Soil Fertility Improvement through Biofilmed Bio-fertilisers (BFBFs):
- Potentials for Field Applications -

Dr M S D L De Silva
Senior Research Officer

Agronomy Division

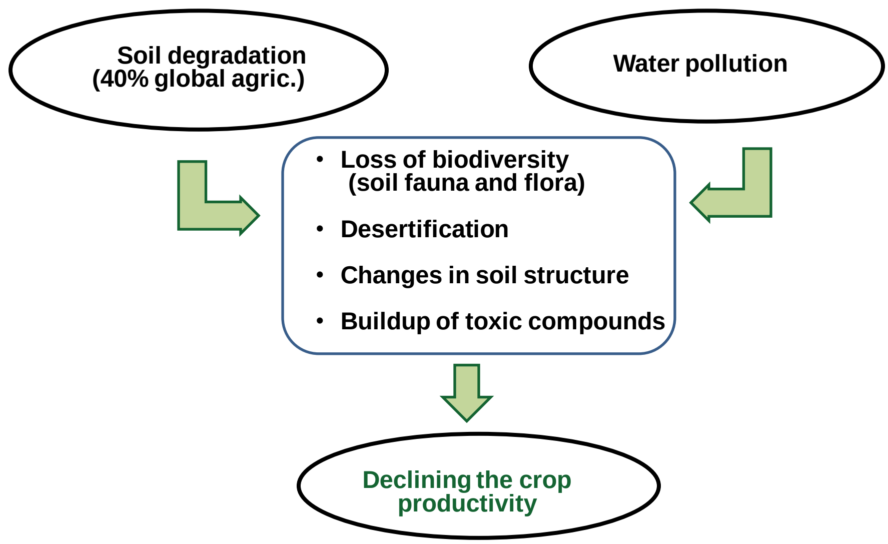
Tea Research Institute of Sri Lanka

Improvement of soil fertility

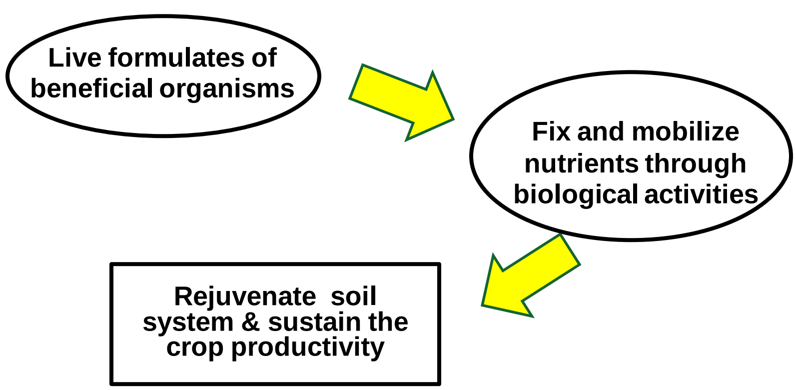
Chemical	• Synthetic /Chemical fertiliser/pH correction

Non Chemical (biological and physical methods)	• Rehabilitation • Burying of pruning • Mulching • Composting • Forking • Shade establishment and management • Soil conservation methods (SALT etc..) • Intercropping

Detrimental effects of Conventional (Chemical) Farming system



Soil fertility Improvement through Biofertilisers



In forest ecosystem , 99% pathogens could be suppressed by beneficial microbes

Soil fertility Improvement through Bio-fertilisers

- **Mono cultures**
  Rhizobium, Azotobacter, Bacillus megatherium
  Mycorrhizal fungi
- **Mixed cultures**
  Rhizobium **+ Phosphobacterium**
  Azotobacter **+ *Pseudomonas***
- **Biofilmed Bio-fertilisers: (developed microbial community)**
  Penicillium **spp. + *Bradyrhizobium elkani* – Soybean (↑ 30% N f.ca.)**
  ***Pleurotus ostreatus* + *Bradyrhizobium elkani* -Mushroom (↑25% N f.ca.)**
  ***Psedomonas fluorescens* + *Pleurotus ostreatus* – Tomato**
  Biofilms of Rice Endophytes - Rice – Experiments in progress

Combination of bacteria and fungi (F3B & FR) - Tea

Definition and functions of Biofilm

What is Biofilm:

