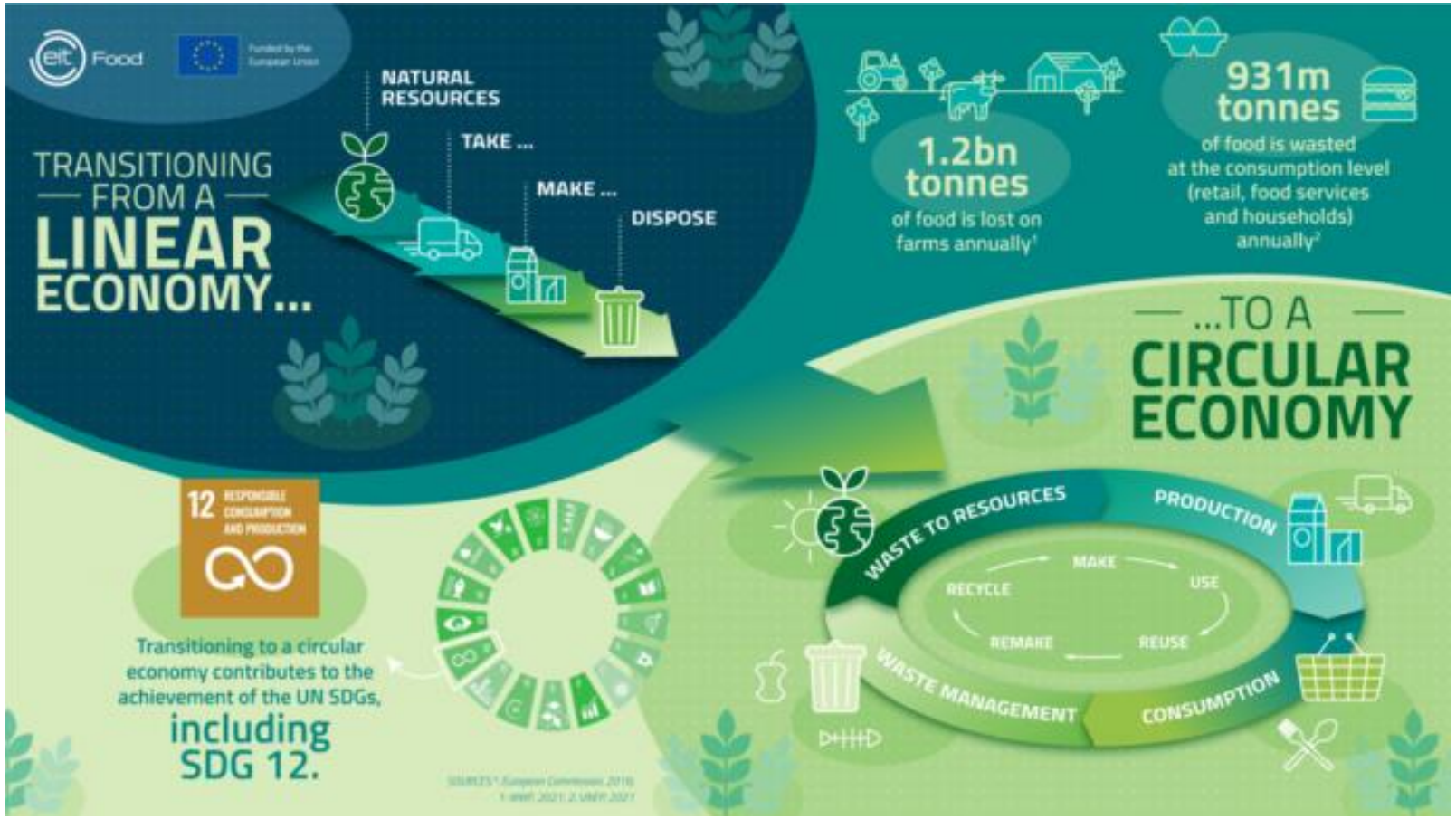
Circular Economy



- Extend the products' lifespan for as long as possible
- Waste reutilization is a part of the circular economy

Chicken Feather Waste as a Potential Growth Stimulant: A Sustainable Approach for Circular Economy

