Mosaic AgriSight®
TRUSTED CROP NUTRITION EXPERTISE℠
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Don't Forget Zinc when Applying Phosphorus to Your Farm

- Adequate Zn is needed with increasing rates of P fertilizer.
- High rates of P without proper Zn nutrition can cause a negative P-Zn interaction and reduced mycorrhizal activity.
- Soil test Zn levels that are low (0.7 - 1.0 ppm common critical range) may hinder crop growth with increasing rates of P application.
- MicroEssentials® SZ® (12-40-0-10S-1Zn) is a co-granulated P-Zn fertilizer source that uses Fusion® technology to provide uniform nutrient distribution (especially important for micronutrients) and increased nutrient uptake.

Phosphorus (P) fertilizer is often added to cropping systems to increase yield, but growers should not overlook the importance of micro-nutrients like Zinc (Zn). Understanding some of the nutrient interactions that affect nutrient availability can help with management decisions like fertilizer source. The interaction of P and Zn has been well researched and documented in the fields of soil chemistry and plant nutrition. For example, research shows that high rates of P fertilizer without adequate plant available Zn can reduce Zn uptake by the roots, induce Zn deficiency, and decrease plant growth and yield. When making decisions for a soil fertility program, it is important to consider some of the factors and situations that may cause P-Zn antagonism and how to best avoid or minimize those factors.

Causes of Negative P-Zn Interaction

Formation of Insoluble Zn-Phosphate Complexes

One of the primary causes of Zn deficiency in soils treated with high amounts of P fertilizer is its reaction with soluble Zn in the soil. This reaction produces insoluble Zn-phosphate complexes which influences the availability of Zn for plant uptake over time (Mortvedt, 1991). A potential outcome is a reduction of Zn availability leading to Zn deficiency and reduced plant growth.

Role of Mycorrhizae in causing Zn Deficiency in Plants

Mycorrhizae are beneficial fungi that form a symbiotic association with roots. Mycorrhizal fungi play an important role in plant nutrient uptake (particularly P and Zn) by extending hyphae (e.g., a fungi produced root-like structure) horizontally and deeper into the soil where plant roots normally can't reach. These fungi allow plant roots to have a greater surface area for increased water and nutrient uptake capacity. In terms of Zn, mycorrhizae may be responsible for up to 50% of the total Zn uptake in crop plants (Marschner, 2012). When high rates of P are applied, hyphae become "lazy" and the overall root footprint is decreased, resulting in a reduction of Zn uptake by the plant. High P application rates may, therefore, reduce Zn uptake mainly due to the reduced mycorrhizae-dependent Zn uptake.

Situations Where Negative P-Zn Interaction Occurs

Antagonistic P-Zn interactions can occur when soils receive high P application rates or those that are very low in plant available Zn. For example, a greenhouse study using a calcareous soil with low plant available Zn discovered that high P application rates induced Zn deficiency and reduced plant growth. In contrast, plants that received adequate Zn did not show any Zn deficiency and responded positively to higher P rates (Fig. 1).

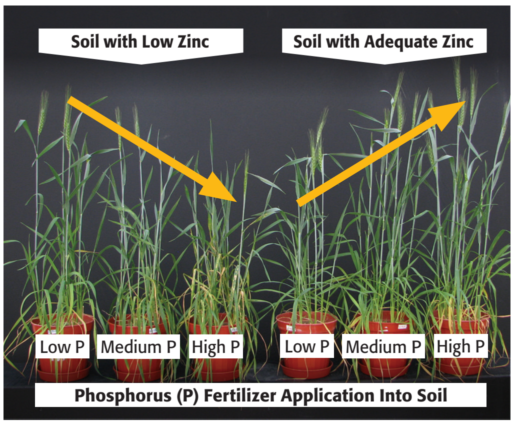

Fig. 1: Growth of wheat plants with increased P rates having low soil Zn supply (left) and adequate soil Zn supply (right). (Ova et al., 2015, Plant and Soil).

Soil Test Zinc

Soil test Zn is commonly measured using a DTPA-extraction. Extensive calibration tests conducted across a diverse set of soils in the US has found that DTPA-Zn concentration in soil is very well correlated with the root uptake of zinc. Soil test laboratories often recommend the application of Zn in soils where values fall below 0.7 – 1.0 ppm. Many high-yield systems where high-rates of P are applied to match removal values may find a benefit from applications of Zn even when soil test Zn values are above these critical levels.

