

Trial 1 – Cabbage

Setup

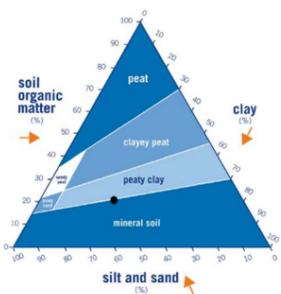
Commercial vegetable grower William Roberts farms on a 2 acre plot in the hills above Ammanford. He practices no-dig and applies municipal and homemade compost to his 22m strip beds.

Grower	William Roberts
Location	Ammanford, Carmarthenshire
System	Commercial organic market garden. Trial bed 22m x 1.4m. Seedling planted at 45cm spacing in two rows.
Crop / Variety	Spring Cabbage, Anatolope F1
Sowing date	5/03/2021
Planting out date	12/04/2021
Harvest date	25/06/2021
Preparations	Biochar - 15t/ha - 253g per plant Biochar Compost - 30t/ha - 501g per plant Compost - 30t/ha - 501g per plant
Replications	3
Plants per preparation	24
Total number of plants	96

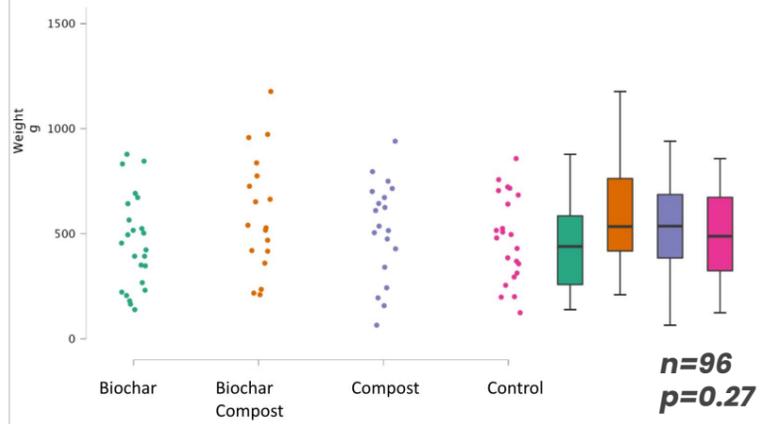


1. Application of biochar at 15t/ha. 2. Cultivating preparations down to 15 cm with hand cultivator 3. Planting out of 4x seedlings into each of the 12 plots. 4. Harvest of cabbages 112 days after sowing

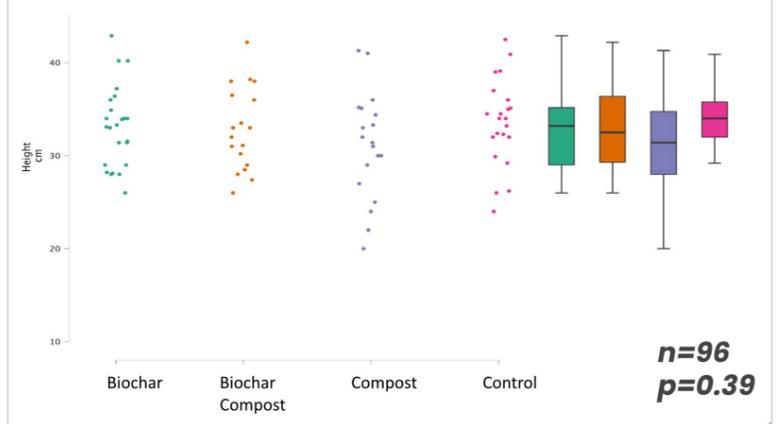
Results



Cabbage – Plant Weight



Cabbage – Plant Height



Soil was sampled with an auger to 20cm depth over the entire length of the growing bed used in the trial. Soil texture analysis showed peaty clay loam with good structure. Very high organic matter content of 20.8%. Very high N values of 22,000 kgN/ha and pH of 6.2. Measurements performed by NRM, fertiliser manager suite.

