Potentials of Plant Growth Promoting Rhizobacteria based bio-fertilizers for tea

P L K Tennakoon[1],
R M C P Rajapaksha[2] and L S K Hettiarachchi[3]

Soils and Plant Nutrition Division, TRI[1 & 3] &
Department of Soil Science, University of Peradeniya[2]

Tea Research Institute of Sri Lanka

Introduction

- Nutrient management in tea cultivation: chemical fertilizers
  - Adverse effects of chemical fertilizers
  - Escalating prices
- Bio-resources
  - To partly replace chemical fertilizers
- Plant Growth Promoting Rhizobacteria (PGPR) – A novel & potential tool

What are Plant Growth Promoting Rhizobacteria (PGPR)?

Naturally occurring soil bacteria that aggressively colonize plant roots & benefit plants by providing growth promotion

- Improve plant growth through direct & indirect effects on plant

Direct effects

- supplying biologically fixed nitrogen
  egs. *Azospirillum, Azotobacter, Rhizobium*
- solubilizing insoluble inorganic phosphate in the soil
  egs. *Bacillus, Pseudomonas, Arthrobacter*
- producing plant hormones

Indirect effect

- suppressing growth of soil borne plant pathogens

- Potential of these organisms as biofertilizers have been reported in many crop plants

- Tea

  In general, comparable or increased yields over RDF & substitution of chemical fertilizers due to PGPR biofertilizers

  » Princy *et al.*, 2014
  » Saikia *et al.*, 2011
  » Easwaran *et al.*, 2002

- Tea contd..

Significantly higher yields in young tea, over recommended rates of chemical fertilizers have been observed, with reduction of 25% chemical fertilizers [basal composed of 30 g each RP and SSP in planting hole & Y. T. D mixture composed of N (Urea), P (RP), K (MOP) :10:5:10] due to PGPR biofertilizers, in Assam, North India (Saikia *et al.*, 2011).

Potentialities;

Approx:25% of tea holdings in the country are low yielding

- Majority in the mid country region
- Decreasing soil fertility – major limitation for crop production
- Beneficial nutrient management
- PGPR based biofertilizers along with commonly available low cost organic inputs

To maximize plant growth promotion by PGPR..

- Identifying efficient strains of PGPR for tea, is a prerequisite
- Formulating bio-fertilizer with efficient PGPR strains indigenous to the soil type
  - as they colonize the rhizosphere successfully and exert beneficial effects better than foreign inoculants
- Understanding the influence of environmental factors

Prerequisites for field applications

- Soil nutritional status

  The bacterial inoculants has a much better stimulatory effect on plant growth in nutrient deficient soil than in nutrient rich soil

  At high N fertilizer rates => suppressing effect on N_2 fixation

Low fertile tea lands in the mid country will provide better habitats for PGPR bacteria

Overall Objective:

- To formulate effective bio-fertilizers for different soil series under reduced chemical fertilizer input conditions for tea grown in the mid country

Methodology adopted

Collection of tea rhizosphere soils along with roots

- Representing main soil series, Kandy, Matale and Ukuwela

Isolation of *Azospirillum* sp. from root samples

- Semisolid N – free malate medium

Isolation of Phosphate Solubilizing Bacteria (PSB)

by following serial dilution and plating technique in Pikovskaya's agar medium (Pikovskaya,1948)

- A total of 32 each Nitrogen fixing (NF) and PSB were isolated
- They were evaluated under *in vitro* for nitrogen fixation, phosphate solubilization & production of growth promoting substances

- 08 N_2 fixing bacteria & 08 PSB were screened from the *in vitro* study for further investigations

The amount of N_2 fixed by the 08 nitrogen fixers:

16.8 – 26.4 kg N ha^{-1}

The amount of Pi released by the 08 PSB isolates:

28 to 37 %

Indole Acetic Acid (IAA): 11.3 – 62.5 mg/l

Gibberellic acid (GA): 19.7 – 80.3 µg/l

- 08 N_2 fixers (NF) and 08 PSB were inoculated to 03 month old nursery tea plants as single inoculants.
- Based on plant growth promotion, 06 single inoculants were identified (03 NF and 03 PSB)
- 03 Dual inoculants (NF + PSB) were formulated from them considering their respective soil series

