

2012 CenUSA Biochar Demonstration Gardens

IS BIOCHAR A GOOD SOIL AMENDMENT FOR GROWING VEGETABLES AND FLOWERS?

To answer this question, University of Minnesota Extension Master Gardeners and Iowa State Master Gardeners will test the productivity of vegetable and flower gardens amended with biochar at three Minnesota sites and three sites in Iowa from 2012-2015.



Extension Master Gardener volunteers have been invited to participate on the Extension and Outreach objective of a five-year national multi-state/university research project funded by the USDA National Institute for Food and Agriculture which is part of an initiative by the United States to lessen our dependence on foreign oil, to reduce greenhouse gas emission and to increase local renewable energy. Information about the project can be found at <http://www.cenusa.iastate.edu/>.

The goal for the Master Gardeners is to develop demonstration gardens amended with biochar and to collect data to determine any positive or negative effects of biochar on typical garden plants such as flowers and vegetables. The approach has been to replicate the home garden experience and techniques. Soil is amended per soil test results. Plants selected are typical home garden choices that are available commercially, and are evaluated by volunteers according to seed packet and catalog information. Gardening practices are those that would typically be employed in a home garden site.

This report reflects the results from the introductory year of 2012 in Minnesota.

SITE ESTABLISHMENT

Three sites in Minnesota and three sites in Iowa were established. Each site was designed to be identical. It was important to have the same varieties and numbers of plants in each location in order to draw

Author
Lynne Hagen

University of Minnesota
Extension

Cenusa Bioenergy, a USDA-funded research initiative, is investigating the creation of a sustainable Midwestern biofuels system.

Research Partners

Iowa State University—Lead
USDA Agricultural Research
Service (ARS)

Purdue University
University of Illinois
University of Minnesota
University of Nebraska—
Lincoln

University of Vermont
University of Wisconsin

a comparison across crops on data collected. All of the gardens are 1000 sq ft and each site was divided into three plots of 300 sq ft.

Each site has a Control (CTRL) plot with no biochar added; a Treatment 1 (TRT1) plot amended with one-half pound of biochar per square foot (150 pounds), and a Treatment 2 plot (TRT2) amended with one pound of biochar per square foot (300 pounds). Application was done by opening bags and dragging each over the garden site and then tilling it into the soil. Protective eyewear and clothing, gloves and a dust mask were worn by the applicators.

The soil structure in each site is uniquely different and it was anticipated that the results in each location would be quite different. Soil tests were also conducted at each site and the gardens were amended with fertilizer-only based on the recommendations of the soil tests.



Planting day at Arboretum site

Minnesota Landscape Arboretum, 3675 Arboretum Drive, Chaska, MN 55318

The Minnesota Landscape Arboretum (ARB) was selected as a site for this project because of its reputation as a world-class arboretum that is visited by over a quarter million visitors per year. With that amount of visibility, we believed it would be a great location to showcase this research project. The biochar research garden was established on the three-mile drive next to the Dahlia Trial Gardens.

The site was amended from a previously mowed turf area. The Arboretum staff prepped the site by removing the sod and tilling the soil to loosen it. Before the site could be planted, Extension Master Gardener volunteers installed deer proof fencing. Once the fence was completed, the soil was amended with biochar and fertilizer on May 18th three day prior to planting.

The soil at this location at the Arboretum is loamy clay. The soil test analysis showed a recommendation for a nitrogen-only fertilizer with a ratio of 23-0-0.

Watering at this site became labor intensive over the course of the season. A hook-up to an irrigation system was not an option, but the volunteers were able to run a hose to a sprinkler. That meant there needed to be a Master Gardener volunteer team to just monitor the moisture closely throughout the summer. In 2012 the season brought a lot of rain early in the season, but that changed later in the season when drought conditions set in.

The CenUSA Biochar plots were a featured site of the Arboretum's "Dig It" exhibition in 2012.

St. Paul Campus, intersection of Folwell and Gortner Avenues, St. Paul, MN 55108

The biochar garden at the St. Paul Campus (SPC), another great location, is in close proximity to the **University of Minnesota Display and Trial Gardens** and is visited regularly by students, staff, faculty and visitors.

The site was a former low-mow turf trial plot. The soil at this site is clay-loam. The sod was not removed but instead was tilled into the soil. The area where the garden is located is irrigated regularly. Planting day was challenging due to the wet clay and turf clods. The soil test in this garden recommended a nitrogen only fertilizer of 23-0-0, the same as the Arboretum site. Deer are not a problem at this site, but rabbits are, so a short fence was installed.



