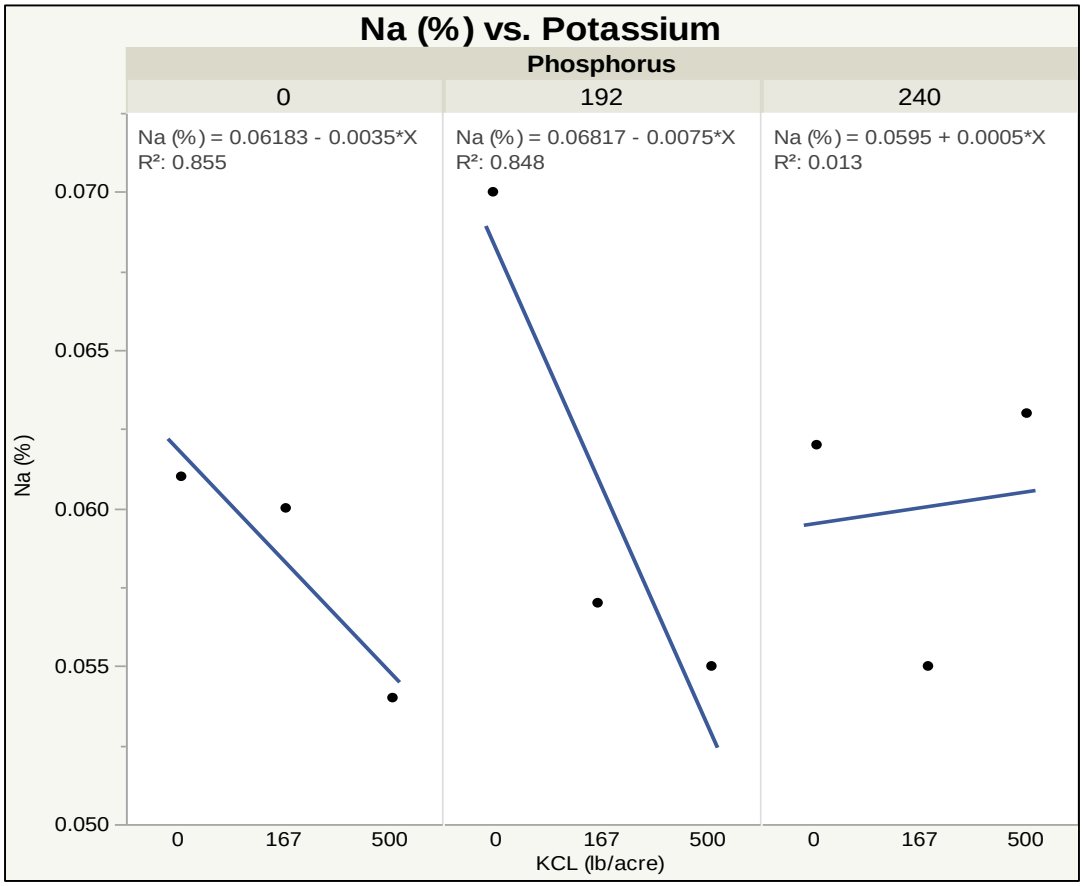
Potassium concentrations Vs. Yield





Maximum yields are usually associated with plant potassium concentrations in mid stem samples of 1.25-1.75% and in the top 6 inches of the plant of 2.0-2.5%. (University of California)





Na response to applied K2O

KEY POINTS TO TAKE HOME:

- P has significant, while K has slight effect on yield individually,
- P & K interaction has synergetic effects on yield,
- Potassium is known to interact with many nutrients. Generally reduce calcium, magnesium, and sodium,
- Better understanding of these interactions is a key for profitable yield,
- Reductions in the concentration of sodium in alfalfa by potassium may be of some benefit in Arizona because of the high sodium levels in the soils and in the alfalfa plant,
- Reductions in the calcium and magnesium concentration due to K application is of minor concern for Arizona, since the levels in the soils and plant is generally high,
- Highest fertilizer application did not result in **significantly** increased yield,
- With increasing fertilizer costs, a conservative approach to identifying fertilizer application rates may be more profitable

References:

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