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Managing for **Drought**

Soil amendments and planting strategies help plants survive tough conditions.

BY BARBARA HESSELGRAVE

The mania for a green lawn, or in some cases green *anything*, across many regions of the US has been quelled by recent droughts (thankfully now abating). Even long before water meters were spinning at record rates for golf resorts, private homes, and corporate campuses, scientists have been devising technologies that help protect, preserve, and promote soil and vegetation health.

"Just add water," is not enough to ensure that seeds germinate and flourish.

"The soil must be nurtured toward an optimum condition," says Dr. Rattan Lal, professor of soil science and director of the Carbon Management and Sequestration Center of the Ohio State University College of Agriculture. He explains that soil moisture and soil temperature are two critical factors that determine growing success.

"We did an experiment here on one of our extension research plots comparing how temperature and moisture affect plants. In 2012, we experimented with acreage where one plot was left with crop residue mulch and cover crops were planted, versus crop residue removed, no cover crop planted, and leaving bare soil."

He reports that during the summer, there was a 10°C temperature difference between the two plots at the warmest time of day, about 2 p.m. "And remember, this is Ohio, not as hot as some grower states like Texas, California, and others," he notes.

Lal compares the heat in the uncovered soil to the difference that would be felt by humans who are in 100°F temperatures, but without protection of an umbrella or a hat.

"Here in Ohio the roots are well below the surface, and we don't have the extreme temperatures where the difference would be even greater from radiant heat. But the point is, anyone planting crops, particularly cereal or corn crops, needs to keep the soil cool to maximize the plant potential.

"This is not so much in the early weeks of growing, but at the six- to eight-week point. If the soil temperature rises at this critical stage to 90 to 110 degrees, compared to 75 to 85 degrees, this can have tremendous impact on growth and productivity," says Lal.

And this critical growing point usually occurs at the hottest time of the growing season.

He describes how corn, a member of the grass family, has fairly shallow roots, but in ideal conditions, corn can be grown in protected soil, such by as a low-growing leguminous system. This "not only acts as a carpet to cover and shade the corn roots, but their deeper roots do not compete with the corn, and can also act as the perfect erosion control system."

"Soil erosion has very good taste," explains Lal. "When water carries soil of unprotected surfaces away, it tends to take away the fine particles of high-quality topsoil, but leaves the bad stuff. So, what you end up with is poor soil health, exposed roots, no means to trap and hold water, and no cover to reduce soil temperature."

A Devastating Experiment Loses Millions

He cites one project that is still infamous after 70 years. Despite its noble intentions, the "Groundnut Scheme" of 1946 in then-Tanganyika, East Africa, was unrealistically conceived and executed, and is a clear example of what happens when we don't pay sufficient attention to the realities of soil suitability, rainfall, and climate.

In 1946, developing a source of peanut oil was suggested as a potential solution to the severe cooking oil shortage in post-war Britain. An entrepreneur from Unilever (the soap people) suggested the British government take advantage of the huge tracts of empty land in East Africa.

However, no one at the time apparently thought long on *why* they were barren.

With a budget of £25 million and a workforce of 100,000 former military soldiers who had volunteered, the project endeavored to clear land and plant peanuts (groundnuts) over 150,000 acres of scrubland, with plans for millions more acres of other crops to follow.

In their excitement over forecasts of success, leadership failed to include comprehensive soil type, compaction, and other analyses and a review of the then-still-scanty records of temperature and rainfall/drought. Nor did they consider the attitudes of local people who would be asked to change their traditional farming methods to help make the experiment work and bring financial stability to their country.

These factors, plus a series of natural disasters, coalesced to doom the ambitious goals. The problems included flash

floods, washed-out bridges, an infestation of scorpions, attacks by lions, impenetrable scrub, and resistant root systems that damaged bulldozers and blades. In addition, there was no accessible water source, and local workers were not trained to handle the fleet of imported Canadian and American tractors.

