Extension Master Gardener Biochar Demonstration Gardens 2014 Annual Report

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"Is biochar a good soil amendment for home gardens?

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

Extension Master Gardener volunteers have been participating on the Extension and Outreach objective of a 5-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 increase local renewable energy. Information about the project can be found at http://www.cenusa.iastate.edu/.

Demonstration gardens are planted each year with typical garden plants such as tomatoes, peppers and zinnias in beds that were applied with biochar prior to the first planting in year-one on the project. No further biochar was, or will, be added during the duration of this project. These gardens are planted and maintained each season by Extension Master Gardeners and youth volunteers. Growth and yield measurements are taken on plants at designated times of the season and compared across the sites to help determine any positive or negative effects of biochar on the garden plots.

This report reflects the results from year three of the four-year study by Extension Master Gardener volunteers in Minnesota.

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SITE ESTABLISHMENT

Originally, three sites in Minnesota and three sites in Iowa were established. In 2013, an additional site was established at the Brookston Community Center on the Fond du Lac Band of Lake Superior Chippewa Reservation located in Northeastern Minnesota adjacent to the city of Cloquet. Due to the discovery of a concrete slab under the first garden site at the Brookston Community Center, a new site was re-established in 2014.

Each site was designed to have the same varieties and numbers of plants in each location in order to draw a comparison across crops on collection dates. Each of the demonstration gardens cover 1000 ft^2 and are divided into three plots of 300 ft^2.

Each site has a control (CTRL) plot with no biochar added, a Treatment 1 (TRT1) plot amended with 150 pounds (1/2 lb per ft^2), of granulated biochar and a Treatment 2 plot (TRT2) amended with 300 pounds (1 lb per ft^2) of biochar. The biochar for this project was donated by the Royal Oak Enterprises, LLC. The biochar was delivered in 50 pound bags. The bags were spread evenly over the specified plots and rototilled into the soil. Protective eyewear, gloves and dust masks were worn by the applicators. The biochar was only added at establishment of the demonstration gardens in 2012 and in 2013 at the fourth Minnesota site. No additional biochar will be added during this study.

The soil structure in each site is uniquely different and it is anticipated that the results in each location will be quite different. Soil tests are conducted at the sites each spring and the gardens are amended with fertilizer one time per season based on the recommendations of the soil tests. No additional compost or other amendments are added.

Rototilling was done in the first season only when the biochar was added. By not rototilling in subsequent years, it has been more observable to determine soil compaction and ease of planting in plots with biochar compared to the control plots. It has been noted that the plots with biochar have less compaction and are easier to plant in than the control plots even if the soil is wet.

THE SITES

University of Minnesota Landscape Arboretum (ARB), 3675 Arboretum Drive, Chaska, MN 55318

Planting day at Arboretum site

The Minnesota Landscape Arboretum was selected for this study because of its reputation as a world-class arboretum that is visited by over a quarter million people per year. With that amount of visibility, it is a great location to showcase this research project. The biochar demonstration garden was established on the Three-Mile Drive next to the Dahlia Trial Gardens.

This site was amended from a previously mowed turf area. The soil at this location at the Arboretum is silt loam. The soil test analysis showed a recommendation for a nitrogen-only fertilizer with a ratio of 32-0-0.

Watering at this site is done manually with a hose and sprinkler and becomes labor intensive over the course of the season during dryer weather. An automatic timer is not an option.

University of Minnesota - St. Paul Campus (SPC),
Folwell and Gortner Avenues, St. Paul, MN 55108

The demonstration garden at the St. Paul Campus is in close proximity to the ***Department of Horticultural Science Display and Trial Gardens*** which is a popular public garden for University students, staff, faculty and the general public.

The demonstration garden site was a former low-mow turf trial plot. The soil at this site is silt loam. The area where the garden is located is irrigated regularly. The soil test in this garden recommended a nitrogen only fertilizer of 32-0-0, the same as the Arboretum site.

Planting crew at St. Paul Campus site

Andover site on planting day

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

The demonstration garden at Bunker Hills Park in Andover is located adjacent to a public hiking/biking trail. The park is located in the Northern metro area of the Twin Cities and is visited by thousands of people each year. This site, before it was converted to a garden, was not maintained and consisted of small trees and underbrush. The soil in this site is almost pure sand; a great place to test the theories of biochar being a benefit in poor or depleted soils. The soil test recommended a well-rounded fertilizer with a 10-0-15 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, plus the plants are less prone to heat stress.

Planting day at Fond du Lac site

Brookston Community Center, Fond du Lac Tribal Community (FDL), Cloquet, MN 55720

Located in Northeastern Minnesota, this demonstration garden site was established in 2013. Upon discovering a concrete slab a few inches below the surface of the garden, the garden was moved and a new site was reestablished in 2014. Extension staff and Master Gardener volunteers coached area youth and family members in developing and planting the demonstration garden. This is the only site that features a youth education component. The soil at this site is pure sand and was amended with a 10-0-12 fertilizer based on the soil test recommendations. A deer-proof fence was also required.

THE VOLUNTEERS

Master Gardener volunteer at AND site

"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/)*

In Minnesota, each of the four sites has team leaders and between 8-14 additional volunteers supporting the needs of each site. All of the Master Gardeners completed a specialized training to learn about biochar and the CenUSA grant. Their hours spent teaching and caring for the sites are reported as part of their volunteer hours.

Master Gardener volunteers are involved in many facets of the study including planting and maintaining the demonstration gardens, collecting and recording data measurements and harvesting crops. Volunteers also teach the public about biochar and share their research findings at state and county fairs, horticulture field days and other community events.


Youth demonstration garden at FDL site

THE GARDENS

The ornamental and edible crops selected at each site are typical of those grown by home gardeners. Edible crops included: green beans, tomatoes, green bell peppers, carrots, leafy kale, cucumbers, lettuce, asparagus, potatoes, and basil. The ornamental crops included zinnias, salvia, gazania, chrysanthemums and shrub roses.

Planting Day


Planting Day ARB site

Due to the cool and wet spring, planting was delayed in the Twin Cities Metro area until the first week of June. The Fond du Lac site was planted a week later.