Planting day at St. Paul Campus site



Andover site before renovation

Bunker Hills Park, Bunker Hills Activities Center, 550 Bunker Lake Blvd NW, Andover, MN 55304

The Andover (AND) site was a last minute surprise and a very exciting prospect. We originally had a site selected at UMore Park in Dakota County. A new gravel mining operation expanded in that area and there was uncertainty about whether the biochar research garden could remain in the same location for four years.

The Anoka County Bunker Hills Park in Andover became a viable alternative. The Anoka County Parks and Recreation department staff was more than willing to accommodate the needs of the project. Not only did they clear out an existing area

of small trees and underbrush, they also enhanced their irrigation system to allow a hose and sprinkler to be set up on a timer. The park's staff also proved a couple of loads of mulch to help complete enhance the project. Since this garden is in a large suburban park, a deer proof fence needed to be constructed there as well.

The soil in this site is sandy, coarse texture, so it is a good site to test the theories of biochar being a benefit in poor or depleted soils. The soil test recommended a well-rounded fertilizer with a 10-10-10 ratio.

One variable in this garden, that presumably will affect the research, and that isn't present in the other sites, is that one end of the garden gets shade in the morning hours, but full sun the rest of the day.

Because of this, moisture is present in the soil longer during the day and the shady end also does not get the same amount of heat stress.

All of the gardens were amended with biochar prior to planting and were planted on May 21, 22 and 23rd.

THE VOLUNTEERS

“The University of Minnesota Extension Master Gardener program is an internationally recognized volunteer program. It exists in all fifty states, in Canada and in the United Kingdom. Nationally, there are nearly 100,000 Master Gardener volunteers from all walks of life. They reach about 5 million people each year – the equivalent of more than \$100 million in value to communities. In Minnesota, the Master Gardener program is coordinated by University of Minnesota Extension and has strong ties to the research and outreach of the Department of Horticultural Science.” (<http://www1.extension.umn.edu/master-gardener/about/>)



Master Gardener Volunteer Leaders

In Minnesota, each of the three biochar sites has team leaders and approximately 10 other volunteers supporting the needs of each site. All of the Master Gardener volunteers completed a specialized training to learn about biochar and the CenUSA grant.

Master Gardeners were involved in many facets of the project including building fences, planting and maintaining the gardens, collecting and recording data measurements and harvesting crops. A large percentage of the edible crops were donated to local food shelves providing hundreds of pounds of produce for families in need. Volunteers on this project also participated at State or County fairs, horticulture field days and other community events to teach the public about biochar and their research on this project.

CHALLENGES IN THE GARDENS

The plants selected at each site were designed to include basic plants that typical homeowners would grow such as annuals, perennials, vegetables and herbs. The design was laid out with short annual plants in the front and perennials near the back. The edible crops that were grown included: green beans, tomatoes, green bell and hot peppers, Swiss chard, leafy kale, cucumbers, lettuce, asparagus, potatoes, and basil. The ornamental crops included zinnias, petunias, marigolds, chrysanthemums and shrub roses. Seeds were started by a local commercial greenhouse. The perennial crops – roses, mums, and asparagus – were purchased from a local commercial grower.



Andover site

Germination

After the gardens were planted, there were some germination issues with the beans in two sites. Teams from those sites opted to replant, but by the time the second planting germinated, the Swiss chard was so large it overshadowed the bean row too much. The results were so poor that measurements of data were not taken. The potatoes also did not perform well. Project leaders believed this was due to the potato sets being shipped too early in the season requiring longer storage. This resulted in some mold issues on the tubers. The tubers were kept under refrigeration; however, rooting and emergence was sporadic and poor overall.

Watering

In order to replicate a typical home garden, overhead irrigation was used at all three sites on all plots. The SPC site was on a regulated irrigation system. Volunteers discovered the CTRL plot received overspray from a neighboring research plot. The ARB site was watered manually by volunteers with a hose and sprinkler. The AND site was watered by a hose and sprinkler that was on a timer.

Weeds, Pests and Diseases

Other challenges in the gardens included a plethora of weeds from Canada thistle to poison ivy. Japanese Beetles were prolific in the SPC and ARB sites. Aster yellows disease destroyed most of the marigolds and petunias in all three sites. Air temperatures were high most of the summer and moisture was plentiful early in the season, but soon ended in drought. The photograph below shows a marigold infected with aster yellows disease embraced by purslane next to a healthy marigold.