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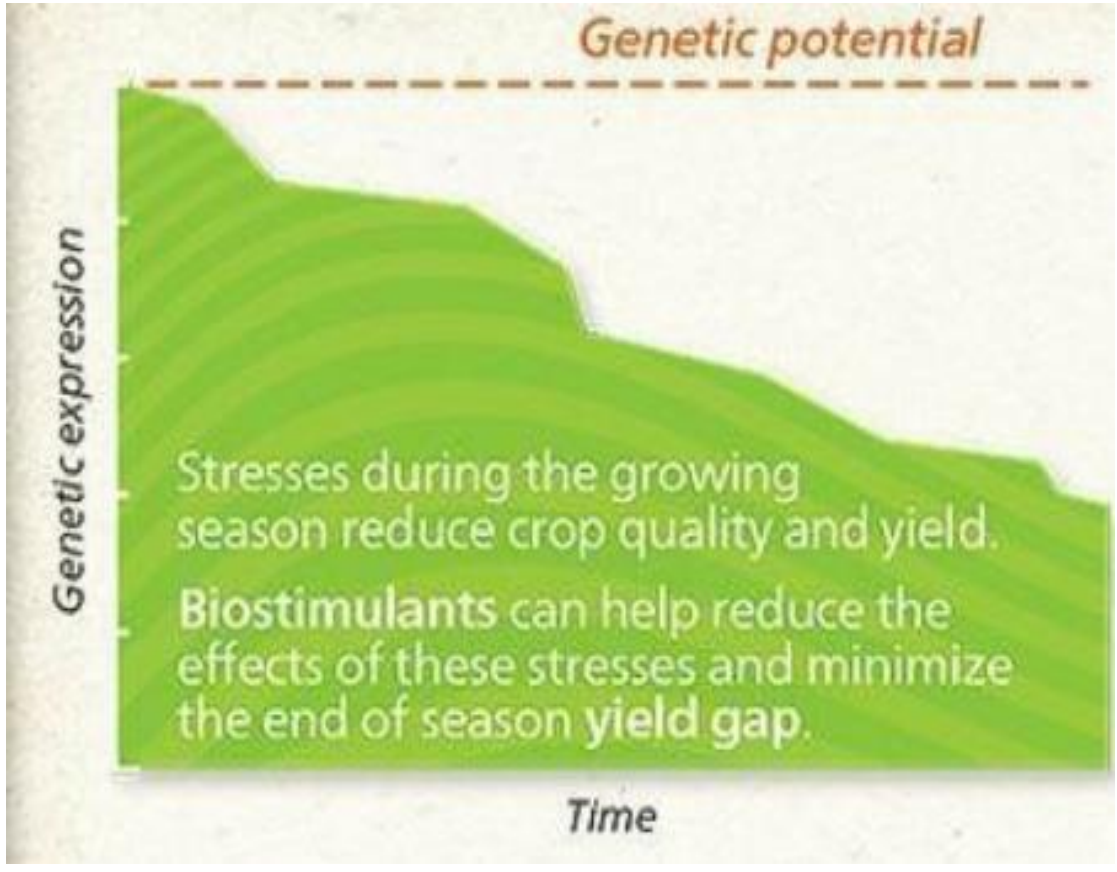
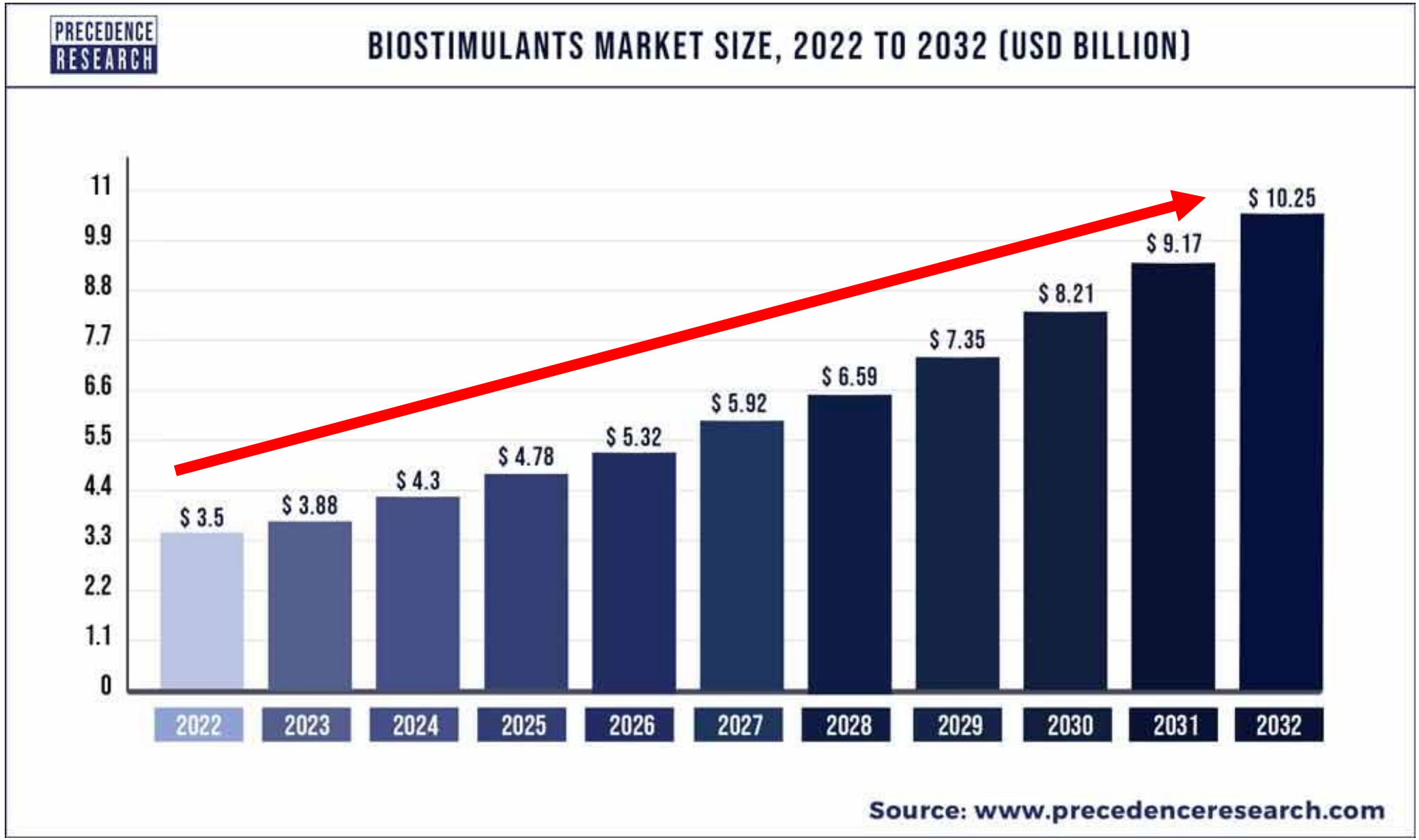
Tea Research Institute of Sri Lanka

What is Biostimulant?