Preparation	Number of mature plants	Average Weight (g)	Average Height (cm)	Weight vs Control	Height vs Control
Biochar	24	455.8	33.1	-5%	-2%
Biochar Compost	18	593.1	32.9	24%	-2%
Compost	19	521.8	31.1	9%	-7%
Control	22	478.9	33.6	0%	0%

Two variables were measured during the trial; 1) fresh aboveground biomass of the cabbage plant (Plant Weight) calculated by cutting plant off at ground level with secateurs, and 2) the longest dimension of the plant (Plant Height) measured by laying the cabbage on a flat surface.

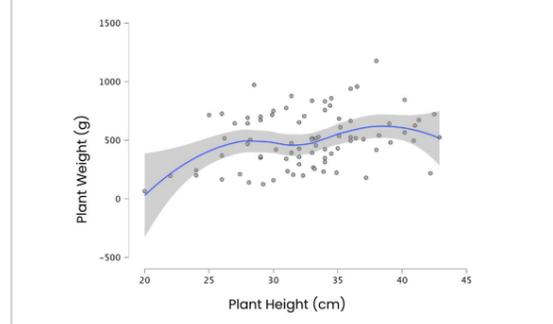
The plants generally performed well for all preparations with around 5 transplants being done within 2 weeks of planting out seedlings.

Analysis

In general the results show very low statistical significance $p > 0.25$ for both Plant Weight and Height.

There is a generally low correlation between plant height and weight with heavier plants often producing denser and smaller heads with fewer large leaves. Therefore Plant Weight is considered a more appropriate variable to determine yield response.

Cabbage – Plant Weight / Height Correlation



Biochar Compost applied at 30t/h resulted in 24% increase in yield over the control (low confidence) with biochar having low or slightly negative impact on yield.

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Existing high levels of organic matter in the soil, together with generally high nutrient availability and a relatively neutral pH may explain the reduced relative impact of the applications on crop yield. Studies suggest that biochar application has the highest impact when added to degraded or low-organic matter soils.

Trial 2 – Basil

Setup

Commercial succulent and herb grower Charles Warner tested the applications as both a growing medium and soil amendment with more than 500 basil plants grown in 32 pots under cover.

Grower	Charles Warner		
Location	Cilgerran, Ceredigion		
System	2L square pots in commercial polytunnel. Plugs of approx 16 plants transplanted after 3 weeks		
Crop / Variety	Basil, Greek		
Sowing date	05/05/2021		
Harvest date	21/06/2021		
Preparations	Biochar_low - 15t/ha - 26g per pot BiocharCompost_low - 30t/ha - 52g/pot Compost_low - 30t/ha - 52g per pot	Biochar_high - 30t/ha - 52g/pot BiocharCompost_high - 240g/pot Compost_high - 250g/pot	
Replications	4	4	
Plants per preparation	65	65	
Number of plants	234	287	



1. Plugs after transplant into 2L pots. 2. Average of 16 plants per pot before harvest. 3. Harvesting basil to and weighing above and belowground biomass

Results

The trial was designed to test both soil amendment (Low Application) and growing medium properties (High Application) of the preparations against the existing commercial compost (Sylvamix Peat Free Potting Mix manufactured by Melcourt).