AZO-6 + PSB-1: for Kandy soil series

AZO-2 + PSB-4: for Matale soil series

AZO-7 + PSB-3: for Ukuwela soil series

Common consortium (AZO-6 + PSB-3: Overall best): to be tested in all 03 soil series

Dual inoculants were tested based on soil series level under nursery & field;

In nursery

- T1 - Modified T 65 fertilizer mixture composed of ½ N & + P replaced with ERP in place of DAP (T 71)
- T2 - Overall best + T1
- T3 – Series best + T1
- T4 - T65 recommended dose of fertilizer

Composition of recommended tea nursery mixture – (T 65)

20 parts	Sulphate of ammonia	(20.6% N)
15 parts	Di-ammonium phosphate	(18% N and 46% P_2O_5)
15 parts	Sulphate of potash	(48% K_2O)
15 parts	Epsom salt	(16% MgO)
65 parts		

Composition of Modified T 65 tea nursery mixture – (T 71)

17 parts	Sulphate of ammonia	(20.6% N)
24 parts	Eppawala rock Phosphate	(28.5 % P_2O_5)
15 parts	Sulphate of potash	(48% K_2O)
15 parts	Epsom salt	(16% MgO)
71 parts		

Field trials were laid down in 05 different locations with both early & latter stages (06 & 15-20 years old) of mature tea fields representing 03 main soil series: Kandy, Matale & Ukuwela.

In field

- T1 – Absolute control
- T2 - Modified VP/UM 910 fertilizer mixture composed of 2/3rd N & + ½ P (VP/UM 652)
- T3 - Overall best + T2
- T4 - Series best + T2
- T5 - VP/UM 910 recommended fertilizer

Composition of VP/ UM 910 mixture :

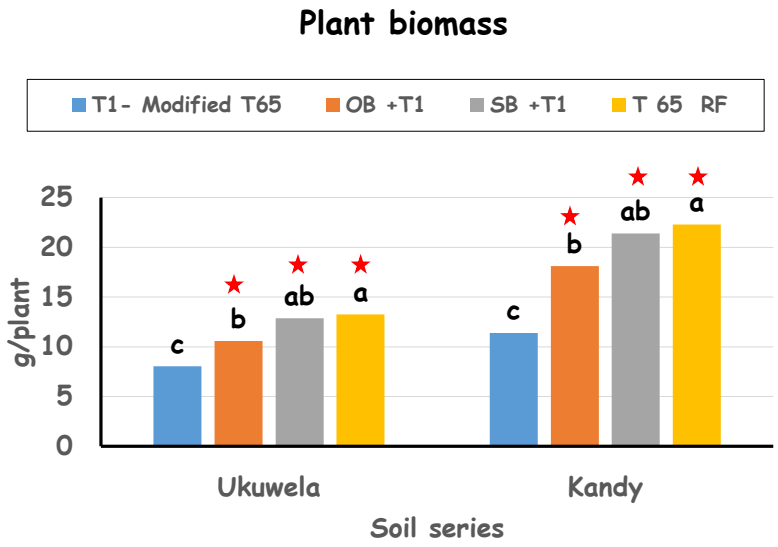
Urea parts	587 (270 N)
ERP parts	123 (35 P_2O_5)
MOP parts	200 (120 K_2O)
	910

Composition of modified VP/UM 910 (VP/ UM 652) mixture :

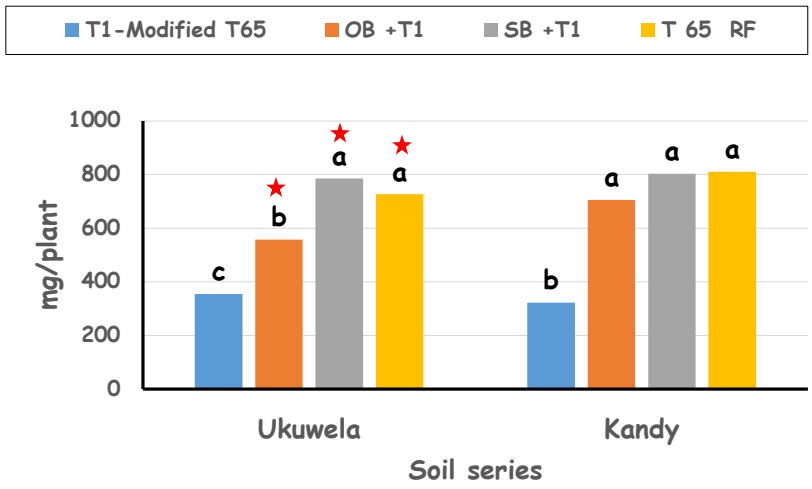
Urea parts	391 (180 N)
ERP parts	61 (17.5 P_2O_5)
MOP parts	200 (120 K_2O)
	652