The weather during the month of May and early June was in a long holding pattern of frequent rains and cold temperatures. This resulted in less than ideal conditions for planting. Regardless, the gardens were planted on schedule.

In spite of the partially wet and compacted soils, it was reported that the biochar treated areas were easier to work in compared to the control plots. This was consistent in all three established sites, even with different soil textures from sand to silt loam. Biochar appeared to improve soil texture in all of the gardens, making planting easier even when the soil was wet.

Germination and Plant Establishment

The 2014 late winter and early spring brought many cool and cloudy days. The zinnias and salvia both had a tough start in the grower's greenhouse due to the lack of natural light, but adjusted well after transplanting.

Lettuce and carrots were planted with seed tapes but once again, germination was very spotty with over 75% failure. This was consistent over all three treatments. It is plausible that the reason for their failure could have been from inconsistent moisture during the tender germination period.

A few tomatoes and peppers had cutworm damage. The plants were replanted within a few short days and protection was added to the plants.

The perennial chrysanthemum 'Gold Country' had winter kill at all of the sites in 2013, with the exception of two remaining plants at the SPC site; the chrysanthemums were not replaced.

Weeds, Pests and Diseases

Rose chafers, Japanese beetles and spotted asparagus beetle nmyphs were observed in the gardens in 2014. The damage was minimal on most of the plants and insects were removed by hand or tolerated. No pesticides are used in these gardens. At the scheduled times for data collection, there were no diseases to report. During the mid-season powdery mildew and a virus was spotted on some of the cucumber plants. By the end of the season there were typical tomato leaf spot diseases. Master Gardeners did a great job of providing good sanitation in the garden by removing infected plants and leaves and they kept general garden weeds under control as well. The poison ivy sightings at the AND site declined from 2012 but there were a few random sprouts that came up and were removed immediately.

Spotted asparagus beetle nymph

Nutrient Deficiency

The demonstration gardens at the SPC and the ARB had the most vigor, most likely due primarily to the silt loam soils which holds moisture and nutrients better than their sandy counterparts. The AND and FDL sites showed early signs of nutrient deficiency which resulted in smaller plants with longer stem internodes, yellow-green colored leaves, and lower yields. Presumably, this was due to the sandy soil which is conducive to fertilizer leeching through rains and regular watering.

YOUTH EDUCATION

It became apparent when available resources and the needs of the community provided a welcome turn in the research project by offering a youth education component at the Fond du Lac site. Fond du Lac tribal community Extension Master Gardeners collaborated with the Brookston Community Center staff to deliver gardening education for elementary and middle school-aged youth in a vibrant season-long program. The volunteers engaged local youth to care for the garden and collect observational data.

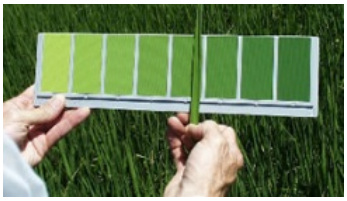
The 1000 ft^2 CenUSA Biochar Demonstration Garden was the center of a 20-week long Junior Master Gardener (JMG) program developed and taught by the five Fond du Lac community Extension Master Gardeners.

At various times, between 10-20 children participated in an after-school JMG program focused on understanding the basics of growing healthy food and even learning about common garden weeds that are edible. Some of the topics covered included planting techniques, observation and garden care, harvesting techniques and cooking. Students

particularly enjoyed the lessons that integrated education, cooking, and tasting the vegetables. They also enjoyed seeing the variations between the different biochar test plots. Because of the change in focus, data from this garden will not be collected in the same way as the other sites in Minnesota, but the volunteers at this site will continue with their youth focus moving forward.

Data Collection

Since this project is a representation of a typical homeowner garden, we wanted to answer questions a homeowner would ask that would address such as, plant growth and health, vegetable yields and bloom production on flowers.The guidelines established for collecting data were based on growers' recommended days-to-maturity. Following the growers' optimal harvest recommendations provides a baseline for the duration of the four-year study and helps determine any long-term patterns.



Leaf color key

Master Gardener volunteers used worksheets to record plant height and widths, weight of produce, bloom production on flowers and leaf color. Weights were measured in grams and converted to pounds and ounces. Heights and widths were measured in inches; bloom data was based on percentage of flowers open and leaf color was based on a key with a scale of 1-8 with the lowest number correlating with the lightest green and the highest number the darkest green. This key gives an indication of nitrogen and health in a plant. The lighter the green green color represents lower nitrogen levels.

The cooler, wet spring conditions resulted in most crops being slightly immature based on the averages for reaching maturity per the growers' recommendations. Regardless, the crops were harvested and measured on schedule as per the suggested days-to-maturity. Some crops such as the tomatoes, peppers, beans and cucumbers that ripen progressively had multiple data collection days and were harvested over a two-week period

Approximately thirty five Master Gardener volunteers were involved in measuring data and recording the results. Though Extension staff provided volunteers with all possible means of training and information for proper data collection, there are notably some levels of error based on individuals' interpretations and subjective opinions. Results from the collection of data follows.

RESULTS

1. Asparagus

Jersey Knight Hybrid asparagus (Asparagus 'Jersey Knight Hybrid') two-year roots were selected and are the only perennial vegetable in the gardens. This variety was chosen because of its adaptability to a variety of soils plus for their disease resistance to rust. Five crowns were planted in each treatment in year-one. There was no harvest in Year 1 or 2. In year-3, growth was very inconsistent between sites and even within plots at each site. This may be due to root dieback or other factors. As a result it will be difficult to get reliable data to determine the effect of biochar on this crop.

