Down the Wormhole

JR Bollinger's Story
first year success with
carbon-smart, biological farming

***David Yarrow*, April 6, 2016**

After last Thanksgiving, I sat down with Missouri bootheel farmer JR Bollinger for a long interview about his experiences in 2015 in his first year of full commitment to growing corn, soybeans and milo by principles and practices of carbon-smart, biological agriculture. After Easter, I was fortunate to enjoy another afternoon with JR learning worm calling.

"I farmed since the day I was born." David "JR" Bollinger spoke quietly, slowly, with careful phrasing. "Worked on the farm my whole life. I'm the 4th generation to farm here in the southeast Missouri Delta. We farm 3,500 acres. Our main crops are corn, soybeans, wheat, and milo."

A Search for Life

"In 2012, I first dabbled in biological farming on a reclaimed coal mine. A gentleman with microbial products first tickled my brain about dead soil. He challenged me to find an earthworm on this farm. So, I went looking, and... None. I noticed there wasn't a lot of life. Soil looked like moondust, vacant of life."

First Principle of Biological Farming
Dirt is inert, but Soil is alive

More than mineral dust, soil is a creation of biological organisms. Soil is not only made by microbes, soil IS the microbes, and a living matrix and infrastructure they create to support their invisible communities.

JR went, "So, I sprayed his microbe mix of bacteria, fungi and humates at 1 gallon/acre on 50 acres. That year was the big drought: three full rains on that farm the whole year. 80% loss on the 1000 acres. But 50 acres where I applied his microbes actually had a good crop."

"So, I said, 'Maybe these wee little guys are something.'

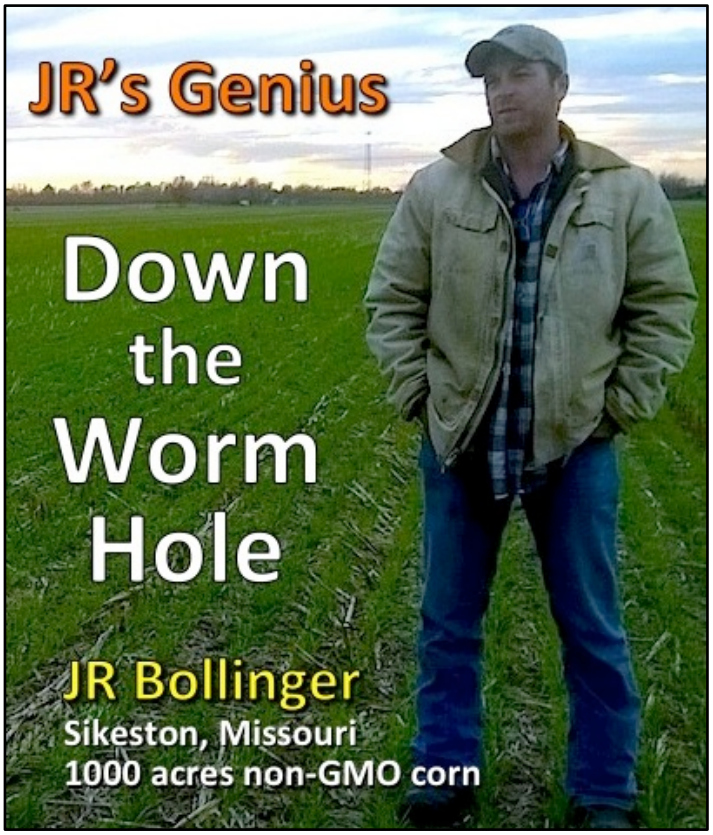
"But what really got me was back home in Missouri, the land my family farmed for four generations looked similar. I looked for earthworms in our soil, for signs of life on our farm. Land we farmed was similar to reclaimed mine land."

Observant, thoughtful, JR questioned why soils were so lifeless. "Because of the kind of person I am, I started digging in, and wow! I'm fortunate to live in a time when I can dig as far as I want. Why is this? Why is that? So many different layers of life.

"I tinkered with mixes under gro-lites in my basement to see what products do. In test pots, I saw effects and benefits. You can say I went down the wormhole."

Down the Wormhole

JR's voice softened to begin to speak of his new farming partners, "When you dig into what earthworms do, they're



fascinating. As a kid, I took them for granted as fish bait. Now, I see all their benefits. Tunnels they make, their movements in soil, their functions. They're key to good, healthy soil. If you have worms, you have healthy soil.