Aster yellows on marigold & weeds

Before planting, the AND site was covered with small trees and underbrush including poison ivy. The poison ivy roots continued to re-sprout throughout the season. The Extension Master Gardeners kept it under control by using herbicides around the exterior perimeter of the garden and hand pulling any sprouts that came up in the garden. Some of the volunteers were nervous about eating produce that may have come in contact with poison ivy. Upon researching this concern with staff at the Minnesota Department of Health, they felt the risk was low, but if the poison ivy roots came into contact with root vegetables like potatoes, it was recommended that volunteers peel them prior to eating them.

Overcrowding & Nutrient deficiency

The nitrogen-amended soils at the SPC site and the ARB sites resulted in overcrowding of some of the rows. To allow the kale to grow to mature size, the Swiss chard was harvested earlier than originally planned.

Overall, the gardens at the SPC and the ARB had the most vigor due to loamy clay soil's nutrient and water holding capacity. However, the AND site with coarse, sandy soil showed early signs of nutrient deficiency: smaller plants, yellow-green leaves and lower yields. In addition, heavy rains and regular watering had diminished the effectiveness and availability of the slow-release fertilizer applied at planting relatively quickly. At all sites, fertilizer was applied only at planting time.

DATA COLLECTION*

Extension Master Gardener volunteers collected a variety of data over the season. Some of the data collected included weights and counts on crops such as potatoes, cucumbers and tomatoes, plus plant heights, plant widths, and bloom production. Results from that collection process follows.



Volunteers collecting data at ARB site

RESULTS

Asparagus

Jersey Knight Hybrid asparagus 2-yr roots were selected as the only perennial vegetable in the gardens. This variety was chosen because of its adaptability to a variety of soils and its resistant to rust, Fusarium wilt and other diseases. Five roots were planted in each treatment. There was no harvest in the first year, but stalk growth was measured.

Asparagus - Results based on average height in inches			
	CTRL	TRT1	TRT2
AND	NA	NA	NA
ARB	32.13	32.00	27.38
SPC	23.00	23.85	26.53
Grand Total	27.87	28.20	26.98

Variances: The 2-year roots arrived too early for planting and were stored in refrigeration. By the planting date, some of the roots appeared somewhat moldy; however, they showed no sign of rot, and so were planted. The asparagus appeared to have fairly steady growth.

Biochar Results on Asparagus: The ARB site appeared to show a slight decline in growth in the TRT 2 plot compared to the CTRL and TRT 1 plots. The SPC site showed a slight growth improvement in the TRT 2 plot. The Andover results were not available.

**Approximately 30 volunteers were involved in measuring data and recording the results. There are notably some levels of error based on interpretation and subjective opinions. For that reason, there will be no results-posted regarding taste, stem strength or plant coloration.*

Basil

Italian Large Leaf basil was the variety selected for its popularity, mild sweet flavor, high yield and slow bolting. Date to maturity is 40-65 days. Seeds were started indoors in mid-April.

Variations: Plants were deadheaded to extend the season. Plants became woody, exhibited yellowing of the leaves and started defoliating early. The volunteers determined the basil plants were exhibiting symptoms similar to those of basil downy mildew, a new pathogen reportedly found in Minnesota in 2012. The basil was harvested in early August. The results for plant height and weight are below.

Basil - Results based on sum of weight in pounds & ounces			
	CTRL	TRT1	TRT2
AND	11.17	5.06	9.25
ARB	7.30	7.19	5.83
SPC	22.50	22.38	22.31
Grand Total	40.97	34.63	37.39
Basil - Results based on average height in inches			
AND	23.03	17.72	18.94
ARB	18.59	19.80	19.84
SPC	20.03	20.71	20.88
Grand Total	20.27	19.65	20.03

Biochar Results on Basil: In the AND site, the CTRL outperformed the other 2 treatments. TRT 2 weight is almost 2X TRT1. Volunteers believed this could be due to morning shade in this area of the plot and thus less droughty conditions. The ARB site had bolted and defoliated prior to weighing. There did not appear to be any significant growth variances at the ARB and SPC sites between treatments.

Beans

Blue Lake Bush beans were selected for this project based on its growth habit and popularity among gardeners. They typically grow a sturdy bush 15-18" tall. When mature, the pods are 6-7" and free of strings and fiber. Days to maturity are 52 days. Seeds were direct sown according to label directions on May 21-23 and the projected date of harvest was July 14-16.