Asparagus from SPC site: L-R: Trt2, Trt 1, Ctrl

2. Basil

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

Basil Sites & Treatments	Plants per Treatment	2014 Average Plant Height	2013 Average Plant Height	2014 Average Plant Width	2013 Average Plant Width	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8	2014 Average weight in grams per Plant	2014 Sum of Weight in Grams all Plants	2013 Sum of Weight in Grams all Plants	2014 Converted Total Weight in Pounds
Control											
AND Team	12.00	17.00	16.25	10.00	10.50	4	4	70.50	846	853	1.87
ARB Team	12.00	23.00	18.50	19.00	13.50	4	5	213.92	2567	1134	5.66
SPC Team	11.00	19.50	17.50	14.75	10.00	3	3	173.73	1977	626	4.36
Control	**11.67**	**18.25**	**17.42**	**12.81**	**11.33**	**3.67**	**4**	**154.72**	**5390**	2613	11.89
Treatment 1											
AND Team	12.00	23.50	16.00	13.50	9.00	5	4	168.08	2017	767	4.45
ARB Team	12.00	24.75	17.50	17.75	13.50	4	5	231.25	2775	934	6.12
SPC Team	12.00	17.75	17.00	13.25	11.00	3	4	131.58	1579	626	3.48
Treatment 1	**12.00**	**19.88**	**16.83**	**13.38**	**11.17**	**4**	**4.33**	**176.97**	**6371**	2327	14.05
Treatment 2											
AND Team	12.00	17.00	18.00	11.00	10.25	5	4	80.50	966	1080	2.13
ARB Team	12.00	22.50	17.50	17.50	12.50	4	5	225.08	2701	513	5.95
SPC Team	12.00	17.00	18.00	16.50	12.50	4	4	195.58	2347	653	5.17
Treatment 2	**12.00**	**17.44**	**17.83**	**13.75**	**11.75**	**4.33**	**4.33**	**167.05**	**6014**	2246	13.25

Variances:

In 2014 the basil did not like the cool start to the season, but seemed to adjust once the weather warmed up. At the time of harvest, the plants were showing early signs of bolting. Flowers were not deadheaded prior to harvest. In 2013 the original crop died and then replanted two weeks after the first planting. This resulted in smaller plants at the designated harvest date which may explain the smaller sizes and weights.

Basil harvest at AND site: L-R Ctrl, Trt1 & Trt2

Comments:

In 2014, more growth was observed in TRT1 plots at AND and ARB. Basil performed better in the TRT2 plots. The most significant differences observed were at the AND site with nearly 2.5 times the yield in weight between TRT 1 & the CTRL plots.

3. Beans

Blue Lake Bush beans (*Phaseolus vulgaris* 'Blue Lake 274') were selected for this project based on their 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 and the scheduled harvest was within three days of July 14th, then subsequently harvested two times per week over a period of 2 weeks.

Beans Sites & Treatments	Plants per Treatment	2014 Average Plant Height	2013 Average Plant Height	2014 Average Plant Width	2013 Average Plant Width	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8	2014 Average weight in grams per Plant	2014 Sum of Weight in Grams	2013 Sum of Weight in Grams	2014 Converted Total Weight in Pounds
Control											
AND Team	15.00	12.50	12.50	18.00	6.00	2	5	11	160	739	.35
ARB Team	14.00	18.00	15.00	19.00	12.75	4.5	6	52	723	263	1.59
SPC Team	14.00	19.50	13.50	19.75	10.25	6	3	178	2489	826	5.49
Control	**14.33**	**16.67**	**11.65**	**18.92**	**12.70**	**3.67**	**4.67**	**80**	**3372**	1828	7.43
Treatment 1											
AND Team	15.00	19.50	12.75	21.00	8.50	5	6	76	1136	1619	2.50
ARB Team	15.00	23.00	17.00	28.00	12.00	6	6	113	1694	725	3.73
SPC Team	13.00	21.50	12.25	20.00	8.50	6	4	124	1615	1148	3.56
Treatment 1	**14.33**	**21.33**	**12.10**	**23.00**	**12.00**	**4**	**5.33**	**104**	**4445**	3492	9.79
Treatment 2											
AND Team	15.00	19.00	12.50	18.50	8.00	7	7	51	763	159	1.68
ARB Team	14.00	21.00	18.00	25.00	13.75	6	7	61	852	463	1.88
SPC Team	15.00	18.50	12.50	21.25	8.00	6	5	136	2041	648	4.50
Treatment 2	**14.67**	**19.50**	**12.75**	**21.58**	**13.75**	**4.33**	**6.33**	**83**	**3656**	1270	8.06

Third harvest at SPC: L-R Ctrl, T1, T2

Variances:

Approximately 60 seeds were planted in each treatment and thinned to 15 plants per treatment. There were some plant losses in both the ARB and SPC plots. The ARB lost one plant in CTRL and TRT 1. The SPC team lost one plant in CTRL and two in TRT 1. The SPC site had the best yields in the CTRL & TRT2 plots. The beans were just starting to set mature fruits for the first harvest and had average yields for the four harvest periods. In 2013, due to the early wet spring, the beans in general were not mature at the time of harvest resulting in smaller yields.

Comments:

The beans appeared to respond well to TRT 1 in both the AND and ARB sites and at the SPC the beans had the greatest yield in CTRL based on average weight per plant. Both AND and ARB sites have a sprinkler that is centered among the TRT1 plots which most likely receives more moisture than the outside plots, which may partially contribute to the higher yields in TRT 1. Overall the SPC site had much better yield results than the other sites. This could be because it has a warmer microclimate and reached maturity faster than the other two locations. The plant losses were most likely from birds and/or cutworms.

4. Carrots (Crop Failed)

Sweet Treat Hybrid carrots (*Daucus carota* var. *sativus* 'Sweet Treat Hybrid') were selected. At maturity, these carrots are best at 6" long. Seed tapes were used to help provide easier, more consistent direct sowing of very small seeds. They are descripted as sweet and crunchy. Japanese kuroda type has tapered spike shaped roots. These carrots should be mature and ready to harvest at 70 days.

Variances: Germination continues to be a struggle for carrots in all sites and treatments. A separate germination test was made to check viability of the seeds, and discovered they germinated well in a controlled setting. The reason for poor germination in the gardens is most likely due to a lack of consistent moisture in the soil during the time of early germination and establishment. Based on the poor germination and limited yields, the results are inconclusive.

Comments:

Based on the poor quality of plants, it is difficult to assess whether the biochar had any effect on plant growth. In 2015, greater efforts will be made to ensure better germination.

Volunteers collecting data at SPC site

5. Cucumbers

The variety selected is **Tasty Green Hybrid** cucumber (*Cucumis sativus* 'Tasty Green Hybrid'). This variety was chosen based on the description of being disease resistant, 9-10" in length and a good variety for growing on trellises. The maturity date listed was 62 days. Seeds were started in the greenhouse and transplanted.

