BULLETIN – IV

FAO-CFC-TBI PROJECT (2008 – 2013)

Need for a Comprehensive Approach to Ensure Sustainable and Cost- effective Organic Tea Cultivation - An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project.

At

Maud Tea Estate

Assam, India

Evaluated by

IORF Research Team

in collaboration with

Advisory Board

BULLETIN – IV

FAO-CFC-TBI PROJECT (2008 – 2013)

Need for a Comprehensive Approach to Ensure Sustainable and Cost- effective Organic Tea Cultivation - An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project.

At

Maud Tea Estate

Assam, India

Evaluated by

IORF Research Team

in collaboration with

Advisory Board

Project At A Glance

Title of the Project	:	**Development Production & Trade of Organic Tea**
Operator	:	Maud Tea and Seed Company Ltd
Project Site	:	P.O – Chabua, Assam
Project Area	:	100 hec
Project Funded By	:	Common Food for Commodity (CFC) – Tea Board of India (TBI)
Project Executing Agency	:	International Federation of Organic Agriculture Movements (IFOAM)
Project Supervisory Body	:	FAO Intergovernmental Group on Tea
Objectivity	:	To Find Out an Effective Pathway for Sustainable Organic Tea Production
Evaluated by	:	IORF Research Team in collaboration with Advisory Board
Duration of Study	:	2008 to 2013

……….The outcome of this project is perhaps the first of it's kind that has delivered the concept of 'Packages of Practice', hence shifting from the input-based approach or component research. This project has conclusively showed the pathway that can be conveniently adopted for large scale organic tea cultivation in an Economically Sustainable manner through attending to all related components.

Prof. A. K. Chatterjee
(*on behalf of Advisory Board*)

TO OBTAIN COMPLEMENTARY COPIES OF THIS BULLETIN

Please write to : Founder Director, Inhana Organic Research Foundation, 168 Jodhpur Park, Kolkata-700030, Email : inhanabiosciences@gmail.com

SUMMARY OF FINDINGS

1. The Organic Package of Practice Experiment in Different Tea Growth Phases led to Identification of three to four promising packages especially in terms of Crop Response and Soil Development.

2. Guideline for Quality Assessment for Organic Soil Inputs was developed & the positive correlation between Soil Input Quality and its post Soil Application Effectivity *vis-à-vis* Economics was documented.

3. Role of Organic Plant Management towards higher Agronomic Efficiency/ Nutrient Utilization Efficiency of Plants was documented.

4. Improved Plant Physiology/ better Agronomy towards successful Establishment & Speedy Achievement of Commercial Plucking Stage in Newly Planted Tea was demonstrated under Organic Mgt. (>2000 kg made tea/ ha from 30 Months Age).

5. Criteria for evaluation of Tea Seedling Quality/ Planting Material was identified and Positive Influence of Organic Management towards Speedy Growth and Better Quality of Tea seedlings, was demonstrated. Plant Development Index (PDI) was formulated to quantify the overall Agronomic Development of Seedling/ Newly Planted Teas.

6. Soil Development Index (SDI) was developed for quantification of soil quality variation under different Organic Packages, by a single unit criteria.

7. Compost Quality Index (CQI) was developed in order to quantify the values obtained for different quality parameters for easy understanding at the Planters' level.

8. Better tea quality was documented under adoption of Comprehensive Organic Practice in Maud T.E. as compared to Good Conventional Assam Gardens.

CONTENT

Continued…………

BRIEF STUDY REPORT OF

FAO-CFC-TBI PROJECT (2008 – 2013)

Need for a Comprehensive Approach to Ensure Sustainable and Cost- effective Organic Tea Cultivation - An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project.