"Now that I appreciate earthworms, what can I do to make them happy? Anything I can do for those guys. "

New insights reveal earthworms are farmers, too. They pull plant biomass into their tunnels, not to eat, but as soft lining to grow bacteria and fungi. Later, a worm returns to graze this fuzzy film of mycelium and microbes. Worms farm their tunnels, cultivate microbes, and thus spread them throughout the underground.

One ton of earthworms in an acre of soil are a primary powerhouse to convert biomass into fertility and growth.

Test Plots

Urged by positive results and research, JR advocated changes in family farm operations. David Bollinger Sr.—also a creation of Missouri Delta farming—told me, "I had my first farm when I was 13. My own acre. So farming is pretty much all my life." David Sr. was skeptical of new products, cautious to spend money for them.

JR continued, "I started talking to Dad about biological farming. We started to farm different, use different methods. We started small. We didn't do it all at once. We did test plots for two years.

"We applied microbes to 1000 acres of corn, and reduced fertilizer on part. We noticed our plants grew bigger, better. We didn't have to water as much.

"In this county, we burn off wheat stubble for a double crop, fall planted.

After June harvest, we burn stubble and plant beans. But burning stubble gives away goodies worms and microbes need. So, we did a no-till second crop with the microbes, and saw more results.

"We were young at this type of farming. We didn't know what we was doing, but we were seeing benefits. Every time you see a benefit, it's human nature to keep doing that."

2015: Complete Commitment

"So, last year, 2015, I stuck my head in books, read about bacteria, fungi, mycorrhizae, cover crops, kelp, fishmeal, the whole smorgasboard.

"I saw benefits from microbes, so what can I do for microbes? If they do me a favor, what can I do for them? They need to be fed, too. Anything I can do to make their survival and functions easier. It's common sense, in my opinion.

"So, I dug into what makes their environment better, like conservation tillage. I see it as 'farming microbes', versus just applying a chemical. I dug into new products. When we applied biologicals, all of a sudden, boom!—plants are thriving, crops are healthy. As a side result, our soil is improving.

"Now that I had confidence in biological methods, I wanted to apply this on all our acreage."

JR didn't need to know IF biocarbon, microbes, trace minerals, and metabolites work. He saw consistent proof. JR decided put them to work on his farm. Not another tiny, one-year test plot, but full-scale, long-term application to fields and crops. One field, one crop, one year at a time.

First Encounter

March 28, 2015, I met JR at Missouri University Bradford Research Farm to teach at a Biochar Symposium sponsored by Phil Blom of TerraChar. Evening before, JR quizzed me all through dinner. Next day, after I taught two hours, JR had a steady stream of questions in the lobby.

In all my time with JR, he never said much, just kept asking. I saw his intense focus to soak up information. This intelligent young farmer had made his choice and set his course. My words would result in his actions.

Clearly, JR did his homework, knew enough to ask incisive, advanced questions. Clearly, JR set his mind to master and demonstrate this new farming. He chose to step in with both feet to implement better farming. My great joy is to pour knowledge and insight into such an intense, inquiring, adventurous mind.

We know biochar, trace elements and microbes are potent in soil—individually, but much more so mixed together. Can carbon-smart, microbe-friendly stewardship of soil be integrated into commercial farming? Can this be easy, economical, feasible for farmers?

JR had to bring these new products and methods together on his farm, in his soil, for his crops, with his equipment—with maximum effect, minimum material, no added cost, and utter efficiency. JR's challenge was to design equipment systems to use biologicals in large-scale operations. His first corn planting was 1000 acres.

JR decided to answer his own questions, design his own equipment, implement his own strategy, use his own resources. He knew no off-the shelf solutions exist. It was his burden to make this work—and convince David Sr. In his heart and gut, JR knew a biological path is key to farming's future—the 21st century farm frontier. I knew JR would make this happen on his family farm.

I didn't see JR again until after Thanksgiving for this interview. I did get a series of exciting photos.

JR's Genius

First was an impressive assembly of equipment, put together, made to operate as a unit to deposit narrow bands of biological nutrients precisely in seedbeds. With extensive farm equipment knowledge and savvy mechanical expertise, JR built apparatus to perform a miracle on near lifeless soil: instantly install the foundation of a healthy ***Soil Food Web***.

JR's genius isn't just to build complicated machinery. Rather, JR designed a way to mix nutrients precisely in the root zone with minimum disturbance. Emerging seeds find nutrients and symbiotic fungi all around budding roots.

"These products exist on the market." JR began to explain the rig he built. "I customized and tweaked them for what we want to accomplish."

"At front, hanging on the tractor, two yellow side-saddle tanks hold liquid nutrients and microbes. We inject this 4-inch off-center as a band. We stagger-step fertilizer in bands to chase roots to grow outward. It's a unique convenience to apply this extra band of nutrients.