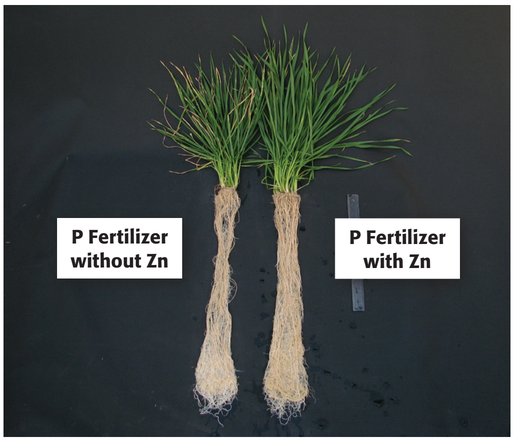

Fig. 2: Effect of P fertilizer without and with Zn on shoot and root growth of wheat with low soil Zn content (Pictures: M. Yazici and I. Cakmak, Sabanci University).

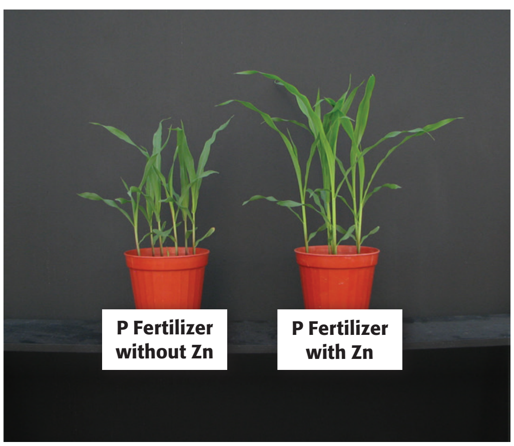

Fig. 3: Effect of P fertilizer without and with Zn on corn shoot growth with low soil Zn content (Pictures: M. Yazici and I. Cakmak, Sabanci University).

Importance of Zn Application along with a P Fertilizer

Due to the negative P-Zn interaction, maintaining proper Zn nutrition is critical, especially when soils receive P fertilizer. It is, therefore, not surprising why wheat (Fig. 2) or corn (Fig. 3) treated with P fertilizer co-granulated with Zn resulted in better growth and yield than plants that received P without Zn. Applying Zn-containing P fertilizers not only improved shoot growth, but demonstrated root growth improvements as well.

Conclusions

The addition of P fertilizer without adequate Zn can reduce crop growth and yield. Research suggests that two of the key reasons are:
1) negative P-Zn interaction and the formation of insoluble Zn-Phosphate complexes and
2) reduced mycorrhizal activity. The negative effect is magnified under conditions where soil Zn supply is very low and P application rates are high. Improved plant growth response to P was realized when the Zn supply was sufficient or when Zn was co-granulated with P fertilizer. Therefore, application of Zn-containing P fertilizers like MicroEssentials® SZ® (12-40-0-10S-1Zn) can be successful in reducing or eliminating the Zn deficiency and realize a greater response to applied P.

Suggested Readings

Cakmak, I. and Marschner, H. (1986): Mechanism of P induced zinc deficiency in cotton. I. Zinc deficiency-enhanced uptake rate of P. Physiol. Plant. 68: 483-490.

Marschner, P. (2012): Marschner's Mineral Nutrition of Higher Plants. 3rd ed., Academic Press, San Diego, USA.

Mortvedt, J.J. (1991): Micronutrient fertilizer technology. In: Mortvedt JJ, Cox FR, Shuman LM, Welch RM (eds) Micronutrients in Agriculture. SSSA Book Series No. 4. Madison, WI. pp. 89–112.

Ova, E.A., Kutman, U.B., Ozturk, L. and Cakmak, I. (2015): High P supply reduced zinc concentration of wheat in native soil but not in autoclaved soil or nutrient solution. Plant Soil. 393:147-162.

Zhang, W., Chen, X., Liu, Y., Dun-Yi Liu, Chen, X. and Zou, C (2017): Zinc uptake by roots and accumulation in maize plants as affected by P application and arbuscular mycorrhizal colonization. Plant Soil, 413:59-71.

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