Phosphorus and Water Use Efficiency

Phosphorus helps crops use water more efficiently in a complete and balanced soil fertility program. Water use efficiency (WUE) can be expressed as units of yield per inch of water used. Phosphorus increases WUE and drought tolerance of crops in several ways.

- Earlier and fuller canopy development reduces soil water evaporation and the erosive energy of raindrops.
- Heavier crop residues decrease soil crusting and increase soil organic matter and tilth, resulting in increased water infiltration and reduced runoff and soil erosion.
- Root activity and proliferation are increased, thereby expanding the soil volume from which roots extract water and nutrients.
- Vigorous and healthy plants have greater resistance to diseases and nematodes and can better compete with weeds.
- Earlier maturity avoids heat and moisture stress during the pollination period for corn and other crops.

Phosphorus (P), in a balanced soil fertility program, increases water use efficiency and helps crops achieve optimal performance under limited moisture conditions.

Phosphorus and WUE

When P fertilization increases root density and rooting depth, the amount of water available to the plant is increased. Furthermore, when P increases yield, WUE also increases. In an Arizona study, alfalfa receiving high P fertilization levels produced higher yields for a given amount of moisture (**Table 1**).

The interaction of P with other nutrients is often important in determining WUE. On a Texas soil that tested medium in P, WUE increased little beyond nitrogen (N) rates of 120 lb/A where no P was applied. However, WUE increased markedly with P fertilization within each N rate (**Figure 1**). The highest N and P rates resulted in a WUE of over 200 percent higher than the control.

Temperature and Phosphorus Affect WUE

Starter P can help overcome slow growth due to cold soil temperatures. Cool soil temperatures inhibit root growth. Phosphorus placed in a concentrated band near the seed can encourage vigorous early growth that results in a larger root system, increased

TABLE 1. Phosphorus increases alfalfa yield and WUE.

P_2O_5, lb/A	Yield, tons/A	WUE, lb/inch of water
100	8.3	188
200	9.4	213
400	11.2	253
600	11.8	267

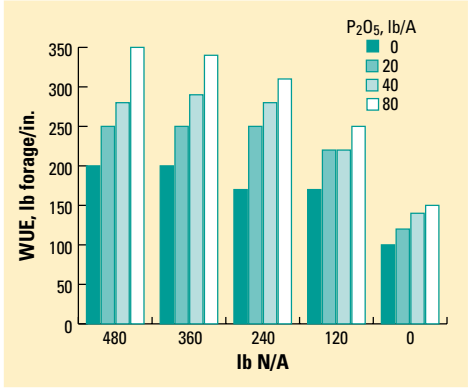

Figure 1. Effect of N and P fertilization on ryegrass water use efficiency.

TABLE 2. Effect of P rate and placement on forage wheat yield.

P rate, lb P_2O_5/A	P placement	Harvest dates March 9	April 2	April 22	Total
		Yield, lb/A			
0	—	500	980	1,814	3,294
30	Surface	430	1,016	1,970	3,416
60	Surface	361	1,208	2,190	3,759
90	Surface	458	1,286	2,278	4,022
30	Deep	616	1,473	2,338	4,427
60	Deep	844	1,807	2,824	5,475
90	Deep	967	1,895	3,380	6,242

WUE, and higher yields. A Texas study showed that yield increases from P placed with forage sorghum seed were higher in cooler soil temperatures (**Figure 2**). These yield increases were observed even though soil test P was very high.

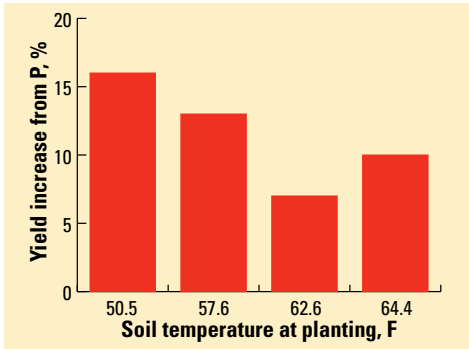

Figure 2. Percent yield increase of forage sorghum due to in-furrow P fertilization.

Phosphorus Placement and WUE

Placement of P can affect WUE. Studies conducted in arid west Texas have shown that deep placement of P increases wheat forage yield over surface incorporated application (**Table 2** and **photo**). Where moisture is low in the upper few inches of soil and P is placed near the surface, neither P nor water is used efficiently. When P is banded 8 to 10 inches deep, where soil water is more abundant, WUE is increased. Optimizing positional availability of P is important in maximizing WUE, especially during dry periods.

