HOMOGENOUS BORON-POTASSIUM FERTILIZER: PLANT UPTAKE

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ABSTRACT

Application of concentrated boron (B) fertilizers is potentially a problem for crops with a narrow root cylinder as some plants may receive the B while others are not in close enough proximity. The objective of this trial was to evaluate a low concentration B fertilizer in a variety of crops. Uptake of B was measured and compared to known B sufficiency levels. Crops with a relatively narrow root cylinder diameter (Kentucky bluegrass turfgrass, onion, carrot, and alfalfa) that were fertilized with the low concentration fertilizer had a significantly higher percentage (15-55%) of plants with B above the sufficiency level when compared with those fertilized with the more concentrated fertilizer. Boron uptake in crops with a wide root cylinder, such as maize and wheat, generally did not show a significant increase in plants above the sufficiency level, although potato did show a benefit with 18% more plants above the critical level for the low concentration B fertilizer. These results exhibit how fusing B into a homogeneous granule at a relatively lower concentration results in better spatial uniformity and improved B nutrition for a larger percentage of plants for plants with narrow root morphologies.

INTRODUCTION

Both potassium (K) and boron (B) are integral in plant growth, development, and health (Hopkins, 2020). Potassium helps plants with synthesis and degradation of carbohydrates and synthesis of proteins, and B is needed for nitrogen fixation in alfalfa, as well as for development of a healthy cell wall etc. (Lissbrant, S., et al., 2009).

The practice of blending dry fertilizers is common and although there are advantages, such as easy customization for specific zones in a field, disadvantages include irregular application due to spatial separation from differences in fertilizer shapes and densities, and a non-ideal uptake of plants from differences in root morphology even when fertilizers are equally spread. The later is especially true for micronutrients needed at very low levels.

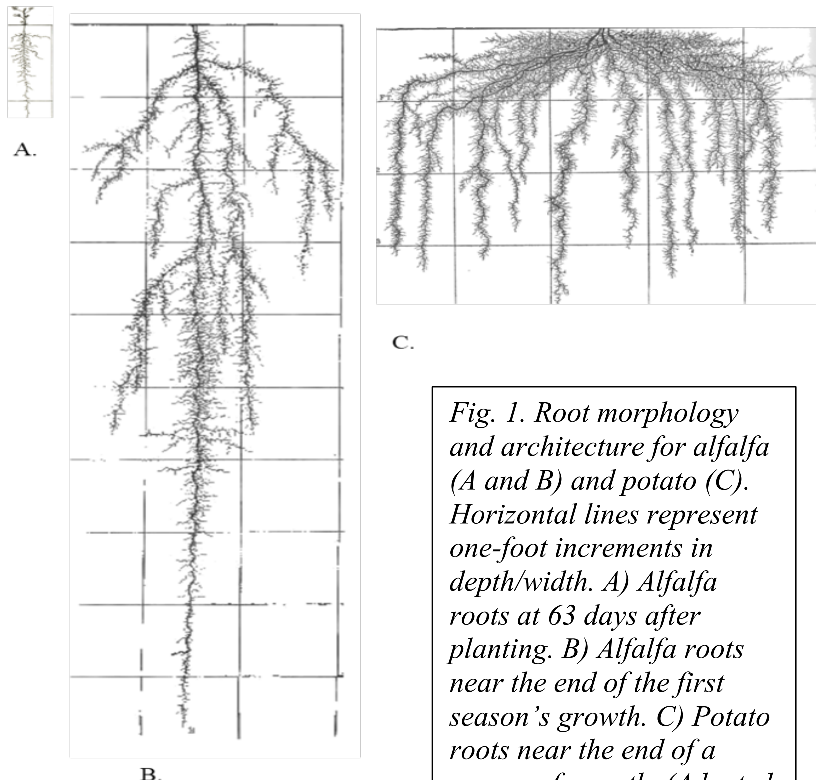

Fig. 1. Root morphology and architecture for alfalfa (A and B) and potato (C). Horizontal lines represent one-foot increments in depth/width. A) Alfalfa roots at 63 days after planting. B) Alfalfa roots near the end of the first season's growth. C) Potato roots near the end of a season of growth. (Adapted from Weaver, 1926.)

An alfalfa plant, for example, has a narrow root system, especially before fully mature (Fig. 1). Assuming a soil test is low in K and B, the most common form of each is muriate of potash (MOP, KCl; 0-0-60) and boric acid (15% B). It would be common to mix these together in a heterogeneous mixture of individual granules. Plants that lie next to where a B fertilizer particle fell will likely have ample, but some plants may receive little to no boron if the distance between their roots and where a B particle fell on the soil is several inches. Other crops with narrow root systems include carrot, onion, and turfgrass. This also potentially poses a potential problem in potato or similar crops with a shallow root system and few root hairs (Fig. 1; Hopkins, 2020).