After two years, only 2,000 tons of peanuts were harvested from 50,000 acres, most of the equipment decimated. By 1951, the losses were a devastating £49 million (more than a billion and a half British pounds in today's currency), and the project was ended.

However, the real tragedy is in the abandoned land. Once vacated, hundreds of thousands of now-unprotected acres became a signal example of erosion, the red soil blowing out to sea, leaving sand behind, a situation Lal says is comparable to the American Dustbowl.

Today, politicians (and British comedians) continue to cite the failed Groundnut Scheme when criticizing the hubris of impractical ideas.

PROFILE PRODUCTS

A Drought by Any Other Name

Friction and hostility over water access can easily raise unpleasant behaviors, as Jim Spindler, director of agronomy at Ecologel Solutions LLC, explains. He offers a view that links respective belief systems to the actions of people affected by drought. In other words, "Your interpretation of the definition of *drought* has bearing on how you behave and what you do about it," he says. He cites four very different definitions.

For example, *meteorological drought* is the measure of precipitation, or lack of it, due to climatic changes. What's defined as drought in one region might not be drought in another.

If the soils supporting crops, turf, and ornamentals are not receiving enough water to sustain them, this is called *agricultural drought*.

Hydrological drought occurs when surface and subsurface water supplies are below normal. And then there is *socioeconomic drought*, when water shortages begin to affect people.

"You can see from these terms that each consumer group believes its water requirements should be primary," says Spindler, adding that it is easy to imagine how "conflicts can occur between these groups, based on the drought definition that applies to them."

Indeed, the recent drought dilemma facing turf grass managers at luxury resorts, sports facilities, and golf courses garnered little sympathy from other sectors.

Spindler says that keeping water in the soil to promote and sustain growth and improving soil quality to do the job is the goal of Ecologel researchers. The company has developed products such as Hydretain, which boosts the success rate in hydroseeding projects.

But as experts caution, simply throwing water on the ground doesn't take care of all seeding and maintenance needs. Spindler illustrates the crucial need for revegetation experts to understand the unique challenges to the soil they are working with. He offers the scientific backstory on diverse soil and water relationships that ultimately will dictate what revegetation solutions will work best.

Why Soil Health Determines the Fate of Water

"We talk about the 'three fates of water' during rainfall and irrigation. The goal is for water to enter the soil system, be taken up by plants, and eventually be lost to transpiration," says Spindler. "But, unfortunately, gravity and evaporation are constantly working against this ideal to keep water away from plant roots."

He explains that numerous attributes of soil—its structure, its chemistry, and the effects of the local water chemistry—are all key factors affecting seeds and plants.

"Sodium is one problem. In regions where the local water has high levels of sodium, there may be plenty of water, but it actually damages soil structure."

He explains that water may run off or drain into soil, but it does not disperse evenly because the salts can physically "seal" the soil, preventing water from penetrating and being evenly distributed to plant roots. Plenty of water can be applied, but it ends up being unavailable to the plants.

"However, this problem can be amended by adding calcium or acid that helps make the salts more permeable. In basic molecular terms, various calcium-containing products can alter the sodium molecules to allow water to penetrate, thus actually altering the soil structure."

In the Midwest where limestone is prevalent, the same problem occurs and affects soil permeability from the bicarbonates that build up, which he says also act to seal the soil and prevent dispersion of water.

"I tell people that if you take a soil sample and drip vinegar on it and you get a 'fizz' effect, you know that bicarbonates are the likely problem. But you can treat this by using different acidic solutions including acid-forming fertilizers injected through the irrigation system, and these help break down the bicarbonates into CO_2 and water."

A third water challenge comes from the decay of organic substances and secretions of certain species of fungi.

"These processes create a waxy type of surface that has no ability to attract water molecules," he says, a condition defined as *hydrophobic soil*. "In this situation water finds a channel and creates its own path via gravity to drain, but this often circumvents plants, which are starved out of that water supply."