Cucumbers Sites & Treatments	Plants per Treatment	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8	2014 Yield Count	2013 Yield Count	2014 Average weight in grams per Plant	2014 Sum of Weight in Grams	2013 Sum of Weight in Grams	2014 Converted Total Weight in Pounds
Control									
AND Team	3	6	4	7	2	1237	3710	41	8.18
ARB Team	3	8	-	46	0	7646	22939	0	50.51
SPC Team	3	3	5	7	6	690	2069	209	4.56
Control	**3**	**5.69**	**4.5**	**60**	**8**	**3191**	**28718**	250	63.31
Treatment 1									
AND Team	3	7	6	12	3	1767	5301	104	11.69
ARB Team	3	8	-	59	5	7443	22330	159	49.23
SPC Team	3	4	4	5	1	810	2430	59	5.36
Treatment 1	**3**	**6.33**	**5**	**76**	**9**	**3340**	**30061**	322	66.27
Treatment 2									
AND Team	3	7	5	11	1	17992	6376	122	14.06
ARB Team	3	8	-	52	13	6299	18897	354	41.66
SPC Team	3	5	4	18	4	1769	5308	209	11.70
Treatment 2	**3**	**6.67**	**4.5**	**81**	**18**	**3287**	**30581**	685	67.42

Variances:

Seeds were started in a greenhouse in April and three healthy plants were transplanted into each treatment. This method provided for a much healthier start than 2013 when the seeds were direct-sown. Late in the season in 2014, there were signs of powdery mildew plus a virus that resembled mosaic in all of the sites. Because it was post-harvest those diseases didn't affect the yields. In 2013, the ARB site had a loss of cucumber plants in the CTRL plot, and SPC had a loss in TRT 1. Overall, the conditions at the ARB site seemed much more favorable to cucumbers than at the other two sites resulting in higher yields. This particular cucumber is also a very fast grower, so if the harvest at the ARB was even a few days later than the other sites, this would contribute to the greater weights as well.

Cucumbers were grown on bamboo tri-pods

Comments: Based on the results in 2014, there were not enough patterns of growth between the sites and treatments to determine if the biochar had any effect on the cucumbers.

6. Kale

Blue Curled Vates kale (*Brassica oleracea* 'Blue Curled Vates') was selected for its durability in the garden and an added bonus is its longevity of growth into the fall. Fifteen kale transplants were planted in each plot. August 1st was selected as the harvest date. Eight of the 15 plants were harvested. The remaining seven were left for aesthetic purposes until after a hard frost.

Kale Sites & Treatments	Plants per Treatment	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8	2014 Average weight in grams per Plant	2014 Sum of Weight in Grams	2013 Sum of Weight in Grams	2014 Converted Total Weight in Pounds
Control											
AND Team	7	9.00	7.00	12.00	14.50	6	5	86	602	904	1.33
ARB Team	7	15.00	-	20.00	-	5	-	318	2223	1551	4.90
SPC Team	7	13.00	16.00	18.75	23.00	6	5	249	1746	3657	8.06
Control	**7**	**12.33**	**11.50**	**16.92**	**18.75**	**6**	**5.00**	**218**	**4571**	6112	10.08
Treatment 1											
AND Team	7	12.00	10.00	17.00	16.50	6	6	183	1284	1321	2.83
ARB Team	7	18.00	-	21.50	-	6	-	382	2673	1754	5.89
SPC Team	7	15.25	16.00	21.25	25.00	6	5	359	2512	4589	10.12
Treatment 1	**7**	**15.08**	**13.00**	**19.92**	**20.75**	**6**	**5.5**	**308**	**6469**	7665	14.26
Treatment 2											
AND Team	7	14.00	9.00	22.00	16.00	7	6	208	1453	1261	3.20
ARB Team	7	18.00	-	21.75	-	6	-	446	3121	1533	6.88
SPC Team	7	13.75	15.00	22.50	24.00	6	5	334	2340	3581	5.16
Treatment 2	**7**	**15.25**	**12.00**	**22.08**	**20.00**	**6.33**	**5.5**	**329**	**6914**	6375	15.24

Kale at the ARB site

Variances: The kale crops for the most part exhibited good health once they overcame transplanting and the cool start from the spring conditions. The CTRL plot at AND may have suffered more drought conditions which could have contributed to smaller plants. With the sprinkler in the middle of TRT 1 and the slight shade in TRT2 could have been why those plants were a little healthier.

Comments: Based on the inconsistencies in yields between treatments in 2014 and from the past year, it is difficult to determine if biochar had positive or negative effects on kale.

7. Lettuce (crop failed)

Black Seeded Simson (*Lactuca sativa* 'Black Seeded Simson') is a common heirloom plant that is known to have tender, buttery texture and pale green leaves. Like carrots, seed tapes were used to help provide easier, more consistent direct sowing of very small seeds. This variety has an average of 45 days-to-maturity. Because of the cool wet spring, and knowing lettuce typically performs well in those conditions, it was considered that the lettuce would be the standout crop in performance, but that wasn't the case.

Variances: As with carrots, germination continued to be a struggle for lettuce in all sites and treatments. A separate germination test was made to check viability of the seeds, and discovered they germinated well in a controlled setting. The reason for poor germination in the gardens is most likely due to a lack of consistent moisture in the soil during the time of early germination and establishment. Based on the poor germination and limited yields, the results are inconclusive.

Comments:
Based on the poor quality of plants, it is difficult to assess whether the biochar had any effect on plant growth. In 2015, greater efforts will be made to ensure better germination.

Poor lettuce germination

8. Peppers

The pepper variety selected was **King Arthur Hybrid Sweet Bell** pepper (*Capsicum annuum* 'King Arthur Hybrid'*)*. The King Arthur peppers are large 4 1/2" bells that grow on 22" plants. The average days-to-maturity is 62. They are known for high yields and are tolerant of Tobacco Mosaic Virus (TMV) and Potato Virus Y (PVY).

