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The Weeds Are Winning!

Resistance to Herbicides in 21st Century Farming

By Paul W. Syltie, Ph.D.

Nature has a way of getting our attention, even in the age of high-technology agriculture. Who would ever think that an article entitled "The War of the Weeds" would ever be seen in a major agricultural magazine? Yet, rather suddenly the realization that weeds are indeed winning the battle against herbicides has indeed made headlines.

For some time it has been known that weeds would eventually adapt to toxic chemicals and survive their application. Genetic variability in plants has allowed a few herbicide-resistant biotypes to survive, especially those resistant to triazine and acetolactate synthase. However, now weeds are being found that tolerate glyphosate, the active compound in Roundup, the world's most popular herbicide. Resistant weeds such as marestail, lambsquarters, and common and giant ragweed are being found in fields all across the United States and in other countries where herbicides are widely used: England, Europe, Asia, and Australia.

Common ragweed may appear harmless and beautiful, but when it develops herbicide resistance it becomes a undignified menace to crop production.

According to Jeff Stachler of The Ohio State University, "No herbicide stays effective forever, and the honeymoon is definitely over for glyphosate and PPO [protoporphyrinogen oxidase-inhibiting) products."[1] He recently stated that 30 to 40% of the soybean fields in Southern Ohio still have visible ragweed after herbicide application. Even 22 ounces per acre of Weather Max — far above the recommended rate — will not kill some ragweeds and lambsquarters.

The ascent of Roundup resistant weeds is a dark harbinger for the future of Monsanto, its producer, whose sales of the herbicide constitute about 40% of its revenues. Because of Roundup's great success, relatively few alternative herbicides have been developed during the past years, so farmers are somewhat limited in choices of chemicals for weed control.

Marestail serves as a good example to illustrate what havoc herbicide-resistant weeds are capable of wreaking. In a

See Cultivation May Replace, page 2

"Terra Pretas", Tutors of Soil Fertility?

By William Corliss

[Edited from Science Frontiers*, No. 144, Nov.-Dec., 2002, extracted from "The real dirt on rainforest fertility" by C. Mann,* Science *297: 920, 2002]*

When, in 1542, the Spaniard Oreliana explored the reaches of the Amazon, he reported that the lower third of that great river was marked by large native settlements bristling with unfriendly warriors. When Oreliana reached the spot now called Tapajos, so many people rushed down to the river bank that he and his men retreated in fear. Yet, many years later, other explorers saw naught of Oreliana's throngs of natives. In fact, the lower Amazon seemed an unlikely place to dig for signs of ancient civilizations. So, most archeologists ended up admiring the architecture of the Inca in the high Andes and the Moche along the Pacific Coast.

The situation is changing, though, because those archeologists who cared to look have confirmed Oreliana's records. The Tapajos site has yielded evidence that 200,000 to 400,000 people had thrived there a few centuries before the Spanish ships sailed up the Amazon. Tapajos was then about the size of Tenochtitlan, the Aztec capital in Mexico and then the largest city in the world.

Could something as simple as charcoal be a key to long-term soil fertility?

Where did all of Tapajos' people go?

See Terra Pretas, Built With, page 6

Cultivation May Replace Chemicals

Continued from page 1

Delaware soybean field in 2000 a few resistant marestails were noted. Within two years the farmer was forced to spray glyphosate several times to kill the weeds, an expensive proposition. Now, according to University of Delaware agronomists, the weed infests tens of thousands of acres in the East as well as in Tennessee, Kentucky, and other states.[2]

Furthermore, water hemp is becoming harder to kill in the Corn Belt. Resistant biotypes of ryegrass have appeared in almond orchards in northern California, as well as in wheat fields in Australia.[3] Interestingly, this degree of resistance has popped up rather suddenly the last several years after about 30 years of glyphosate use. The reason for the rather sudden emergence of resistance may be due to such widespread recent use of the chemical across the world: 40% of the corn acreage, 85% of the soybean acreage, and 75% of the cotton acreage in the United States in 2006 were planted to Monsanto's Roundup

Lambsquarters is common throughout the nation and can develop herbicide resistance over time.