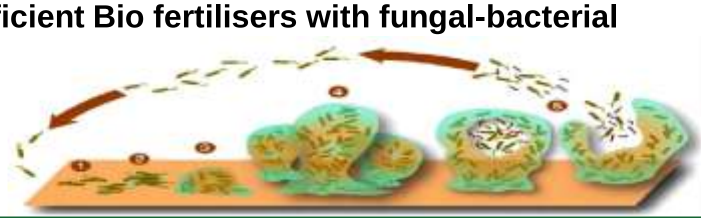
- **It's a complex aggregation of microorganisms that include bacteria, fungi, algae etc. with EPS-(Extracellular Polymeric Substance) which provides structure and protects the community**

Functions of Biofilm:

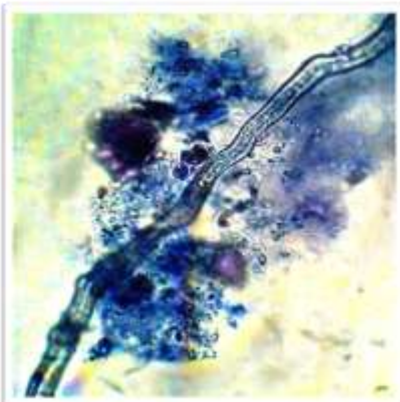
- **Agents for bio-fertilisers –Corporative microbes and bio control of pests – Competitive microbes**

What is Biofilmed Biofertilisers:

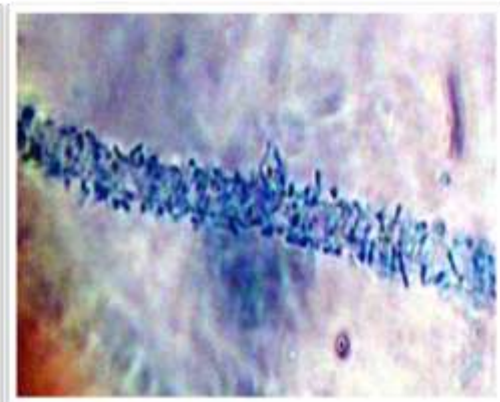
More efficient Bio fertilisers with fungal-bacterial biofilm



Microscopic view of Biofilms

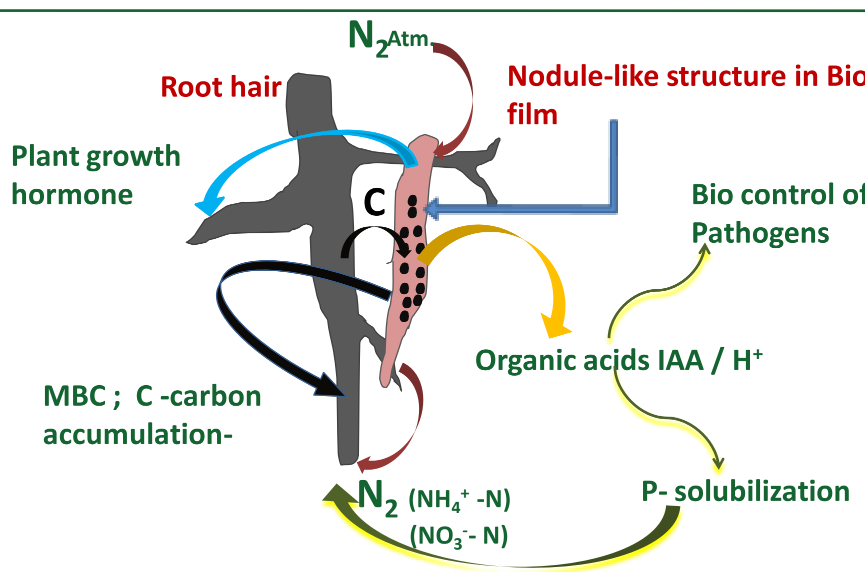


Bacterial cells attached to root hair of tea



Fungal-bacterial bio-film in maize

Functions of BFBFs: A diagrammatic sketch



Advantages of BFBFs

- Effective in N2 fixing
  - can be used for non legumes as bio-fertlisers -
- Enhance P use by improving P solubilization
- Enhance soil K by chelating action
- Enhance plant growth by growth hormones
- Production of antimicrobial compounds
- Enhance mycorrhizal association
- Increase uptake of nutrients (P, N, Zn, Cu, Fe)
- Plant withstand better for environmental stress
- Inhibit fungal pathogens