"Liquid tanks had everything from synthetic fertilizer to

fishmeal—a smorgasboard. We tried different products, all kinds of goodies: humates, humic acid, sea minerals, microbes, fishmeal, even biochar powder. I wanted to give everything a fair shot, in our conventional way, and gradually introduce the biologicals.

Most microbes JR applied were liquid. One lab-brewed blend combines 16 bacteria and 9 fungi, plus supporting nutrients, like humates, trace elements and fish meal. The inoculant has free-living, nitrogen-cycle bacteria and phosphate-dissolving fungi. The goal is to get them in under the surface, in cool, moist soil with nutrients and metabolites to assure they proliferate.

Biological Farming Maxim:

Feed soil microbes, not plants

Biochar, however, is not a nutrient, and doesn't break down in soil—maybe 3%. Char is shelter, not food. Microbes don't eat this super-stable biocarbon, they live in it. Burnt biomass is community infrastructures to house microbes, with plumbing for water, thin-film wiring for power and shopping malls of nutrients. Biochar isn't a fertilizer, but greatly boosts fertilizer efficiency and curbs nutrient leaching and outgas.

Dry Fertilizer Buggy

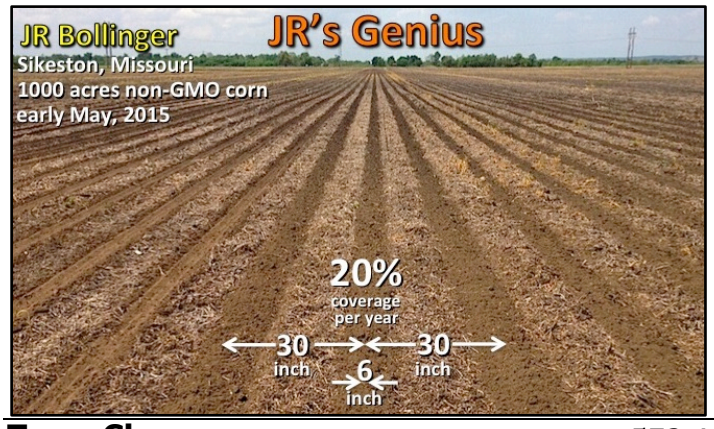
"Montag is our dry fertilizer cart," said JR. "We get a blend that meets the needs of our soil test. What's put in the Montag is based off each field's soil test.

"We mixed in anything from biochar fines to crab meal, shrimp meal, SEA-90, humates. The Dawn unit does an excellent job to mix fertilizer, char—anything that goes through the hose—and incorporate them into soil."

"The convenience to use chemicals like urea was something we had to do. You can't just go full bore into this. There's too many variables. You got to have some checks.

"With precise strip-till application, and biological amendments, I had confidence to cut dry fertilizer in half. We reduced our liquid fertilization as well. We didn't see any lag. If anything, we saw a boost."

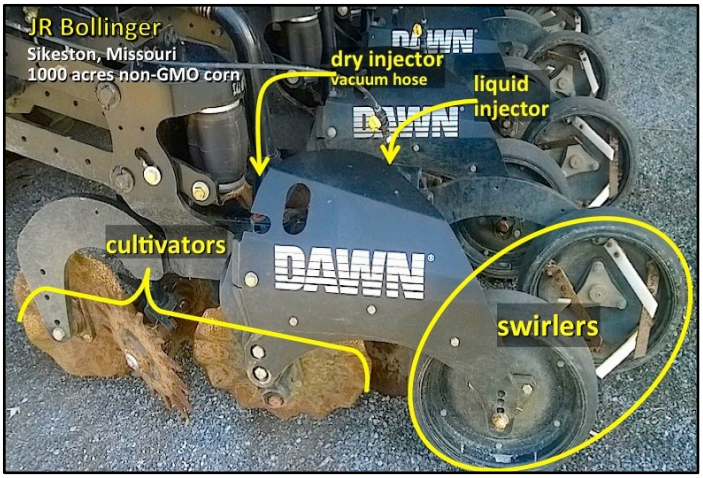
Dry ingredients are agitated and sucked by vacuum hose to injectors on Dawn cultivators. When they land in soil, biochar and fertilizer are mixed intimately. Biochar and biologicals were supplied by TerraChar, a 3-year-old biocarbon business near Columbia, MO. Owner Phil Blom delivered a semi-load of biochar sawdust fines for JR's soils, plus supporting minerals, microbes and metabolite. Phil was also steady guidance and support through the growing season.



