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Tall planting beds to improve drainage and reduce the detrimental effects of heavy rainfall and flooding

Ramón Arancibia

Heavy rains are common in Missouri and the Midwest, in particular 2019 with record rainfall in May resulting in flooding that delayed planting for quite long. Last year was abnormal and Missouri's agriculture struggled to recover from the record rainfall (see J. Quinn's article in the "Missouri Produce Growers" bulletin, June 2019). A number of vegetable growers in low areas nearby rivers lost substantial fields of sweet corn, cantaloupes and watermelons including production in high tunnels. These loses were clearly attributed to river overflow and flooding. However, less noticeable are losses to flash flooding and soil saturation due to heavy rainfall in normal years in fields with poor drainage.

A large proportion of soil planted to fruits and vegetables in Missouri are silty clay to clay loam with relative poor drainage in comparison to deep sandy soil in other specialty crops growing areas. Excess soil moisture is conducive to soil saturation, that promote root asphyxia and rotting (damping off, root rots, etc.) where pathogens such as *Pythium* spp, *Fusarium* spp, *Phytophthora* spp, and others can cause serious loses (Figs. 1 and 2). Planting in shallow beds with excess moisture and poor drainage due to the soil type may exacerbate the problem since plant may not die, but they will perform poorly.

Figure 1 Rotting lettuces after 10 days of standing water and saturated soil.

Figure 2 Blueberries plant losses to *Phytophthora* spp. promoted by excess soil moisture and shallow beds.

Also in this Issue:

Tall planting beds (12 to 15 inches) are known to reduce the detrimental effects of excess moisture and/or flooding events in specialty crops. In most cases, tall beds improve drainage decreasing long periods of root zone saturation and maintaining good air exchange for root respiration and plant growth. Furthermore, soil conditions in tall beds are less prone to soil-borne diseases. Figure 3 shows a study with tomatoes where superior plant growth is evident in tall (12 inches) compact beds under excess soil moisture in comparison to conventional (6 inches) beds. This difference in growth was reflected in similar differences in yield between the two bed heights.

Figure 3 Tomato grown on conventional beds (three 6-inch tall beds on the left) and on tall beds (three 12-inch tall beds on the right) subjected to excess soil moisture. Difference in growth is evident.

Essentially, there are two types of bed forming implements. The most common ones drag and pack the soil under the metal shaper forming a shallow bed prior to laying plastic mulch. The other type is a row hipper with two disc gangs (2-3 disc each) that throw soil up to the middle leaving a raised row (Figures 4A and 4B). The disc gangs in the hipper can be moved in two ways to adjust the positions and angles of the discs for shallow or tall rows. To form a tall bed, the rear-outer discs should be lower than the front-inner disc to make a deeper furrows. Therefore, the height of the bed depend on the angles and position of the disc gangs, and the number of discs. In figure 4A, the disc gangs are positioned to form a shallow bed. In figure 4B, the disc gangs are in angle to form a raised bed/row. Once the bed is formed, it may need a roller shaper with cones on the sides to pack the soil and shape the bed if plastic mulch were to be laid down. Roller shapers with cones can be custom made to the desired bed width and height. Some farmers raise the beds in the fall to plant cover crops and promote drainage during the winter.

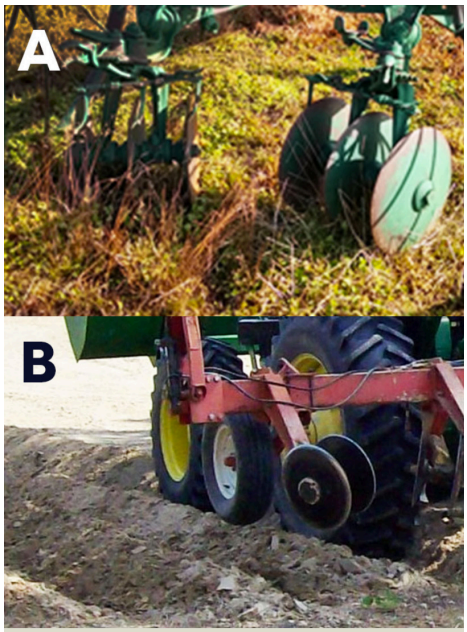

Figure 4 Row hipper with two 3-disc gangs in position for shallow beds (A) and 2-disc gangs in position for hilling (B).