Outcomes of nursery experiments

Treatments T65 , BFBF + ½ T65, & ½ T65

- Improved soil C, K, available P, MBC and nitrogenase activity
- Improved plant growth and physiological parameters
- Chemical Fertiliser inputs could be reduced by half

Field application of BFBFs

Objectives

- **To investigate the influence of BFBF on soil, plant nutrient status and yield of immature tea**
- **To explore possibility of reducing synthetic/chemical nutrient inputs**

Treatment combinations and methodology

T1: TRI recommended quantity of fertiliser (T750) & 4 appli.^{ns} (CF)

T2: BFBF + Half of recommended chemical fertiliser & 4 appli.^{ns}(BFBF + ½ CF)

T3: Half recommended chemical fertiliser & 4 applications (½ CF)

BFBF

F3B: Bacteria isolated from *Arachis pintoii*
Bacteria isolated from tea rhizosphere
Fungi isolated from tea rhizosphere
Bacillus megatherium **or**

FR: Bacteria isolated from refuse tea
Bacteria isolated from Mana roots
Bacillus megatherium

Three locations: R'pura (TRI 4042), Elkaduwa (TRI 2025), Kottawa (TRI 4006)

Dosage and frequency of application

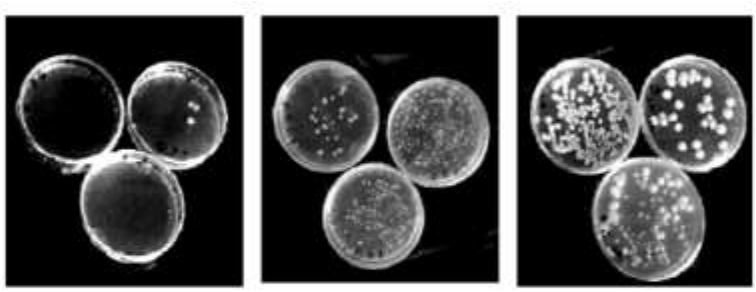
- **Fertilizer application**

  3 months interval (T750)- 1750 kg/ha/annum

- **BFBF application**

  1-2 weeks after fertilizer application
  By knapsack sprayer without nozzel
  (50 mls in tank- required 25 tanks/ha)

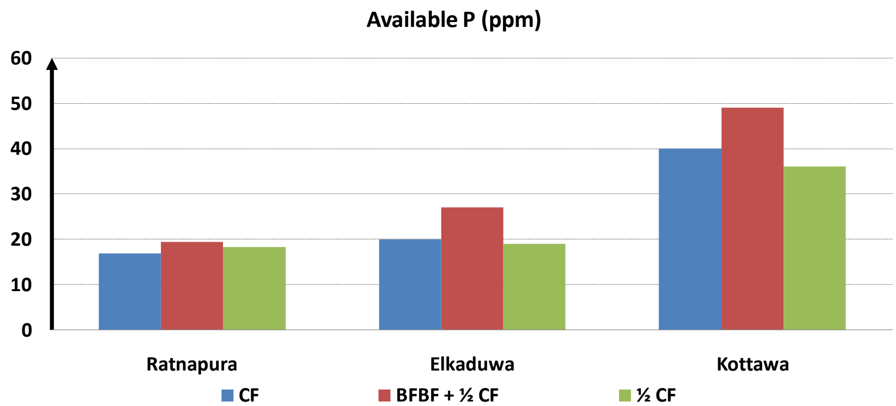
Development of N_2 fixing bacteria in a soil (in vitro)