Ready varieties.

In England, five major weeds have especially become problematic in herbicide treated fields.[4] Black-grass occurs on virtually every farm where herbicides are regularly used to control it, and it resists nearly all herbicides. Wild oats has developed resistance in many areas, as has Italian rye-grass. Common chickweed and common poppy have become problems where sulfonylurea herbicides have been used heavily. Some plants have developed resistance to triazines, and even paraquat in certain locales.

The Solution

To prevent or delay herbicide resistance in fields, it is first best to scout for weed patches in treated fields. Strips of weeds usually mean only a spray pattern problem.

Even if a resistance problem is not apparent, it is wise to employ the following suggestions.[5]

1. **Rotate herbicides**
2. **Rotate crops**
   a. Plant a crop having a different growing season.
   b. Plant a crop having a different registered herbicide.
   c. Plant a crop for which there are alternative weed control methods.
3. **Monitor weeds after herbicide application**
   a. Check for weedy patches.
   b. Hand-weed patches that are not a result of spray pattern problems.
4. **Utilize non-chemical control methods**
   a. Cultivation
   b. Hand weeding
   c. Mulching
   d. Solarizing
5. **Use short-residual herbicides.**
6. **Plant weed-free certified seed.**
7. **Clean weed seeds from equipment**

If resistant weeds are already present these same points will help control the species. As herbicide resistance becomes more of a problem, the time will come that time-proven methods of weed control will return: cultivation, manual pulling, flame cultivation, and other innovations. Of one thing we can be sure: nature always wins its battles with mankind, and chemical methods will not forever hold sway on the land. ❑

Spraying herbicides like Roundup on weeds in corn, soybeans, or cotton is an easy way to rid the field of weeds, but eventually they will cause resistance to the chemical.

Bibliography

1. Schrimp, F.P., 2006, The war of the weeds, *Crop Life*, October.
2. Pollack, A., 2003, Widely used crop herbicide is losing weed resistance, *The New York Times*, January 14.
3. Same as 2.
4. Moss, S., 2006, *Weed Resistance Action Group Latest News*, Herts., England.
5. Vargas, R., 2001, Herbicide resistance, University of California Cooperative Extension Service, Madera and Merced Counties, California.

Green Grass?

The grass is not, in fact, always greener on the other side of the fence. Fences have nothing to do with it. The grass is greenest where it is watered and fertilized. When crossing over fences carry water with you, and tend the grass wherever you may be.

Adapted from Robert Fulghum, *Bits and Pieces,* sample issue

Crop Yield Records Keep Coming

by Paul W. Syltie, Ph.D.

Yield records, like weather records, seem to know no limit these days as farmers push the limit for achieving maximum yields. Ever since Francis Childs' phenomenal 442 bu/acre corn yield in 2002 at Manchester, Iowa, many farmers have tried to surpass that record. Some year someone will.

The secret to high soybean yields is to set lots of pods and keep them there.

While the corn yield record did not fall in 2006, the soybean record did, and not by a little. A whopping 139.39 bu/acre were harvested by Kip Cullers near Purdy, Missouri! That yield, however, was not produced under the conditions most farmers use for their 40 to 60 bu/acre harvests. Cullers raised his bean crop like he would a crop of green beans, the main focus being on preventing pod bloom abortion.

He started with a good soil — Newtonia, a rich, red sandy loam in a conventionally tilled 40-acre irrigated field. The variety he chose was Pioneer 94M80, a late-Group IV Roundup Ready variety having cyst nematode resistance. A population of 300,000 seeds was planted in 7.5-inch rows, the final stand being 245,000 plants/acre.

A major effort was made to irrigate the beans regularly, every day or two, to prevent heat stress and thus signal the plants to retain their blossoms. Since the potential for disease with wet plants was high, he sprayed them with Headline and Warrior as the label directed. Foliar feeding with ammonium sulfate was performed through the irrigation system.