R. Bera[1], A. Datta[1], S. Saha[1], A. Seal[1], A.K Dolui[2], A.K. Chatterjee[3], R.K. Sarkar[4], G. C. De[5], A.K. Barik[5], and D. Majumdar[6]

[1]Inhana Organic Research Foundation, Kolkata, India
[2]Dept. of Soil Science, Calcutta University, India
[3]Dept. of Soil Science, Visva Bharati University, India
[4]Dept. of Agronomy, Calcutta University, India
[5]Dept. of Agronomy, Visva Bharati University, India
[6]Dept. of Agricultural Statistics, Bidhan Chandra Krishi Viswavidyalaya, India

ABSTRACT

Organic agriculture has become the quintessential solution for reverting the cycle of depletion propelled by chemical farming practices. However, despite the compulsion, organic farming is still to be adopted at large considering that crop sustenance at an economical cost is yet to be achieved under this farming system. In case of plantation crops like tea, which are already plagued by variety of limitations *viz.* old aged bushes, continuous stress on plants due to multiple vegetative propagation, limited scope for soil rejuvenation, soil acidity/ improper nutrient dynamics and unresolved pest/ disease infestation, the idea of sustainable crop production at a convenient cost seems too good to be true. This is because the tea clones, being mostly fertilizer sensitive suffer from depressed physiological functioning under application of nutritionally low organic manures and slow reacting organic inputs. Also there has been no specific guideline regarding compost/ organic soil input quality or their application dosage depending on qualitative variations, in order to ensure the dynamism that is necessary for soil to act as a good growth medium for plants. **The present organic practices fail to sustain because they have not diverted from the compartmental approach of chemical farming and follow the same input substitution theory, only the chemicals being replaced by organic formulations. In this scenario a comprehensive organic approach/ pathway that can give guidelines for effective soil management, enable activation of**

plant physiology and provide measures for composite pest/ disease control; can perhaps bring about the desired sustainability.

The present study at Maud tea estate (Panitola circle, Assam; average yield: 1900 kg/ha approx.), India under FAO-CFC-TBI Project (2009-2011) was aimed at **finding out an effective pathway for sustainable organic tea production through evaluation of different organic methods/ 'Packages of Practice (POP)' under all stages of tea growth i.e. nursery, new plantation, young tea and mature tea.** All available organic methods *viz.* Biodynamic Farming (BD) and Inhana Rational Farming (IRF), which are practiced in organic tea gardens in India in reasonably large scale, were taken up for evaluation. Different organic inputs *viz.* vermicompost, bio-fertilizers, bio-pesticides, herbal formulations, etc., which are used in Indian tea industry or agriculture were also taken up for study. However, these inputs were not studied individually but combined to form different POP based on scientific rationale. The POP were evaluated in terms of meeting target yield, their efficiency over control, soil development and finally in terms of economic viability. Also different on- farm composting methods were evaluated in terms of speed, cost and end product quality. Finally these inputs along with oil cake and bio-fertilizers were evaluated for their post application effectivity in terms of crop performance and soil development.

Evaluation of the effectivity of different POP in terms of yield performance revealed highest and consistent efficiency of IRF under all the different tea growth phases [Mature tea- 13.3% over target yield, 45.2% over control (>control); Young tea- 55.2% >control; New plantation - 48.2% >control). VMI (Vermicompost+ Microbial Formulations for soil and plant) came out as the next best package in mature tea (3.5% over target yield, 44.8% >control) and young tea (25.6% >control) but lost its position to VCO (Vermicompost+ Conventional organic package) in new plantation (34.4% >control). In nursery, effectivity of different POP were evaluated in terms of 'Plant Development Index' (PDI), where IRF once again showed highest potential followed by MI (Microbial Formulations for soil and plant) and CO (Conventional organic package).

Soil quality development under different POP was evaluated through Soil Development Index (SDI), using soil analytical data of pre and post experiment soil samples. Here also IRF followed the same trend as observed in terms of crop response, scoring 41.5, 47.3 and 151.5 percent higher SDI than the next best performing package i.e. VMI in case of mature and young tea while VCO in case of new plantation respectively.

