Characterization of Soil Resilience as influenced by Organic Management Practices in Perturbed *Vertisol*

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Introduction

- **Soil degradation declines soil's inherent capacity to produce economic goods and perform ecological functions (Lal, 1993).**

- **It is accelerated by anthropogenic disturbances is a major problem for the natural ecosystem.**

- **Soil degradation has emerged as an important issue due to adoption of inadequate or improper management practices.**

Soil Resilience

- **the capacity of a soil to recover its functional and structural integrity after a disturbance (Herrick and Wander, 1998; Lal, 1997 & 1993; Blum and Santelises, 1994; Sombroek, 1994).**

- **the capacity of a soil to resist change caused by disturbance (Rozanov, 1994; Lang, 1994).**

This concept of "resistance to change" is different from resilience

Soil Resistance

- **the capacity of a soil to continue to function without change throughout a disturbance (Seybold et al, 1999).**

Factors affecting Soil resilience and resistance

- **Soil type**
- **Land use/Nature of vegetation**
- **Climate**
- **Disturbance regime**

Rationale

- **Black soils are problematic in nature in terms of soil quality and resilience.**
- **The black soil (*Vertisols*) possesses low strength to undergo excessive volume changes, cracks are unique feature in the soil with strong shrink-swell potential.**

Objective

- **To study the effect of organic amendments on soil resilience in relation with soil physical and biological properties under *Vertisol***

Soil Physical Properties

Soil physical properties	Mean Value
Soil texture	Clay
Clay content (%)	49.23
Bulk density (Mg m^{-3})	1.45
Total Organic carbon (%)	0.97
Walkley Black carbon (%)	0.40
Water stable aggregates (%)	52.42
Mean weight diameter (mm)	0.89
Plasticity index	33.68
M.C at field capacity (%)	29.70
M.C at PWP (%)	17.81

Soil Fertility Status

Soil properties	Mean value
Available N (kg/ ha)	201
Available P (kg/ha)	4.0
Available K (kg/ha)	533.7
Total N (%)	0.067
C : N ratio	12.7

Treatment details

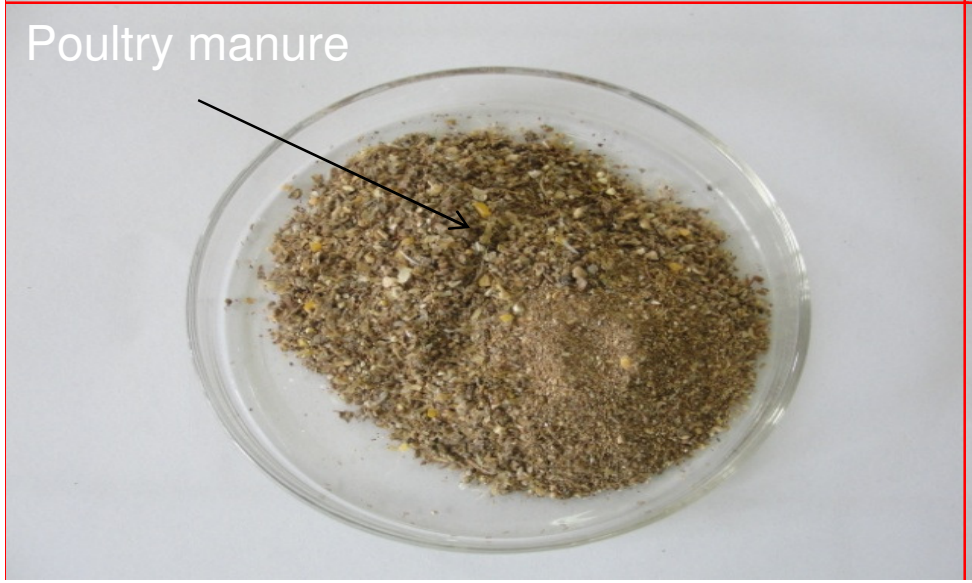
- T_0 :control (without soil amendment)
- T_1: FYM @ 25 t ha^{-1}
- T_2:Biochar @ 25 t ha^{-1}
- T_3:poultry manure @ 25 t ha^{-1}
- T_4:Fly ash @ 1% weight basis
- T_5:T_1+Fly ash @ 1% weight basis
- T_6: T_2+Fly ash @ 1% weight basis
- T_7:T_3+Fly ash @ 1% weight basis