Pepper Sites & Treatments	Plants per Treatment	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8	2014 Average weight in grams per Plant	2014 Sum of Weight in Grams	2013 Sum of Weight in Grams	2014 Converted Total Weight in Pounds
Control											
AND Team	8	17.00	14.00	13.00	10.00	5	2	15	120	0	.26
ARB Team	8	21.00	17.00	12.00	11.00	4	5	124	991	2295	2.18
SPC Team	8	19.75	8.50	12.25	5.50	3	5	0	0	200	0-
Control	**8**	**19.25**	**16.00**	**12.42**	**11.50**	**4.00**	**4.00**	**46**	**1111**	**2495**	**2.45**
Treatment 1											
AND Team	8	16.00	14.00	12.00	10.00	5	2	15	117	399	.26
ARB Team	8	21.00	18.00	12.00	14.00	3	6	202	1612	3316	3.55
SPC Team	8	17.00	11.00	12.00	7.50	3	6	12	95	340	.21
Treatment 1	**8**	**18.00**	**10.50**	**12.00**	**11.00**	**3.67**	**4.50**	**76**	**1824**	**4055**	**4.02**
Treatment 2											
AND Team	8	14.00	13.25	11.00	9.25	4	3	11	87	0	.19
ARB Team	8	20.00	18.00	10.00	13.00	2	7	95	763	2554	1.68
SPC Team	8	19.75	8.00	12.25	5.00	2	4	23	186	113	.41
Treatment 2	**8**	**17.92**	**13.50**	**11.08**	**10.00**	**2.67**	**4.50**	**43**	**1036**	**2667**	**2.28**

1st pepper harvest at the Andover site.

Variances: The peppers showed delayed growth due to the prolonged cool temperatures in the spring. Very few fruits were ripe at the designated harvest dates based on days-to-maturity.

Comments: The peppers were harvested twice, once per week over a two-week period and only if the fruits were of mature size. Based on the poor yields at all sites and in all treatments, there were no significant differences in the results from peppers grown in biochar.

Pepper plant SPC site

9. Potatoes

A new variety of potato from University of Minnesota called **'Runestone Gold'** was selected. They are a mid- to full-season variety with dark green foliage. 'Runestone Gold' has excellent culinary qualities and dark red skin, deep yellow flesh and a round to oval uniform tuber. The estimated days-to-maturity is 80-100 days. The date of harvest selected was 90 days after planting. Each site had three healthy eyes planted per treatment and all survived until harvest.

Sites & Treatments	Plants per Treatment	2014 Average Weight in Grams per Plant	2014 Sum of Weight in Grams	2013 Sum of Weight in Grams	2014 Converted Total Weight in Pounds
Control					
AND Team	3	655	1964	1361	4.33
ARB Team	3	985	2954	2921	6.51
SPC Team	3	615	1844	8110	4.07
Control	**9**	**752**	**6762**	**12392**	**14.91**
Treatment 1					
AND Team	3	592	1777	2921	3.92
ARB Team	3	1127	3380	3175	7.45
SPC Team	3	512	1537	9009	3.39
Treatment 1	**9**	**757**	**6694**	**15105**	**14.76**
Treatment 2					
AND Team	3	548	1645	2921	3.63
ARB Team	3	850	2551	3629	5.62
SPC Team	3	827	2481	6210	5.47
Treatment 2	**9**	**742**	**6677**	**12760**	**14.72**

Left to right: Ctrl, Trt 1, Trt 2 at Andover site

Variances: Since potatoes typically have dieback in the vegetative portion of the plant at the time of harvest, the volunteers were only asked to measure weights on this crop.

Comments: There were no consistent or significant patterns of growth between plots to determine if biochar had any effect on growing potatoes.

10. Tomatoes

The **Celebrity tomato hybrid** (*Lycopersicon esculentum* 'Celebrity Hybrid'), a 1984 AAS winner, was selected for its outstanding disease resistance, determinate form and productivity. 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 feet and width of 3 feet. Seeds were started indoors and the projected date of harvest was mid-late August. Five plants were grown in each treatment.

Tomato harvest at Andover Site

Sites & Treatments	Plants per Treatment	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8	2014 Average Weight in Grams per Plant	2014 Sum of Weight in Grams	2013 Sum of Weight in Grams	2014 Converted Weight
Control											
AND Team	5	32.00	27.00	22.00	14.50	8	5	1062	5308	2155	11.70
ARB Team	5	42.00	33.00	36.00	23.50	7	7	1788	8938	1701	19.70
SPC Team	5	33.25	30.00	33.25	26.00	5	6	1458	7291	3148	16.07
Control	**5**	**35.75**	**30.00**	**30.42**	**21.33**	**7**	**6.00**	**1436**	**21537**	**7004**	**47.47**
Treatment 1											
AND Team	5	33.00	30.00	25.00	21.00	8	5	675	3373	12220	7.44
ARB Team	5	40.00	37.75	32.00	31.50	7	8	893	4465	3289	9.84
SPC Team	5	37.50	-	39.00	-	5	-	1164	5820	2722	12.83
Treatment 1	**5**	**36.83**	**33.88**	**32.00**	**26.25**	**7**	**6.50**	**911**	**13658**	**18231**	**30.11**
Treatment 2											
AND Team	5	35.00	35.00	25.00	20.00	8	6	595	2974	8931	6.56
ARB Team	5	42.00	38.25	32.00	29.25	7	8	752	3759	2014	8.29
SPC Team	5	37.50	30.00	38.50	32.00	5	6	635	3175	1701	7.00
Treatment 2	**5**	**38.17**	**34.42**	**31.83**	**27.08**	**7**	**6.67**	**661**	**9908**	**12646**	**21.85**

Variances: Within 3-5 days of the initial transplanting, a few tomatoes succumbed to cutworm damage. Those plants were immediately replaced and protective collars were placed around all plants. No further damage occurred.

Comments: The tomatoes in the CTRL plots outperformed those in the biochar treatments in 2014 in regards to weight. This was a surprise compared to 2013 where the TRT1 plots of tomatoes appeared to outperform the CTRL and TRT2 plots. With this inconsistency, it is difficult to determine if biochar had a positive or negative effect on tomatoes.