In order to potentially solve this problem, fertilizers that are a homogeneous blend of K and B are a potential solution for better distribution and uptake. One such fertilizer is Aspire (0-0-58-0.5B; The Mosaic Company, Plymouth, MN, USA). Wooley et al. (2019) reported on a three study with alfalfa having a small, but significant increase in yield compared to traditional K and B fertilizers (Fig. 2.). They also reported on potato that had a significant increase in size of US No. 1 tubers treated with this homogeneous K-B fertilizers over those treated with traditional fertilizers (Fig. 3.). It is theorized that this homogeneous blend results in better distribution uniformity and, thus, improved uptake by a majority of plants.

The objectives of this trial were to Compare Aspire® (0-0-58-0.5B) against traditional K and B fertilizers in alfalfa and potato for uptake of B.

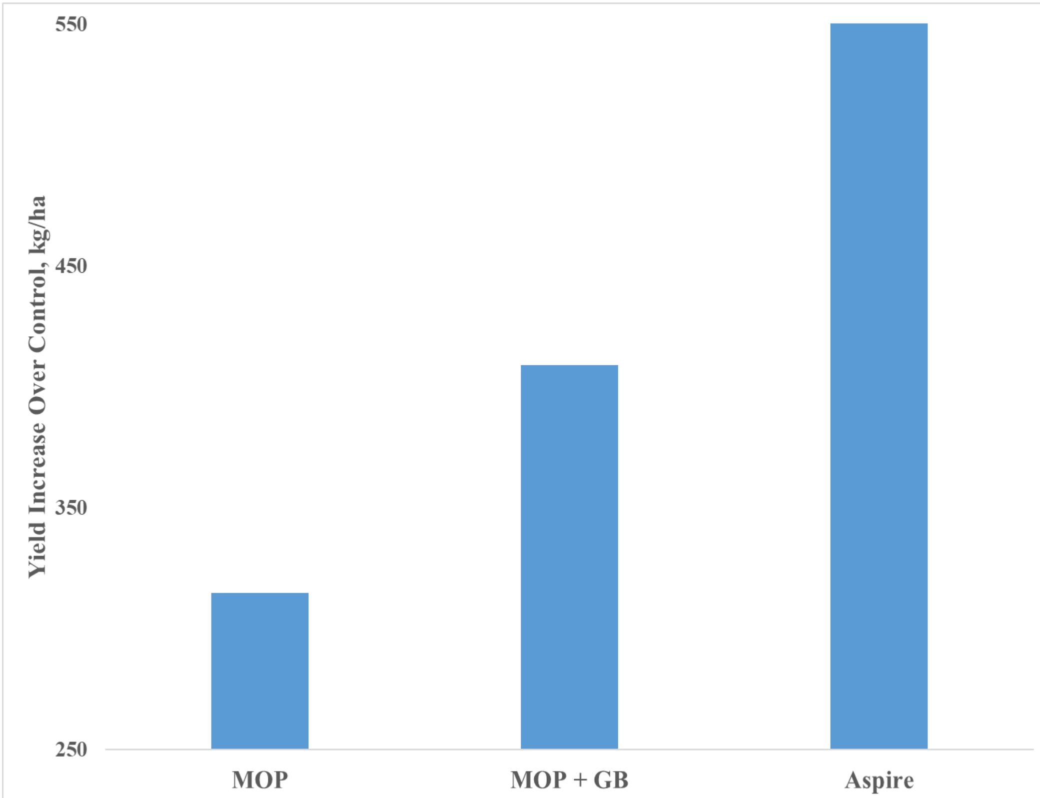

Fig. 2. Orthogonal differences for alfalfa forage yield between combined Aspire vs. muriate of potash (MOP) with or without boric acid (Granubor; GB) averaged over three years of field trials (2016-18). Reported on an "as fed" basis with 15% moisture. Bars sharing the same letters above are not significantly different. P = 0.10