Dawn Cultivators

A gang of 16 Dawn cultivators ride behind the tractor, each with injectors for dry, then liquid amendments. A complex weave of hoses, tubes and manifolds deliver nutrients to each unit.

JR explained, "I use Dawn 'cause we have sandy ground. Dawn has waffle blades, and is more vertical till, not deep tillage. It moves residue out of the way so it's easy to plant through the residue. I don't do deep till, like with shanks, because this leaves a trench fertilizer tends to go into. A deep trench can increase leaching.



"One side gets dry fertilizer, all mixed. Then, a few inches off center, the liquid band is applied. I get precise nutrient placement this way. Soil between rows isn't disturbed at all, so it's easy on microbes in that zone.

"Dawn keeps soil within the unit. Eventually, dirt hits it, flies up where dry and liquid lines come in. Then hits the lead edge of a disc blade. That fills up, hits a fender, then turns, like mixing potting soil with your hand.

"Dawn fluffs soil to make a seedbed. Soil warms quicker in spring to speed up planting dates. It's a perfect tool to closely place fertilizers. I love how Dawn handles residue, and keeps it confined."

Last part of each Dawn unit are "swirlers"—two rolling wheels with inward-facing fingers that lift and stir soil to mix ingredients and aerate soil in 4-inch slots.

Biological Farming Maxim:

Get it in the root zone

The great benefit of JR's rig is to concentrate precious nutrients and inoculants in soil where seeds will germinate, not broadcast wide, but thin, across the field. JR gently injects his menu in a dark, moist sub-surface world microbes

prefer, not exposed to hot sun and dry wind. Precision placement and intimate blending assures close proximity of nutrients for fast-acting effects.

Strip-Till

First way farmers degrade soil, burn out carbon and disrupt microbes is tillage. JR now knows tillage is to earthworms what Katrina was to New Orleans: catastrophic infrastructure degradation. Why burn fuel tilling, if worms will pull biomass into their tunnels? Let worms do the work.

JR explained, "I call this 'strip-till', or 'conservation till' because we do a percent of tillage. Each year, 20% of a field is tilled in 6-inch wide strips, to leave a nice mat of residue on 80% to suppress weeds. We notice when we irrigate, or a rain, covered soil stays moist longer due to thick residues.

"Residue was completely gone by end of July. I was fascinated to see how quick it disappeared. We're talking heavy, thick residue. I was concerned that residue, plus new residue, might be trouble next year, when we move tillage over a few inches.

"I also call this "carbon-smart" or "biological" farming. It's a hybrid—combining both traditional and modern. Really, what we do now is truly traditional. In my life, traditional became N-P-K, herbicides, lots of tillage and all."

Strip-till bands are spaced 30 inches apart. Each year, guided by GPS, JR will move his rig over a few inches, to inject another band of biochar plus inoculants, minerals and nutrients. In five years, he will deposit biochar, minerals and microbes all over his field, and need to use very little chemical fertilizer.

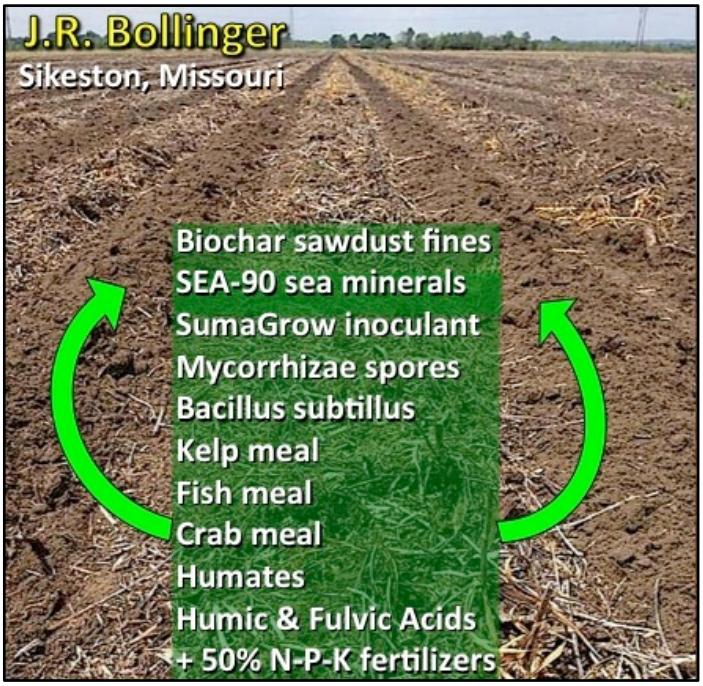
JR's rig spreads labor and cost to boost soil carbon and biology over a few years of incremental applications. Biologicals are integrated with normal farm operation, and their expense is offset by savings on fertilizers and chemicals. Meanwhile, JR is assured steady income, larger yields, higher crop quality, improving fertility as soil regenerates. Slowly, JR will wean his farm off chemical dependence.