Adopting tall beds is expected to improve drainage and reduce soil saturation, soil-borne diseases and the overall sustainability of specialty crops farmers and industry in Missouri.

Calculating the area to apply and amount of spray solution

(example in parenthesis)

Determine the row length (150 ft), the area between the plastic beds (4 feet) and number of row middles (7). (150 feet x 4 feet x 7 = 4200 sq ft.)

This area (4200 sq ft) is very close to 1/10th of an acre (43,560 sq ft per acre). To mix any herbicides, add one tenth of the acre amount into the solution that will be applied.

To calculate the amount of solution to mix to apply on that area, start by determining how much a certain amount of water will cover. A good amount would be about ½ gallon.

It is VERY important to use a properly functioning sprayer with a flat tip nozzle, to get the right spray pattern. Keep a good level of pressure in the sprayer and walk at an easy pace you can mimic later.

Example- ½ gallon of water covers 2 of the row middles and 1/3rd of another. (This is 1400 sq ft; 150 x 4 x 2.33).

This is 1/3 of the area that will need to be sprayed (1400/4200= 0.33). One would need to mix up 3 times that amount to treat the area or 1.5 gallons of spray solution (3 x ½ gallon). A cup or pint of additional water might be good to make sure it doesn't run out just before finishing.

Preemergent Herbicides for Aisles between Plastic Covered Beds James Quinn

Commercial vegetable production throughout much of this country relies extensively on raised beds covered with plastic mulch. Some longer season vegetables in this system may be in place for three to four months, making season long weed control more challenging. Examples are crops like cantaloupes, peppers, tomatoes, and watermelons. A common weed control tactic has been to repeatedly spray between these beds with glyphosate, using shields over the nozzles to prevent drift onto the crop. This can give season long control to upright crops (e.g. tomatoes) but for vining crops this practice is limited to about the third week following transplanting, when vines run off the raised beds. Other disadvantages on relying on glyphosate repeatedly are:

- Some weeds (e.g. water hemp) are becoming resistant to glyphosate.
- Glyphosate is less effective on certain weed species than other herbicides. As an example, Sandea provides better control of yellow nutsedge, with Sandea than glyphosate.
- More applications of glyphosate required than when other herbicides are use. For example, weed control program based on preemergent herbicdes should be possible with two applications. For glyphosate, during a rainy season, four or more applications may be required.

Failure to control weeds earlier in the season is more harmful to the crop growth, as the weeds significantly compete for moisture, nutrients and light. Later in the season, weeds are less impactful, but continue to harbor insect pests and restrict airflow, thus increasing disease pressure. Weeds are also likely to increase the amount of protective pesticides needed, as they generally will increase the total leaf surface in a given area.

Growers may be reluctant to use preemergent herbicides; they are more complicated to use in an integrated program and hand applying them can challenging. Tilling the soil after applying can only be accomplished with very specialized equipment, so rain activated products are generally used. This article provides some very simple suggestions on products to use, when to apply and scaling to smaller areas. Missouri lost its special use permit for Dual Magnum on cantaloupes and watermelons this year, so it is important for growers make adjustments. League is an herbicide now labeled for tomatoes and peppers, but it does not control grasses, so was not included. All herbicides in the table below control grasses and small seeded broadleaves, except Sandea, which controls large seeded broadleaves.

A major limitation to using preemergent herbicides is their effect on subsequent crops. Typically several months up to a year or more may be required to elapse before sensitive crops are planted. Thus, if a grower wants to replant a mixture of vegetable crops back to the same area of land, this could be limit use of preemergent herbicides. It is up to the grower to become familiar with the rotational crop restrictions, which can be significant. An example is with Sandea, which should not be followed with Cole crops for 15 to 18 months.

Melon plot on June 11, which was 25 days after the beds were formed and 22 days after preemergent herbicides were applied. Some weeds were becoming noticeable.

Melon plot at end of June. A second round of preemergent herbicides (and a burndown) was applied about 2 weeks prior (the day of the photo above). A light layer of straw was then applied, mostly to facilitate harvesting during rainy conditions, but it likely suppressed some weed growth.

Table 1* Preemergent herbicide options or combinations for consideration between plastic covered beds of described vegetables.