He says, "Today, the industry has developed a number of very efficient water retention technologies that address and solve these problems, and we can get water where it needs to be."

From Diapers to Baseball Diamonds

Describing these water-absorbing products, called *super-absorbent polymers*, Spindler says the latest commercially available varieties are produced in five

different chemical forms, each with different application and function for diverse soil needs.

Cross-linked *polyacrcrylamides* are made in crystalline form and when they are exposed to water expand into a gelatin-like block. This creates mini-reservoirs of water that plants can tap into until it is depleted. These are rated at holding from 80 to 200 times their weight in water.

Other polymer types include the water-soluble *non-cross-linked polyacrylamides*, and *polyacrylates*, *polyacrylonitrile*, and *starch-grafted polymers*.

Depending on soil conditions, the types of acids or salts in the soil will affect the polymers' efficiency, but they can all increase soil water-holding capacity, increase germination rates, decrease or mitigate soil compaction, and increase the number and size of pores in the soil.

Other technologies that address undesirable hydrophobic conditions are surface-active agents, or surfactants, also known as wetting agents, which Spindler says change the polarity of the soil.

Polarity describes molecules with an electrical charge similar to magnets. Opposite charges are attracted to each other while the same charge repels. When water and soil have the same charge they repel each other, or become hydrophobic. Surfactants allow the soil surface to have the opposite charge, attracting water to and through the soil.

An example of how this works can be seen with dish soaps, which are also wetting agents. When oil is dropped on a dish of water it sits on the surface, but when a drop of dish soap is added, it breaks the surface tension and the oil is dispersed, perfect for washing those greasy dishes. Wetting agents in soil perform the same function, breaking surface tension and allowing dispersion.

"When we overcome the polarity of water's resistance there is greater water distribution throughout the soil. This allows the soil to hold water, which improves the rates of seed germination and seed survival," he adds.

Newer to the industry, hygroscopic humectants are continuing to gain attention for their ability to reduce overall water requirements and improve seed germination. Hygroscopic humectants such as Hydretain function to condense soil water vapor or soil humidity back into liquid droplets of water. The hygroscopic ability of these materials can be compared to condensation or "sweat" that occurs on the side of a cold drink.

"Using Hydretain is like an insurance policy," suggests Spindler. "When contractors are applying seed on slopes for roadside revegetation or planting grass or annuals, the comparison between sites that use Hydretain in hydroseeding versus none is fairly dramatic. In most regions, we recommend applying this every 90 days for turfgrass, but it's not just for grass but for farms, ornamentals—any situation where you want to establish and maintain plants.

"Plus we know that Hydretain condenses humidity. So it has another benefit in preventing winter desiccation of cover crops and grasses and plants in regions where there is cold and wind, but not much snow."

Hygroscopic humectant products are now being increasingly used globally for diverse needs.

"Using these products is about more than keeping a nice lawn or germinating seeds. In Texas they use this for deep root injection for trees. We have projects to control erosion in mining areas of Chile, and developing countries such as Ethiopia with very scarce water are adding this technology to drip irrigations to get the most out of production. And if we keep plants and grass with a healthy root system intact, how many mudslides can we potentially avoid?" he says.

Healthy lawns and turf are good for air quality, he says, and they act as carbon sinks and reduce heat stress, so Spindler is in favor of natural grass sports fields, versus artificial turf.

"We have data from cemeteries and park districts that have saved huge amounts in irrigation and watering costs. Their properties can beautify the community and enhance environmental quality and keep more facility management money in the bank."

> Years ago, a stand up comic described leaving her child in the care of dad, and coming home to find her toddler burdened with a disposable diaper that had long ago reached capacity. "Why didn't you change this diaper?" she asked incredulously. He replied matter-of-factly, "Well the box said 'Good for up to 25 pounds,' so I was just following directions!"
>
> This old joke perfectly illustrates the water retention technology that not only revolutionized baby diapers (and many other products) but is crucial to technologies that increase the water-holding capacity of soils.