Seed Starter

JR described another biological application at planting, "We also drench with a seed starter. We apply biological nutrients in furrow, right on top of seeds. As soon as a seed kicks out of its tiny nursery sack, I want it in a happy environment. Another stair-step for optimum germination and seed growth. I only use biological products over top of seed. I'm real cautious.

"Later, we sidedress 8 inches off the row—another stair-step. You can, at each stage of plant growth, key in nutrients before it needs them, to sit there waiting on the plant.

"We use a lubricant such as talc to help seeds flow and not lodge. This year, we used very fine, 40-micron biochar powder and mycorrhyizal inoculant as lubricants. We get beneficial fungi and biocarbon right by the seed, in direct contact. What's nice about biochar powder is spores definitely stick to char particles. Powder is tacky, sticks to my hand, so definitely will stick to seed.



"How much good it did, I don't know, but it can't hurt. I know our seed germination was off the charts this year."

Until nutrients are abundant and soil fully mature, soil nutrients must be supplemented by seed treatment, foliar feeding, root drenches, and sidedresings. The most critical extra feeding is starter food to wake up embryos and stimulate root growth.

JR used a TerraChar formula to blend biochar powder, kelp, humic acid, and a common bacteria. SEA-90 supplied complete trace elements with alkaline charge. Spores of endo-mycorrhizae added to initiate symbiosis with infant roots. Fishmeal offered amino acid nitrogen to emerging embryo and colonizing microbes.

SEA-90's unrefined sea minerals supply abundant trace elements. The sea is a complete menu of elements in balanced, fully soluble form. SEA-90 is fast-acting "igniter" to jumpstart soil biology, which then digests rock into new soil. The same full spectrum minerals are in other sea products, packed in different chemistry: kelp (carbon), fish meal (amino acids), shrimp meal (protein), crab meal (chitin).

Healthy Start

"I planted a population of 34,000. That's typical for this day and time. Years past, I planted 28 to 30,000. My planter can change populations. In strong or weak parts of a field, I can change the population. This corn was 33,500 to 34,000.

"Typically, seed companies tell you to push population up until you get what they call "tipback"—corn will grow, but not produce complete ears. My corn had full ears with no tipback. Should I increase population more? I don't know, but greater population definitely didn't stress plants.

"Corn came up very uniform, germination almost 100%." JR's voice leaned forward to tell exciting news of corn's summer growth. "Real interesting was the health of

plants when they came up. Often corn comes up in its early stage yellow. You see purpling in inclement, wet conditions—phosphorus deficiency.

"I didn't see any, and we didn't apply in-furrow fertilizer other than pre-planting strip-till. Phosphorus was in dry fertilizer. In past, we put phosphorus right in furrow.

"This year, all we did was add mycorrhizal fungi, which find phosphorus and move it in soil. Did it have effect that quick? What was going on there? I don't know, but I do know we didn't have purple corn.

The Right Choice

Early June, a photo arrived of JR in head-high corn. I couldn't see his face, but I knew he was smiling. His corn was 16 inches taller than neighbors, with thicker, longer leaves, distinct darker green. His corn had more chlorophyll making more sugar to grow faster. JR knew he made the right choice to go carbon-smart and grow biological.

"The corn, for its early stage, was taller than it should be. You can see in photos, healthy corn has a glossy, waxy look. See how wide the leaves are. And inner veins all consistent color. Not much striping that shows deficiencies. It's just a healthy plant—as healthy as corn gets. We were just tickled.

"Hard to explain, but I can tell plants were healthier this year. Some say it makes no difference, but I can tell a healthy plant by leaves right off. One thing was thickness of leaves. Note in this early corn how wide leaves are. Leaf length is a lot longer.

"You can go in a field and tell if life is going on, or if it's hanging on to life. Times of stress, like if it hasn't rained, is hard on your body. You know it stresses plants. But this year, our plants weren't stressed the way they should have been. A few fields, some non-irrigated sand, never had a bad day. They held on, set there and waited until it rained.

"Since I started this new farming, when I drive by a field, it's like my plants are smiling. They're happy and healthy. Healthy plants are the best chance of optimum yield.

JR closely observes nature. In our first meeting, I saw an intense sentience in his dark eyes. As a farmer, JR notes many details of plant physiology and growth. JR's attention is charged with an empathy that admires plants and bugs as intelligent creatures, not mere objects. Such an open mind learns direct from nature.