Crop	Timing	Products	Comments
Melons and Watermelons	After plastic laid, before planting	Command or Curbit and Sandea	Include glyphosate if weeds are present
	Before vines run, about 3 weeks after planting	Prowl H2O	Include a burndown if weeds are present***
Cucumbers and Squash**	After plastic laid, before planting	Curbit and Sandea	Include glyphosate if weeds are present
Peppers	After plastic laid, before planting	Command and Sandea	Include glyphosate if weeds are present
	About a month later	Sandea	Include a burndown if weeds are present***
Tomatoes	After plastic laid, before planting	Dual Magnum (1.33 pt/acre or less) and Sandea	Include glyphosate if weeds are present
	About a month later	Sandea	Include a burndown if weeds are present***
Cole Crops	After plastic laid, before planting	Satellite Hydrocap 3.8 CS****	Include glyphosate if weeds are present

* See the 2020 Midwest Vegetable Production Guide for Commercial Growers for complete details. Pay special attention to the description on weed control in the chapters specific to these crops.
** While labeled for cucumbers, Command has a 45 day preharvest interval. This may limit its use for cucumbers that bear quickly.
*** Use shields to protect vegetable crop when using a burndown. Glyphosate is more likely to damage crop (as it is a systemic) than a product like Gramoxone SL 2.0. If only grasses are present, use of Poast or Select would be sufficient and pose less risk to adjoining crop.
**** Dacthal is an option but only controls grasses. Command is only labeled for cabbage.

Mycorrhizae: Nature's Gift to Plant Health

David Trinklein

Late in the 19th century, a Polish scientist by the name of Franciszek Kamienski made a remarkable discovery. He found there were soil-borne fungi that formed a mutually beneficial (symbiotic) relationships with the root systems of plants. Today, those fungi carry the common name of mycorrhizae which, literally interpreted, means "fungus-roots". Nearly 150 years later, scientists continue to make novel discoveries about these unique micro-organisms, and the benefits they bring to modern agriculture.

A symbiotic relationship can be defined as two living organisms living in close physical association, most often to the benefit of both. It is estimated that nearly 80 percent of all plant species on earth form mycorrhizal associations of one type or another. Mycorrhizal classification is based on the relationship of the hyphae (branching filamentous structure that form the main body of the fungus) and the roots of plants.

Ectomycorrhizae, commonly found on the roots of woody plant species, produce hyphae primarily on the exterior of plant roots. The result is a hyphal sheath known as a mantel. In contrast, endomycorrhizae (a.k.a. arbuscular mycorrhizae) grow inside the roots both between and within root cells. The relationship between fungus and plant of endomycorrhizae is a more invasive then that of ectomycorrhizae. Endomycorrhizae colonize a wide array of plants species.

At one time skeptical about the importance of mycorrhizae, the scientific community now acknowledges their benefits as both numerous and important to plant growth. For example, because of an improved "connection" of a plant's root system and the soil that surrounds it, mycorrhizae allow for increased uptake of both water and essential mineral elements, especially phosphorus. These benefits lead to improved drought tolerance, a reduction in the amount of fertilizer need to be applied to soil and increased disease resistance.

The benefit of increased disease resistance imparted by mycorrhizae has been the result of much research. It has long been theorized that a healthy, vigorous plant is better able to withstand disease pressure when compared with a malnourished, stressed plant. Causing a plant's root system to be able to take in additional nutrients and water, undoubtedly makes for a healthier plant. However, there are additional reasons why mycorrhizae help plants to resist diseases.

Since some mycorrhizae form a mantel enveloping roots, their presence represents a physical shield against invasion by other soil-borne microbes. In short, they compete with microbial pathogens for both space and root exudates. Additionally, they cause cell walls to thicken, making pathogen invasion more difficult.

Additional to the above, it has been demonstrated that mycorrhizae excrete enzymes that are toxic to soil-borne pathogens such as nematodes. Disease suppressive effects against soil-borne fungi such as Fusarium, Verticillium and Phytothora also have been documented.

Of great curiosity is the defense response plants exhibit when mycorrhizal affiliations are present. In short, plants respond with countermeasures when under the attack of disease organisms. For example, certain chemical compounds with anti-microbial actions (e.g. alkaloids) are released by plants when disease organisms attack. Again, these responses appear to be stronger in plants having mycorrhizal associations compared with those that do not.

Although most mineral soils contain mycorrhizae, their numbers often are insufficient for adequate root colonization. Additionally, soilless media used in container production lack mycorrhizae unless blended into the mix as an additive.