Variations: There were multiple germination issues at both the SPC and AND sites. The ARB site had better germination possibly due to a more accurate planting depth, and based on their success, they harvested their first beans the week of June 23 approximately 3 weeks before the estimated date of maturity.

Beans were replanted at both the SPC and AND sites, but by the time they germinated, the rows became shaded by other nearby crops. Due to the lack of germination, the bean crop is considered a failure in 2012.

Cucumbers

The variety selected was Tasty Green Hybrid Cucumber. These were selected based on the description of being disease resistant, 9-10" in length and a good variety for trellises. The maturity date listed was 62 days. Seeds were started April 28th and were transplanted May 21-23 with the projected harvest date to be July 22-24 based on the transplant date and date-to-maturity.



First cucumber harvest at AND site

Variations: There were nine cucumbers planted at each site; three for each treatment. Each site lost one plant. In AND, one plant was lost in TRT 1; ARB lost one in the CTRL, and SPC lost one in TRT 2. Both the ARB and AND sites were the first to harvest cucumbers during the week of June 30th, approximately three weeks ahead of schedule. By the first week of July, all three sites reported harvests. The following tables show the final results of counts and weights measured up until the first frost.

Cucumber - results based on average height in inches			
	CTRL	TRT 1	TRT 2
AND	33.75	28.63	32.95
ARB	101.27	139.49	124.54
SPC	82.49	91.69	100.89
Grand Total	217.51	259.82	258.38
Cucumber - results based on count			
AND	40	27	33
ARB	92	115	109
SPC	100	119	120
Grand Total	232	261	262

Biochar Results on Cucumber: By calculating the variances in the missing plants, it appears that in the AND site, that TRT 1 performed better by weight compared to the CTRL, but about the same based on count. TRT 2 performed worse than CTRL and TRT 1 in both weight and count. At the ARB site, the CTRL performed better by weight and count. At the SPC site, TRT 2 outperformed the CTRL & TRT 1 plots.

Kale

Blue Curled Vates kale was selected for its durability in the garden. It was important to maintain some aesthetics in the garden past the first frost and this crop provided for that. Seeds were started indoors on April 21st. The date to maturity was 60 days and the recommended harvest dates would have been June 21-2. However, kale performs well even past the first frost. Master Gardener volunteers instead deadheaded decayed lower leaves. A harvest date was selected for all sites to take place between the dates of September 15-22.

Kale - results based on sum of weight in pounds & ounces			
	CTRL	TRT 1	TRT 2
AND	7.56	10.61	15.88
ARB	25.90	34.30	25.29
SPC	29.39	37.85	44.33
Grand Total	62.85	82.76	85.49
Kale - results based on average height in inches			
AND	11.00	13.29	17.64
ARB	18.17	18.97	16.97
SPC	17.49	16.04	17.45
Grand Total	15.92	16.32	17.33
Kale - results based on average width in inches			
AND	20.71	21.71	25.71
ARB	28.17	27.48	23.97
SPC	26.80	24.52	26.04
Grand Total	25.59	24.80	25.20



Kale harvest at SPC

Initially, the kale and Swiss chard were inter-planted for aesthetic reasons, but that resulted in overcrowding. It was decided to harvest the Swiss chard to give room for the kale for the duration of the season. There were six plants in each treatment.

Variations: Overall, the crops exhibited good health, especially in the nitrogen-amended sites at SPC and ARB. The SPC site did lose one plant in their CTRL plot due to bacterial rot.

***Biochar Results on Kale:** the nutrient deficient AND site compared to the Nitrogen rich SPC and ARB sites really shows

substantial differences in growth overall.

The AND site does show signs of nutrient/moisture holding capacity from the biochar in Trt 1 and Trt 2 (Trt 2 also has morning shade).

Considering the loss of one plant in the Ctrl plot at SPC, the Ctrl plot seemed to perform better in terms of weight. At the Arb site, Trt 1 performed slightly better, while Trt 2 showed decline.