JR's inquiring, observant mind discovered crop stubble isn't mere mulch, but habitat and food for tiny life from fungi

to earthworms. Residue digestion releases nutrients and energy to Soil Food Web microbes. Teeming hordes of invisible creatures swarm over debris, strip out nutrients to recycle as new growth. Decaying debris closes the circle of soil nutrient cycles. JR's shaded soil needs no herbicide of conventional no-till. However, three growing cycles are needed to mature soil's full digestive power to rapidly recycle crop biomass.

Cheap Labor

"I was on hands and knees crawling through the crop, looking at soil and plants, at different bugs, different insects, growing and going on in there. All different fungi, all kinds of mushrooms. Lots of life in that soil.

"You can see earthworms. Microbes, you can't see. I expected to see mycorrhizae signs in soil after a test I did last winter with seedlings in pots. I overdosed with spores, and saw thick white fungal fuzz like snow on the soil.

"We're dealing with living organisms. You got to treat them right, or they won't treat you right. It's very tricky, especially to combine different species together. The whole living community, intertwined together."

How much spcace do fungi need to grow?

As mushroom as possible.

JR has learned to think holistic. He knows there's no single shot solutions. He sees soil is a complete and complex, interactive, living system. JR's concept of soil stewardship now embraces the whole community of living organisms that inhabit healthy, fertile soil. To fight off pathogens is secondary strategy after he encourages roots, enlists microbes as allies, and a complete menu of minerals.

Unaided, our eye sees a few fungi—mostly mushrooms and thick mycelium. Most mycelium is as fine or finer than spider web, and as sticky. Each mycelia is a tiny tube with a mouth on one end—invisible plumbing to pump liquid nutrients around in soil.

But we can't see bacteria; they're too tiny—microscopic. Transparent, too. Even if we can see something so small,

they're almost invisible. Yet, microbes digest rock into protoplasm and boost nutrients and water flow into roots.

Fungi and their "helper" bacteria form extensive networks throughout soil that are connected to roots. Their microscopic plumbing amounts to miles in a tablespoon, "intertwined together…"

Ripe Ears by July 4

On July 4th, I got a photo of a nearly ripe ears. I'm unfamiliar with southern Midwest corn growth, yet this seemed early. Someone said, "Unprecedented."

"End of June," said JR, "corn tassel starts here. Sweet corn is a little earlier. We start to get sweet corn July 4th. Around 13th, we usually can sweet corn.

"Thing was, we had a late planting, so I didn't expect such early tassels and ears. I would say, because we planted late, the corn was two weeks early."

July 16th, email brought a photo of three ears. JR said, "Ears were 43 long, 16 around. One was 18 around. Typical throughout the field. Majority had 16 around, many 18. In the past, it might be 12, or 14, a few 16s. But this year, 16 was the norm. Two extra rows on each ear adds to overall yield."

Remarkable Roots

Corn ears by July 4th fed my faith JR's 4-inch strips would work. But photos of roots on cornstalks blew a fuse in my imagination. Thick beards of white roots erupted from the base of stalks. I never saw such dense, fine roots. Corn knew nutrients were there and saturated the zone with roots to suck up the goodies.

In the photo, black grains of sawdust biochar are visible. Each absorbs eight times its weight in water, adsorps immense amounts of mineral ions, held loosely, ready for H+ exchange with root or microbe. Biochar's special benefit is to hold anions (Nitrogen, Phosphorus) as well as cations to keep them near roots.

JR was thrilled by the remarkable roots—and mystified, "I was scouting corn for insects the first day I saw roots six inches long. Hard to say how long they got, 'cause they twisted and turned, but some grew to three foot.

"This was widespread throughout the field. In fact, that whole 50 acres looked that way. Something special was going on in that 50 acres. Looked like spaghetti across the field. In close-up photos, I see really fine root hairs. Maybe the white fuzz is mycelium.

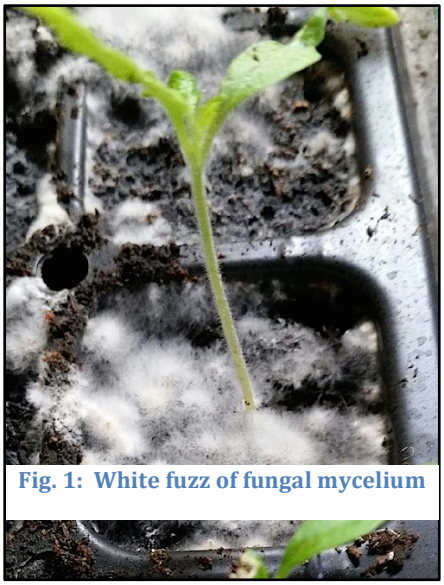


Fig. 1: White fuzz of fungal mycelium

Fig. 2 Full ears maturing on July 4th, while below, a profusion of roots

Moisture, Weeds and Bugs

"We had a wet spring. Timely rains at tassel helped. Later, we bridged gaps with irrigation. Foliar sprays to put on nutrients help, but aren't a full watering.