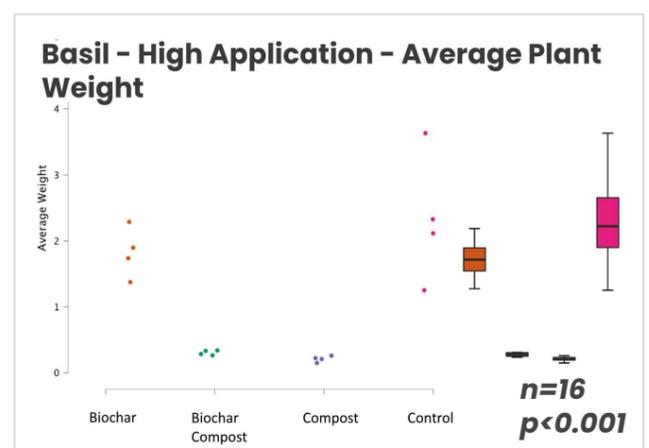
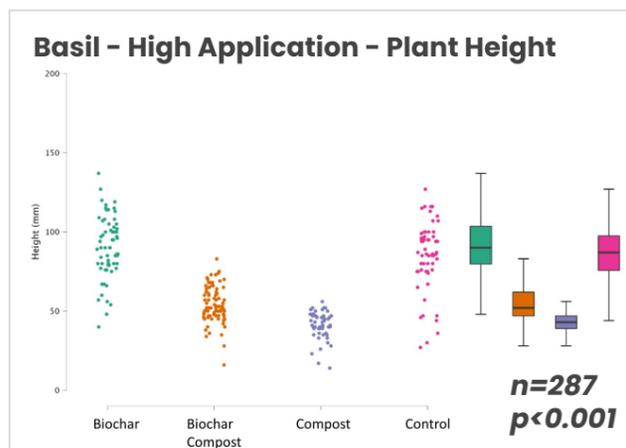
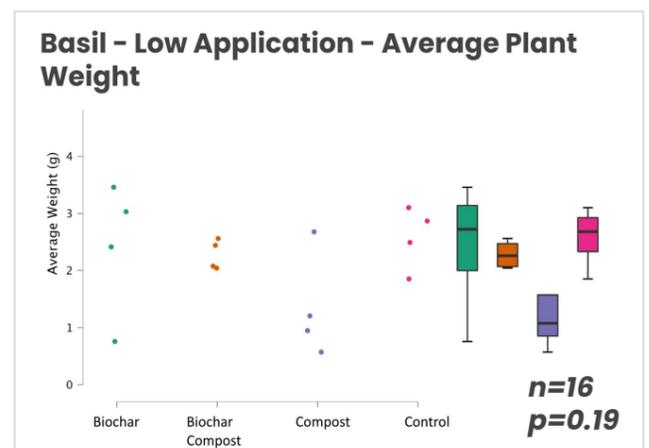
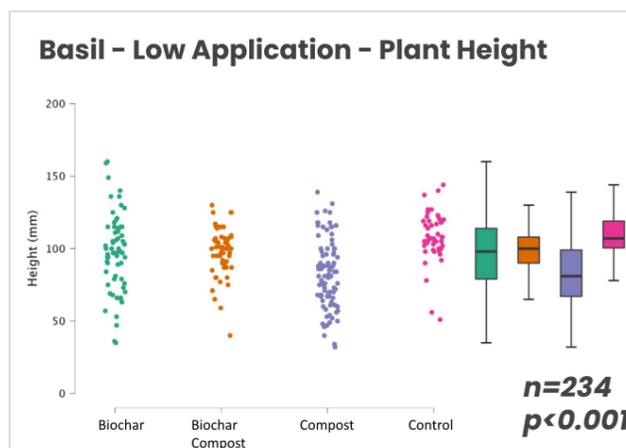
All plants grew well except for High Application Compost and Biochar Compost which failed to develop roots outside of their transplanted plug and displayed visibly yellowing leaves.

Two variables were measured for each preparation after harvest:

- 1) Total above ground biomass (Plant Weight) calculated on a per pot basis rather than individual plants to avoid potential compound measurement error of weighing very small plants.
- 2) Length of plant excluding roots (Plant Height), measured on an individual plant basis to nearest mm.

All tests except for Plant Weight with Low Application showed highly statistical significant results.

There is strong correlation between Plant Weight and Plant Height



Preparation	Plant Weight (g)	Plant Weight vs Control	Plant Height (mm)	Plant Height vs Control	Number of Plants
Biochar_low	2.41	-6%	97.3	-10.04%	65
BiocharCompost_low	2.28	-12%	98.6	-8.80%	59
Compost_low	1.35	-48%	82.7	-23.49%	87
Control_low	2.58	0%	108.1	0.00%	46
Biochar_high	1.75	-25%	90.5	6.10%	64
BiocharCompost_high	0.30	-87%	54.0	-36.72%	87
Compost_high	0.21	-91%	41.2	-51.65%	53
Control_high	2.33	0%	85.3	0.00%	60

Analysis

This trial produced perhaps the clearest result of the 5 crop trials completed during this stage of the project. The Biochar Compost and Compost are not appropriate substrates to be used as a 100% growing medium for small plants ($p < 0.001$). Both Plant Height and Plant Weight were significantly lower than the control for these preparations and the plants were visibly nutrient deficient.