Lettuce

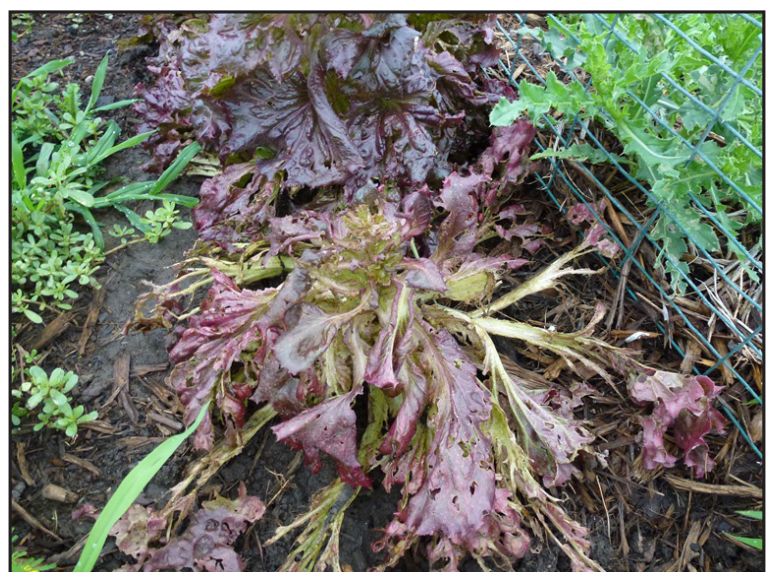
Red Sails Loose Leaf lettuce was selected based on its resistance to early bolting, tip burn and bitterness. This variety was a favorite AAS winner for salads forming large clumps approximately 10" across. The maturity date was listed as 40-45 days-seeds were started indoors. Based on that date of maturity the harvest date would have been July 1-3. Since that was a national holiday week and knowing many of our volunteers would not be available we opted to harvest during the week of July 14th.



After the washout - AND Site

Variations: A major rainstorm in late May 2012 washed out some of the transplants in the AND site two days after planting, resulting in 20-30% transplant loss. Each treatment, CTRL, TRT 1 and TRT 2 were planted with 15 plants each. After the storm there were 10 (30% loss), 12 (20% loss) and 12 (20% loss) respectively at the AND site. Hot temperatures right after transplanting was another problem. The ARB site experienced decline from heat and harvested eight, 13 and 12 plants. The SPC sites suffered the most due to a Japanese beetle (JB) infestation with only five, seven and three plants harvested. The ARB site experienced some JB damage, but not as severely. The AND site did not have JB pest issues. The results of the weights reflect the decline at the time of harvest. On the upside, the nitrogen-amended soils at the SPC and ARB initially produced larger lettuce heads than those at the AND site.

Lettuce - results based on average height in inches			
	CTRL	TRT 1	TRT 2
AND	7.83	8.15	11.45
ARB	9.25	9.38	10.00
SPC	8.31	7.94	10.09
Grand Total	8.46	8.49	10.51
Lettuce - results based on average width in inches			
	CTRL	TRT 1	TRT 2
AND	10.93	9.00	14.50
ARB	14.38	17.50	18.63
SPC	12.98	12.88	12.03
Grand Total	12.76	13.13	15.33
Lettuce - results based on sum of weight in lbs. & ounces			
	CTRL	TRT 1	TRT 2
AND	3.11	2.12	9.96
ARB	5.19	6.44	6.19
SPC	3.06	1.29	2.05
Grand Total	11.36	9.85	18.19



Japanese beetle damage at SPC

Peppers

Two pepper plants were selected. The Mariachi Hybrid pepper and King Arthur Hybrid Sweet Bell pepper. Mariachi, a 2006 AAS winner, is considered a high-yielding plant variety that grows fruits 3-4" long when mature. It is an upright bush, 18-24" in height and matures in 62 days. Seeds were started indoors on April 7th. The King Arthur peppers are large 4 1/2" bells that grow on 22' plants. They, too, are known for high yields and are tolerant to Tobacco Mosaic Virus (TMV) and Potato Virus Y (PVY).

Variations: The peppers were inter-planted for aesthetic reasons. Unfortunately, on planting day, the varieties became mixed, thus unequal numbers of peppers were planted in each treatment at each site. Due to this error, the data comparison is inconclusive and not presented in this report.

Potatoes

'*Kennebec*' potato sets were selected based on their history of excellent yields, disease resistance and having large tubers. They are considered a midseason variety maturing in 80-100 days. The plants grow to 2-3' tall and 18-24" wide.