100% CF | **50% CF** | **50% CF + BFBFs**

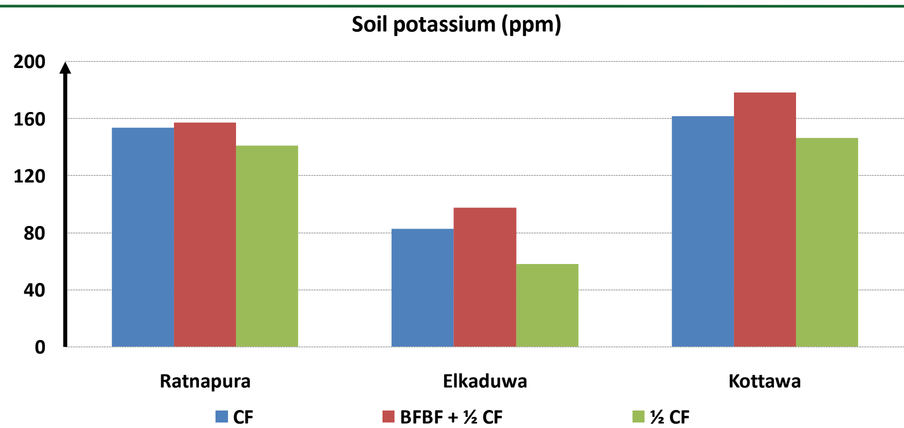
100% Chemical Fertiliser suppressed growth of N_2 fixing bacteria

BFBF on soil available P



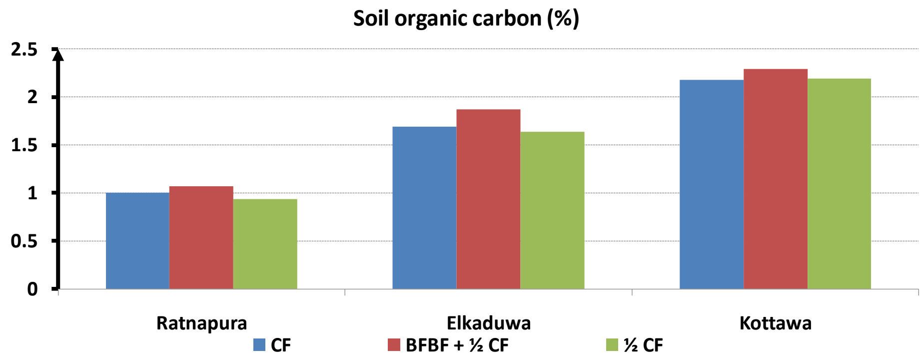
P availability increased with BFBF + ½ CF (T2)

BFBF on soil exchangeable K



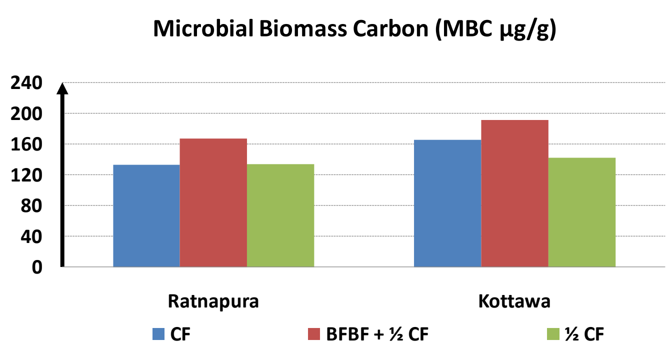
Exchangeable K increased with BFBF + ½ CF (T2) in comparison to CF (T1) in Elkaduwa and Kottawa

BFBF on soil organic carbon (%)



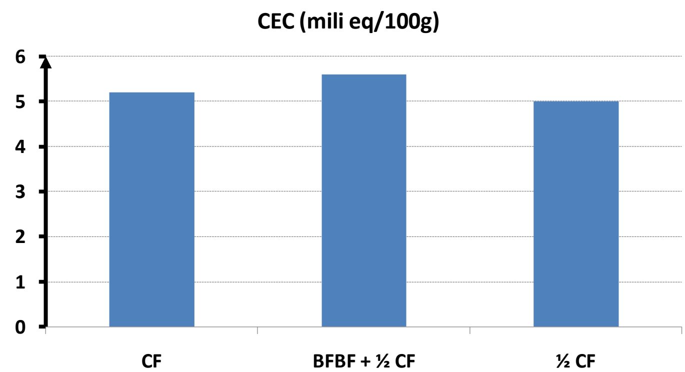
No significant difference in OC content between CF (T1) and BFBF + ½ CF (T2)

Microbial biomass carbon (µg/g)