- Any substance or microorganisms applied to plants with the aim to enhance nutrient use efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrient content (Patrick Du Jardin, 2015).
- Materials other than fertilizers, that promote plant growth when applied in low quantities (Kauffman et al., 2007).
- Major groups plant biostimulants

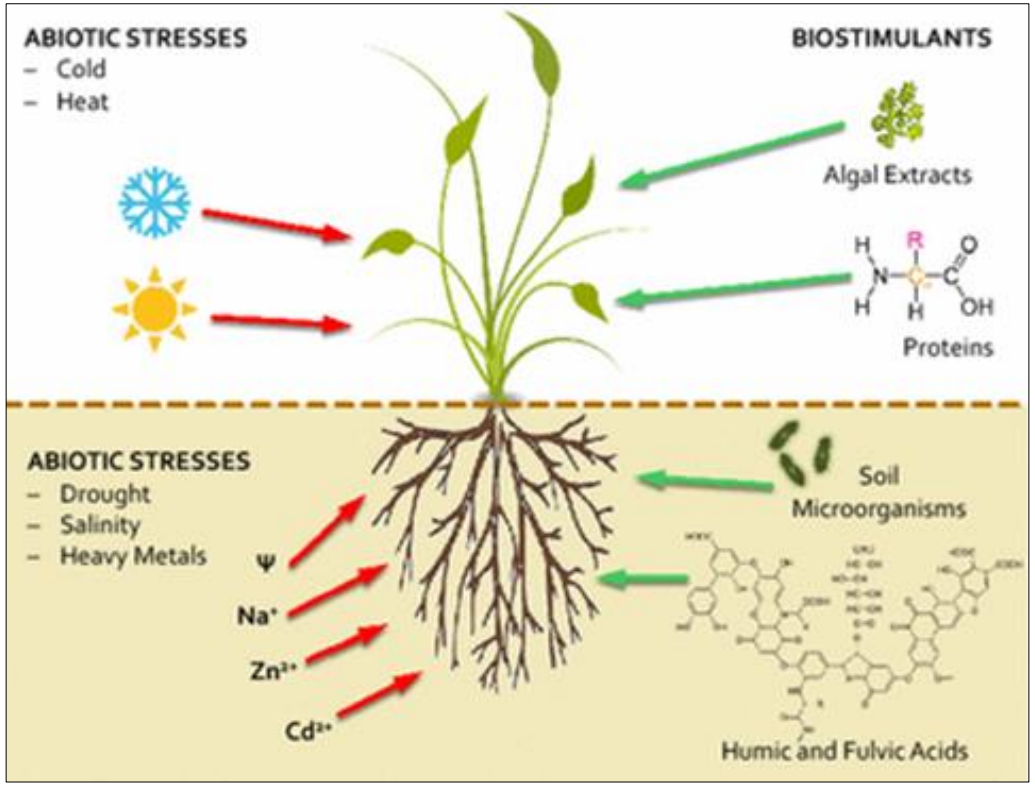
    1. Humic substances
    2. Amino acid containing products
    3. Sea weed extracts
    4. Plant growth-promoting microorganisms




PRECEDENCE RESEARCH
BIOSTIMULANTS MARKET SIZE, 2022 TO 2032 (USD BILLION)
11
9.9
8.8
7.7
6.6
5.5
4.4
3.3
2.2
1.1
0
$ 3.5
$ 3.88
$ 4.3
$ 4.78
$ 5.32
$ 5.92
$ 6.59
$ 7.35
$ 8.21
$ 9.17
$ 10.25
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
Source: www.precedenceresearch.com

Benefits of Plant Biostimulants

- ✓ Yield enhancement
- ✓ Quality enhancement
- ✓ Greater vigour
- ✓ Stress resistance
- ✓ Germination and root development
- ✓ Nutrient assimilation and translocation
- ✓ Water use efficiency
- ✓ Metabolic process optimization



Why Chicken Feather?

- Every week - 3000 tons globally (Prasanthi *et al*., 2016)
- Rich in N up to 15%
- Feathers make up 4-9% of live weight
- 91% keratin - highly insoluble, mechanically stable and resistant to degradation
- Natural degradation > 2 years

Home › NEWS › Meat › Sri Lanka chicken meat production hits a new record

Meat Poultry

Sri Lanka chicken meat production hits a new record

By **Zahrah Imtiaz** - 11 July, 2024, AM

Sri Lanka produced the highest-ever amount of chicken meat in 2024. A record 269,000 tons were produced, while the annual average production was 220,000-230,000 tons. The country's average annual consumption is 230,000 tons. Minister of Agriculture and Plantation Industry, Mahinda Amaraweera said th...

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TAGS chicken meat Sri Lanka

Use of Chicken feathers in Sri Lanka

- Large-Scale Farms – Produce feather meal
- Small-Scale Farms – Landfilling & Dumping
- Backyard System - Illegal dumping

What is Protein Hydrolysate?