Deep-placed fertilizer benefits wheat forage production. On the right, N, P, potassium (K), and sulfur (S) were deep-banded, while the center received N only.

Phosphorus Improves Crop Yields in Saline Conditions

Crop yields may suffer in saline soil conditions. South Dakota research showed that P fertilization can help overcome the adverse effects of salinity (**Figure 3**). The yields of both oats and barley increased remarkably under saline soil conditions as P rate increased. Furthermore, application of P with the seed proved to be much more effective in alleviating the adverse affects of salinity then broadcasting P. Symptoms of salt injury in the field were completely alleviated with applications of at least 40 lb broadcast or 20 lb in-furrow banded P_2O_5/A.

Summary

- Phosphorus increases water use efficiency by increasing crop yields and root density and depth.
- Good P nutrition helps maximize crop

(continued on page 27)

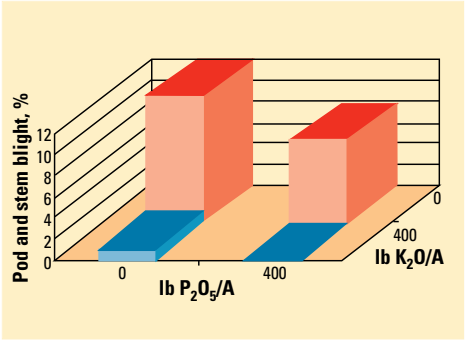

Figure 1. Effect of P and K fertilization on pod and stem blight infection of soybeans.

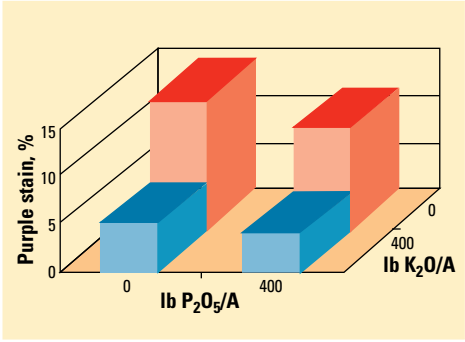

Figure 2. Effect of P and K fertilization on purple stain of soybean seed.

can be considered for disease control in the field".

Scientists concluded in a survey of Illinois field research that applied P reduced cob rot of corn on low P soils when the causal organism was Fusarium. Other studies have revealed that P can reduce the incidence of boil smut of corn.

Phosphorus and K helped reduce purple stain, Cercospora, in soybean seed in a Virginia study (**Figure 2**). Purple stain can lead to dockage and reduced profit. Other studies relate sound P nutrition to less shriveled seed and improved soybean seed germination.

Plants under nutrient stress are more susceptible to disease attack. Therefore, balancing P with other nutrient inputs is essential in reducing the risk of disease occurrence. For example, high levels of nitrogen (N) relative to P and other nutrients can lead to severe outbreaks of *Pythium*, *Rhizoctonia*, *Drechslera*, *Bipolaris*, *Typhula*, and other diseases in turfgrass.

Plant resistance to diseases can be reduced by any of several factors that result in stress. Some of these factors are drought, compaction, excess moisture, temperature extremes, physical plant injury, and nutrient imbalances. Phosphorus is a critical component of a balanced fertility program that results in crops that are better able to withstand stress and are consequently less susceptible to disease infection. BC

Water Use Efficiency... *(continued from page 15)*

yields and water use efficiency in periods of moisture stress and in saline conditions.

- Placement may be a factor in maximizing the moisture-related benefits of P. BC

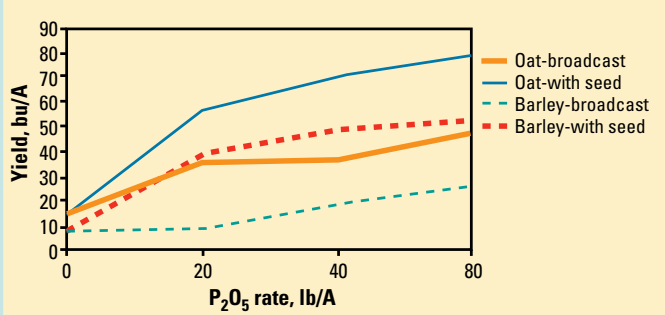

Figure 3. Effect of P fertilization rate and placement on yield of oats and barley under saline soil conditions.