ORNAMENTALS

Data on flowers were collected on plant growth and leaf color. Blooms were also measured by percent of blossoms open with a ranking of 1-5, as such: 1=1-25%; 2=26-50%; 3=51-75% & 4= 76-100%. Leaf color was determined by a leaf color key ranking the colors as 1-8 with the lowest number showing the lightest green and the highest number the darkest green. The color chart gives an indication of nitrogen in the plant.

11. Gazania

***Gazania* 'Big Kiss White Flame '**was selected for its unique coloring and size, and adaptability. This particular variety has super-sized, 4 1/2 inch, pinwheel striped blooms which are nearly 50% larger than most other gazanias. They are mounded in growth habit and top-out in height and width at 8-10 inches.

Gazania Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	6.00	8.00	8.50	8.50	4	2	8	7
ARB team	8.00	8.00	8.00	11.00	4	3	8	-
SPC team	16.23	8.50	9.50	9.00	4	2	8	8
Control Total	**10.08**	**8.17**	**8.67**	**9.50**	**4**	**2.33**	**8**	**7.5**
Treatment 1								
AND team	8.00	8.75	7.50	9.00	4	2	8	6
ARB team	8.00	9.75	8.00	11.00	4	3	8	-
SPC team	9.13	8.50	10.25	9.00	3	2	8	7
Treatment 1 Total	**8.38**	**9.00**	**8.58**	**9.67**	**3.67**	**2.33**	**8**	**6.5**
Treatment 2								
AND team	8.00	9.00	10.00	10.75	4	2	8	7
ARB team	9.00	7.50	7.00	10.00	4	4	8	-
SPC team	13.70	7.50	12.75	9.00	3	2	7	7
Treatment 2 Total	**10.23**	**8.00**	**9.92**	**9.92**	**3.67**	**2.67**	**7.67**	**7**

Variances: There were some height variances at the SPC site, but without other sites also showing similar growth, the reason for taller plants in the CTRL and TRT 2 plots at SPC is unknown.

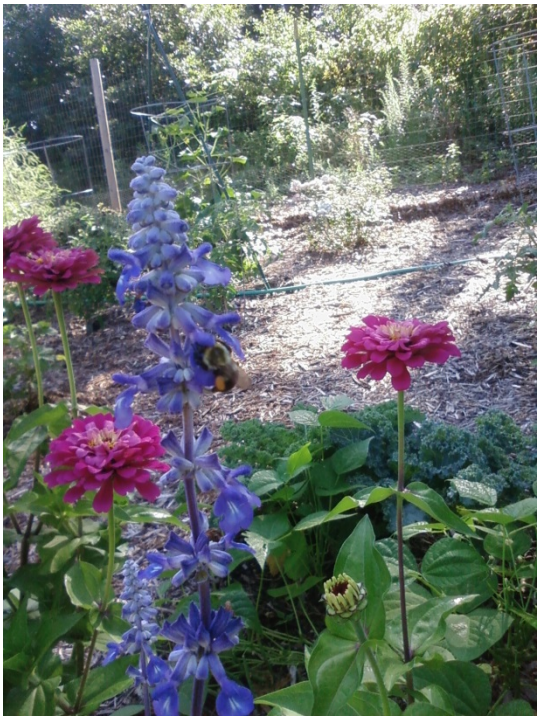
Comments: Other than the anomaly in average height measurement at the SPC site in the CTRL and TRT 2 plots, there were not a lot of significant differences between treatments.

Soldier beetle on gazania-SPC site

12. Salvia

***Salvia farinacea* 'Victoria'** was selected for its prolific, long bloom time, dense, blue flower spikes and light gray-green foliage. This salvia can tolerate some shade or sun. Mature size is 14-24 inches high, and 12-14 inches wide.

Salvia Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	16.90	16.50	9.00	8.50	3	1	4	5
ARB team	21.00	37.00	11.00	17.00	4	2	8	5
SPC team	25.70	24.50	15.50	12.50	4	2	4	5
Control Total	**21.20**	**26.00**	**11.83**	**12.67**	**3.67**	**1.67**	**5.33**	**5**
Treatment 1								
AND team	23.80	18.25	11.75	10.75	3	2	6	7
ARB team	24.50	37.00	12.00	16.00	4	1	5	5
SPC team	23.14	28.50	14.50	14.00	4	2	5	4
Treatment 1 Total	**23.81**	**27.92**	**12.75**	**13.58**	**3.67**	**1.67**	**5.33**	**5.33**
Treatment 2								
AND team	20.25	21.25	11.25	12.00	2	2	6	6
ARB team	21.00	35.00	13.00	17.00	4	2	5	5
SPC team	25.00	27.00	15.75	15.50	4	2	5	4
Treatment 2 Total	**22.08**	**27.75**	**13.33**	**14.83**	**3.33**	**2**	**5.33**	**5**



Salvia at AND site

Variances:,The salvia showed less vigor in 2014 when comparing to the 2013 growth data. Many factors could have contributed to that, such as temperature, moisture, nutrient retention and sunlight.

Comments: The CTRL plot at the AND site showed significantly poorer results in growth and leaf color. Because of the growth and leaf color, biochar may have contributed to better nutrient retention and better overall results in TRT1 and 2 compared to the control plot.

13. Zinnias

***Zinnia* 'Uproar Rose Hybrid'** was selected for its large (4-6") magenta blooms, long bloom time and disease resistance. Mature size is 28-36" tall.

Zinnia Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	21.50	17.25	10.50	11.25	2	4	4	4
ARB team	30.50	24.00	24.00	16.00	4	3	3	3
SPC team	30.00	21.00	21.50	13.00	3	1	3	3
Control Total	**27.33**	**20.75**	**18.67**	**13.42**	**3**	**2.67**	**3.33**	**3.33**
Treatment 1								
AND team	26.25	13.75	15.75	13.75	2	4	4	3
ARB team	29.00	22.00	22.00	22.00	4	2	3	3
SPC team	26.25	20.50	16.75	14.00	4	1	3	3
Treatment 1 Total	**27.17**	**18.75**	**18.17**	**16.58**	**3**	**2.33**	**3.33**	**3**
Treatment 2								
AND team	27.50	16.00	21.00	15.25	2	3	5	6
ARB team	32.00	23.00	22.00	21.00	4	4	3	3
SPC team	27.75	18.50	19.50	12.50	4	1	1	3
Treatment 2 Total	**29.08**	**19.17**	**20.83**	**16.25**	**3.33**	**2.67**	**3**	**4**

Variances: The zinnias performed better in 2014 compared to 2013. Weather conditions between the two years most likely contributed to the differences.

