Micronutrients Promote Nutrient Use, Pest, and Disease Control

Phenotypic expression of modern genetic traits another plus.

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Summary: *We are on the threshold of a new era for seed treatment methodology and agronomic application that will routinely include micronutrients to realize maximum nutrient use, pest and disease control, and phenotypic expression of modern genetic plant traits. Our work shows that seed treatment with micronutrients can be a valid component of an integrated total crop production program. In time, we visualize genotypic matching for such programs from germination to harvest by maximizing season-long gene expression.*

One of many treatments in a constant evaluation of different nutrient combinations, this one showing soybeans with top row containing Manganese and Calcium.

Our early research on the subject of micronutrient seed treatments revealed the following:

- It is not a new concept
- Most data point to a positive agronomic response
- It is not easy at a practical dealer/farmer level
- Early-season applications do not necessarily cover entire growing seasons.

The seed of most common crop species is a phenomenal physiological capsule equipped with the genetics (DNA) of the next generation, ready to create the next iteration as an identical cultivar or a hybrid. This is a fact that agriculture has been taking advantage of for eons. The mineral content of the seed serves two purposes:

- Nutrition to the consumer
- Nature's starter for the next planting.

The primary seed proteins (phytin) are phosphate-rich and are the original starter fertilizer. As nitrogen (N), phosphorus (P), and potassium (K) fluid mixes soared in popularity during the 1960s and 1970s to supplement seed reserves, it became clear that early-season or at-planting applications of fluid starters or pop-ups actually hindered yield in certain circumstances. The fluid fertilizers in question were predominantly ammonium polyphosphate solutions. Though highly effective in delivering much needed P to the germinating seed, such a high P content in the immediate root zone reduced zinc (Zn) uptake to effectively retard early growth and subsequent gene expression.

At this juncture, the introduction of micronutrients to seed application of starter or pop-up fluids became a fairly widespread practice. However, chemistry prevailed largely over agronomics. Compatibility with fluid fertilizer was an issue. It is a very harsh chemical environment but eventually EDTA and related true, strong chelates became the norm. The original complete starter was born. "Close to the seed but not in damaging proximity" was the new maxim established by Glenn Brandt, Bill Lohry, and other early pioneers of the new "NPK fluid plus micronutrient" concept.

Early issues

Salt index, free ammonia, and positional availability of the nutrients were all issues with the starter, strip, split regimes that included the early crude (agronomically) micronutrient inclusions. Nowadays, superior chemistry, application, and timing prevail to allow continued use of seed-placed NPK, plus micronutrient fluid formulations, tailored to the crop in question.

Another early use of fluid fertilizers with micronutrients and seed gained some popularity in the 1980s, the so-called seed and feed applications. Suspension type fluid NPK fertilizers were mixed directly with the seed (such as wheat and alfalfa) prior to broadcast application via flood jets. Intimate contact of nutrient and seed was thus assured at critical early growth stages of the crop.

In earlier and later crop protection developments, micronutrient applications to seed became somewhat of an accidental tourist, yet widely accepted as the progenitor to modern seed micronutrient treatment options for many crops. The inclusion of dithiocarbamate fungicides with seeds to prevent fungal pathogens would include nutritionally significant levels of zinc, manganese, and copper or combinations thereof. Subsequent widespread use of other seed fungicide treatment has perhaps further justified specific micronutrient application to the seed.

Seed treatment

There is ample evidence that in-season micronutrient applications, combined with a multitude of husbandry and environmental factors, strongly influence the expression of the genes carried by the seed. However, seed treatment with micronutrients has hitherto proved problematic from a widely adopted agronomic perspective. One of the major practical issues of seed treatment lies in the morphology of the seed coat itself.

Early seed treatments were mostly fine powder dusts that relied upon static charges to adhere to the seed. Some micronutrient powders can still be applied in this manner, but separation during seed handling may be an issue resulting in an irregular dose rate per seed. As with fluids, the seed coat will also influence adherence of the seed treatment and dictate dosage rates. Wheat and cotton, for example, have a relatively coarse seed surface, which assists in the buildup of a liquid or dry seed treatment. Canola and soybeans, on the other hand, have very smooth "slick" seed coats, which can limit both treatment dose and therefore ingredient inclusion. In the case of most fluid micronutrients, concentration of the metal is a limitation, as too much liquid is required to provide an agronomically significant level of metal, particularly when the desired level of fungicide, insecticide, and possibly a microbial inoculant are already standard in the seed treatment liquid.