- Hydrolysis of proteins
- Consists
  - Mixture of peptides, oligopeptides and amino acids
  - May have carbohydrates, small quantities of mineral elements, phenols and other compounds (Olbrycht et al., 2020)
- Directly influence the plant by
  - Stimulation of C and N metabolism
  - Regulation of N assimilation (Nardi et al., 2016)
  - Interfere hormonal activities through bioactive peptides (Colla et al., 2014, 2015)
- Indirectly affect growth and plant nutrition (du Jardin, 2015)

Crop Responses to Chicken Feather Protein Hydrolysates

- **Bengal gram seedlings**
  - Enhanced germination and promoted secondary roots development of Bengal gram seedlings.
  - Improved soil fertility by modifying N, P, K and C/N ratio by 1.2-fold (Paul et al., 2013).
- **Banana**
  - Increased the photosynthetic rate and chlorophyll content, fruit set, filling and yield (Gurav et al., 2012)
- **Maize**
  - Improved the leaf nutrient status (macro and micronutrients)
  - Increased protein content and yield (Tejada et al., 2018)
- **Patchouli**
  - Cut down chemical fertilizer by 50% on yield
  - Significantly increased leaf area, dry weight, and chlorophyll content (Nurdiawati et al., 2019)
- **Wheat seedlings**
  - Enhanced root and shoot length, photosynthetic pigment content and fresh and dry weights of seedlings (Genç and Atici, 2019)

Objective

To explore the potential of chicken feather waste derived protein hydrolysate on the growth of vegetatively propagated tea nursery plants

Research Methodology

Study 1

- Dose Response of CFPH & Comparison with Commercial Product

Study 2

- Validation Experiment

Study 1: Dose Response

Objective

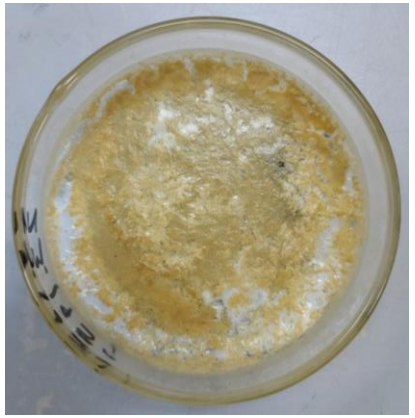
To identify the optimum rate that would exert biostimulant action on the early growth of tea nursery plants

Materials and Methods

- CFPH extracted using alkaline hydrolysis.
- Dried at 80^{o}C until become a constant weight
- Amino acid profile - High Performance Liquid Chromatography
- Nutrient composition - ICP-OES
- RCBD with 3 replicates

Treatment	Details
T1	Control or CFPH 0 g/L
T2	CFPH 0.5 g/L
T3	CFPH 1 g/L
T4	CFPH 2 g/L
T5	CFPH 3 g/L
T6	CFPH 4 g/L
T7	Fish Protein Hydrolysate (10 ml/L)

Chicken feather



CFPH Dried Form

Fish Protein Hydrolysate

Greenhouse experiment

- The experiments were carried out in a greenhouse for a period of five months under 70% shading
- Eight weeks old uniform size healthy nursery tea (Cultivar TV 8) plants were selected
- Fertilization done at alternative weeks to biostimulant application
- T-65 DAP fertilizer mixture (10.5% N, 10.6% P_2O_5, 11.1% K_2O and 3.7% MgO)
- Control plants received same amount of water.

Plant growth and physiological measurements

- Shoot growth
  - Plant height
  - Number of leaves
  - Shoot fresh weight
  - Shoot dry weight
- Root growth
  - Length
  - Surface area
  - Fresh weight
  - Dry weight
- Leaf gas exchange (Li-6400XT Portable Photosynthesis System)
  - Photosynthetic rate (Pn)
  - Stomatal conductance (Gs)
  - Intercellular CO_2 concentration (Ci)
  - Transpiration rate (Tr)
- Chlorophyll content (a, b and total)

Nutrient composition of the chicken feather and CFPH

Elements	Chicken feather	CFPH
Total C (%)	47.09	9.42
Total N (%)	13.54	3.06
C/N ratio	2.81	2.31
P (%)	0.12	17.13
K (%)	0.29	25.41
Ca (%)	0.31	0.074
Mg (%)	0.03	0.007
S (%)	1.61	0.44
Zn (mg/kg)	0.02	< 0.01
Mn (mg/kg)	< 0.01	< 0.01
Cu (mg/kg)	< 0.01	< 0.01
Fe (mg/kg)	0.04	< 0.01

Amino acid composition of CFPH

Amino acids	Composition(% of total amino acids)	mg/g Chicken Feather
Alanine	6.21	10.27
Arginine	6.61	10.94
Aspartic acid	8.03	13.29
Cysteine	0.79	1.30
Glutamic acid	13.36	22.11
Glycine	7.28	12.04
Histidine	ND	0.00
Isoleucine	6.28	10.40
Leucine	9.42	15.59
Lysine	2.73	4.53
Methionine	0.75	1.25
Phenylalanine	4.77	7.90
Proline	11.75	19.45
Serine	8.11	13.43
Threonine	2.42	3.71
Tyrosine	2.56	4.24
Valine	9.06	14.99
Hydroxyproline	ND	0.00
Total	**100**	**165.50**

- Amino acid yield - 165.5mg/g of feathers
- Higher amount of glutamic acid and proline
  - Glutamic acid – Root architecture
  - Proline – Protection from abiotic stresses
- Short-chain peptides & AAs like phenylalanine increase production of endogenous auxin