Comments: Here we see that the biochar treated plots resulted in better growth than the CTRL plot at the AND site. Again, this could possibly be attributed to better nutrient and moisture retention.

Zinnia and Salvia at ARB site

PERENNIALS

14. Garden Chrysanthemums

There were three garden chrysanthemums selected for the demonstration gardens. All are part of the "***Mums of Minnesota"*** series developed by the University of Minnesota. They are considered cold tolerant, prolific bloomers and disease resistant.

'Gold Country' was selected as 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.

Four-lined plant bug nymphs on mums at SPC site

'Gold Country' Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	-	-	-	-	-	-	-	-
ARB team	-	-	-	-	-	-	-	-
SPC team	19.00	21.50	18.50	18.00	1	3.5	5	6
Control	**4.75**	**21.50**	**4.63**	**18.00**	**1**	**3.5**	**5**	**6**
Treatment 1								
AND team	-	-	-	-	-	-	-	-
ARB team	-	-	-	-	-	-	-	-
SPC team	21.00	13.50	14.00	17.00	1	3	5	5
Treatment 1	**7.00**	**13.50**	**4.67**	**17.00**	**1**	**3**	**5**	**5**
Treatment 2								
AND team	-	-	-	-	-	-	-	-
ARB team	-	-	-	-	-	-	-	-
SPC team	-	-	-	-	-	-	-	-
Treatment 2	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Variances: Most of the *'Gold Country'* variety had winter kill after the first season. The remaining plants at the SPC struggled initially and recovered fairly well though not with the vigor expected. The plants that died were not replanted.

Comments: Without the comparison across sites, plots and treatments, it is not possible to observe any benefit of biochar on this variety.

'Betty Lou,' was selected as 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".

'Betty Lou' at SPC Site

'Betty Lou' Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	20.00	19.50	26.00	21.00	2	2	6	7
ARB team	24.00	20.00	36.00	33.00	3	2	8	8
SPC team	24.50	20.50	47.00	30.00	4	3	8	8
Control Total	**22.83**	**20.00**	**36.33**	**28.00**	**3.00**	**2.33**	**7.33**	**7.67**
Treatment 1								
AND team	23.00	23.00	36.00	30.00	3	3	7	8
ARB team	27.00	27.00	48.00	42.00	3	3	8	7
SPC team	26.00	24.00	47.00	44.00	3	2	7	7
Treatment 1 Total	**25.33**	**24.67**	**43.67**	**38.67**	**3.00**	**2.67**	**7.33**	**7.33**
Treatment 2								
AND team	22.00	21.50	36.00	25.00	3	2	8	8
ARB team	26.00	26.00	44.00	35.00	3	3	8	8
SPC team	20.00	24.00	40.50	43.00	2	2	7	7
Treatment 2 Total	**22.67**	**23.83**	**40.17**	**34.33**	**2.67**	**2.33**	**7.67**	**7.67**

Variances: All of the mums experienced four-lined plant bug nymph damage early in the season. The damage was primarily aesthetic on the leaves and did not show long-term damage on plant growth or bloom production.

Comments: There appears to be some consistency in plant growth between the two years, showing slightly better results in TRT1 over the other treatments.

'Maroon Pride' blooms in early September and matures to a height of 15-18" with a width of up to 30". The dark red flowers are 4.5".

***'Maroon Pride'* at ARB site**

'Maroon Pride' Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	20.00	21.00	32.00	31.00	4	4	5	-
ARB team	22.00	-	35.00	-	4	-	8	-
SPC team	17.00	15.00	31.00	30.00	4	4	4	7
Control	**19.67**	**18.00**	**32.67**	**30.50**	**4**	**4**	**5.67**	**7**
Treatment 1								
AND team	23.00	23.00	34.00	31.00	3	4	7	-
ARB team	29.00	-	42.00	-	4	-	8	-
SPC team	27.00	20.00	53.00	44.00	4	4	4	8
Treatment 1	**26.33**	**21.50**	**43.00**	**37.50**	**3.67**	**4**	**6.33**	**8**
Treatment 2								
AND team	21.50	24.00	37.00	41.00	4	4	7	-
ARB team	17.00	-	34.00		4	-	8	-
SPC team	18.00	19.00	42.00	36.00	4	4	5	8
Treatment 2	**18.83**	**21.50**	**37.67**	**38.50**	**4**	**4**	**6.67**	**8**

Variances: All of the mums experienced four-lined plant bug nymph damage early in the season. The damage was primarily aesthetic on the leaves and did not show long-term damage on plant growth or bloom production. There was an error in the 2013 report which stated that the *'Maroon Pride'* mums had died at the ARB site, instead, data was just unavailable for this plant.

Comments: There appears to be some consistency in plant growth between the two years, showing slightly better results from biochar in TRT1 over the other treatments.

15. Northern Accent Shrub Roses

Selected for their cold-hardiness and minimal care, the Northern Accents™ Sven Rose (*Rosa* 'BAIsven'), Ole Rose (*Rosa* 'BAIole') and Lena Rose (*Rosa* 'BAIlena') were developed by the University of Minnesota rose breeding program. These polyantha roses are prolific bloomers and require no special winter protection. Pruning is required only for removal of dieback and overall shaping for plant form.

Rose Chafers were found on all the roses at all sites. They seemed to favor the lighter colored roses at first. Chemicals are not used in the gardens, so insects were handpicked and placed in containers of soapy water. It did not appear that insects had any effect on the growth of the plants overall.

The ***'Sven'*** variety grows between 2.5- 3' height and their small 1-2" flowers are mauve in color and fragrant.