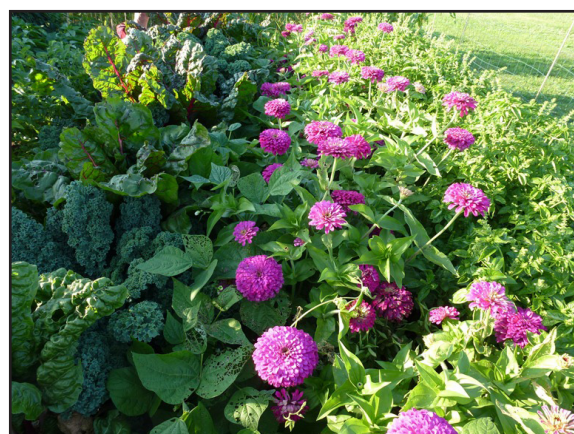
AND site - photo by Dave Hansen

Potatoes - results based on sum of weight in pounds & ounces			
	CTRL	TRT 1	TRT 2
AND	NA	NA	NA
ARB	3.47	1.69	5.58
SPC	1.01	4.01	2.02
Grand Total	4.48	5.70	7.60
Potatoes - results based on average height in inches			
AND	NA	NA	NA
ARB	22.22	22.22	23.67
SPC	19.07	19.63	18.81
Grand Total	20.84	21.09	21.54
Potatoes - results based on average width in inches			
AND	NA	NA	NA
ARB	28.00	28.44	27.78
SPC	24.29	25.44	21.57
Grand Total	26.38	27.13	25.06

Variations: There was poor root and stem emergence across all three locations. Each treatment, CTRL, TRT 1 and TRT 2 were planted with five sets each. The ARB site produced three, one and five plants respectively. The SPC site produced two, four and two plants. There was no data available from the AND site. All weight results were very poor. The data on this crop is inconclusive.

Swiss Chard

Bright Lights Swiss Chard, a 1998 AAS winner, was selected for its popularity for home gardens and its colorful petioles. The plants grow to a height of 20" and are mature after 60 days. Seeds were started indoors April 21st resulting in the projected harvest date of June 21-23. The Swiss chard was inter-planted with the kale. Harvest was scheduled for later in the season to extend the aesthetic appeal of the garden, but due to a very large plants causing overcrowding, the chard was harvested during the week of August 11th.



Overcrowding - SPC site

Swiss chard - results based on sum of weight in lbs. & ounces			
	CTRL	TRT 1	TRT 2
AND	2.56	4.06	7.19
ARB	4.94	29.69	22.56
SPC	27.81	16.00	21.94
Grand Total	35.31	49.75	51.69
Swiss chard - results based on average height in inches			
AND	15.00	15.57	19.57
ARB	22.00	24.19	21.81
SPC	21.31	19.01	19.39
Grand Total	19.44	19.59	20.26
Swiss chard - results based on average width in inches			
AND	19.43	20.71	24.14
ARB	35.36	33.76	33.13
SPC	22.51	17.58	21.18
Grand Total	25.77	24.02	26.15

Variations: Originally, there were six plants in each treatment. The ARB site reported loss of two plants in each of CTRL and TRT 2. The other sites did not indicate the number of plants at harvest so any loss is unknown. No explanation was recorded regarding the low weight for the CTRL crop at the ARB site compared to the other treatments. The AND site recorded an abundance of leaf spot at all three treatments.

Biochar Results on Swiss Chard: Between the crop loss and leaf spot diseases causing decline in the plants, the weight results are inconclusive.

Based on the average growth, there appeared to be minor decline between the Ctrl and Trts 1 & 2 on the healthy soils and minor improvement in both treatments compared to the Ctrl at the AND site.

Tomatoes

The *'Celebrity'* hybrid tomato, a 1984 AAS winner, was selected for its outstanding disease resistance. These tomatoes are determinate plants that are generally supported well by short stakes or cages. According to the growers, the fruits are large, about 8-10 oz. and are very productive with the ability to produce under a broad range of conditions. They reach maturity in 72 days and grow to a height of 3-4' and width of 3'. Seeds were started indoors on April 7th and the projected date of harvest was mid-July. Five plants were grown in each treatment.

Variations: The TRT 2 plot at the AND site with the morning shade added a significant improvement in tomato yields. The nitrogen-amended soils in both the SPC and ARB sites produced very vigorous plants. At the SPC, the cages collapsed in a strong wind from the weight of the tomatoes plants and needed additional staking.

Biochar Results on Tomatoes: Overall, the CTRL plots outperformed the TRTs 1 & 2 plots in both count and weight of tomato yields in all three sites with the exception of TRT 2 in AND (see variance). Considering the morning shade and increased moisture in TRT 2 at the AND site could account for the better results in that plot.