Effect of CFPH on the growth of tea plants

Control CF 0.5 g/L CF 1 g/L CF 2 g/L CF 3 g/L CF 4 g/L FPH 10 ml/L

Effect of CFPH on shoot growth of tea plants

Treatment	Height (cm)	Number of leaves	Shoot fresh weight (g/plant)	Shoot dry weight (g/plant)
Control	22.7 ± 1.4^{e}	7.0 ± 0.6^{d}	6.6 ± 0.4^{e}	2.13 ± 0.17^{e}
CFPH 0.5 g/L	27.2 ± 1.0^{d}	8.0 ± 0.6^{cd}	8.5 ± 0.5^{d}	2.76 ± 0.23^{de}
CFPH 1 g/L	39.6 ± 0.7^{b}	10.0 ± 0.6^{ab}	12.5 ± 0.6^{ab}	4.87 ± 0.43^{a}
CFPH 2 g/L	45.0 ± 1.1^{a}	11.3 ± 0.3^{a}	13.7 ± 0.7^{a}	4.34 ± 0.27^{ab}
CFPH 3 g/L	37.7 ± 0.6^{bc}	8.6 ± 0.3^{bc}	12.2 ± 0.6^{abc}	4.03 ± 0.32^{bc}
CFPH 4 g/L	34.3 ± 1.3^{c}	8.6± 0.3^{bc}	10.6 ± 0.5^{c}	2.73 ± 0.06^{de}
FPH (10mL/L)	37.0 ± 1.5b^{c}	8.6 ± 0.3^{bc}	11.5 ± 0.5^{bc}	3.31 ± 0.13^{cd}

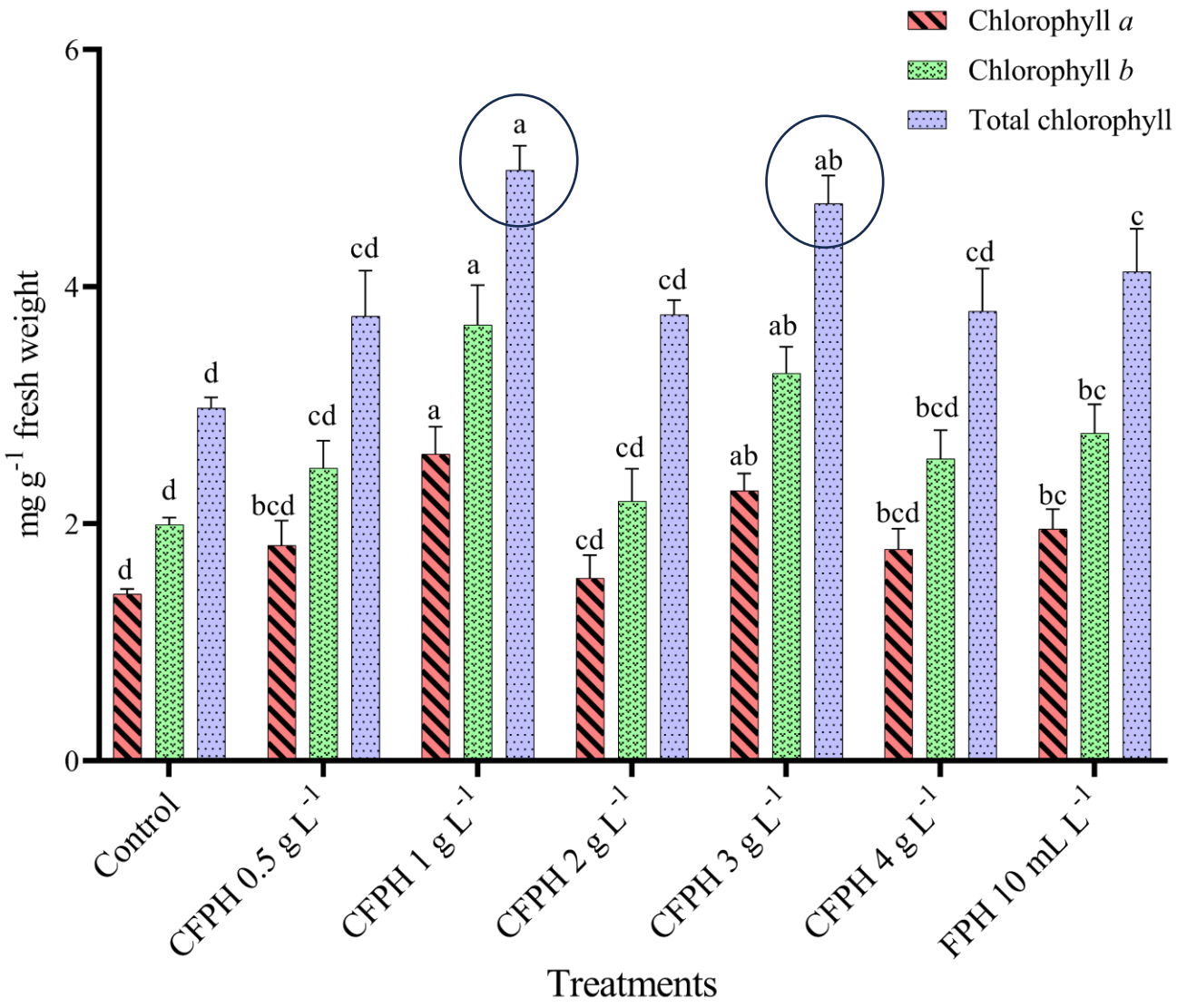
Same letters within each column are not significantly different ($p < 0.05$)