PROFILE PRODUCTS

A Profile of Engineered Soil Media

The Banff National Park in Alberta, Canada, world renowned for magnificent natural beauty amidst the majestic Rocky Mountains, was founded by a happy accident nearly 135 years ago.

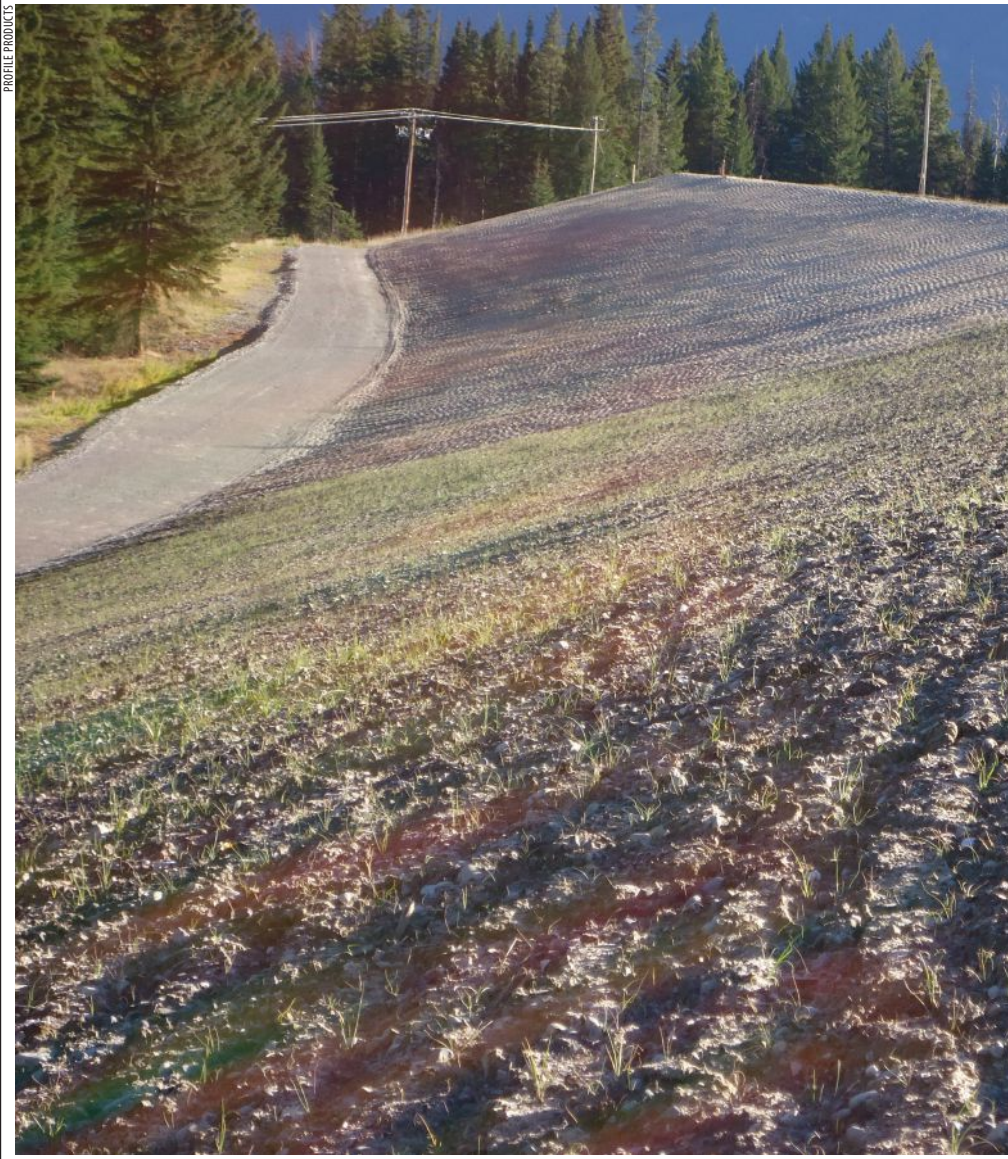
While building the transcontinental Canadian National Railway, workers stumbled upon a cave with naturally occurring warm mineral springs, and from this discovery a national park was formed—Canada's first, and the world's third. But with dry air at 4,500-foot elevations, "the region is not known for moisture," says Damon Sump of Profile Products LLC.

