Community led experiments using Biochar as a Climate Adaptation and Mitigation Strategy

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Introduction

- Pyrogenic Carbon (PC) is an important source of environmental/chronological information and well as having application in soil amelioration, carbon sequestration and energy generation
- A requirement for all of the above is the ability to reliably quantify biochar and this has remained a difficult task, with a range of methods used with varying success
- Ideally a method for PC quantification should rapidly, cheaply and unambiguously, isolate a consistent, stable component of biochar for analysis

Sub Objectives

- Q-1 - Is all biochar (different agri residues) the same? – Lab & Field
- Q-2 - How stable (mean residence time) is biochar in soil?
- Q-3 - Is biochar/biochar compost (Clean/ contaminated) safe to use in Alkaline/Acidic soil?
- Q-4- What are the agronomic benefits (crop productivity through increased nutrient use efficiency, microbial load, increased water-holding capacity and decreased bulk density)?

Q1- Is all Biochar the same?

	pH	EC
Rice Husk	8.78	0.05
Prosopis juliflora	9.02	0.06
Rice Pellet	9.63	0.04
Coconut	9.34	0.03
Mixed Fuelwood	8.34	0.75
Rice Straw	9.62	0.27
Cashew Raw	7.07	0.02

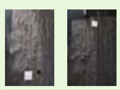
The feedstock material, temperature and time at which it is processed affects the chemical and physical properties of the biochar produced when compared with local available compost sources. The same biochar also produced different results in different soil types and climatic conditions in two regions (Tamil Nadu & Odisha)

Biochar

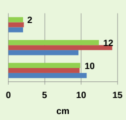
Composition Estimation – Kolli Hills	pH	EC	Phos-phorus	Nitro-gen	Bulk Density	Particle Density	WHC	Poro-sity
FYM	7.71	0.04	3.9	9.8	0.5	0.6	94.2	45.3
Vermi compost	6.7	0.04	6.6	9.8	0.6	1.5	134.9	48.13
Charcoal	7.3	0.03	6.6	21	0.5	0.6	84.7	39.5
Plan soil	5.1	1.52	12.5	53.2	1.2	2.2	47.4	59.6
Bio C⁺ (PJ)	7.12	0.03	7.6	11.2	0.2	1.2	800.8	59.8
Biochar+ FYM+soil	5.87	0.9	NA	NA	NA	NA	NA	NA
FYM+ Soil	5.94	1.6	NA	NA	NA	NA	NA	NA
Composition Estimation – Odisha								
FYM	6.87	0.02	2.64	7	0.76	1.4	75.8	57.6
Vermi compost	7.08	5.85	8.6	14	0.63	0.5	108.6	36.9
Charcol	7.3	5.85	3.96	23.8	0.24	0.6	307.3	104.4
Plan soil	6.04	0.7	6.6	49	1.14	1.8	44.1	48.1
Bio C⁺ (Rice Husk)	7.44	0.02	5.28	9.8	0.42	0.9	178.2	67.8

Lab (Germination test)

Roll towel test



VC Biochar
Radish (Odisha) – Root -Shoot length



The effect of biochar on percentage of chickpea seed germination. The roll towel and Petri dish bioassay represents different rates equivalent to 0, 10 tonnes per hectare based on 10 centimetre field depth and char dipped in 100 ml water for 5 minutes. In all combination it has performed better than control, FYM but not comparable to vermicompost. It has also shown variation in different seeds growth such as chickpea, radish and tomato. Performance of growth and germination rate was better in radish.

Petri Dish Test

VC (29) FYM (13.5) Char (8.5) BioC⁺(49)
Nutrient Agar- Bacteria colonies – Odisha (after 24 hrs)

VC (36.5) FYM (37) Char (15) BioC⁺ (78)
Nutrient Agar- Bacteria colonies – Kolli Hills (after 24 hrs)

VC (24) FYM (23.5) Char (19) BioC⁺ (41)
Potato dextrose Agar-Fungal colonies – Kolli Hills (after 48 hrs)

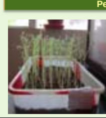
VC (26.5) FYM (6.5) Char (13) BioC⁺(18.5)
Potato dextrose Agar- Fungal colonies – Odisha (after 48 hrs)

Changes in microbial communities have been observed following the application of biochar and compared with other available compost sources in study locations. The direct effects of biochar on the physical and chemical functions of soil are likely to have indirect effects on the soil microbial community. Altered biological functions, including carbon and nutrient turnover, are likely to change crop productivity. In Odisha, biochar has been found to increase mycorrhizal fungi and bacterial colonisation of chickpea roots.