'Sven'- Northern Accent Rose Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	22.00	20.00	33.00	36.00	3	4	8	7
ARB team	22.00	-	32.00	-	4	2	8	-
SPC team	26.50	22.50	36.50	46.00	2	3	6	8
Control	**23.13**	**21.25**	**33.63**	**41.00**	**3**	**3**	**7.33**	**7.5**
Treatment 1								
AND team	20.00	18.00	30.00	34.00	3	4	8	6
ARB team	22.75	-	31.50	-	4	1	8	-
SPC team	27.00	22.50	26.00	34.00	2	2.5	6	7
Treatment 1l	**22.44**	**20.25**	**29.38**	**34.00**	**3**	**2.5**	**7.33**	**6.5**
Treatment 2								
AND team	21.00	20.00	34.00	23.00	3	4	7	7
ARB team	25.25	-	38.50	-	4	2	8	-
SPC team	-	24.00	-	36.00	-	-	-	7
Treatment 2	**16.81**	**22.00**	**26.63**	**29.50**	**3.5**	**3**	**7.5**	**7**

***'Sven'* variety at SPC site**

Variances: The 'Sven' variety struggled to survive over the winter and succumbed to what appeared to be winter kill in the TRT2 plot. An oversight error resulted in unrecorded data at the ARB site in 2013 for all shrub roses.

Comments: There were no significant patterns of growth, color or bloom differences between treatments at all sites.

The ***'Ole'*** variety is a semi-double blush pink rose that fades to white. It grows to a height of 2.5-3'.

Rose Chafers on *'Ole'* variety at AND site

'Ole'- Northern Accent Rose Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	20.00	26.00	28.00	40.00	3	4	8	8
ARB team	26.75	-	34.50	-	3	-	8	-
SPC team	18.00	29.50	35.00	46.00	3	1	7	6
Control	**21.19**	**27.75**	**31.38**	**43.00**	**3**	**2.5**	**7.75**	**7**
Treatment 1								
AND team	12.00	23.00	17.00	34.00	1	4	8	8
ARB team	17.50	-	24.00	-	2	-	8	-
SPC team	21.50	23.50	34.00	43.00	3	2	8	5
Treatment 1	**15.75**	**23.25**	**23.00**	**38.50**	**1.75**	**3**	**8**	**6.5**
Treatment 2								
AND team	17.00	22.00	28.00	28.00	3	3	8	8
ARB team	23.25	-	32.50	-	4	-	8	-
SPC team	17.00	4.00	31.50	6.00	4	0	5	8
Treatment 2	**18.56**	**13.00**	**30.00**	**17.00**	**3.5**	**1.5**	**7.25**	**8**

Variances: The 'Ole' variety struggled emerging in the TRT2 plot at the SPC site in 2013 and bounced back a little better in 2014. . An oversight error resulted in unrecorded data at the ARB site in 2013 for all shrub roses.

Comments: There were many inconsistencies between sites and treatments in growth and bloom ranking. Without a consistent pattern it is difficult to determine if biochar had a positive or negative effect on the *'Ole'* variety of roses.

The ***'Lena'*** variety has a single-flowered blush pink blossom reminiscent of apple blossoms. It grows to 2.5' tall and 2-3" wide.

'Lena' variety in foreground at AND site

'Lena'- Northern Accent Rose Sites & Treatments	2014 Average Plant Height in inches	2013 Average Plant Height in inches	2014 Average Plant Width in inches	2013 Average Plant Width in inches	2014 Average of Bloom Ranking	2013 Average of Bloom Ranking	2014 Leaf Color Average; Scale of 1-8	2013 Leaf Color Average; Scale of 1-8
Control								
AND team	24.00	23.00	30.00	54.00	0.00	4	8	7
ARB team	30.25	-	37.75	-	3.00	-	8.00	-
SPC team	24.50	22.00	36.00	39.00	4.00	2	8.00	5
Control	**25.35**	**22.50**	**32.75**	**46.50**	**1.40**	**3**	**8**	**6**
Treatment 1								
AND team	18.00	28.00	25.00	40.00	2.00	4	8.00	7
ARB team	27.50	-	29.00	-	2.00	-	8.00	-
SPC team	21.00	24.00	30.00	39.00	3.00	2	5.00	5
Treatment 1	**21.13**	**26.00**	**27.25**	**39.50**	**2.25**	**3**	**7.25**	**6**
Treatment 2								
AND team	24.00	18.00	24.00	30.00	3.00	4	8.00	7
ARB team	24.50	--	30.00	-	3.00	-	8.00	-
SPC team	21.00	16.00	25.00	26.00	4.00	0	6.00	4
Treatment 2	**23.38**	**17.00**	**25.75**	**28.00**	**3.25**	**2**	**7.50**	**5.5**

Variances: The *'Lena'* had not significant variances. . An oversight error resulted in unrecorded data at the ARB site in 2013 for all shrub roses.

Comments: There were not any consistent patterns determine if biochar had a positive or negative effect on the *'Lena'* variety of roses.

SUMMARY

The year-three results in the demonstration gardens were mixed. There were some notable growth differences in some plants, some responding well to biochar and others not as much. In particular the chrysanthemums seemed to respond well, while the shrub roses did not show any significant differences.

Seasonal climate factors also made significant challenges in the gardens early in the season. Biochar was a great benefit in regards to soil texture. The wet spring soils provided a good opportunity to observe that the biochar-amended plots were easy for volunteers to plant in compared to the CTRL plots, especially since no rototilling took place.

Engaging volunteers on a research project such as this has shown to have widespread benefits. Their support is not only helpful in the gathering of data, but their role as Extension Master Gardener volunteers brings a voice offering first-hand experience to the general public during the State Fair and at horticultural events.

The new online reporting system established in 2014 increased the accuracy of reporting; that process will continue in 2015.

A goal in 2015 will be to add hose splitters at both the AND and ARB sites and instead of watering from the center of the garden in the TRT1 plots with just one sprinkler, watering from two sprinklers will take place on each end. This will hopefully allow for more even watering across the gardens. The SPC site is on a timed irrigation system so watering practices will not change there.

In 2015, it is also our goal to remain as consistent as possible with our methods established in 2013 in order to have more accurate comparisons for the remainder of this project.

CenUSA Annual Meeting–Master Gardener biochar garden tour at the ARB site