He explains, "Inside the park, a contractor needed to revegetate an area with a steep slope near a canal, so it was a perfect demonstration site to test our engineered soil media [ESM] topsoil alternative against standard reseeding techniques. We anticipated comparing the outcome after one year to measure its efficacy in seed germination, site growth and plant sustainability, and erosion prevention capacity."

The slope revegetation was part of the work done on a canal that feeds a TransAlta (Canadian) power plant. Sump says the project became a perfect case study to see how both applications performed on a challenging slope site.

"Although the client [the park] had not specified our ProGanics Biotic Soil Media and Flexterra product, we discussed the test idea with the contractors and they were open to this project scheme."

Sump says that the project, done in June 2015 during a very dry summer, used ProGanics in one area, testing against the adjoining area that received hydroseeding treatment of



wood mulch with tackifier. He says the ProGanics site produced "amazing positive results."

"First of all, it is around 50% cheaper to use this product over bringing in tons of topsoil, and then hoping that when you add seed it will take hold and grow under challenging conditions."

He explains that ProGanics is made of pre-consumer wood waste fibers, "so it is sustainable, and also contains wood bark fibers, plus biochar, which is wood waste that is pyrolyzed under low-oxygen, high-heat conditions. This creates a product that has a tremendous amount of surface area, and this composition is excellent at holding nutrients, moisture, and beneficial bacteria, and also supporting fungi such as mycorrhizae," says Sump.

He adds that the ProGanics and Flexterra combination has tremendous water-holding capacity, and "when combined, holds 13 times their weight in water, a valuable asset to help vegetation establish in this arid climate. When you have low topsoil, low rainfall, and no organic matter, you need to compensate."

He notes, "With this project we could see clearly how this soil did not hang onto the moisture. Plus, the Canadian parks are very strict about what kinds of plantings can be done, and we had to provide certification that verified no foreign weed, unwanted plant material, pathogens, or other undesirables would be introduced."

Although it was not required, Profile did perform a soil test to determine the composition of native soil to be able to create a suitable biomass mix. The test showed that the slope soil was high in pH (8.2), and very low in organic

Test plots in Banff National Park

matter (0.5%). Ideally, says Sump, the soil pH should be 6.3 to 7.3, with organic content of 3 to 5%.

The comparison site received 4 inches of locally sourced topsoil, seed mix, tackifier, and fertilizers. The ProGanics/Flexterra site received 3,500 kilograms per hectare of ProGanics, 3,900 kilograms per hectare of Flexterra, 116 kilograms per hectare of 16-20-0 fertilizer (identical to that used on the comparison site), and the same seed mix at 100 kilograms per hectare.

"We used hard and creeping fescue, rye, and bluestem, seeds suitable to this region and climate, and we used identical hydroseeding technology on the two sites. Our comparisons and evaluation a year later showed dramatic differences."

The ESM site had lush growth with substantial root systems, while the comparison site had scanty growth, at least 75% bare and exposed soil from seed loss, die-off from drought, and lower germination.

"I think the takeaway from this demonstration is that with the engineered soil media we could quickly and successfully get sustainable vegetation, allowing the perennials and natives to establish." When the area does get rain, he says, "then the soil really hangs onto that moisture and it prevents evaporation."

He adds, "This is a project where there is no irrigation, so you're pretty much hoping that Mother Nature will be on your side to establish growth. Our products certainly give a big boost to that effort."

The test site survived subsequent drought conditions with flying colors as the organic matter, growing media, and root systems supported the plants. "Looking at the two side by side that endured the same conditions, you can't really argue with these results," he says.