Effect of CFPH on root growth of tea plants

Treatment	length (cm)	Surface area (cm^2)	Fresh weight (g/plant)	Dry weight (g/plant)	R/S Ratio
Control	561 ± 26^{c}	847 ± 11^{d}	4.1 ± 0.1^{d}	0.70 ± 0.03^{e}	0.17^{a}
CFPH 0.5 g/L	1304 ± 46^{b}	858 ± 13^{cd}	4.8 ± 0.2^{cd}	0.88 ± 0.02^{d}	0.18^{a}
CFPH 1 g/L	1126 ± 106^{b}	$901b \pm 22^{c}$	8.6 ± 0.4^{b}	1.58 ± 0.03^{b}	0.19^{a}
CFPH 2 g/L	1629 ± 167^{a}	959 ± 23^{a}	11.7 ± 0.5^{a}	1.81 ± 0.05^{a}	0.21^{a}
CFPH 3 g/L	1410 ± 140^{ab}	919 ± 12^{ab}	9.0 ± 0.4^{b}	1.38 ± 0.07^{c}	0.19^{a}
CFPH 4 g/L	474 ± 26^{c}	903 ± 11^{bc}	3.9 ± 0.2^{d}	0.58 ± 0.06^{e}	0.17^{a}
FPH (10mL/L)	1119 ± 92^{b}	920 ± 19^{ab}	5.67 ± 0.3^{c}	0.98 ± 0.10^{d}	0.21^{a}

Same letters within each column are not significantly different ($p < 0.05$)

Effect of CFPH on chlorophyll content of tea plants



Effect of CFPH on leaf nutrient concentrations

Treatment	N (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})
Control	38.4 ± 0.4^{b}	2.20 ± 0.07^{b}	22.8 ± 1.3
CFPH 0.5 g/L	37.7 ± 1.8^{b}	2.15 ± 0.03^{b}	24.8 ± 0.2
CFPH 1 g/L	38.9 ± 1.2^{b}	2.18 ± 0.07^{b}	24.1 ± 1.8
CFPH 2 g/L	43.7 ± 1.9^{a}	2.63 ± 0.19^{a}	23.6 ± 0.9
CFPH 3 g/L	45.4 ± 0.7^{a}	2.53 ± 0.12^{a}	24.4 ± 0.6
CFPH 4 g/L	44.0 ± 1.1^{a}	2.63 ± 0.04^{a}	23.8 ± 0.8
FPH (10 mL/L)	44.4 ± 0.7^{a}	2.56 ± 0.03^{a}	23.2 ± 0.9

Same letters within each column are not significantly different ($p < 0.05$)

Conclusions

- Alkaline hydrolysis yielded 165 mg of amino acids per gram of feathers
- CFPH 2 g/L enhanced all of the shoot growth and root growth parameters
- FPH positively enhanced the growth of nursery plants, but the exerted positive effect was less pronounced than CFPH

Study 2: Validation Experiment

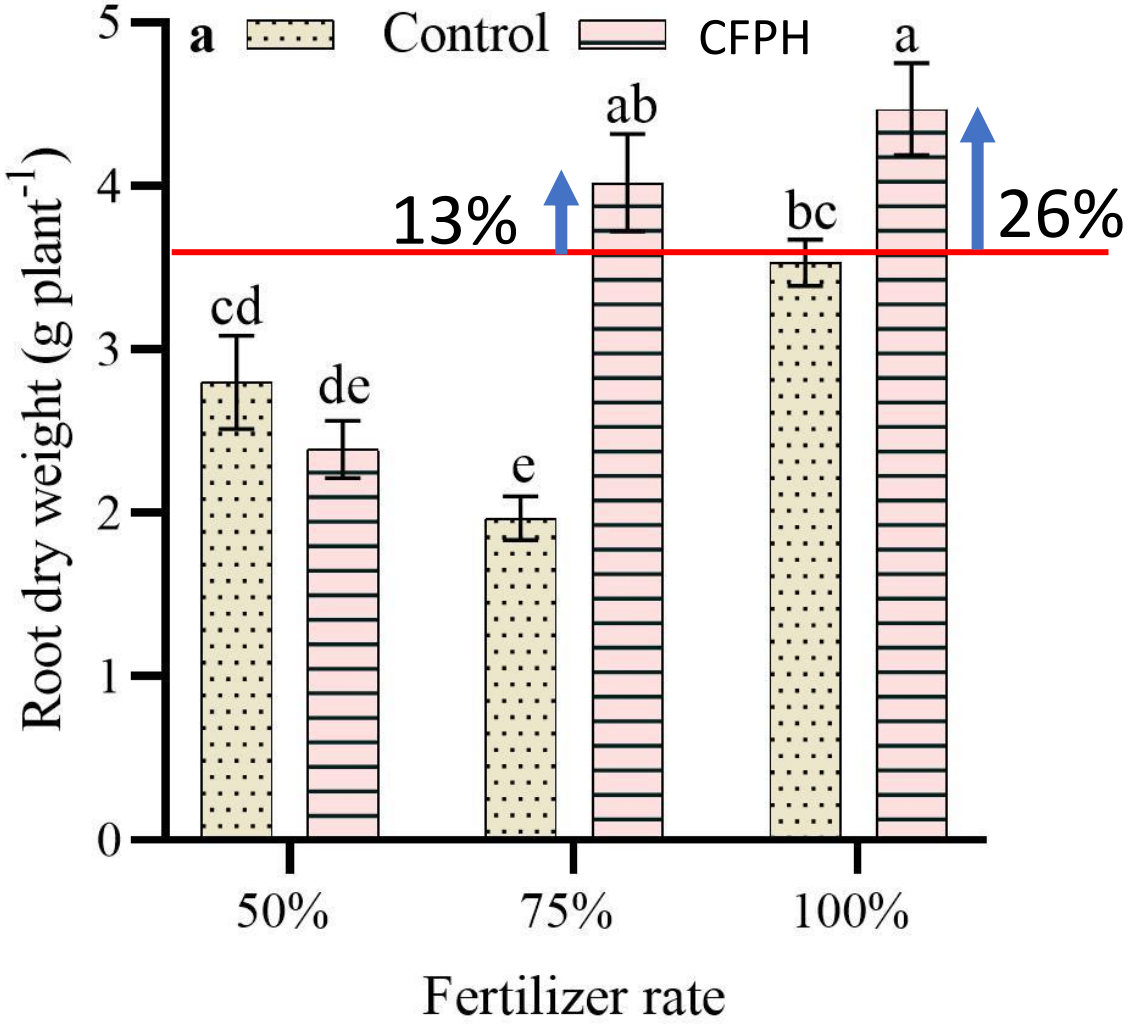
- Cultivar – TRI 5000 series 23/5
- Age – Six months old
- Foliar – 2 weeks interval
- Experimental Design – 2 x 3 factorial in RCBD with three replicates
- Study period – 10 applications (5 months)
- Destructive sampling