Various soil amendments

Farmyard manure

Biochar

Poultry manure



Fly ash

Chemical composition of amendment

Properties	Farmyard manure	Biochar	poultry manure	Fly Ash
pH (1:10)	6.82	8.4	7.15	7.8
EC (1:10) dS m^{-1}	2.99	0.62	5.14	6.53
Total organic carbon (%)	15.55	60.64	31.25	0.35
Total Nitrogen (%)	0.56	0.85	1.2	0.1
Total Phosphorus (%)	0.37	0.09	0.73	0.08
Total Potassium (%)	0.67	0.12	0.95	0.02

Experiment details

- 500 g soil taken in plastic container for incubation study.
- Soil in sets of 3 replicates (container) was prepared for each treatments
- The soil was first pre-incubated for 5 days at 25°C under aerobic conditions to allow microbial activity to stabilize.
- The soil was mixed with these amendments and then transferred to the plastic container.
- After 10 days of interval, added distilled water (175 mL) for maintaining the moisture content to 60 % of the water holding capacity of the soil.

- After 24 hours, the soil samples were treated with $CuSO_4.5H_2O$ (1g 500 g^{-1} of soil) for destroying the microbial community.
- There were a separate set of soil samples, which is considered to be absolute control, as there was no Cu stress treatment.
- The soil along with the plastic container was then incubated in darkness for 10 weeks at 25°C.
- After 0, 2, 4, 6, 8, and 10 weeks of incubation, the plastic container of each treatment were removed and stored in plastic vials at 4°C until enzyme activity (DHA) and microbial biomass carbon (MBC) were determined.

CBR (Californian Bearing Ratio)

- **It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston.**

- **It indicates:**

– the soil's resistance to force

– the swell and strength potential of soils

Resilient Modulous (M_r)

- **Primary soil property : Dynamic Test**
- **Defined as the ratio between repeated deviator stress and resilient strain.**