Insulation of the Green Kind

For more than 35 years, Carolina Precision Fibers has been an innovator in reusing post-consumer recycled fiber products. Today, the company's cellulose fibers are used in a number of industrial applications such as asphalts, fillers, fuel pellets, caulks, and absorbents.

Over the last 12 years, says the company's Don Benham, there has been an additional use for these fibers.

"We've developed new uses for these products that offer hydromulching and seeding professionals a high-quality, high-coverage product with excellent water retention capabilities," he explains.

"These fibers are lightweight but very strong and are a great alternative to synthetic fiber, particularly for mulches in an erosion control application where you want the material to decompose and add to the soil naturally."

He explains that cellulose fibers, when mixed with an absorbing polymer, can provide a water-holding capacity of up to 1,500 times their own weight.

"When you apply our premium cellulose Mulch & Grow product, which is a 100% fiber product, along with our super-absorbing polymer, called SAP 1500, our unique patented product, it mixes and blends well with seed and other growth amendments," says Benham.

Hydroseeding machinery, which is often gummed up after a workday, benefits as well. Benham says the mixing of the product creates a well-balanced slurry that practically self-cleans the equipment as it works, reducing the tedious cleanup process.

Bryan Repko of Virginia-based Trinity Turf agrees. He says the product consistency of the Mulch & Grow products are a benefit to his business.

"We provide hydroseeding services in Virginia, Maryland, and North Carolina, and Carolina Fiber products are always consistent in their mix. There's nothing worse than having a hydroseeding machine block up because of a poor mix in the tank. But the SAP 1500 acts like a lubricant, so it doesn't stick to the sides of the tank. It delivers a uniform stream and makes it easy to clean up."

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Repko says crews just cut open the 50-pound bag of Mulch & Grow, drop it in the 2,000-gallon tank, agitate, and it's ready to go.

"Customers also really like the natural green color as it is applied. They want the reseeding to look nice as it is coming in, and the polymer holds the water so well that even on slopes the seeds can germinate and you get good cover."

He describes using the product in a variety of situations where these attributes—color, water retention, and fast germination—are a plus to the customer and to the community.

"We do a lot of roadsides, airports, and landfills. As they are being covered over, we need to get growth coming in quickly, and there's often no irrigation to help. Plus if there are torrential rains on those hillsides, the last thing you want is a mudslide with all the seeds falling to the bottom edges."

He adds, "On flat surfaces, like a new housing project, we can get seeds going quickly, and this makes for good curb appeal for those developers who are showing sites, compared to bare ground or patchy, failed turf grass installations."

Helping Soil Thrive

Clearly, the conclusion of Lal and other experts is that a healthy soil is truly "at the root of everything." Today's products can nurture soil, keep it cool and moist, and maintain a well-balanced composition to promote growth. And we also need to conserve every inch of good soil.

According to the US Composting Council, it can take nearly 2,000 years to naturally replace the top 15 centimeters of lost soil. However, new incentives and technologies are supporting the development of composting of biomass such as wood waste and organic food, which can, through water treatment plants and composting facilities, dramatically hasten the process.

For example, the Council cites a dramatic scenario in Washington state, where 7 million people contribute a total 70 kilograms per person, per year in combined food scraps and biosolids. After processing, this creates 1,343 tons of soil per day. The Council reports that a net effect of these processes can replace that crucial top 15 centimeters of soil in less than two days, rather than two millennia.

As these techniques become more widespread, Spindler affirms that keeping soil productive through the latest amendments will only become more important. "We have developed a number of very efficient water retention technologies that address and solve water and soil problems, and depending on the situation—keeping and nurturing high-quality soil, new seeding and maintenance of existing turf, trees, and ornamentals, and applications in agriculture—today we can address and improve all aspects of this continuum." **EC**

Barbara Hesselgrave *is a writer specializing in environmental topics.*