Dosage	Fertilizer (T-65)
0 g/L	50%
2 g/L	75%
	100%

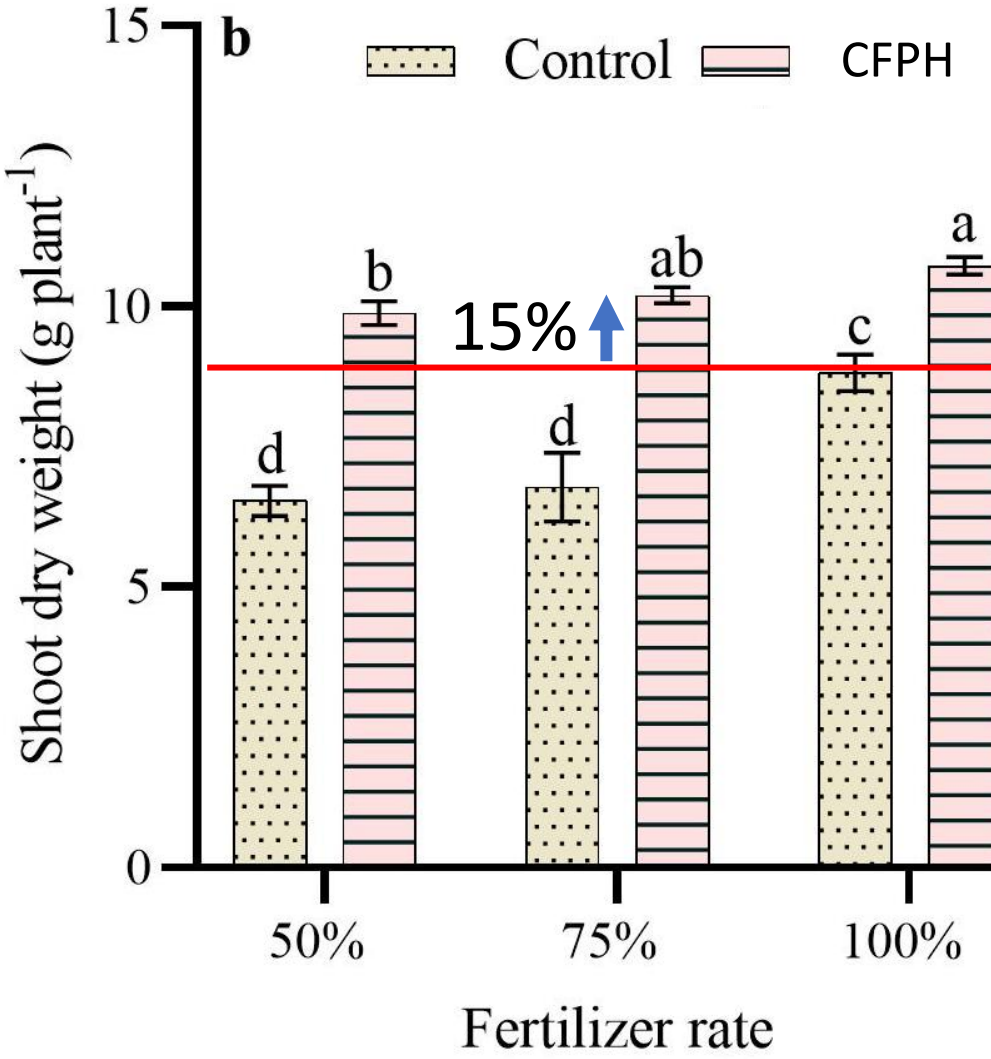
Treatments details

Treatment	Details
T1	CFPH 0 g/L + 50% Fertilizer
T2	CFPH 2 g/L + 50% Fertilizer
T3	CFPH 0 g/L + 75% Fertilizer
T4	CFPH 2 g/L + 75% Fertilizer
T5	CFPH 0 g/L + 100% Fertilizer
T6	CFPH 2 g/L + 100% Fertilizer