As a result of this management program, his beans developed extraordinarily thick stems, as big as one's thumb, having two branches.

The yield potential of soybeans is indeed remarkable if one can keep the developing pods from falling off. Cullers' beans averaged 120 pods per plant, but even that number is far below the potential for soybeans. Look at the facts:

A typical soybean plant has about 20 nodes on the main stem, and two branches with five nodes each, a total of 30 nodes.

- There are 12 to 14 flowers per node, each of which is a potential pod.
- This gives a total of about 360 potential pods per plant.
- With three beans per pod, there would be 1,080 beans per plant.
- If there are 250,000 plants per acre, then there would be 2.7 x 10^8 seeds/acre.
- At 3,000 seeds/lb, there would be 90,000 lb/acre of seeds, or ***1,500 bu/acre of soybean yield potential!***

Thus, it is obvious that the yield potential of soybeans is tremendous if every factor within the environment — water, nutrients, temperature, disease and predator suppression, root growth, etc. — is optimum. Yet, we live in a world in which environmental conditions are often far from perfect, and our cultural methods do not always encourage high porosity and low bulk density of the soil. Machinery, pesticides, and reduced soil organic matter contribute to compaction and reduced rooting.

Take a look at Francis Childs' major methods and goals for raising record corn yields in the information box. ❑

To raise record corn yields the conventional way

◆ Maintain a high plant population (up to 44,000 plants/acre).

◆ Keep soil tilth strong by reducing tillage and trips over the field.

◆ Build high soil nutrient levels at deep levels: phosphorus at three to four times normal optimum levels, and potassium at 10 times optimum levels to 24 inches are not excessive.

◆ Apply nitrogen several times, such as fall plowdown (50 lb/acre, urea), pre-plant (250 lb/acre, anhydrous ammonia), sidedressed with herbicide (50 lb/acre, 28% UAN), and sidedressed two weeks before silking (55 lb/acre, 28% UAN).

Band or Broadcast Fertilizer Basics

By Paul Fixen, Ph.D.
Potash & Phosphate Institute

Several benefits are often cited for band application of fertilizer in contrast to broadcast application. They include:

♦ Higher yields and drier grain at harvest due to a "starter" effect.

♦ Reduced potential for P loss in runoff.

♦ Greater effectiveness of fertilizer in high fixing soils.

♦ Increased efficiency in reduced or no-till systems where P and K become severely stratified, and applied N has the potential to become temporarily immobilized by surface residues.

♦ Some suggest nutrient rate reductions compared to broadcast applications due to increased efficiency for band placement.

Careful examination of research results across years and locations indicates that these benefits of banding are not always measured and that several factors influence the shape of relative response curves for band and broadcast applications. The following graphs contain hypothetical curves based on many experiments where band and broadcast comparisons have been made. Four general situations with associated types of response seem apparent and are described in the graphs on page 7.

Wise nutrient management incorporates a long-term approach to fertility management in which site-specific soil test target levels are established for each field or field area and nutrient management plans developed to attain and maintain the target levels. Facts arguing for such an approach are: (1) Soil tests are better at predicting the probability of a profitable response to nutrient application

See Banding Fertilizers Not, page 7

15-Minute Soils Course

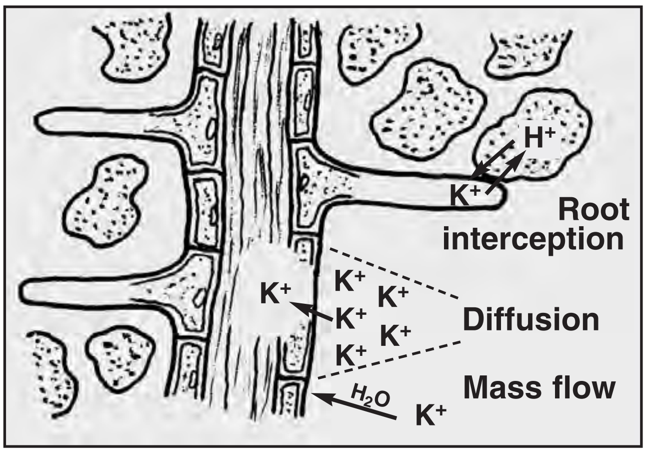
Lesson 23:

Potassium (K): a Chemical Traffic Cop

Amongst the major plant nutrients, none is more important than potassium (K). It is essential to all life, both plant and animal, and because the element is so reactive it is never found uncombined. The seventh most abundant element on the planet, soils contain from 2 to 30 tons per acre 6-inch furrow slice.

It is found in four basic forms in soils:

1. **Minerals and rocks** (very slowly unavailable)
2. **Fixed within clay interlayers** (slowly available)
3. **Exchangeable on clay and organic matter surfaces** (easily available)
4. **In the soil solution** (readily available)



The means by which K is taken up by plant roots are illustrated in the figure above. A 373 bu/acre corn crop is said to absorb about 4 lb/acre by root interception, 32 lb/acre by mass flow, and 138 lb/acre by diffusion, but in reality the mycorrhizal fungi and other organisms play a major role in bringing K to the root. Microbes are also the means by which potassium is solubilized from rocks and clay minerals.

In the plant, K is concentrated against a gradient by an energy-requiring "ionic pump" across cell membranes. The plant sap K concentration is much greater than in the soil.

Functions of Potassium in Plants

1. Enzyme activation. Enzymes are biological catalysts that govern all plant metabolic processes. Potassium functions to help shape the proteins so they remain active, and its concentration governs reaction rate.

2. Water use. Potassium serves to "pull" water into cells through osmatic pressure. It governs the opening and closing of guard cells in leaf pores (stomata).

3. Photosynthesis. Potassium maintains the balance of electrical charge at the site of ATP production, the initial high-energy product of photosynthesis.

4. Transport of sugars. Moving sugars from photosynthetic sites requires ATP energy, a result of potassium activity.

5. Protein synthesis. Again, ATP is required to bring nitrogen into the plant and polymerize amino acids into proteins.

6. Starch synthesis. Enzymes essential for this process are activated by potassium.

Fertilizer Potassium Effects

Potassium is a great **reliever of drought stress**. During drought the water films on soil particles which transport K become very thin, making it difficult to move into the plant; more soil K allows more to be taken up. Also, adding K brings in more of this element during cool temperatures when it is harder to get into the plant.

Although K does not form an intergral part of organic compounds — as do N and P — it functions as a "**chemical policeman**" or "**free**

Typical Maturity and Yield Responses to Potassium

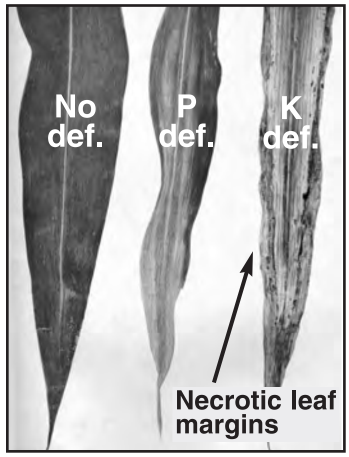
K_2O rate	Days to silk	Yield
lb/acre	days	bu/acre
0	83	142
60	81	155
240	80	170

Continued on the next page

15-Minute Soils Course

agent” to keep the plant growing and aid in metabolic processes. It **hastens silking** of corn while lengthening the grain filling time. With soybeans, maturity is delayed somewhat as pods fill better.