- **Calculated by:**

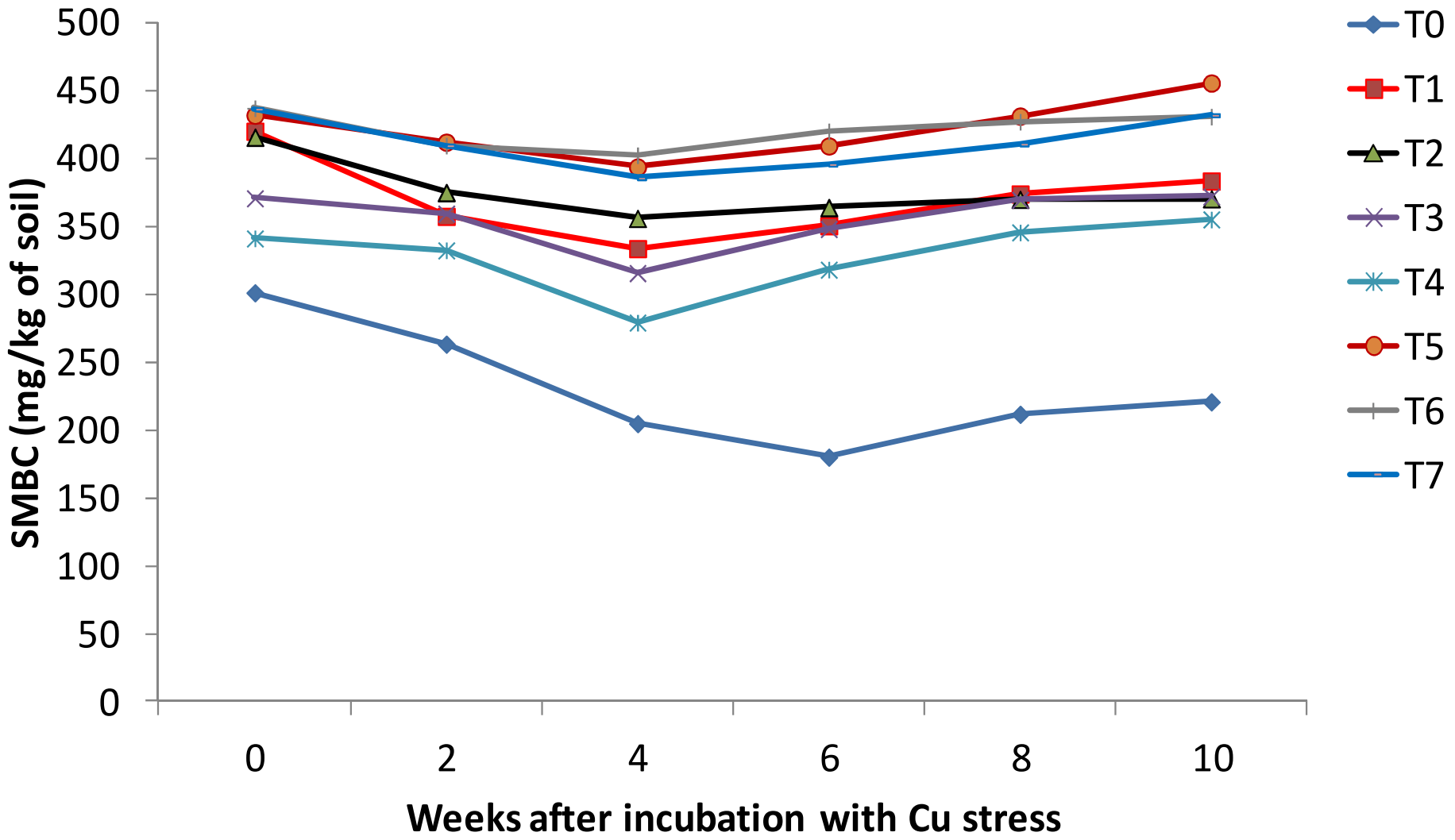
$$M_r\ (MPa) = 10.342\ (CBR)$$