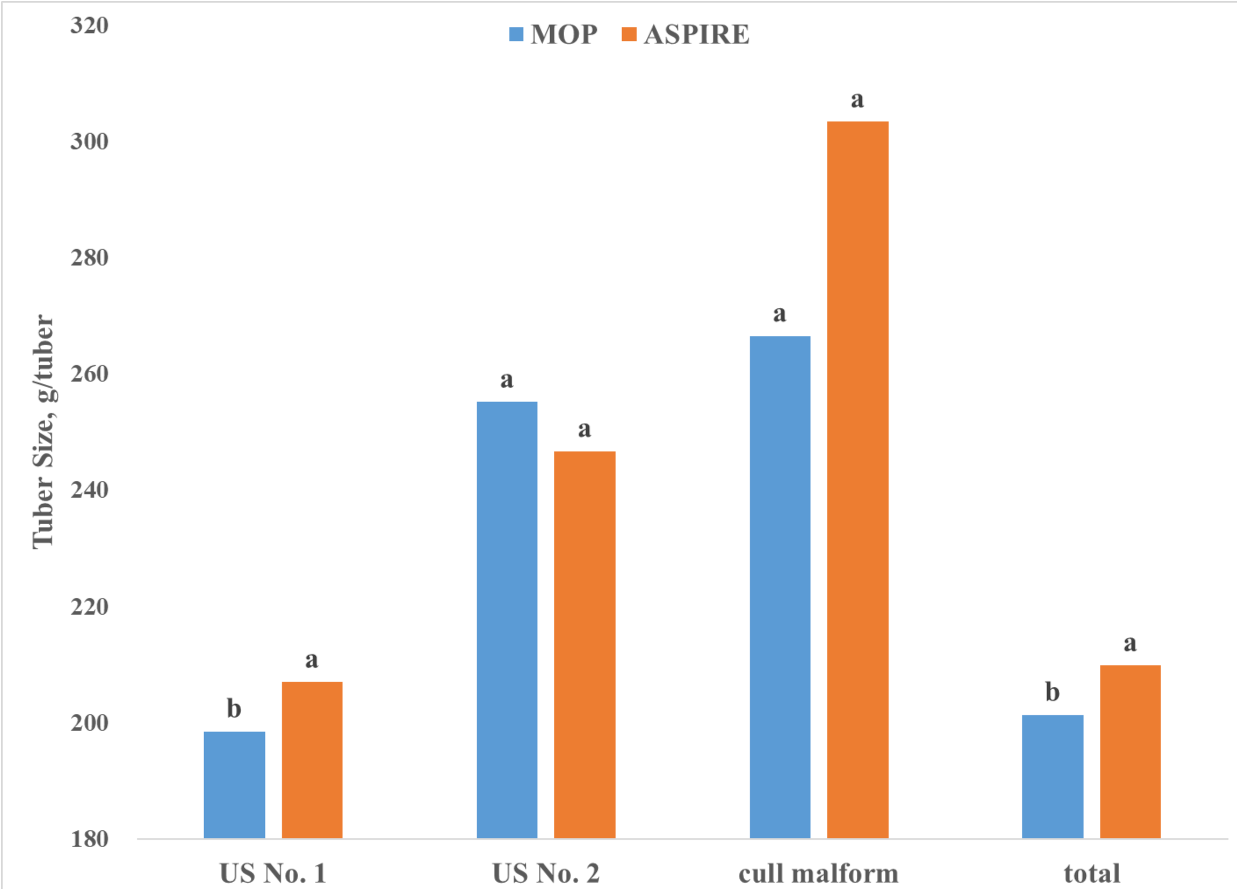

Fig. 3. Differences in tuber size of US No.1, 2, and cull malform Russet Burbank potatoes when treated with MOP or Aspire as a source of boron and potassium. Tuber yield was not impacted significantly. Bars sharing the same letters above are not significantly different. P = 0.10

MATERIALS AND METHODS

Two fertilizer treatments were evaluated with eight plants species with 20 replications in a RCBD in a glasshouse study at Brigham Young University in Provo, UT, (40.2450° N, 111.6412° W). The fertilizer was applied based on soil test at 115 and 1 lb ac^{-1} of K_2O and B, respectively (other nutrients were applied uniformly according to soil test to avoid any deficiencies). Fertilizer treatments included: 1) K applied as muriate of potash (0-0-60) and B applied as Granubor (15% B; Borax, Chicago, IL, USA) or 2) K and B applied as Aspire (0-0-58-0.5B; The Mosaic Company, Plymouth, MN, USA). (An unfertilized control was also included, but is not reported here.) The plant species include: maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), soybean (*Glycine max* L.), potato (*Solanum tuberosum* L.), alfalfa (*Medicago sativa* L.), carrot (*Daucus carota* L.), onion (*Allium cepa* L.), and Kentucky bluegrass (mowed at turfgrass height weekly at 2 inches; *Poa pratensis* L.). Seeds of each were planted in 5 gallon buckets with a 10 inch diameter. The K and B fertilizers were placed by hand, with the B applied uniformly. In the case of the homogeneous blend, the distance between B and seed was short with a range of 0 to 2 inch, but with the more concentrated boric acid the distances were more variable—ranging from 0 to 8 inches. Best management practices were followed in raising the plants. Plants were irrigated as needed to keep the soil moist (surface allowed to dry out after establishment with irrigation occurring when the soil was beginning to dry to a depth of about 1 inch), but avoiding any leaching losses. The hot water extractable B was 0.4 ppm, which is considered low.