FYM Biochar
Chickpea (Kolli Hills)

Parameters	Shoot (cm)	Root (cm)	Leaf (No.)	Germination Rate (%)
BioC⁺	11	14	3	100
Char	9	6	2	40
FYM	12	11	3	40
VC	16	13	4	60

VC FYM (13) Char (12) Biochar (Odisha-13) Biochar (Kolli Hills-14)
Petri dish germination test for 14 seeds



	Final count	Root	Shoot	Leaf
T1 Soil	45	18.15	11.2	2.6
T2- Biochar-Soil – FYM	47	12.45	14.05	2.8
T3 Soil-VC–Char	24	4.7	4.25	1.4
T4-Soil-FYM	45	13	16.3	3.8
T5- Soil-Char	43	13.7	13.4	3.3
T6- Soil –VC	44	15.65	20.45	4.3
T7-Soil - VC-FYM	46	10.4	11.3	2.4
T8-Soil-VC-FYM-Char	32	3.85	5.8	1.5

T	Composition		Germination	
	1.5 kg	0.75 g	FCD	FnCD
T1	Soil +	fym 4.5 g	18	20
T2	Soil +	fym + vc 7.5 g	16	19
T3	Soil +	fym + bioc+ 275 g	19	22
T4	Soil +	fym + bioc+ 375 g	20	25
T5	Soil +	fym + bioc+ 750 g	25	30
T6	Soil +	fym+ bioc+	15	21

FCD – First count day; FnCD – Final count day

Tub Test Multiwell Test

Root / shoot growth of plant in tub and multiwell in a week to two weeks time has shown positive effect as tested with different crops. Chickpea result in germination shows that the excess nutrient (mixture of Soil-VC-FYM-Char) can effect the plant growth

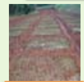
Q2 , Q3 & Q4

Field Test

Pot Test

Experiment Plot (RBD)

Odisha (RBD – 2 season)



Kolli hills (RBD-2 Season)

Farmers Field

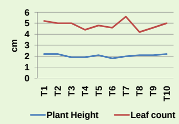
Odisha

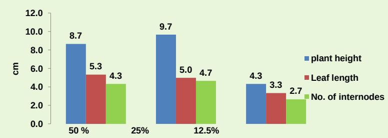
Farmer's Field – (RBD-1 season)

Kitchen Garden (2 season)

Nursery (2-season)

Field scale (1-season)





- Growers wishing to use biochar on their own property should apply a few trial strips (kitchen garden, nursery and farmer's small plot) and then monitor results in subsequent years. As we are aware, a biochar suitable for long term carbon sequestration is likely to be derived from a high carbon feedstock (such as wood waste) and produced at high pyrolysis temperature for achieving greater long term stability.
- Manure biochar, and biochar produced from agri residues waste, tends to have greater nutrient content compared to unamended agri / wood waste biochar. It is important to consider the concentration of available nutrients rather than total nutrients of biochar. Trials have shown that biochar may provide opportunities to increase plant height, leaf length and no. of internodes of crops with susceptible acidic soils. 180 days field experience shows that sorption increased with biochar amendment, but with ageing of biochar in soil this sorption capacity reduces to levels similar to control soils.

	N		P		BD		PD		WHC		Po		pH		EC		Bacteria		Fungi	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
T1	238.6	234	79.8	179	1.04	.99	1.49	1.3	41.8	47.3	46	55	5.5	5.6	1.12	1.2	35.5	13.3	14.5	7.7
T2	299 .7 (21)	272 (14)	87.9 (9)	129 (-39)	1.08 (4)	1.09 (10)	1.52 (2)	1.5 (12)	47.7 (12)	39.3 (-20)	54.5 (16)	52.1 (-6)	5.5 (-1.2)	5.8 (4)	0.96 (-17)	1.1 (-6)	42.3 (16)	10.3 (-29)	11.3 (-28)	8.2 (6)
T3	247.8 (4)	250.1 (7)	76.7 (-4)	77.3 (-132)	1.05 (2)	1.05 (6)	1.4 (-7)	1.6 (15)	64 (35)	65.1 (27)	41.2 (-12)	40.4 (-36)	5.3 (-6)	5.4 (-4)	0.9 (-27)	1.1 (-3)	57.7 (38)	15.8 (16)	14 (-4)	8.7 (12)
T4	258.2 (8)	244.4 (4)	97.2 (8)	109.7 (-63)	1.06 (3)	0.99 (0.1)	1.33 (-12)	1.5 (10)	50.8 (18)	64.5 (27)	89.1 (48)	74.7 (26)	5.4 (-2)	5.1 (-9)	0.7 (-66)	0.7 (-64)	24.5 (-45)	18.2 (27)	19.7 (26)	8.2 (6)
T5	237 (-0.5)	238.6 (2)	109.3 (27)	108 (-66)	1.10 (6)	1.10 (11)	1.35 (-11)	1.8 (23)	37.4 (-12)	33.1 (-43)	42.0 (-9)	44.2 (-24)	5.3 (-4)	5.5 (-1)	0.7 (-50)	0.8 (-38)	24.3 (-46)	17.3 (23)	20.3 (29)	9.7 (21)
T6	240 .9 (1)	231.7 (-1.0)	102.1 (2)	72.8 (-146)	1.10 (6)	1.06 (7)	1.36 (-10)	1.7 (21)	40.3 (-4)	40.7 (-16)	36.2 (-27)	44.6 (-23)	5.3 (-4)	5.8 (4)	1.2 (13)	1.9 (41)	30.3 (-17)	20.8 (36)	20.7 (30)	10.8 (29)
T7	245.5 (3)	245.5 (4.7)	66.3 (-20)	56.4 (-217)	1.04 (0.3)	1.05 (6)	1.84 (19)	1.9 (29)	43.2 (3)	41.8 (-13)	46.1 (0.3)	63.8 (14)	5.9 (5)	5.3 (-5)	0.8 (-48)	0.8 (-40)	24.5 (-45)	11.8 (-13)	27 (46)	12.7 (39)
T8	260.6 (8)	259.4 (10)	51.5 (-55)	59.7 (-200)	1.02 (-1.3)	1.09 (9)	2.04 (27)	2 (32)	52.4 (20)	41.3 (-15)	51.2 (10)	57 (4)	5.2 (-7)	5.7 (1)	1.4 (19)	2.6 (55)	22.3 (-59)	11.3 (-18)	33.5 (57)	14.5 (47)
T9	210 (-13)	219 (-7)	63.2 (-26)	59.4 (-202)	1.08 (4)	1.07 (8)	2.01 (26)	1.9 (28)	41.6 (-0.5)	55.9 (16)	50.6 (9)	50 (-10)	5.7 (3)	5.1 (-9)	0.7 (-66)	0.9 (-29)	32.8 (-8)	12.2 (-10)	20.5 (29)	15.2 (49)
T10	230.5 (-4)	262 (11)	60.8 (-31)	65.9 (-171)	1.06 (2)	1.05 (6)	1.53 2.4	1.9 (29)	68.5 (39)	74.8 (37)	51 (10)	49.4 (-11)	5.6 (2)	5.4 (-3)	1.1 (-1)	0.9 (-21)	55.5 (36)	16.5 (19)	30.2 (52)	16 (52)