$$M_r\ (psi) = 1500\ (CBR)$$

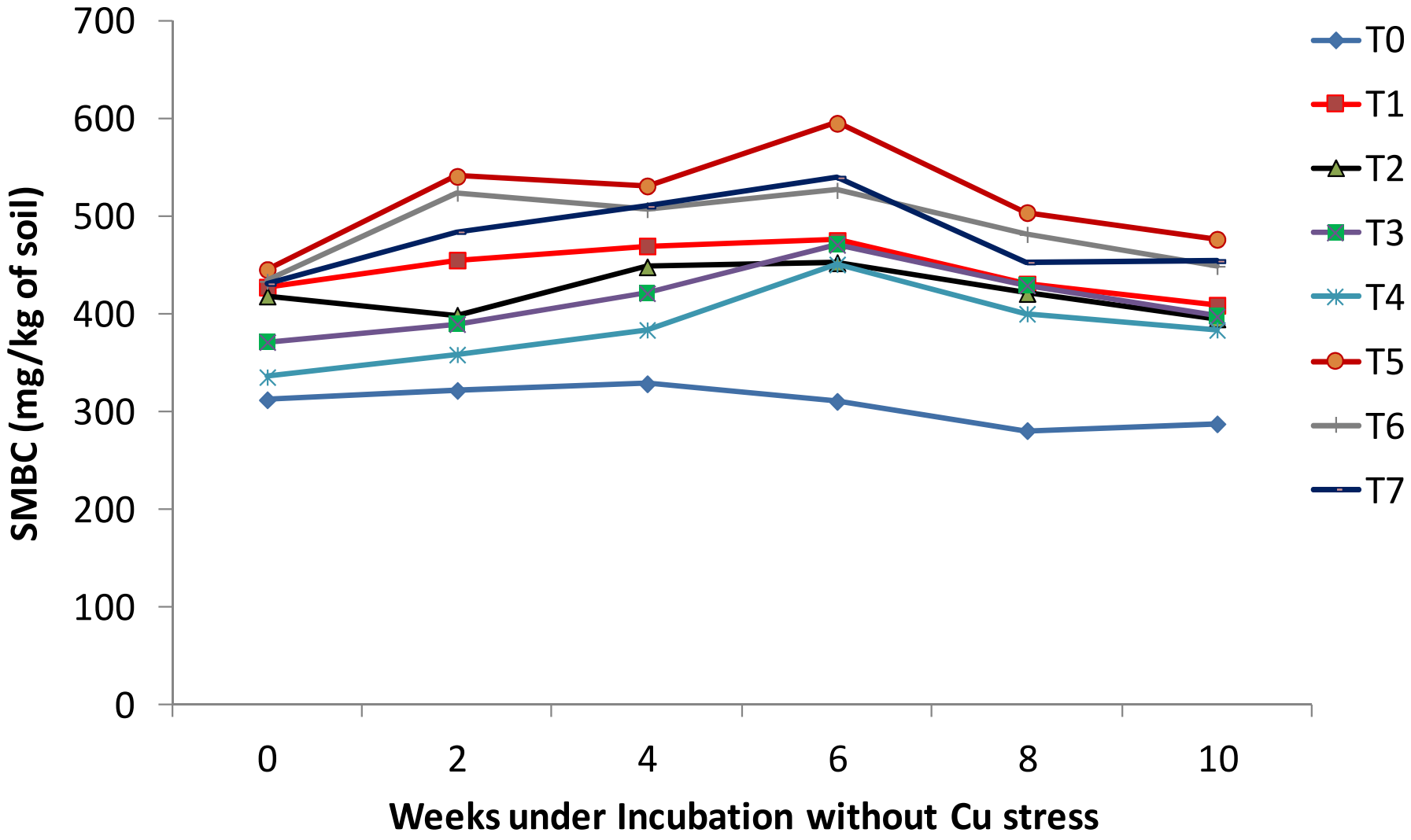
(Vogrig & McDonald, 2001)