Plants were grown for 60 days and then harvested, dried, ground, and analyzed by nitric peroxide digestion with determination of K and B with ICP. Plants in each bucket were separated by distance from B in 1 inch increments, counted and then composited as needed per bucket in order to have enough plant tissue for analysis (eg. corn plants could be analyzed individually, but several dozen Kentucky bluegrass plants were required to composite for analysis). Data was collected on a relative scale by subtracting the average nutrient uptake of plants fertilized with Aspire from the average nutrient uptake of plants fertilized with Granubor and comparing with the published critical level of B in each crop. Statistical differences were determined by ANOVA within each species using SAS software.

RESULTS AND DISCUSSION

Potato, alfalfa, carrot, onion, and Kentucky bluegrass turfgrass all showed a significant increase in the number of plants that were above the established sufficiency levels for each species (Fig. 4). With the exception of potato, each of these was found to have a narrow root cylinder (less than 4 inch diameter at harvest). Potato is known to have a shallow, inefficient root system with few root hairs even though its root cylinder is relatively wide. The maize, wheat, and soybean showed no increase in percentage of plants above the critical level for B.

These results show that some species benefitted at varying levels from improved B distribution uniformity with the low B concentration, homogeneous fertilizer. This appears to be related to root morphology. Crops with root systems having a narrow diameter showed an increased benefit from the use of homogeneous K/B granules as compared to the blended traditional fertilizers. In general, species with wide root systems appeared to see little benefit of one B fertilizer over another due to their ability to collect nutrients from a wider area of soil and subsequently have a greater chance of encountering more individual fertilizer granules. The potato is an apparent exception, being responsive despite its wide root system. This is likely due in some unknown way to its relatively weak root system.

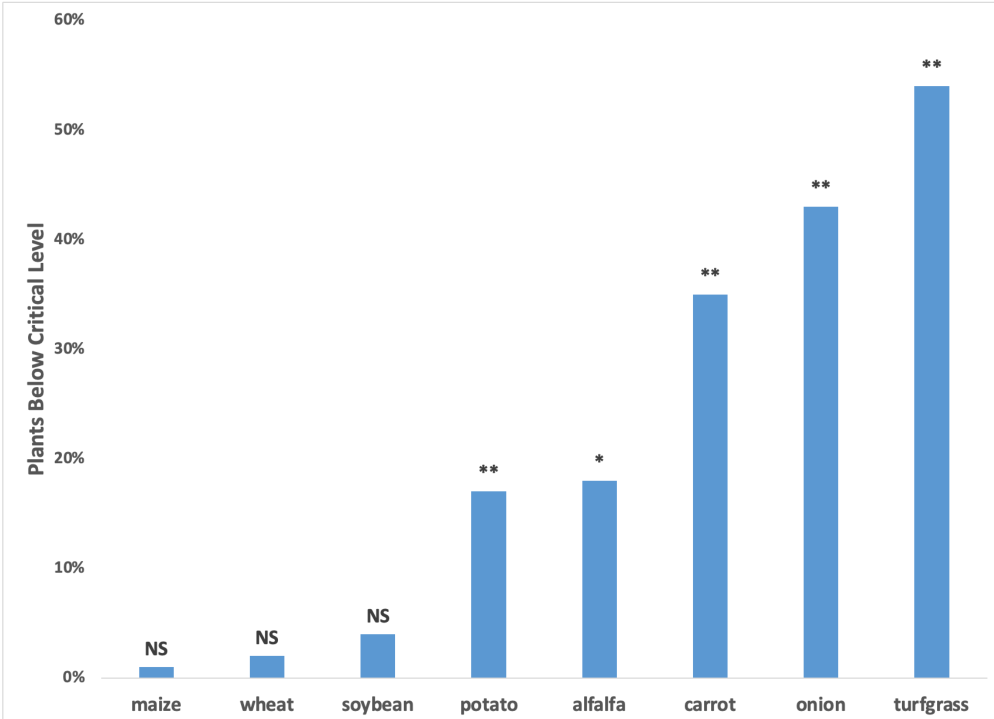

*Fig. 4. Nutrient Uptake and percentage of plants below critical level of B. NS = not significant, * = significant at P = 0.05, ** = significant at P < 0.01.*

SUMMARY

The utilization of fertilizer with homogeneous K/B granules (such as Aspire) provides a better spread of B and allows for better B nutrient uptake (especially in crops with narrow root cylinders) than the utilization of blended fertilizers with B as individual granules (such as Granubor). For crops with wide root systems, there seemed to be no advantage of one fertilizer over another.

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