A- 0-15 cm, B- 15-30cm, N-Nitrogen(kg/ha), P-Phosphorus (kg/ha), BD- Bulk density (g/cc), PD- Particle density (g/cc), WHC- Water Holding Capacity(%), Po –Porosity (%), pH, EC- Electrical Conductivity (m.mhos/cm) , Bacteria load- 10^4, Fungi load- 10^2
Treatment- T1- Control (5 t/ha), T2- VC (5t/ha), T3 (2 t/ha), T4(4t/ha),T5(8t/ha),T6 (10t/ha) – Char, T7 (2t/ha),T8(4t/ha),T9(8t/ha),T10(10t/ha)-BioC⁺

Crop	Shoot Length (cm)		Root Length (cm)		Fruit Weight (Kg/m^2)		Biomass Weight (Kg/m2)		Variety
	Bio-char	Con-trol	Bio-char	Con-trol	Bio-char	Con-trol	Bio-char	Con-trol	
Lady's Finger	51.2	47.8	17.6	15.2	1.3	1.1	1.3	1.2	Bejo
Cauliflower	45.1	45.5	8.4	8.3			11.5	12.0	Barka, Pusa
Onion	3.7	3.7	20.2	20.2	3.5	3.5	1.9	1.8	Durga, Shakti
Tomato	37.0	36.9	9.8	9.8	10.0	9.9	3.2	3.1	Pusa ruby, Utkal kumari
Beans	42.5	43.8	14.8	15.1	18.4	19.7	2.0	2.2	Durga
Brinjal (2 M, 3H)	33.5	32.7	12.3	11.9	137.0	128.0	7.2	7.1	Blue Star
Colcosia	42.5	42.3	16.7	15.9	14.1	13.9	2.9	2.7	Bada Suru
Pumpkin					40	40			Baidyabati

The effects of biochar vary according to feedstock (Rice husk and *Prosopis juliflora*), processing temperature and time, and interaction with different soil types. However, rice husk biochars have shown substantial benefits for crop yield, soil fertility, soil pH, available soil phosphorus. Root structure analysis has shown healthier root systems in plots and fields where biochar was applied. Percentage (12.25, 25, and 50%) and 10 ton/ha trials have demonstrated improved water-holding characteristics, reduced tensile soil strength and improved nutrient availability. Biochar can also been have a beneficial impact on low-nutrient and compacted soils and has demonstrated potential for rehabilitating degraded soils where crop was not grown almost five years (More scientific evidence required).

Conclusion

- In a number of case studies, Biochar has been demonstrated, to impart significant positive effects on agriculture. Rice husk Bio C⁺ (Odisha) performed better than *Prosopis juliflora* Bio C⁺. (Kolli Hills). These include:
  - Yield enhancement. Increases in yield approaching 5-20% have been reported for crops such as leafy vegetable , horticulture crop and staple crop.
  - Increased water holding capacity. Biochar helps soils retain moisture, reducing the need for irrigation and alleviating water stress
  - Increased nitrogen fixation. Reported increases in biological nitrogen fixation in response to biochar application has been attributed to increased availability of minerals
  - Reduced fertilizer run-off. Increased fertilizer retention and utilisation result in less negative environmental impact from agriculture.
  - pH correction. Biochar is generally alkaline; its application can increase soil pH and availability of phosphorous but we have observed effect in field than lab condition.

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