Incubation study at a glance

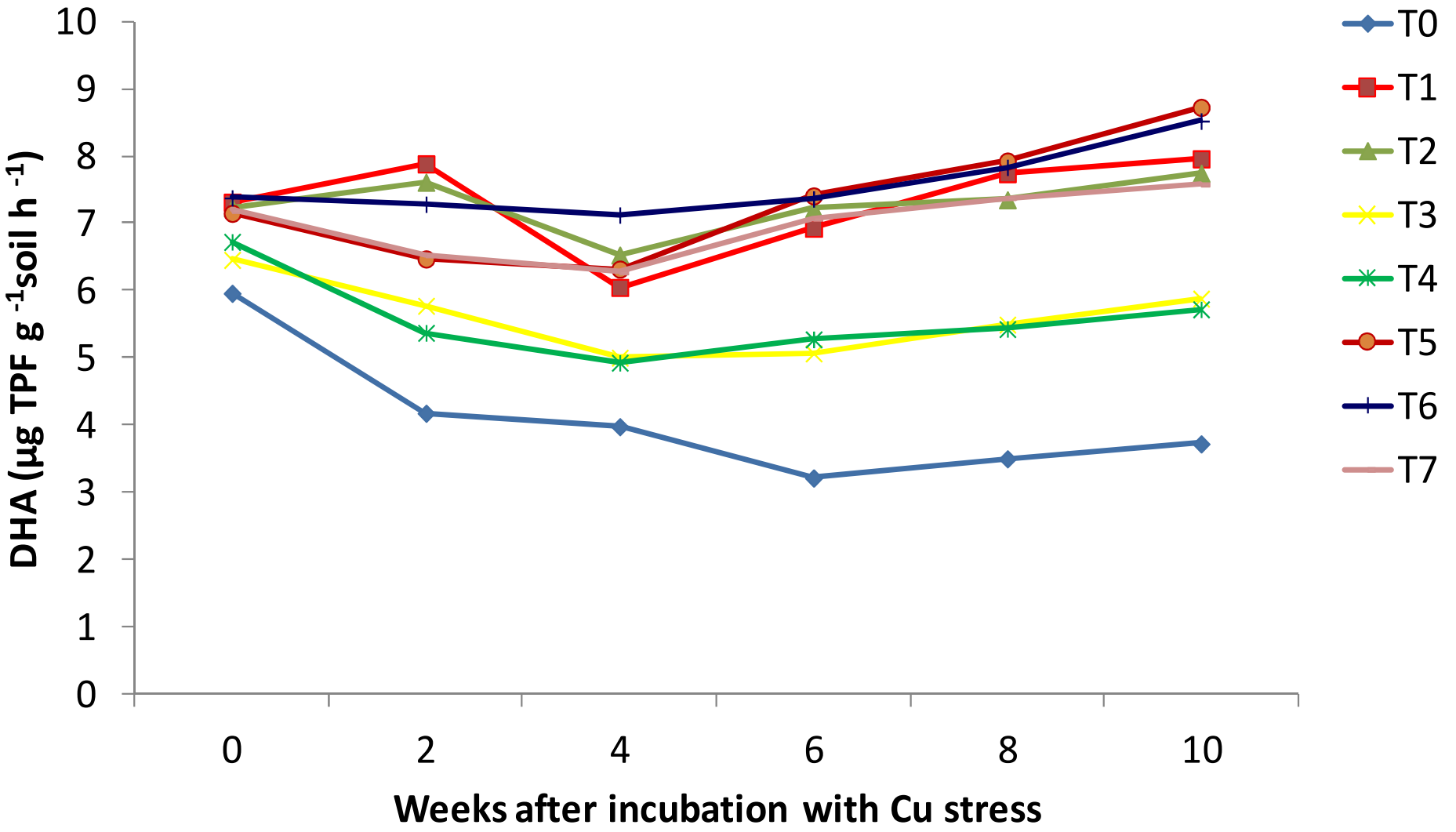
SMBC (mg kg^{-1} of soil) status of *Vertisol* under Cu Stress