Field lay-out of Elkaduwa trial

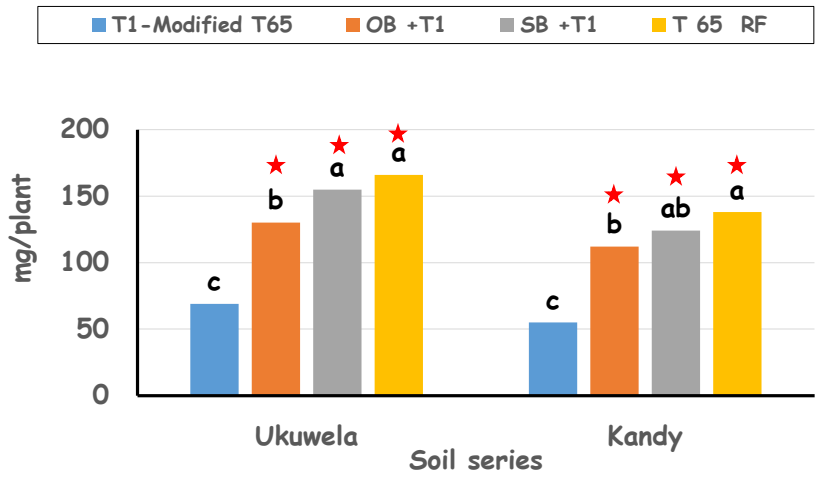
Results -Nursery



Total N uptake



Total P uptake



Application of dual inoculants on nursery tea plants raised in Kandy soil series

T1	T2	T3	T4
Modified T 65	OB +T1	SB +T1	T 65 RF

Results -field

Impact of dual inoculants on soil available N and P and leaf N and P at Elkaduwa Estate, Elkaduwa (Matale soil series)

Treatment	Soil ava. N (mg kg^{-1})	Soil ava. P (mg kg^{-1})	Leaf N %	Leaf P%
T1 (Control)	19.3 ^{c}	9.0 ^{b}	2.35 ^{c}	0.16 ^{c}
T2 (modified VP/UM 910)	20.7 ^{c}	11.3 ^{b}	3.07 ^{b}	0.19 ^{bc}
T3 (overall best +T2)	27.7 ^{bc}	18.7 ^{ab}	3.00 ^{b}	0.19 ^{bc}
T4 (series best +T2)	40.7 ^{ab}	31.0 ^{a}	3.48 ^{a}	0.21 ^{ab}
T5 (VP/UM 910 RDF)	50.3 ^{a}	21.3 ^{ab}	3.56 ^{a}	0.25 ^{a}
LSD ($P \leq 0.05$)	14.3	14.4	0.39	0.03

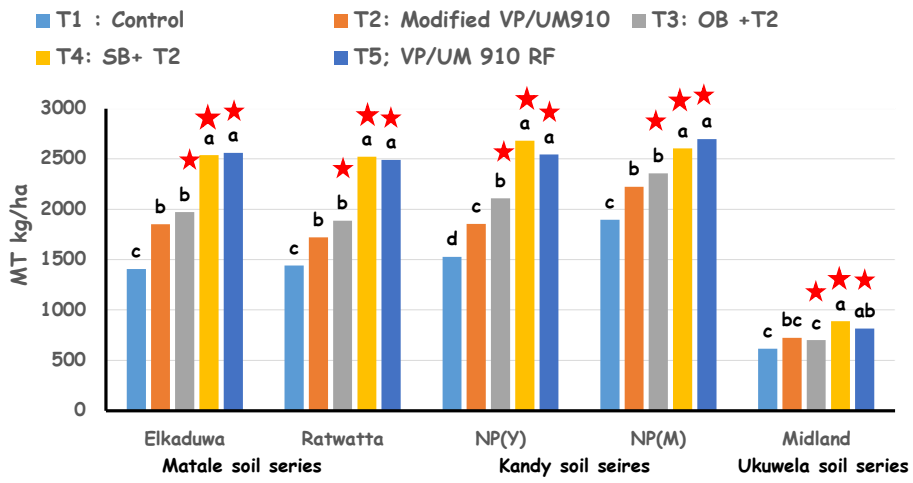
- ✓ Only series best, showed soil av. N contents comparable to RDF
- ✓ Both inoculated treatments showed soil av. P content comparable to RDF
- ✓ Only series best showed leaf N and P contents comparable to RDF