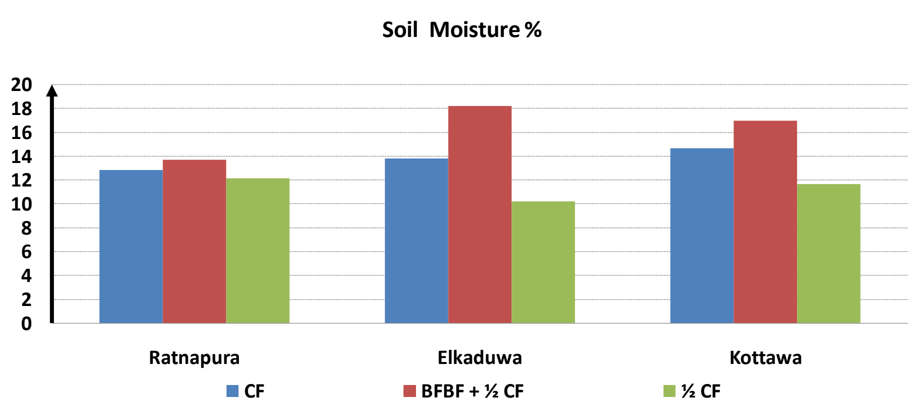
Improved microbial biomass carbon in BFBF + ½ CF (T2)

Cation Exchange Capacity - (CEC) Ratnapura soil



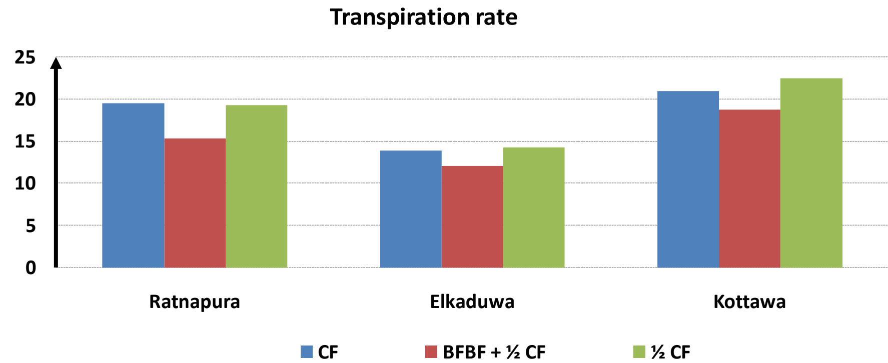
Improved CEC in BFBF + ½ CF (T2)

Soil moisture status (%)



Improved soil moisture status in BFBF + ½ CF (T2)

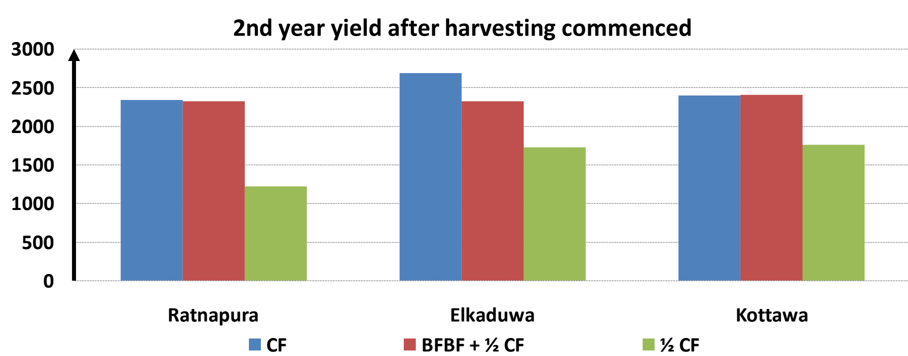
Transpiration rate (milimol cm^{-2}s^{-1})



Reduced transpiration rate in BFBF + ½ CF (T2)

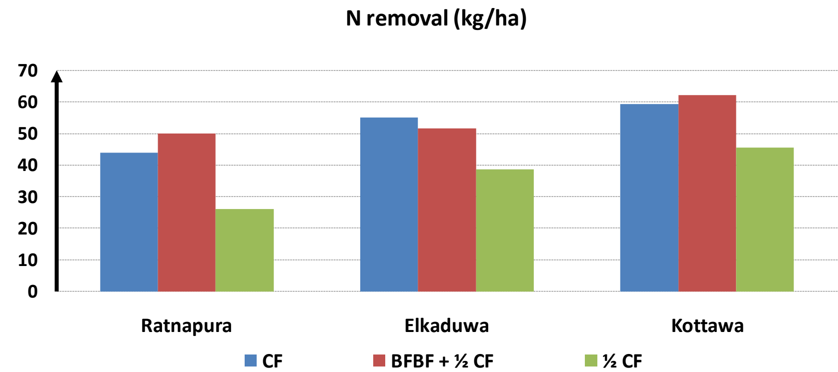
Yield data - 2nd year after bringing into bearing