Tomato - results based on sum of weight in lbs. & ounces			
	CTRL	TRT 1	TRT 2
AND	39.53	37.11	81.40
ARB	141.23	139.98	124.37
SPC	202.11	186.46	171.73
Grand Total	382.87	363.55	377.50
Tomato - results based on sum of count			
AND	125	104	154
ARB	365	302	264
SPC	591	549	511
Grand Total	1081	955	929
Tomato - results based on average height in inches			
AND	33.88	36.13	36.13
ARB	38.14	38.86	36.86
SPC	40.24	38.84	38.02
Grand Total	37.51	37.94	37.05
Tomato - results based on average width in inches			
AND	31.63	31.63	33.50
ARB	34.86	34.86	31.43
SPC	41.51	38.69	36.53
Grand Total	36.28	35.22	34.03

The AND site showed a decrease in count of tomatoes of 16.8% in TRT 1 compared to the CTRL plot. The Arb site showed a decrease of 17.3% in TRT 1 and a larger decrease of 27.8 % in TRT 2 compared to the CTRL plot. The SPC site showed a decrease of 7.1% in TRT 1 and a larger decrease of 13.5% in TRT 2 compared to the CTRL plot.

ANNUALS

Marigolds

The marigolds that were selected were '*Mexican Marigold-Tagetes*', Golden Gem Seeds, *Signata pumila*. They were the shortest crop and were chosen for their bloom longevity and short size with a maximum height of seven inches.

The SPC site showed the first bud break the week of June 23 in the CTRL and TRT 2 plots. By the next week the ARB site had bud break in all three treatments with TRT 1 showing a little stronger show. The AND site suffered early washout from a heavy rainstorm and struggled after that. Within the next few short weeks, the marigolds became very poor performers. At the ARB site there had been some early drought effects, plus damage from wildlife, possibly birds. Aster yellows disease became a problem in all three sites and plants were removed when symptoms appeared. Because of these issues, it was difficult to get viable data.



Zinnias at AND site

Petunias

The petunias that were selected were the specialty 'Pinstripe' variety. Performance data on growth habit and disease resistance was not available. Plants were started by plugs early in the season. By the planting date they were in full bloom. The petunias performed poorly much like the marigolds. They also succumbed to aster yellows disease and many plants were removed. Because of these issues, it was difficult to get viable data.

Zinnias

The zinnias became the star performers among the annuals in the gardens. The variety selected was 'Uproar Rose Hybrid'. They were selected for their bold deep magenta color and large blooms that measure 4-6 inches across, and for their disease resistance and non-stop performance. Seeds were started indoors. With aster yellows disease prevalent in the marigold and petunia crops, the zinnias seemed to tolerate it better with only a couple of flowers showing symptoms. There were no significant effects between treatments on blooming times. Each treatment bloomed at the same rate per location. The SPC location bloomed a little faster than the other two sites.

Zinnia - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	24.77	26.18	26.92
ARB	26.50	25.40	24.17
SPC	22.38	23.33	23.13
Grand Total	24.55	24.97	24.74
Zinnia - results based on average width in inches			
AND	20.90	21.70	24.26
ARB	23.11	20.89	20.56
SPC	22.33	21.68	21.69
Grand Total	22.11	21.41	22.19

Biochar Results on Zinnias: There was a slight increase in average height and width in the TRT 1 plot over the CTRL plot in the AND site.

There was a slight decrease in average height and width in the TRT 1 & 2 plots compared to the CTRL plots in both the ARB and SPC sites. There did not appear to be a significant difference between TRTs 1 and 2 at either site.

PERENNIALS

Chrysanthemums

There were three mums selected for the gardens. All were 'Mums of Minnesota' varieties developed by the University of Minnesota. All are cold tolerant and considered prolific and disease resistant.

- The first variety, 'Betty Lou,' was selected for being an early bloomer- starting in August. The plant grows to 10-12" in the first year and 2.5-3' when it reaches maturity. The average plant width is 30". Blooms measure about 2.5".
- The 'Gold Country' variety was selected because it is a late-season variety blooming in mid-September. Mature height reaches 21" and width is also 21". Blooms are a peachy bronze tinged with yellow and are 4.5" in width.
- The third variety of mums selected was 'Maroon Pride.' This plant matures to a height of 15-18" with a width of up to 30". The dark red flowers are 4.5" and this one blooms in early September.

Biochar Results on Chrysanthemums: Results are very inconsistent with some sites and plots showing increases of growth, while others showing decreases. Results are inconclusive from this first year. Hopefully, years 2-4 will show more consistency in the results.