Experimentation

Recent advances in polymer and inert technology and the process of seed treatment have all contributed to a renewed interest in practical application of early-season micronutrients to the seed. Our early experimentation concentrated on chelated metals, such as EDTA manganese, added as a fluid to the seed treatment mix and introduced into the treatment machinery with the seed. Concentration was indeed an issue as was the integrity of different polymers used as a sticker in the process. On a number of occasions, we could produce a solid fifty-pound seed "brick" in the bag or at best a poorly flowable seed mix, which would "bridge" in the planter boxes, resulting in missed seed planting and clogged planters. Needless to say, even if the agronomics made perfect sense, the practicality of the technique did not. Elsewhere, other teams had reported varying degrees of field success with soybean (dry EDDHA iron) and rice (zinc oxysulfate/oxide suspension) seed treatment.

We had chosen fluid EDTA chelates as we recognized the need for a soluble plant-available micronutrient from germination onwards in the plant life cycle. Concentrated suspensions can be made with inorganic salts such as metal sulfates and oxides, but water solubility (soil solution, rhizosphere) and plant availability are a concern. Release and uptake of the metal are often reliant on root exudates, including solubilizing organic acids as the plant grows–such a process is heavily species and environmentally dependent, another practical uncertainty.

Solid contender

We are optimistic that progress in material chemistry advances have put practical, reliable seed treatment with dry chelated micronutrients as a solid contender for future agronomic uses. Moreover, our current experimentation includes the interaction of metal with fungicide, insecticide, and inoculant treatments and increasingly a variety of bio-stimulants. Such treatments are also contrasted with major fluid fertility options including starter fertilizers, strip banding, and side-dressing. The subsequent use and rationale of in-season foliar micronutrients to further supplement plant growth and development is another important dimension.

Worldwide references

A review of literature on the subject of micronutrient seed treatment reveals many worldwide references covering zinc, boron, manganese, molybdenum, cobalt, copper, and iron. Much of the research has concentrated on easy seed application techniques for developing countries to enhance the nutritional quality of grains and legumes with varying success. Our information suggests that for high yield and intensive crop production, supplemental foliar or side-dress applications will be required to assist grain and seed concentration of micronutrients at harvest.

Probing deeper

Much of the foregoing has covered seed coating and/or pelleting techniques, the norm in developed agriculture. A continuous layer over the seed coat is designed to influence early micronutrient nutrition at a very intimate soil/seed interface, notably zinc. Such influence can improve yield and stress resistance. Since a great deal of stress mitigation after herbicide application or drought is through metalloproteins acting within cells to detoxify compounds or mop up free radicals (e.g. stress induced peroxides), this makes perfect sense. Interestingly, boron seed coats have increased yields of a number of crop species, including legumes. By contrast, early experiments cautioned over use of boron because of phytotoxicity. In legumes, however, adequate root B levels are positively correlated with nodulation--low levels, foiling colonization by N-fixing bacteria.

Our early data show a very positive effect from manganese seed treatment in soybeans in the absence of "deficiency". We postulate a role for metalloprotein synthesis and phosphate availability as a possible mechanism. Nickel and molybdenum have also been included in seed costs but concentration can be problematic--Mo can kill inoculant bacteria in some cases and Ni can be a fairly effective herbicide if over-dosed. Nonetheless, molybdenum/cobalt mixes are fairly popular seed applications in South American soybeans.

Seed priming

An old gardener's trick is to soak seeds in water prior to planting to speed germination and emergence after sowing. In such a manner seeds are partially hydrated and permit the start of metabolic processes without germination. In an agricultural context, such seed priming has involved dilute solutions of micronutrients to elevate seed and young shoot tissue levels to produce positive agronomic effects, including faster emergence, drastic reductions in soil application rates, early growth and subsequent yield enhancement. Such priming with zinc solutions, for example, has improved early seeding development, hormone synthesis (cell extension), stress mitigation, and resistance to soil pathogens. Similarly, seed priming with boron can improve early physiological functions including protein sythesis, hormone production, cell wall integrity, and N metabolism. Molybdenum is also intimately involved with N assimilation in legumes (N-fixation) and non-legumes (soil N utilization, reduced leaf nitrate accumulation). Some others have postulated that seed priming with Mo solutions can be much more effective than soil applications yet the antagonism toward N–fixing bacteria needs further evaluation. The beneficial effects of seed priming with Cu, Co, and Mn have also been documented.

Summing up

In conclusion, we believe we are on the threshold of a new era for seed treatment methodology and agronomic application that will routinely include micronutrients to attain maximum major nutrient use, pest and disease control, and phenotypic expression of modern genetic plant traits. Much of the positive effects will not necessarily require traditional deficiency levels but will improve cellular and organelle functions to improve productivity on the modern farm matched with modern genetics for many crop species. Seed treatment with micronutrients can be a valid component of an integrated total crop production program. In time, we visualize genotype matching for such programs from germination to harvest by maximizing season-long gene expression.

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