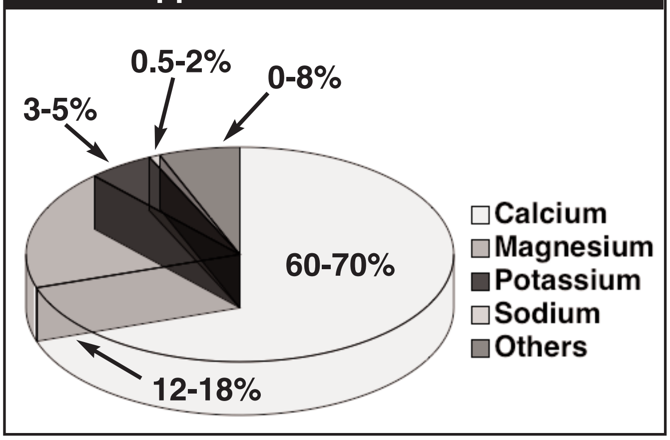
Potassium aids in **disease resistance** by strengthening cell walls, increasing the silica content of cells, and improving overall plant nutrition and health. As a result, stem strength is increased and **lodging is reduced**. Also, **legume nodulation** and **nitrogen fixation** are enhanced with K, sometimes dramatically.



Improved yields

In virtually all situations, supplying K when the soil is deficient will improve crop yield and health. In fact, plants will take up more K than it needs if supplies are available (“luxury consumption”), probably giving added benefits to plants. It is important to balance K with the other soil elements, since all of the elements work together to build yields and quality. ***SUCCESS IS IN THE BALANCE***.

Soil Cation Base Saturation Should Approximate This Balance



Interactions

Potassium interacts positively with nitrogen and phosphorus to increase yields and plant health. It will depress zinc, magnesium, and molybdenum uptake, and can lead to hypomagnesemia of livestock grazing on grass recently treated with K. The monovalent (+1 charged) K will displace some of the magnesium in cells.

Deficiency Symptoms

Because K is highly mobile in plants — much of it is in the plant sap — it will move from older to newly growing tissues in deficient plants. For corn, the symptoms first show up as necrotic edges of the lower leaves, and likewise for grapes. One the other hand, nitrogen deficiencies are defined by yellowing along the midrib areas of most plants. ❑

See How Much You Learned

1. Potassium can be taken up by plants by what methods?
   a. Diffusion b. Root interception
   c. Mass flow d. All of these points
2. Potassium is very important for plant drought tolerance. T or F
3. A major way that K acts in plants is through ____________ activation.
4. Potassium is highly mobile in plant tissues, and will move from older to newer leaves if the plant is deficient. T or F
5. Which of these effects are usual with adequate K?
   a. Better disease resistance
   d. Overall better plant health
   b. Poorer drought tolerance
   e. Reduced photosynthesis
   c. Reduced lodging
6. A plant that takes up more K than it needs is enjoying “_____________ consumption”.
7. Enzymes are not activated with K. T or F

Answers: 1. d; 2. T; 3. enzyme; 4. T; 5. a, c, d; 6. luxury; 7. F.

Terra Pretas, Built With Charcoal?

Continued from page 1

How did they and their sister cities along the Amazon and its tributaries make a living before they disappeared?

They left no pyramids, no Stonehedges, no steles carved with symbols to tell us. In fact, their most remarkable creations that have survived the centuries are incredibly fertile plots of black earth called "terra pretas".

The terra pretas were much more valuable than stone circles to the early Amazonians because they provided food in abundance. Most jungle soil is very poor. Almost all of the jungle's carbon and soil nutrients is stored above ground in the vegetation. Slash and burn this vegetation into ashes — as is the habit of today's natives — and you can raise crops for only a couple of years, and then the soil is worn out.

But, beginning about 600 B.C. the ancient Amazonians learned how to make their terra pretas. These rich plots of black earth, when farmed properly, can provide food crops almost indefinitely. They are the key top dense populations in the South American tropics.

Some terra pretas occupy just a few acres and remain the most valuable farmland in the Amazon Basin. Some of the old terra pretas stretch for 7 kilometers and were a kilometer across. Their black soil is only a few feet deep and,

A typical Amazon Oxisol soil with little carbon and fertility.

An Amazon Terra preta soil having high fertility and carbon.

strangely, chock full of broken pottery — much of it apparently broken *intentionally*!