The control group performed best in all but the Plant Height Biochar_high preparation indicating that the Sylvamix commercial compost was better suited than the substrates under investigation in most cases.

Further investigation should be directed towards understanding the optimal concentration of biochar with the high biochar concentration performing better than the low.



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Trial 3a – Courgette

Setup

Organic grower Mike Warrick conducted a trial of courgette plants in 3x2m vegetable beds. 4 applications of were trialled with 2 replications of 2 plants each. Soil was clay loam with high SOM values and regular application of home made compost.

Grower	Mike Warner
Location	Llandrindod Wells, Powys
System	Outside, strip beds, non-commercial, organic. Bed size
Crop / Variety	Courgette, Zucchini F1
Sowing date	10/04/2021
Planting out date	11/05/2021
Harvest date	15/09/2021
Preparations	Biochar - 15t/ha - 3.3kg Biochar Compost - 30t/ha Compost - 30t/ha
Replications	2
Plants per preparation	4
Total number of plants	16



1. Seedling planted out after long germination over cold spring. 2. 4x plants for each application. No replications due to lack of space. 3. Harvest X days after planting out. Total of 357 courgette crops harvested

Results

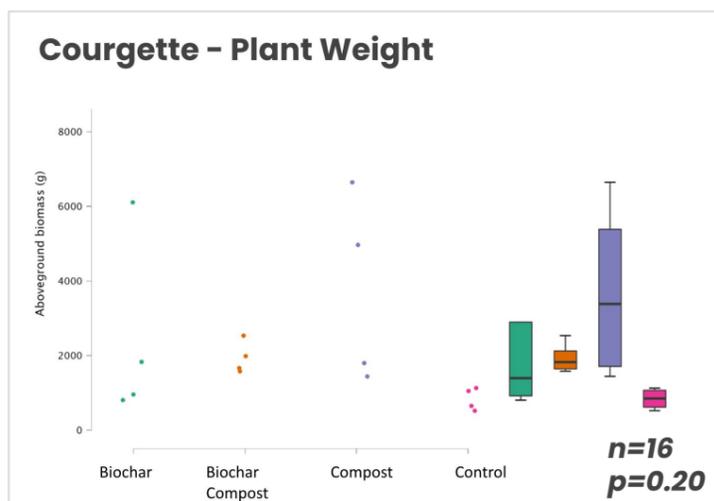
Two variables were measured during the trial - total above ground biomass of the courgette plant (Plant Weight) and the number of courgette fruit harvested per plant (Crops per Plant).

Crops per Plant was recorded during the trial by the grower who picked fruit once it had reached ~10cm in length and recorded the weight (average 102g per fruit, standard deviation 51g)

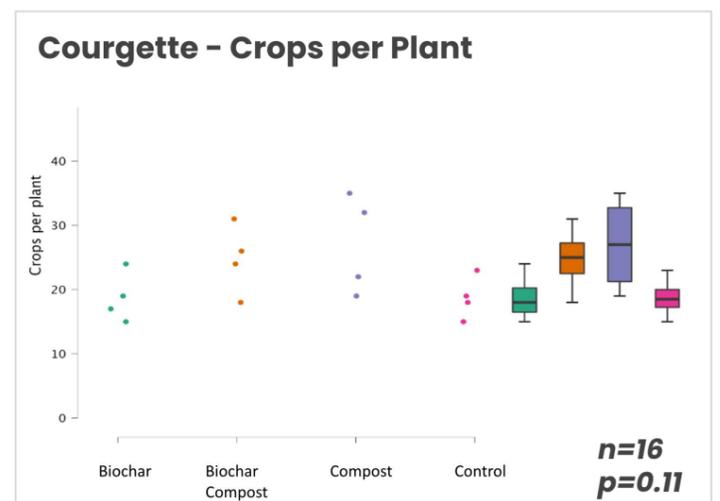
Plant Weight was measured by cutting plants at ground level and weighing on a calibrated mass balance accurate to 0.1g

Soil analysis indicated high soil organic matter (10.3%), high nitrogen stock (9,200 kgN / ha), neutral (pH 6.5) and silt loam texture.