"We used a moisture probe this year to monitor water use. We didn't over-water, but once it got to a certain point, we kept it at that range. Seems like the crop was very efficient with water.

"Weed pressure this year was down. Residue left in middles suppressed weeds. Corn grew so fast, canopy shaded middles quick. Weeds set there and didn't grow. Fast-growing corn really stretched out, leaves were so wide, they shaded ground quick. Photos at harvest show not a weed growing.

"Not much bug pressure, either. One zone—a high-sand ridge—a bit more."

Once in the year, I got a question from JR about an insect pest. I gave him non-toxic remedies to discourage bugs and strengthen plants. He later reported bugs ate the weeds, hardly touched his crop. Consistently well-nourished plants don't attract pests. If pests do infest, vigorous plants outgrow the bugs.

Blending Biochar

Estimating biochar application rates was difficult. Field conditions, complex calculations, equipment malfunctions, uncertainties in blending, changing recipes, and other variables made a precise rate for each field elusive.

Minimum 2% biocarbon is needed to sustain strong microbe communities. Certified Organic requires 4-5% carbon. I suggest half as super-stable biochar and humus, another 2.5% as digestible carbon, like crop stubble, compost, manure, etc. But 2.5% biochar tilled in six inches is 8 tons/acre. At $.50/pound, $8000/acre is too costly for farmers.

JR's genius to concentrate biochar in narrow bands, and cut rates to hundreds of pounds/acre. This slashes annual costs, and spreads expenses over several years. TerraChar sawdust fines and 40-micron powder provide far greater functional surface area per volume of char. Mixing in minerals and microbes charges char with nutrient ions, and injects a Soil Food Web foundation. This cuts quantity needed further, while boosting effects. Together, benefits assure farmers strong response and continued high yields at financially feasible yearly expense.

Biochar is a classic inert ingredient. Char doesn't react with atoms, but is a substrate to bring other atoms together to react with greater ease, speed and efficiency. Like a catalyst, char is unchanged by a reaction. Because char doesn't react, it remains in soil decades, or centuries, continuing to provide services to microbes and roots.

Yields: First Place Milo

"That corn field produced 235 bushels," JR was proud. "The 20-year average for that field is 180 bushel. The crop was easy to grow. It was no trouble. Didn't have issues with it. Just watered it, set back and let it do its thing.

But JR's biggest surprise was his grain sorghum crop.

"One field of sorghum made 186 bushel in non-irrigated sand," JR revealed. "Normal is 100 bushel; most farms were 120, even irrigated. Believe it or not, my field had irrigation on part, but non-irrigated yielded same as irrigated. "

Good enough yield to win First Place in Missouri for both irrigated and non-irrigated milo. JR's unwatered milo brought a few extra bushels than irrigated. Together, the milo got him a winter vacation to New Orleans.

Continuing to talk numbers, I asked about money saved cutting NPK fertilizer 50% versus costs for biochar and biological fertilizers and amendments.

David Sr. spoke up, "Yeah, we got some figures. I'll do some fine tuning on fertilizers—exact amounts we cut back. I'd say close to $100 an acre cheaper. May not be $100 an acre, but way up there."

So, 1000 aces of corn saved near $100,000 just on fertilizers. Biological materials cost far less than this. Plus no expense for herbicides and other sprays, and then the bonus of a bumper crop. With those economics, JR can go out in his fields and smile with his plants. And this is only his first year to grow with a full biological program. Each year, as JR builds his soil carbon, trace elements and biology, he can cut fertilizer more, increase yields, upgrade quality.

Soybeans

JR's head shook to begin talk of his #2 crop, "Basically, same story all over again. After long delay due to heavy rains, we planted beans after the 4th. If we don't get beans in by July 4th, I risk lots of problems, like frost. They had the worst conditions possible when they came up."

David Sr. commented, "We had 25 inches of rain in July, and after the 28th, never got another rain for two months."

JR continued, "With heavy rains, several times water rose over bean tops a couple days. Yet, they overcame and bounced back. I was shocked how they kept growing! Yellowing went away fast. I think bacteria got right back in full swing. From that, they just kept on.

