Technical Manual: Biologically Enhanced Agricultural Management (BEAM)

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Foreword
Biologically enhanced agricultural management (BEAM) is a type of regenerative agriculture developed by Dr. David Johnson at New Mexico State University. This technical manual on how to practice BEAM is designed to be updated to reflect and share community knowledge, so if you have experiences with BEAM that you’d like to share, we’d love to hear from you—send us an email at patavivafarm@gmail.com. With your contributions, we can make future versions of this technical manual even more comprehensive and helpful for those in our area. As the manual is updated, you can find the latest versions at www.mesanm.org.

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**BEAM and Its Benefits**
Biologically enhanced agricultural management (BEAM) is a type of regenerative agriculture that cultivates diverse communities of beneficial soil microbes as well as crops, offering multiple benefits:

- Increased soil nitrogen, which is provided by both free-living and nodulating nitrogen-fixing bacteria;
- Increased soil carbon, provided as exudates that plants produce through photosynthesis (acids, sugars, polysaccharides and ecto-enzymes) and exude into the soil to feed microbes;
- Biological suppression of pathogenic microbes and pests;
- Microbially provided plant growth hormones;
- Increased biomass production;
- Increased crop yields;
- Increased resilience to drought and flood from increased soil water infiltration and water retention;
- Cost savings through decreased need for inputs such as fertilizers, herbicides, and pesticides

This technical manual provides an overview of the BEAM process, from acquiring beneficial soil microbes to cultivating them alongside crops.

**Getting Beneficial Soil Microbes**
The beneficial soil microbes in BEAM are provided by mature compost from a Johnson-Su Composting Bioreactor, a type of aerobic, no-turn composting system whose construction and operation is described in “Best Management Practices: Johnson-Su Composting Bioreactors” (available at [https://mesanm.files.wordpress.com/2016/12/johnson-su-composting-bioreactor-technical-manual-version-1.pdf](https://mesanm.files.wordpress.com/2016/12/johnson-su-composting-bioreactor-technical-manual-version-1.pdf)).

**Applying the Beneficial Soil Microbes**
The compost product and microbes from a Johnson-Su Composting Bioreactor can be applied directly to a field, made into a slurry to coat seeds, or used to make an extract that can be sprayed on a field or injected into the furrow as you plant seeds.

**Direct Application**
Without any further treatment after the composting period, the compost product from the Johnson-Su bioreactor can be used as a growing medium, spread onto soils at any desired rate, or used as a soil substitute. Mix in some native soil, about ⅓ by volume, to offer additional material from which the microbes can extract macro and micro-nutrients that are needed for plant growth.

**Extract**
Compost end-product from a Johnson-Su bioreactor can also be used to create liquid extracts that contain a rich and diverse community of soil microbes, especially fungi. The compost extracts are especially useful for inoculating large areas with beneficial soil microbial communities.
Small Applications of Extract:
To produce the extract, add 2-3 heaping handfuls of mature compost to 5 gallons of water, and stir the mixture vigorously. I use a hand drill with a large paddle blade mixer for 4-5 minutes. The goal is to dislodge as many microbes as possible from the organic matter. After vigorously mixing the compost and water solution, pour the mixture through a paint screen (such as a 5-gallon mesh bag from your local hardware store) into another container. After straining, the extract is ready to be sprayed through a sprayer or sprinkler onto the leaves of plants or onto soil plots. After spraying the extract, water it into the soil with a garden hose sprayer or sprinkler to ensure that the microbes have filtered down into the soil.

Larger Applications of Extract:
On large acreages, the extract can provide very beneficial results when applied to directly into the furrow while planting, a process which ensures that microbes are right next to germinating seeds. Through the spray method, application rates of 1 kg of compost/hectare (1 pound/acre) have been successfully implemented. Vigorously mix ~1 lb of compost with 20 gallons of water per acre applied. This screened extract can be introduced into the furrow when planting or injected into an irrigation system.

Slurry
Beneficial microbes from the mature compost can also be applied directly to seeds before they are planted. To inoculate seeds, create a slurry through the following steps:

- Into a 5-gallon pail filled halfway with compost, add a mixture of about 1 cup of milk and 1 tablespoon of molasses (8 parts milk to 1 part molasses).
- Add additional water (amount varies) while stirring this mixture until the compost slurry has a viscosity similar to pancake batter.

One liter (approximately a quart) of the resulting slurry can then be poured into a cement mixer with 50 pounds of seed and tumbled until the seeds are thoroughly coated. Smaller batches can be done by hand in a 5-gallon bucket. The coating process takes approximately 1-2 minutes, and then the seed can be air dried by spreading the seed out on a tarp in the shade and allowing it to dry, with occasional raking to expose wet areas. After drying, the seeds can be planted. Alternatively, if the seeds are large, they can be planted wet because the seed will flow well through a planter.