Courgette - Plant Weight



Courgette - Crops per Plant



Preparation Group	Preparation	Number of mature plants	Average Plant Weight (g)	Crops per Plant	Plant Weight vs Control	Crops per Plant vs Control
B	Biochar	4	2,425	75	190%	0%
BC	Biochar Compost	4	1,940	99	132%	32%
C	Compost	4	3,712	108	344%	44%
Cn	Control	4	837	75	0%	0%

Analysis

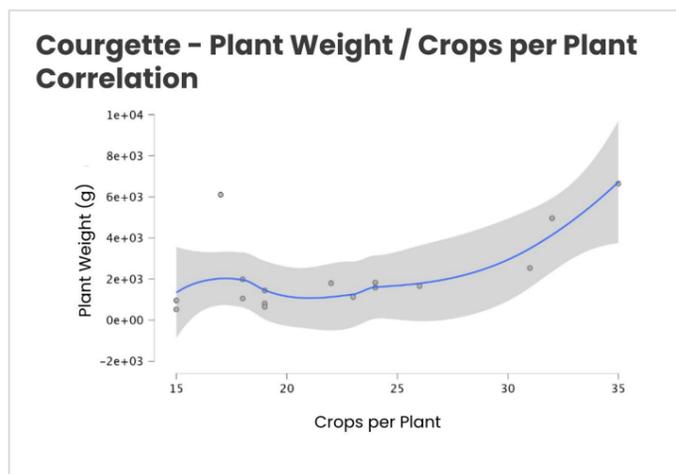
Both variables produces results with relatively low statistical significance.

The Control group performed significantly worse than all preparations. Compost performed the best with a >300% increase in Plant Weight and 44% increase in Crops per Plant compared to the control group.

There was a strong correlation between Plant Weight and Crops per Plant with all results lying within 1 standard deviation of the mean.

The Biochar Compost performed worse than the Compost, potentially due to the high organic matter already present in the soil.

Courgette - Plant Weight / Crops per Plant Correlation



Setup

Organic grower Mike Warrick experimenting with Sweetcorn. The plot was small and only allowed for 16 plants with no room for replications of each application. Soil was a fertile silt loam with high SOM from to regular application of home-made compost.

Grower	Mike Warner
Location	Llandrindod Wells, Powys
System	Outside, strip beds, non-commercial, organic. Bed size
Crop / Variety	Sweetcorn, Sundance F1
Sowing date	10/04/2021
Planting out date	11/05/2021
Harvest date	15/09/2021
Preparations	Biochar - 15t/ha - 3.3kg Biochar Compost - 30t/ha - 7.7kg Compost - 30t/ha - 7.7kg
Replications	0
Plants per preparation	4
Total number of plants	16



1. Molinia biochar applied to the soil, cultivated to 20cm by hand. 2. Planting out of 16x healthy seedlings in mid-May. 3. Grower manually recorded crop yields after picking over the cropping period. 4. Harvest and measurement of plants in September.

Results

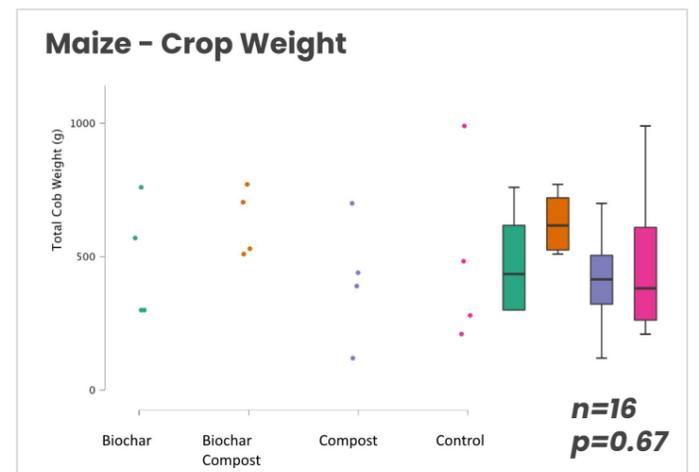
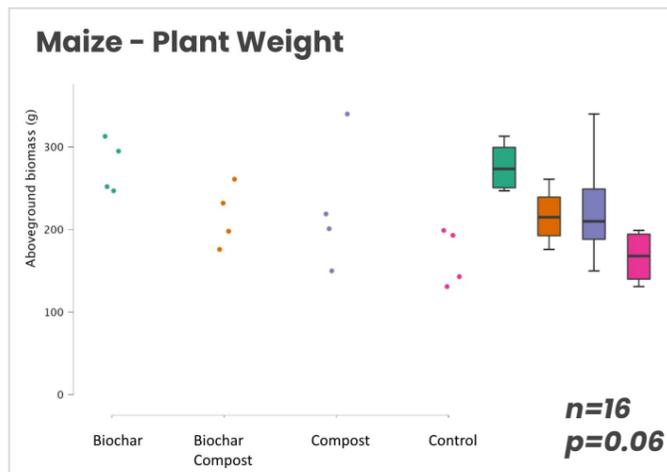
Two variables were measured during the trial - total above ground biomass of the maize plant (Plant Weight) and the total fresh biomass of the cobs per plant (Crop Weight).