In light of the many benefits of mycorrhizae, supplements of the latter are available to make certain sufficient populations are present in the root zone area. Brand names* include but are not limited to Asperello® (*Trichoderma asperellum*, strain T34), Obtego® (*Trichoderma asperellum*, strain ICC 012 + *Trichoderma gamsii*, strain ICC 080), PreStop® (*Gliocladium catenulatum*), RootShield® (*Trichoderma harzianum*), RootShield Plus® (*Trichoderma harzianum* + *Trichoderma virens*) and SoilGard® (*Gliocladium virens*). All are OMRI listed and labeled for use on both vegetable and ornamental crops. Although natural, the above products are considered (bio)pesticides and should be handled with care. Always read and follow label directions.

Additional biofungicides labeled for vegetable crops include Actinovate® (*Streptomyces lydicus*) and Cease® (*Bacillus subtilis*). However, the latter two contain beneficial bacteria rather than mycorrhizae.

In most cases, the above products are applied both before and after transplanting crops such as vegetables. Typically, the first application is made as a drench to transplants (e.g. tomato) growing in a greenhouse. Additional applications normally are made after setting plants in the field (or production greenhouse/high tunnel) via "chemigation", using drip irrigation equipment. Frequency of repeated field application depends both upon product and disease pressure.

**Mention of brand names does not imply endorsement by the author or University of Missouri Extension.*

Free microbial water testing for Missouri produce growers

Londa Nwadike

As noted in the previous edition of this newsletter, the microbial quality of the water that you are using pre-harvest, as well as post-harvest is very important to the safety of your produce. In order to know the quality of the water you are using, the water must be tested regularly. Growers using municipal (rural or city) water can utilize the annual test results from the municipal water source, but for growers using ground or surface water, testing is essential. The Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR) requires produce growers to develop a microbial water quality profile (MWQP) of their agricultural water source(s) over time and Good Agricultural Practices (GAPs) auditors also require water testing. Importantly, knowing the quality of your water can help to provide a safer product to customers.

Therefore, the University of Missouri and Kansas State University Extension are continuing to provide free microbial water testing to produce growers, through a second grant from USDA. Through this new grant, MO produce growers can now get their water sources used for produce (both pre- and post-harvest) tested through your local public health department for free. Note that this free testing program will last until at least December 31, 2020.

Growers can go to your local (usually county) health department to ask for a bacteriology private water testing kit, which will include a sample bottle and submission form. If growers are planning to test more than one water source, they can ask for as many bottles as the number of different water sources they will test. In order to get the free testing, growers need to fill out the form as indicated in this article. An example of how growers might fill out the form for a pond sample is included as an insert to this bulletin.

In the "Test requested" section at the top of the form, growers should select "other" and write "MPN for produce" in that line. MPN stands for Most Probable Number, which is the type of numerical test result that you will need. Please fill out the form completely and if you are testing a surface water sample, please write in "pond" or "creek" or the type of surface water you are testing in the "other" line of the "construction type" section toward the bottom of the form. Also mark "no charge routine well" in the "Test Requested" section. In the "No Charge Justification" section at the bottom of the form, mark "USDA/Non USDA inspected facility" to ensure that you do not need to pay for the test.

Further instructions on how to collect water samples for this free testing include:

- Label collection bottle with your name, sample identity (i.e. west well, north pond, etc), and the date it was collected.
- Wash hands thoroughly with soap and warm water. Gloves are not required but are a good practice.
- If using a water sampling stick for surface water (such as a pond), attach the provided water sample bottle onto it.
- Remove the lid from the container with care to not touch the inside of the container or lid. **Do not rinse the sample container.** There will be a white powder in each bottle which is needed for testing purposes.
- For a surface water source, dip the sample bottle down to a depth of 6-12 inches.
- For well water, run the pump for a few minutes to make sure the water in the well riser is not sampled. Make sure the sample represents the current well water.
- Fill the water a little past the 100mL fill line on the bottle.
- Cap the sample container, again with care to not touch the inside of the lid or container.
- Ensure that the labeling remained on the bottle, as described above.
- Place the sample bottle inside a sealable plastic bag and bring to your local public health department (generally Monday-Thursday, 8AM-4PM) within 24 hours of collection of the sample.

Results

You will receive the test results within approximately one week of the sample arriving at the laboratory and will include the level of generic *E.coli* and total coliforms. The sample analysis results will also be shared with MU Extension and the Missouri Department of Agriculture only for research and educational purposes, but will not be shared or used in other ways.