(Made tea kg/ha)



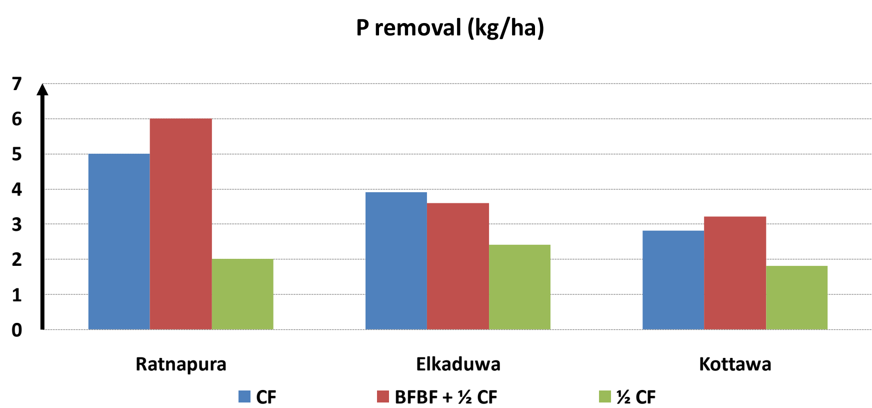
No significant difference between CF1 (T1) and BFBF + ½ CF (T2)

N removal (kg/ha)



No significant difference in N removal between CF(T1) and BFBF + ½ CF (T2)

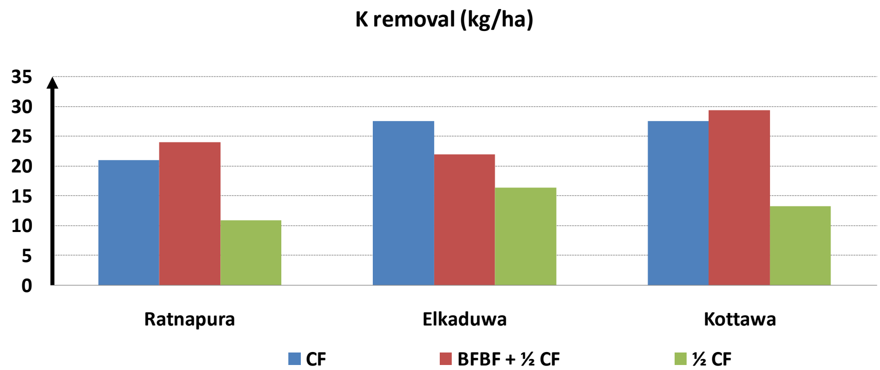
P removal (kg/ha)



No significant difference in N removal between CF(T1) and BFBF + ½ CF (T2)

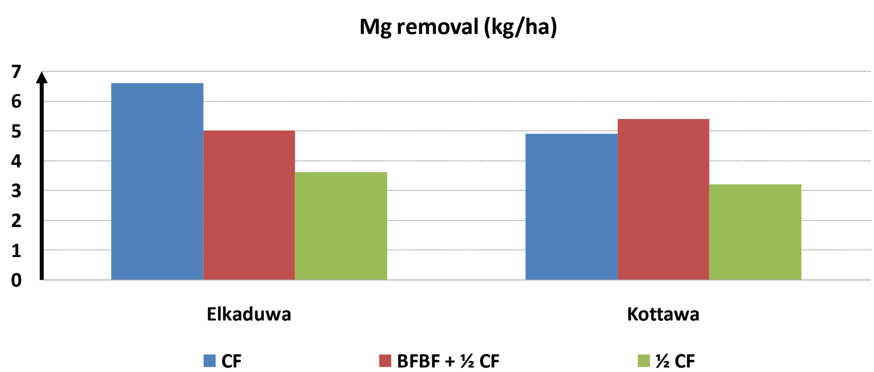
In Ratnapura trial, BFBF + ½ CF (T2) was higher than CF (T1)