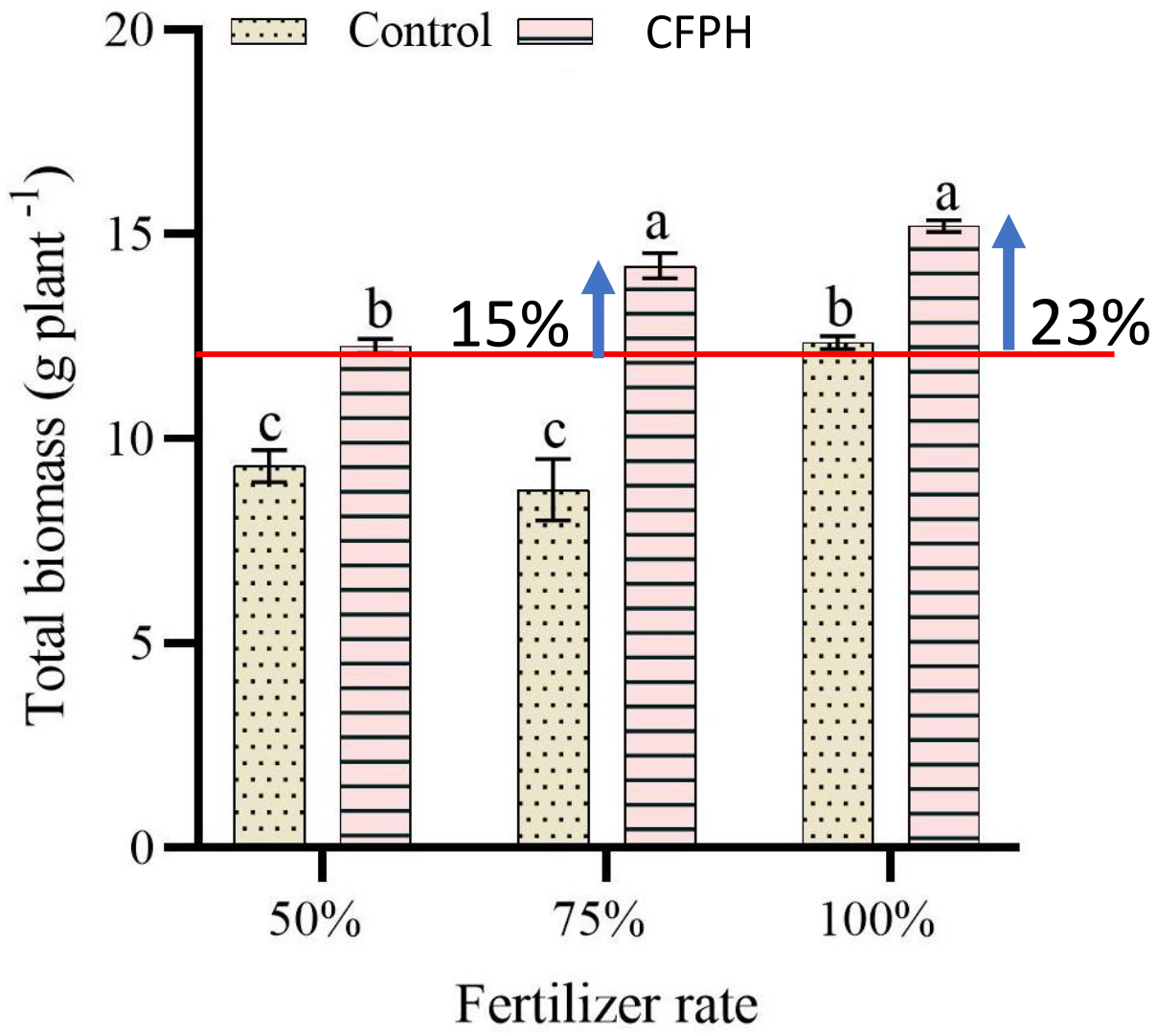
Root dry weight



Shoot dry weight



Total Biomass



Growth & Physiological Parameters

Parameter	Control	CFPH
Number of active buds (n Plant^{-1})	6.63b	9.83a
Leaf count (n Plant^{-1})	21b	31a
Photosynthetic rate (µmol $CO_2 m^{-2} s^{-1}$)	6.35b	8.16a
Stomatal conductivity (mol H_2O $m^{-2}s^{-1}$)	0.095b	0.141a
Intercellular CO_2 concentration (µmol CO_2 mol^{-1})	213b	278a
Transpiration rate (mmol H_2O $m^{-2}s^{-1}$)	2.14a	2.56a
Chlorophyll a (mg g^{-1})	9.8a	10.64a
Chlorophyll b (mg g^{-1})	5.36a	5.73a
Carotenoids (mg g^{-1})	0.450a	0.466a
Leaf N (%)	3.34a	3.54a
Leaf P (%)	0.12b	0.14a
Leaf K (%)	0.57b	0.72a

Conclusions

- CFPH (2 g L^{-1}) improved the growth of tea nursery plants (50%, 75% & 100% Fertilizer rates)
- Plants treated with CFPH under 100% and 75% fertilizer levels – Similar Plant Biomass
- CFPH as a foliar spray is highly effective in producing vigorous tea nursery plants along with a 25% saving of T-65 fertilizer

Future Studies

- Reducing the nursery period of tea plants

- Field planting of CFPH treated plants and evaluate at field level

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Thank You !