Tim Baker retires from University of Missouri Extension

It's amazing how time goes by. 27 years ago, I started as a Horticulture Specialist with University of Missouri Extension down in Southeast Missouri. As with all Extension jobs, you help everyone you can, including homeowners, Master Gardeners, and the general public. But my main thrust was helping watermelon and peach growers, as well as a few mixed produce growers.

In 2006, my wife and I moved to Northwest Missouri, to take another Horticulture Specialist position in Daviess County. Again, I worked with a lot of different kinds of folks, but like SEMO, there was a lot of commercial produce being grown in the area, especially around Jamesport, with the North Missouri Produce Auction. One difference though, there was a much greater variety of produce being grown in NWMO, which made my job more interesting.

For those of you that I had direct contact with, It has be great working with you through the years. I wish you the best in your future endeavors.

My Time to Say Farewell James Quinn

I am retiring effective March 17th, so this will be the last newsletter you're likely hear from me. I will be staying active with MU Extension as a volunteer, in the Master Naturalist and Gardener programs. Given the level of personal involvement I've had with many of you, and my name familiar to others who read this newsletter, I wanted to share some highlights of the last 17 years.

My first encounter with Amish and Mennonite vegetable growers was through the Central Missouri Produce Auction, in the summer of 2003, as I attended my first Central Missouri Vegetable and Greenhouse Farm tour. What a treat seeing wonderful quality vegetables being grown in what is between 'cow pastures and Lake of the Ozarks rocks'! That year I began working with Lewis Jett, then Missouri's state vegetable specialist, and we had a number of vegetable variety trials (sometimes in high tunnels). I was encouraged from a couple of growers to 'bring the extras' up to the Clark Produce Auction. Once I received approval that this was an 'approved way to dispose of surplus University property', I made many journeys. To this day, those interactions 'grower to grower' are some of my warmest.

Many of you (probably) mostly recognize me from the (dreaded?) Food Safety trainings of recent years. Let me say right up front, that was not my favorite task. Over time though, I have realized how important the issue is. Growers are depending vegetable sales for their livelihood and consumers increasingly want local grown; there needs to be a shared confidence in this supply and demand.

My first chance to travel the state and visit all the auctions and Rich Hill was through a pair of projects funded by the EPA, which ran from 2008-2011. This all got started when Tim Baker made the comment 'somebody should write a grant to do XYZ etc.'. We started out with a series of vegetable production focused workshops during the offseason, dubbed the Tim and Jim 'dog and pony show'. Well Tim and I are right in line again (note his retirement announcement). The 2nd project focused on activities during the growing season and the opportunity to visit many farms and all the auctions in Iowa; it was great. This newsletter began simply as a 'handout' we used for IPM mini-clinics during those summers at the auctions. Some of you may remember irrigation water quality testing or the insect display boxes.

I enjoyed engaging with many of you for what would become a newsletter article. We'd talk about an issue that was likely of common interest to other growers. It was my pleasure to explore those issues in greater depth, be it marketing, production, food safety, business, etc. (50+ articles by now). Another favorite of mine has been the annual Central Missouri Vegetable and Greenhouse Farm tour; this year was the 20th! A lot of growth has happened since the 1st I attended in 2003. Based on the analysis by the recent Census of Ag article (December 2019 issue), it's estimated that the amount of fresh vegetables produced in Missouri by the auctions and similar facilities, has doubled from 2007 to 2017 (from 13% to 26%). It has been my privilege to be on this journey with you during this time of growth. My best wishes to all of you in the coming years.

The produce auctions and similar facilities have helped us in Extension to educate about our fresh produce industry in Missouri. Many times nearby farms and businesses would open their doors as well. I wanted to express my deepest gratitude for this. You can't imagine the glowing comments that typically followed these occasions. While most of the visits I arranged went to the Central Missouri or Clark Produce Auctions, my MU Extension colleagues coordinated many similar events. I also helped the University of Missouri with many international visitors learning about Midwest agriculture. Below is a list of countries I could document. I am sure each of the visitors appreciated their experience. Thank you for sharing!

Armenia	South Africa
Brazil	South Korea
China	Tajikistan
Ecuador	Tanzania
Ethiopia	Texas
Georgia	Trinidad/ Tobago
Ghana	Turkmenistan
Honduras	Vietnam
Kenya	
Nigeria	

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