"Stalk is important in soybeans—usually a little pencil-like stalk. This year, stalks were like tree trunks. The plant pumped nutrients into it. We noticed more lateral branches. Typically, we have a single stem, and nodes stretched farther apart. This year, nodes were more stacked, with three or

four lateral branches off the main stalk. The extra branches was like one plant turned into three."

As I often do, I pointed up that biochar, fungi and many biologicals affect mostly roots underground, where we can't see them. We saw this at Kansas State Forestry Dept. Tree Nursery in Manhattan where thousands of potted pine and cedar seedlings grew in a greenhouse. Someone gave the staff a sandwich baggie of mycorrhizae fungi spores, which they applied to some of the seedlings. Although top growth showed no obvious differences, when we pulled half a dozen out of their cones, root growth was 50% greater on treated seedlings. Most were outgrowing their containers.

JR agreed, "Every soybean plant I pulled up, Rhizobia were always vibrant, pink, bigger in size, and more of them than typical, especially on poorer ground. It surprised us.

"On average, in this ground, after-wheat soybeans get 35 bushels. We ended in 50 to 55. Quite a difference. Certain areas, they laugh at such soybean yields. But here, that's as good as we find. I'm real pleased with that.

"Also, we cut our soybean population way back to the 80 to 100,000 range. Many farms plant up to 180,000 per acre.

NRCS Cover Crops

"Two years ago was first I came on cover crops. This is our first year for multi-species cover crop. We'll see how it goes, but we understand it's a good thing. Our soil is really low in organic matter—one thing we want to increase, and cover crops is a good way.

"The way our farm works in the past, it's hard for us to do multi-species, because we late-plant soybeans in fields that will be corn the next year. This year, we cut beans into November, then aerially applied cover crops when leaves started to yellow, so leaves fell over seed to germinate it. Looks like a successful population coming up.

"In the past, we put a cover in after winter wheat to help with wind erosion, we have such sandy ground. We work ground in spring, and need some foliage for wind. But now we do strip-till and keep all the residue.

"Cover crops tie everything together—the whole soil life ecosystem. It's no one thing, but bridges gaps. Keeps living systems going in soil through drought and winter. Helps with weed suppression. I get deep penetration of roots. Keeps soil nicely loose. In spring, plants have cover crop roots as pathways to follow.

"It helps with wind erosion, a major problem here. If you don't have a cover, your dirt winds up on your neighbor's farm, and his dirt's coming on yours."

Earthworm Calling

"What started this for me was earthworms. All this began because a guy challenged me to find an earthworm. It tickled me yesterday to walk out in a field, stop in a random spot, dig the soil with two fingers, and there was an earthworm, then five more. Back in 2012, I couldn't find an earthworm. Yesterday, at a random spot, we found them.

"That shows me we're going in the right direction. It's a good gauge things are going well if I see those guys."

March 31, we returned to the cover crop field. JR

brought a "worm caller"—a pointed, broken hardwood stick he hammered into sandy soil until firm. He rubbed the top of this embedded stake with a hardwood board with a bumpy, serrated edge. This stroking vibrated the stake, and sent low frequency pressure waves through soil all around.

JR first "worn caller" was in his grandmother's garden. He used a metal stake and wood rasp, which emit a higher frequency. Before long, large worms came up out of soil.

Now, in a carbon-poor crop field with a new green cover that had no worms two years before, JR had trouble calling up any worms. But he persisted at stroking the stake, and carefully fingered through surface litter and soil. Eventually, he proudly showed us three 3-inch long worms.

JR was disappointed not to find more. I explained these skinny worms are his first crop—still only teenagers. By mid-summer, his young worms will be adults and hatch out hundreds of cocoons. By harvest, with continued food and habitat, a second generation will boost his worm population.

2016

JR couldn't be more happy and blest to contemplate his farm's future. "We plan next season to use what we learned last year, fix a few gaps, apply things in a timely fashion, really tweak the system. This year, we'll flex our muscles with what we learned last season. I'm excited."

"For example, I saw bubbles in the liquid tubing. We had trouble with vacuum hoses to start of each row. There's a percent of mechanical errors, spots with bubbles, stones in equipment, and all. We have lot of refining and advanced learning ahead before we can go all out."

David Sr. volunteered to gather financial information on savings, "I'll do some fine tuning on the fertilizers. I can get you real close, 'cause I don't want to tell somebody something we didn't do, you know what I mean?"

I had to ask, "So, you like what you're seeing so far?"

"Yeah," the senior Bollinger admitted, "as soon as we make it easy to do, I'll be all about it. I'm all about cutting fertilizer back and strip-till, because of erosion and all that."