How were the terra pretas made? Modern agriculturalists do not really know. In fact, they are currently trying various ways to duplicate them. Perhaps the most important component is charcoal — *not* ashes. The Amazonians also added animal bones, excrement, and other biological debris. And, as just mentioned, an abundance of potsherds. One terra preta mound is estimated to contain 40 million potsherds!

The major questions associated with the terra pretas are:

1. Why so many potsherds, which seem to have no agricultural value?

2. Why was so much labor-intensive pottery deliberately smashed?

3. What happened to the great crowds of natives seen by Oreliana?

4. How did the Amazonians control the weeds? This is not a trivial concern to today's terra preta farmers because the native weeds, given such rich soil, easily out-compete food plants and overrun the plots.

The Soil Biogeochemistry Program at Cornell University is studying terra preta soils in the Amazon Basin, and has concluded that incompletely combusted wood likely makes up much of the high content of carbon in these soils. They contain up to 50 grams of carbon per kg of soil, five to seven times more than surrounding infertile Oxisols. The depth of the fertile soil layer may be 2 meters, but is generally 40 to 50 cm. They have higher phosphorus levels and a fairly high cation exchange capacity, pH, and base saturation than surrounding soils. Some of the native farmers who have begun farming the terra preta soils have noticed a marked improvement in health and vitality, surely related to the superior nutritional value of the food crops being grown on these soils. ❑

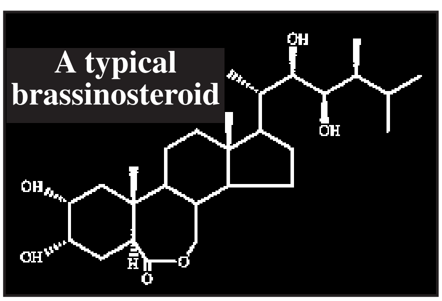
Brassinosteroids...Growth Regulators for Century 21

An entire new group of growth regulating compounds has been discovered. First isolated in the late 1970s, these compounds are called "brassinosteroids" and are especially found in the phloem of plants. They are also present at extremely low levels in all plant tissues.

Plant steroids are nearly identical to the steroids of mammals, birds, and reptiles, and are close cousins of cholesterol. Applied at levels of about 20 to 50 mg per hectare (2.47 acres) — which is hardly detectable — these biostimlant molecules can cause profound growth and yield stimulation.

Of great interest is the fact that Vitazyme, produced by Vital Earth Resources, contains levels of brassinosteroids that are active at the usual 1 liter/ha (13 oz/acre) application rate. You will be hearing more about this new discovery in upcoming issues.

Below is a typical brassinosteroid found in nature, one out of dozens that have only recently been discovered.



NEVER, NEVER GIVE UP!

Past performance is oftentimes a good indicator of a man's future potential ... but not always.

In 1860 a 38-year-old man was working as a handyman for his father, a leather merchant. He kept books, drove wagons, and handled hides for about $66 a month.

Prior to this menial job the man had failed as a soldier, a farmer, and a real estate agent. Most of the people who knew him had written him off as a failure.

Eight years later he was President of the United States. The man was Ulysses S. Grant.

Bits and Pieces, May 30, 1991..