K removal (kg/ha)



Increased K removal in BFBF + ½ CF (T2) at Ratnapura and Kottawa.
In Elkaduwa trial CF (T1) was higher than BFBF + ½ CF (T2)

Mg removal (kg/ha)



Increased Mg removal in BFBF + ½ CF (T2) at Kottawa Trial.
In Elkaduwa trial CF (T1) was higher than BFBF + ½ CF (T2)

Effect of BFBFs on soil N_2O emission and carbon storage (Ratnapura soil)

Treatments	N_2O µmol/g soil/4hr	Soil C Storage (tC/ha)
Rec. fert. (CF)	12.3	8.38
BFBF + ½ rec.fert.	ND	10.92
½ rec.fert	4.21	9.43

In BFBF + ½ CF (T2): N_2O emission was not detected.
Carbon storage was higher (2t/ha) in BFBF + ½ CF (T2) than (CF) T1

Benefits

- Increased soil exchangeable K, Available P, CEC and MBC
- Reduction of leaching
- Improved soil carbon level
- Improved soil moisture level
- Reduced transpiration rate
- Savings (National level)

Cost benefits (Rs/ha/yr)

Application of Chemical Fertiliser	Che. Fer. Cost	kg/ha	Unit Price	Amount (Rs.)	Total Rs./ha/yr
4th yr	T750	1750	50.5	88,375.00	
	Worker	4*15	572	34,320.00	88375.00
Application of BFBF		Tanks/ha			
	BFBF	4*25tanks	90	9000.00	
		(50ml/tank)			
	Worker	4*3	572	6864.00	
	½T750	875	50.5	44187.50	60051.50
	Worker	4*15	572	34320.00	
			Savings		28323.50

Conclusions

a) As compared to CF (T1) plants treated with BFBFs + ½ CF (T2) showed

- Similar productivity level in immature tea,
- Improved physiological performances,
- Increased soil exchangeable K, available P, soil OC, MBC and CEC.
- Increased soil carbon storage,
- Reduce greenhouse gas emission (N_2O)

b) Tested BFBFs are cost effective

c) There is a potential to replace recommended fertiliser use by application of BFBFs.

Acknowledgements

Dr KG Prematileke, Head, Agronomy Division

Dr G P Gunaratne, Head, SPND

Dr M A Wijeratna, OIC, LCS

Mr APDA Jayasekera

Ms ETWP Prematunge

Ms S N Wijesekera

Mr U P Abeysekera

Ms L A S P Jayasinghe

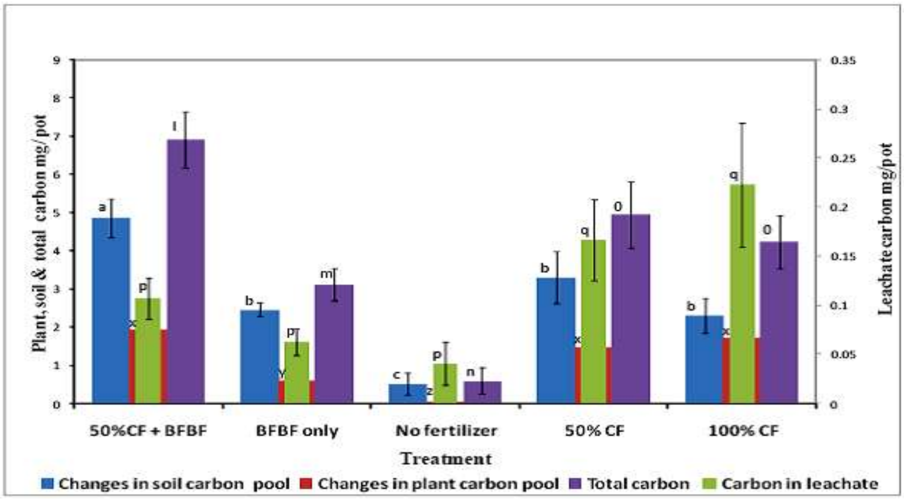
Prof. G Seneviratne, IFS, Hantane

Tea Research Institute of Sri Lanka 31

Thank you

Tea Research Institute of Sri Lanka 32

Net C accumulation in plant, soil, and C leached



Tea Research Institute of Sri Lanka 33