All seedlings reached maturity with no significant insect or disease pressure.

Crop Weight was calculated during the trial by the grower once the sweetcorn had reached maturity.

Plant Weight was measured by cutting plants at ground level and weighing on a calibrated mass balance accurate to 0.1g

Data was analysed using ANOVA statistical package in JASP v0.16



Preparation	Number of mature plants	Average Plant Weight (g)	Average Crop Weight per Plant (g)	Plant Weight vs Control	Crop Weight vs Control
Biochar	4	277	483	66%	-2%
Biochar Compost	4	217	629	30%	28%
Compost	4	228	413	37%	-16%
Control	4	167	491	0%	0%

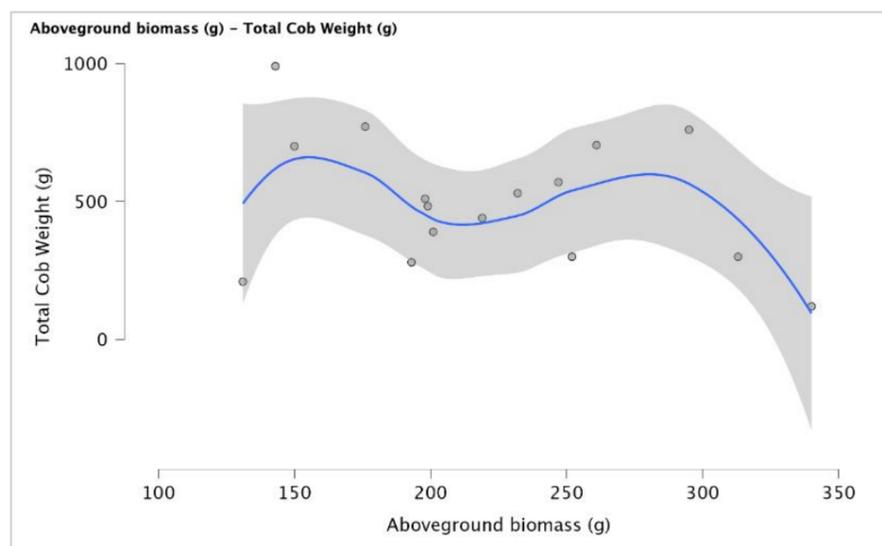
Analysis

The limited space available to conduct the trial had serious impact on the reliability of the results.

The Biochar application improved the Plant Weight yield by 66% (medium confidence) with the control group performing worst overall.

The Crop Weight was found to be poorly correlated to the Plant Weight, implying that a large plant did not necessarily mean a higher crop yield.

Biochar Compost was found to increase the crop yield by 28% (very low statistical significance) with Biochar producing a lower yield than the Control.



The results indicate the non-controlled variables had a more significant effect on yield than the applications. This could be improved by increasing the size of the sample, but maize cob yield may be considered an inappropriate indication of application effectiveness.

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Trial 4 – Radish

Setup

Upland farmer Tony Davies manufactures the biochar and compost used for this trial on his farm above Rhayader. He conducted a pot trial with radish in soil taken from an adjacent field. Plants were grown outside during warm weather and regularly watered.