SMBC (mgkg^{-1} of soil) status of *Vertisol* under normal condition



DHA (µg TPF g^{-1} soil h^{-1}) status of *Vertisol* under Cu Stress



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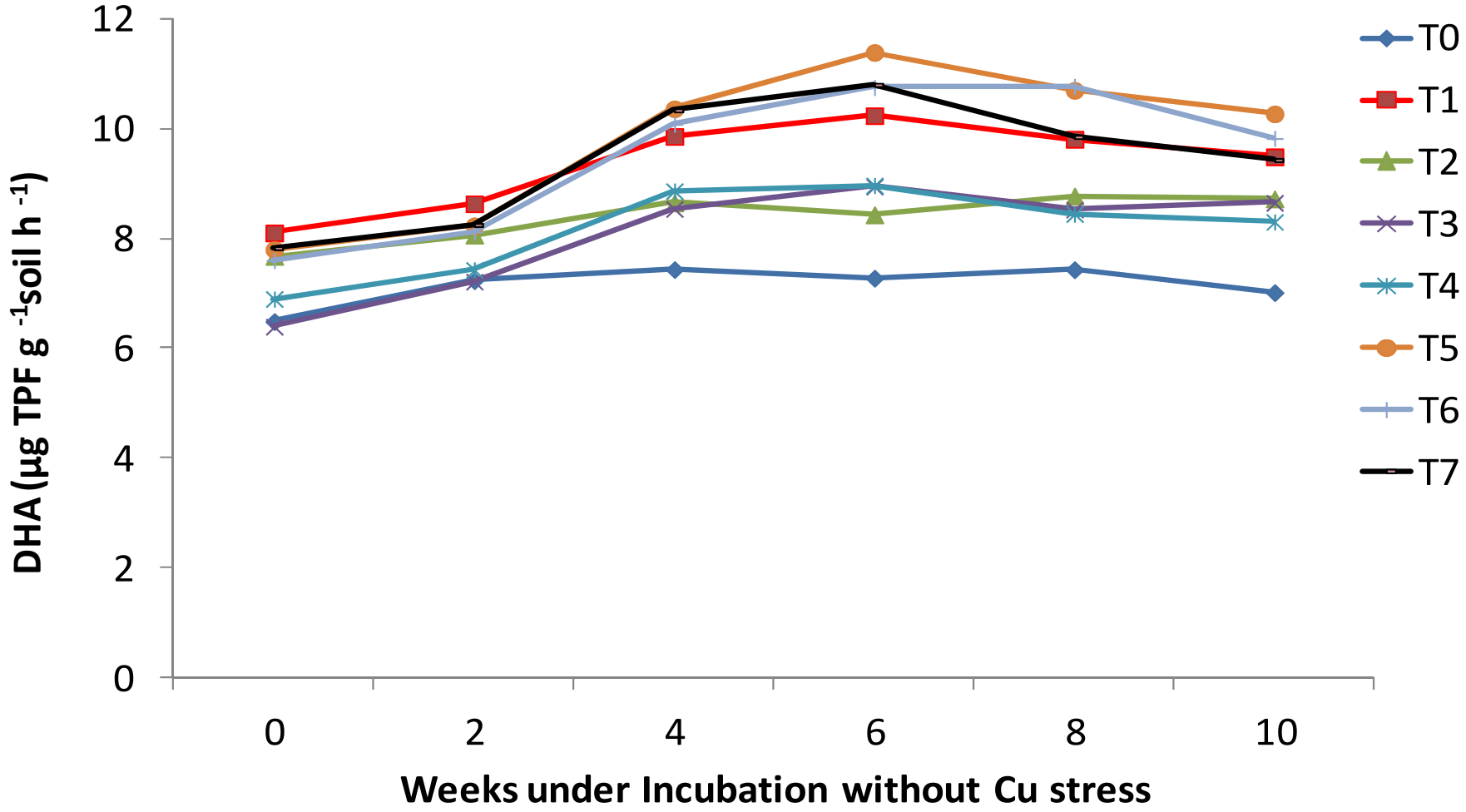
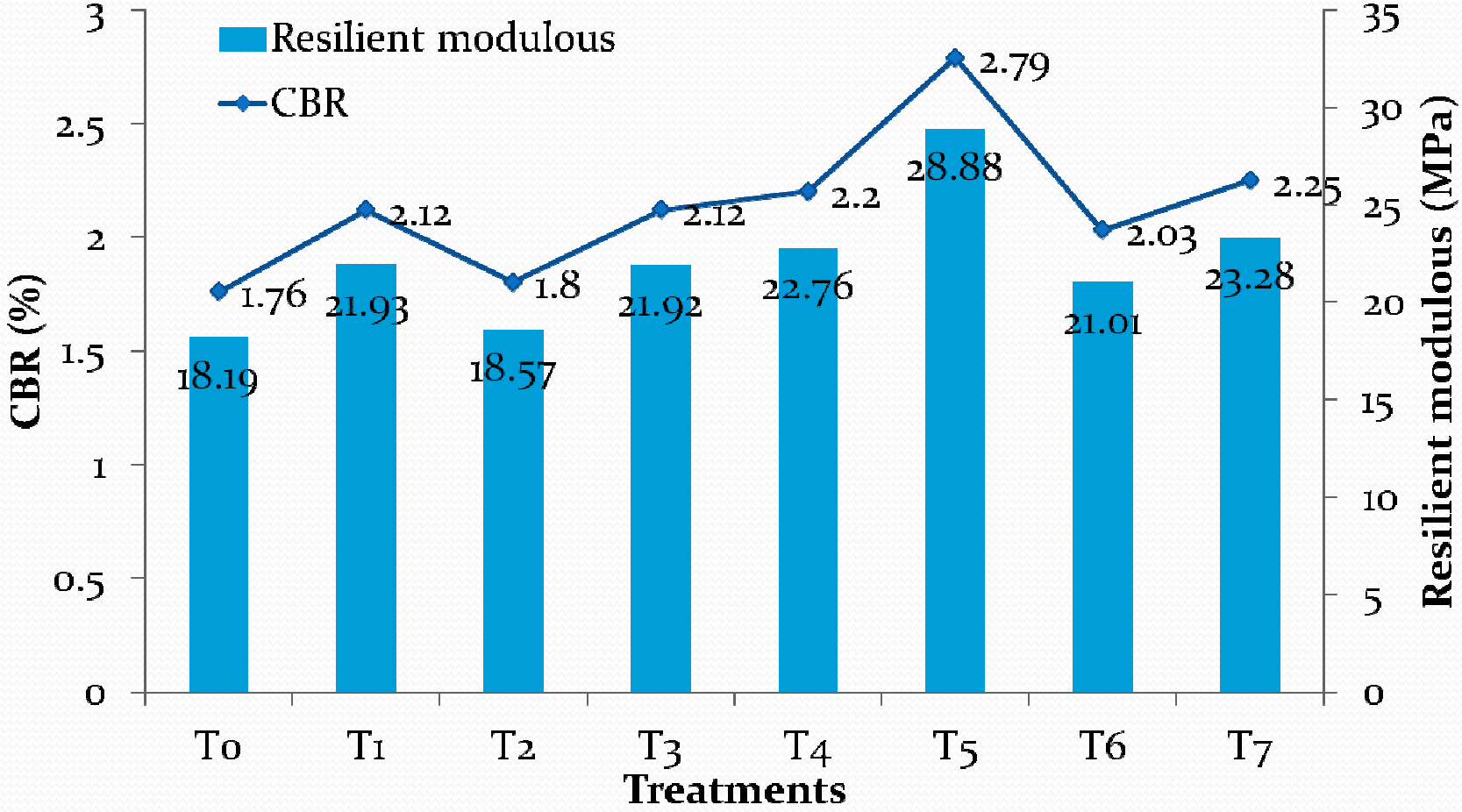