Impact of dual inoculants on soil ava. N and P leaf N and P at Newpeacock Estate, Pussellawa (Kandy soil series)

Treatment	Ava. N (mg kg^{-1})	Ava. P (mg kg^{-1})	Leaf N %	Leaf P%
T1 (control)	16.0 ^{d}	44	2.30 ^{d}	0.16 ^{b}
T2 (modified VP/UM 910)	30.0 ^{bc}	43	3.13 ^{c}	0.17 ^{b}
T3 (overall best +T2)	25.2 ^{cd}	45	3.30 ^{bc}	0.18 ^{ab}
T4 (series best +T2)	39.3 ^{ab}	57	3.80 ^{ab}	0.18 ^{ab}
T5 (VP/UM 910 RDF)	43.7 ^{a}	51	4.10 ^{a}	0.19 ^{a}
LSD ($P \leq 0.05$)	11.6	NS	0.57	0.02

- ✓ Correlating well with soil av. N contents, series best improved leaf N comparable to RDF
- ✓ Both inoculated treatments showed leaf P contents comparable to RDF

Made tea yields



Note: Yield obtained only for 12 plucking rounds during the year from Midland estate

NP(Y): Newpeacock young (6 years) NP (M): Newpeacock mature (18 years)

Study outputs

- Added inoculants showed specificity towards soil at series levels & a clear synergistic effect seen in improving growth & yield of tested tea cultivars under nursery and field conditions
- Results provided clear evidence of 50% reduction of N and replacement of DAP with ERP in the T65 mixture, for nurseries with application of dual inoculants formulated with respective series best strains.

- In field, results of one year data revealed that, approximately 33% reduction of N & 50% reduction of P from mature tea fertilizer mixture (VP/UM 910) are possible with application of dual inoculants formulated with respective series best strains

- Hence, these formulations could be used as efficient bio-fertilizer products capable of reducing chemical fertilizer requirement while improving soil fertility of low yielding tea growing fields in mid country region under favorable soil environmental conditions

- It could also be seen that, application of series best formulations together with reduced N & P from chemical fertilizer resulted in yield increment ranging from (37% to 80%) from low yielding tea growing fields in mid country, compared to absolute control.

Acknowledgements

Superintendent and staff – Elkaduwa Estate, Elkaduwa
Superintendent and staff – Ratwatta Estate, Ratwatta
Superintendent and staff – Newpeacock Estate, Pussellawa
Superintendent and staff – Midland Estate, Rattota
Superintendent and staff – Loolecondera Estate, Hewaheta
Superintendent and staff – Greenwood Estate, Nawalapitiya
Superintendent and staff – Kenilworth Estate, Ambagamuwa
Superintendent and staff – Craighead Estate, Dolosbage
Superintendent and staff – Galamuduna Estate, Dolosbage
Superintendent and staff – Uplands Estate, Galaha
Superintendent and staff – Gamiseva sewana , Galaha
Superintendent and staff – Mooloya Estate, Hewaheta
Superintendent and staff – Harepark Estate, Medamahanuwara
Superintendent and staff – Rothschild Estate, Pussellawa
Superintendent and staff – Mooloya Estate, Hewaheta
Superintendent and staff – Hathale Estate, Kalabokke
Superintendent and staff – Madulkelle Estate, Kalabokke
Superintendent and staff – Rangala Estate, Rangala
Superintendent and staff – Goomara Estate, Nuckles
Superintendent and staff – Stellenberg Estate, Pupuressa

Thank you for your attention

No such thing as a free lunch
Invest in healthy soils