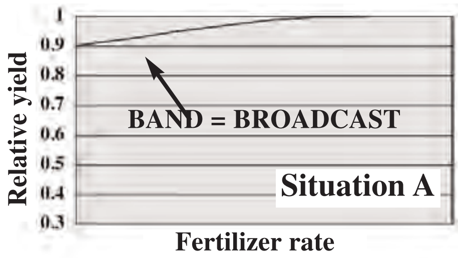
Banding Fertilizer Not Always Best

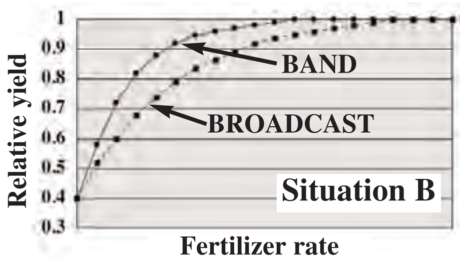
Continued from page 3

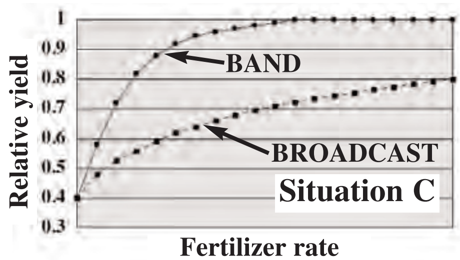
than they are at predicting the actual quantity of nutrient that will be needed in any one year; (2) Research in the U.S. and Europe shows that in any one season, a soil testing low in a nutrient often will not yield as well as a soil testing at an optimum level no matter how much fertilizer is applied that year. The target levels are influenced by many factors including relevant soil test calibration, land tenure, grower cash flow, yield potential, soil test level variability within the area sampled, grower goals, and … fertilizer placement.

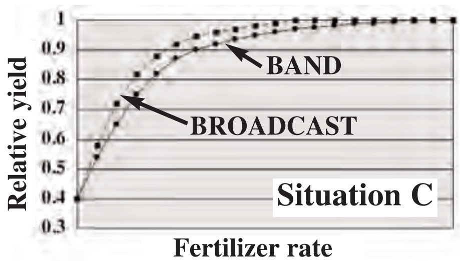
Band application in situations B and C reduces the probability of losing yield or quality while soil tests are being built to their optimum or target levels and allows for a slower rate of build. Regardless of placement method and for long-term profit optimization, rates should be sufficient to build to and maintain planned soil test targets. Conservative soil test targets increase the probability that placement differences will exist (Situations B and D), while more liberal targets offer greater flexibility in placement and timing of applications (Situation A). Remember that Setting 1 of Situation C, a true "starter" effect, can occur regardless of soil test level.

Different hybrids and varieties can differ in their responses to starter bands. There is often not enough information to know which ones will respond well, so caution is urged when making decisions about whether or not one cropping system will apply to another. ❑









Band equals broadcast

◆Most commonly observed when soil test levels are relatively high, resulting in limited fixation of broadcast P or K.

◆Thorough incorporation of fertilizer results in good root contact and fertilizer located in moist soil.

◆Warm season crops such as soybeans, sorghum, and sunflowers.

Band exceeds broadcast at low rates but both eventually reach the same maximum yield

◆Most commonly observed when soil test levels are low, fixation of applied nutrients is moderate to high, and soils are cold and wet.

◆The assumed response type when fertilizer rates are reduced if band placement is used.

◆As soil test levels climb the differences between band and broadcast placements diminish and usually become zero (Sit. A).

Broadcast never attains band yield. At least two sets of circumstances:

◆***Set 1***: A cold, wet soil leads to large early growth response to banding when this accelerated early growth is critical in achieving the season's full potential ("starter" effect).

◆***Set 2***: A relatively low soil test level, minimal incorporation of broadcast fertilizer, and dry surface soil conditions.

◆Under these circumstances the optimum band rate can be higher than the optimum broadcast rate…the opposite of Situation B.

Broadcast exceeds band at low rates but both eventually yield the same

◆Most common on low fixing soils with heavy residue cover and a warm moist soil surface such as in no-till systems in humid environments or under irrigation.

◆Band applications are not as effective because of insufficient root-fertilizer contact. Sometimes observed with soybeans.

◆In cooler environments or where early growth is critical, a combination of broadcast and band applications likely give best results.

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Vitazyme has once again been shown to significantly increase corn and soybean yields in the heart of the Corn Belt. At Cedar Falls, Iowa, corn grain increased by 25.8 bu/acre (18%), and soybeans increased by 4.6 bu/acre (9%) in studies having four replicates (P = 0.05).

Only a seed and a foliar application of Vitazyme, each at 13 oz/acre, caused this excellent response in root and stalk growth. The Vitazyme treatment is on the right.

Vital Earth/Carl Pool logo and return address