Grower	Tony Davies
Location	Rhayader, Powys
System	In pots, outdoors in sheltered location. 10 seeds sown and thinned to 5 seedlings after 2 weeks.
Crop / Variety	Radish, Scarlet Globe
Sowing date	17/05/2021
Harvest date	17/07/2021
Preparations	Biochar - 15t/ha - 26g per pot Biochar Compost - 30t/ha - 53g per pot Compost - 30t/ha - 53g per pot
Replications	4
Plants per preparation	20
Total number of plants	80



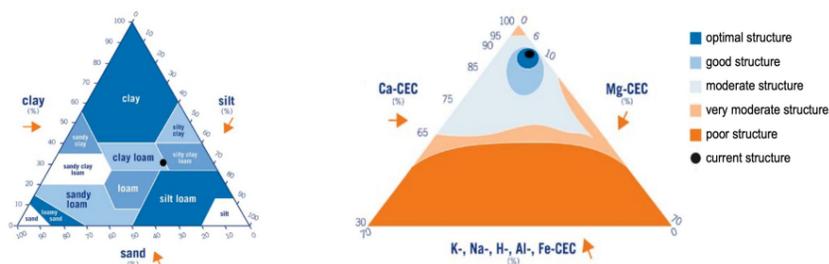
1. Farmer and manufacturer of the biochar and compost Tony Davies. 2. Pots after planting outside in sheltered space. 3. 15cm pots holding 1.3kg of soil, each with 5 thinned seedlings. 4x replications of each preparation giving total of 16 pots. 4. Above and belowground biomass measured with balance accurate to 0.1g. 5. Significant variation in yield. Left Biochar Compost, Right control.

Results

A single variable of total wet weight biomass, including leaf and root (Plant Weight) was measured 60 days after sowing with mass balance accurate to 0.1g.

Around 15% of the crop had slug damage. There was no correlation between insect damage and application of the preparations and this has not been controlled for in the data analysis.

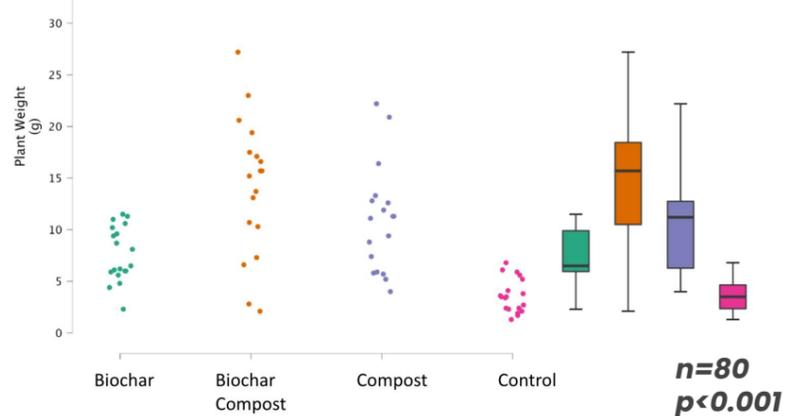
Data was analysed using ANOVA statistical package in JASP v0.16



Soil was taken from mole hills in adjacent field previously used for potato cultivation. Soil texture analysis showed clay loam with good structure. Organic matter of 10.3%, very high N values of 11,000 kgN / ha and pH of 5.8. Measurements performed by NRM, fertiliser manager suite.



Radish – Plant Weight



Preparation	Number of mature plants	Average Weight (g)	Weight vs Control
Biochar	20	7.6	111%
Biochar Compost	20	15.2	323%
Compost	20	10.9	203%
Control	20	3.6	0%

Analysis

The trial produced statistically significant results (p<0.001) with the control group performing significantly worse than the other preparations.

Biochar Compost saw the largest increase in average yield, with plants showing a more than 300% increase vs the control group.

The results may be explained by biochar increasing soil organic matter and improving water holding capacity of the soil during a warm period with potential water stress.

Soil analysis revealed a very low P concentration in the soil (0.5kg/ha - with a UK average of between 4 and 7 kg/ha). Biochar is known to be a source of P (depending on the input substrate) and may have had a positive impact of yield. Further chemical analysis of the biochar samples will confirm this.

Furthermore biochar is known to have a liming effect which may have been beneficial to the crops growing on very acidic soil (pH 5.8)



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