Cultivating Beneficial Soil Microbes
After you have inoculated your soil with beneficial microbes, the microbes require a full-time living plant or green cover that will introduce exudates into the soil and enable the microbiota to survive, thrive, and offer their benefits to your crops and soils. To cultivate the microbes,

Do:
- Use no-till, strip-till, or other conservation tillage approaches
- Continuously grow plants on the soil, using cover crops as necessary
- Lightly disc crop residue back into the soil after the crops are terminated, or, if you have a no-till drill, roll the covers down and plant directly into the rolled thatch
**Don’t**

- Use conventional tillage
- Leave fields bare or without crop cover
- Use herbicides, pesticides, or synthetic fertilizers

Each of these guidelines is described in more detail below. Note that, although these general principles apply to all uses of BEAM, the particular approaches to take (for example, the cover crops to cultivate) should be tailored to the specific conditions at your farm, ranch, or garden. For a list of resources that can offer further guidance on cover cropping and reduced-till agriculture, see “Additional Resources.”

**Do: Use no-till, strip-till, or other conservation tillage approaches**

Conventional tillage practices disrupt soil microbial communities, decreasing their populations and diversity. To cultivate a thriving soil microbial community, minimize tillage to the extent possible by employing no-till, strip-till, or other conservation tillage approaches. Several excellent resources on these tillage practices are available, including those listed under “Additional Resources.”

**Do: Continuously grow plants on the soil, using cover crops as necessary**

Living plants exude carbon through their roots, providing an essential nutrient for soil microbial communities. So that soil microbes can have continuous access to enough carbon, it is essential to continuously cultivate crops on the soil. During periods when cash crops are not grown, cultivate cover crops.

In the BEAM field trials that identified many of the approach’s benefits, cover crops have included Colorado River Hemp (*Sesbania exaltata*) and Arugula “Wild Rocket” (*Eruca sativa*) in the summer and a mixture of cover crops including Bell Beans, Biomaster Peas, Dunsdale Peas, Lana Vetch, Common Vetch, Purple Vetch, and Cayuse Oats in winter. The short growing time of *Eruca sativa* (less than 35 days) and its roles in nitrogen scavenging and soil root formation make this plant especially useful for any short-season cover cropping to keep a soil covered.

There are many other options for cover crops, and you can choose the cover crops that best suit your goals and the needs of your farm/ranch/garden. For further guidance on choosing cover crops, please see “Additional Resources.”

**Do: Roll your cover crops and plant directly into the rolled thatch if you have the equipment, and if not, lightly disc crop residue back into the soil (top 2-3 inches) after crops are terminated**

Crop residue increases soil carbon and provides nutrients for microbes and future crops. Although diskng does adversely affect soil microbes, the adverse impact from diskng is not particularly large, and the harmful impacts of diskng are more than offset by the benefits from incorporating additional organic matter.
**Don’t: Use conventional tillage practices**
Conventional tillage practices significantly disturb soils, reducing microbial population numbers and diversity. Many of the microbes that establish symbiotic relationships with plants are aerobic and live only in the top 4-6 inches of soil where air penetrates, and tilling practices (moldboard plowing) that invert the soil disrupt microbial communities, preventing their thorough establishment. Also, conventional tillage practices open up the soil and promote significant soil carbon loss (up to 30% loss in a six-week period) due to increased microbial breakdown.

**Don’t: Leave fields bare or without crop cover**
Many beneficial soil microbes depend on the carbon that plants exude through their roots. Without a steady supply of carbon provided by living plants, many beneficial soil microbes will not have enough nourishment and will die.

**Don’t: Use herbicides, pesticides, or synthetic fertilizers**
They reduce soil microbe populations.

**Challenges and How to Address Them**
Although BEAM offers many benefits, it also involves challenges. These can include terminating crops without using herbicides and controlling weeds without herbicides. Some options for addressing these challenges are below.

**Terminating Crops without Using Herbicides**
Options for terminating crops without using herbicides include rolling and crimping as well as green chopping with a mower. In general, terminate cover crops at flowering or before seeding to prevent them from becoming unwanted weeds.

**Controlling Weeds without Using Herbicides**
Controlling weeds without using herbicides can be difficult. In BEAM, weed control can be done through mowing, rolling and crimping, manual removal, mulching, crop selection to suppress weeds, and the use of alternative irrigation approaches—such as subsurface drip irrigation and carefully timed surface irrigation—to avoid providing surface water at times conducive to weed germination. For further guidance on these weed control approaches, see “Reducing Tillage in Arid and Semi-Arid Cropping Systems: An Overview” in “Additional Resources.”
Additional Resources

Resources for No-Till, Low-Till, and Conservation Tillage


Cover Crops for the Paso del Norte Region