Resistance and Resilience index under various management

Treatments		Resistance index	Resilience index
T_0	Control	0.41	0.32
T_1	FYM	0.55	0.68
T_2	Biochar	0.66	0.58
T_3	poultry manure	0.60	0.61
T_4	Fly ash	0.57	0.57
T_5	FYM + Fly ash	0.59	0.74
T_6	Biochar+ Fly ash	0.70	0.66
T_7	Poultry manure+ Fly ash	0.61	0.70

CBR and Resilient modulous of Black soil under various treatments



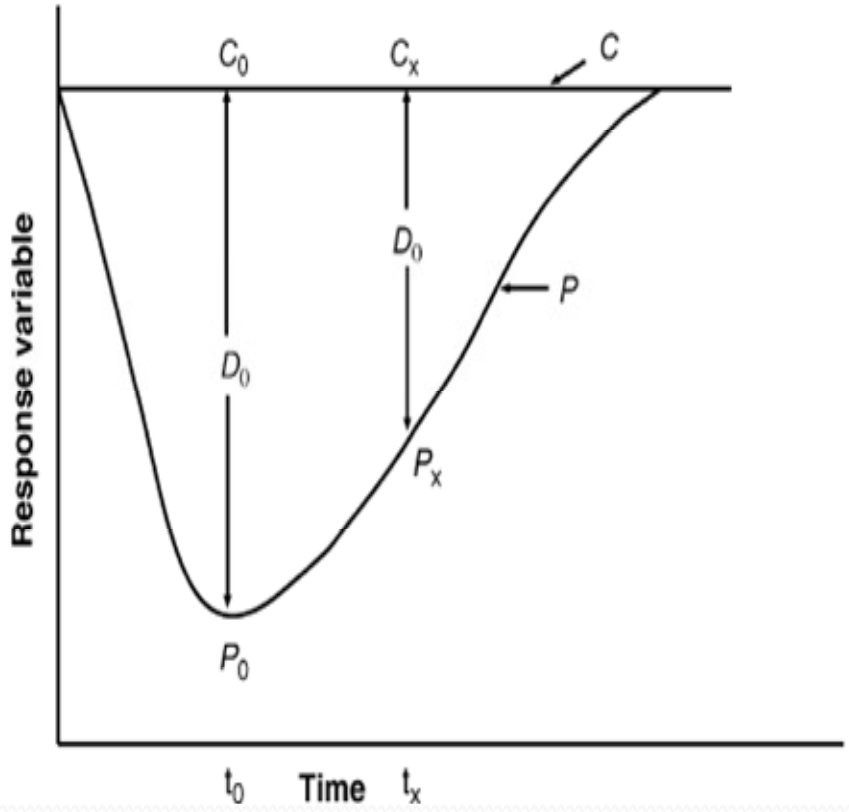
Conclusion

- **Soils treated with amendments rich in organic matter showed better performance in terms of soil resilience. Fly ash along with organic amendments had better resilience.**
- **FYM with fly ash treated soil is highly resilient because biological properties of soil increased (SMBC and DHA) and bio-char with fly ash treated soil is highly resistant .**
- **Study suggested that fly ash along with organic amendments like FYM or poultry manure can be used for better resilience in vertisols of Central India.**

Thank you all

Resistance & Resilience index

(Orwin & Wardle, 2004)



The upper line represents the undisturbed control soil (C) and the lower line represents the disturbed soil (P): For resistance (i.e. time 0 or t_0), the value for the control soil is C_0; the value for the disturbed soil is P_0; and
$C_0 - P_0 = D_0$
An example of the data used to show resilience is given at t_x; with the value for the control soil as C_x; the value for the disturbed soil as P_x and the difference between the two as D_x Time x can be any time point beyond t_0

Calculations for Indices

- Resistance index at t_o – $1 - \frac{2|D_0|}{(C_0 + |D_0|)}$
- Resilience index at t_x= $\frac{2|D_0|}{(|D_0| + |D_x|)} - 1$
- where Do is the difference between the control (C_o) and the disturbed soil (P_o) at the end of the disturbance (t_o) and D_x is the difference between the control (C_x)and the disturbed soil (P_x) at the time point (t_x) chosen to measure resilience (**Orwin & Wardle, 2004**)

Some moments of compaction study

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