Mum "Betty Lou" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	6.86	16.11	11.54
ARB	10.33	7.00	7.00
SPC	8.93	14.28	13.52
Grand Total	8.16	14.64	12.20

Mum "Betty Lou" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	8.36	15.86	13.46
ARB	12.67	8.00	9.00
SPC	12.37	22.22	18.60
Grand Total	10.64	18.43	15.66

Mum "Gold Country" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	13.21	15.07	10.00
ARB	9.67	7.00	9.67
SPC	10.87	12.85	13.10
Grand Total	11.78	13.48	11.42

Mum "Gold Country" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	12.14	11.43	9.86
ARB	8.33	6.00	7.67
SPC	12.92	14.90	13.80
Grand Total	12.15	12.76	11.50

Mum "Maroon Pride" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	12.57	13.79	11.25
ARB	6.50	8.00	10.00
SPC	13.97	14.45	13.30
Grand Total	12.85	13.73	12.16

Mum "Maroon Pride" - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	16.07	20.14	14.00
ARB	8.50	8.50	10.00
SPC	24.03	26.45	22.13
Grand Total	19.44	22.44	17.68

Northern Accent Shrub Roses

The roses selected were ‘Northern Accent’ shrub roses developed by the University of Minnesota. These are of the polyantha variety and die back to the crown in the winter. By early summer, these plants grow to 2’ tall, and are very prolific bloomers. These cold hardy roses need no special care and no pruning is required except for removal of deadwood.

- The ‘Lena’ variety has a single-flowered blush pink blossom reminiscent of apple blossoms. It grows to 2.5’ tall and 2-3” wide.
- The ‘Ole’ variety is a semi-double blush pink rose that fades to white. It grows to a height of 2.5-3’.
- The ‘Sven’ variety grows between 2.5- 3’ height and their small 1-2” flowers are mauve in color and fragrant.

Biochar Results on Northern Accent Shrub

Roses: Most of the roses seemed to perform slightly better in growth in the CTRL plot at the AND site. Most of the roses in the ARB and SPC sites showed some slight improvement in the TRT 1 & 2 plots over the CTRL plots. There appeared to be a lot of inconsistencies in the data to determine if biochar had any improvement over bloom performance.

Roses ‘Lena’ - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	22.75	17.17	16.00
ARB	17.67	18.33	18.67
SPC	19.41	19.63	20.11
Grand Total	20.05	18.82	18.85

Roses ‘Lena’ - results based on average width in inches			
AND	24.33	22.00	23.17
ARB	21.67	22.00	21.33
SPC	23.82	26.57	26.16
Grand Total	23.67	24.78	24.75

Roses ‘Ole’ - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	16.50	13.83	14.17
ARB	19.00	15.00	19.00
SPC	18.79	21.04	18.63
Grand Total	18.18	18.52	17.44

Roses ‘Ole’ - results based on average width in inches			
AND	23.83	20.67	23.17
ARB	18.00	14.50	14.50
SPC	25.77	28.16	29.43
Grand Total	24.53	24.88	26.36

Roses ‘Sven’ - results based on average height in inches			
	CTRL	TRT1	TRT2
AND	14.67	16.83	14.83
ARB	17.67	17.67	17.33
SPC	17.96	19.63	18.75
Grand Total	17.07	18.64	17.54

Roses ‘Sven’ - results based on average width in inches			
AND	24.17	21.00	20.50
ARB	19.67	18.00	20.00
SPC	24.73	23.14	25.80
Grand Total	23.92	21.91	23.66

SUMMARY

The more we learn about biochar, the more we need to learn. From an overall standpoint, there appeared to be some benefit of using biochar in the nutrient-depleted sandy soils at the Andover site for some crops. Yet, there was a decrease in growth in some plants and higher yield in others. In the Arboretum and St. Paul campus sites, we noted similar results, but more crops seemed to decline with biochar than without it.

Extension Master Gardener volunteers have been instrumental and valued in their support on this research project. During this first year, volunteers learned about the importance of accuracy, and project leaders learned about instructing volunteers in data collection. Our goal in 2013 will be to continue to improve and streamline data collection, making sure we are asking volunteers to collect the data most important to research results. One of the biggest changes will be the timing of data readings. All crops will have measurements taken or harvested only one time during the season based on the maturity dates, and no longer will volunteers take weekly readings. Projects leaders are also focused on developing a clearer and easier method for documenting the data to help guarantee more consistency in data reporting.

As we move into the next phase of our research, it will be valuable to compare across the four years slated for this project.



Volunteers at AND site