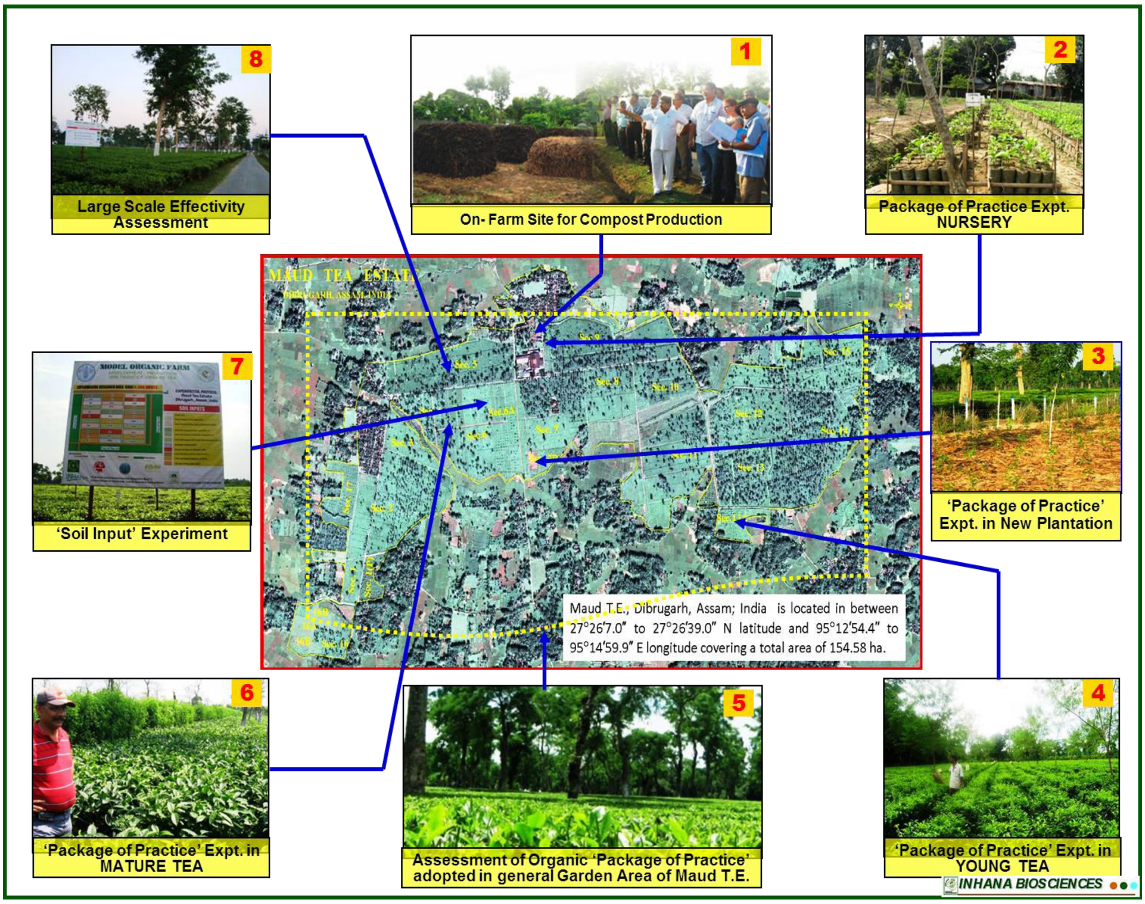
Comparative evaluation of crop efficiency *vis-à-vis* economics under different POP indicated IRF as the most effective package in terms of highest crop efficiency at a low cost [Cost of Inputs (COI): Rs. 13,796/ ha]. High Value Cost Ratio (VCR i.e. the ratio of value of increased yield and package cost) of 6.20 under IRF also confirmed higher scope of economic sustainability under the package. On the contrary the next best packages i.e. VMI (COI: Rs. 66,257/-) and VCO (COI: Rs. 40,184/-) produced much lower crop efficiency but at 5.0 to 3.0 times more cost than IRF respectively. **Inclusion of vermicompost in packages like CO and MI enabled slight upliftment in crop; however, their adoption potential is seriously questioned by the very high economics.**

The results obtained in experimental area especially w.r.t. the relevance of plant management (for activation of plant physiology) toward higher agronomic efficiency of tea plants; were substantiated by findings from general garden area. Here **post adoption of IRF in 2009, yield went up by 36 percent in 2011 (w.r.t. 2008). The finding was further corroborated by the crop performance of Maud and another sister organic garden in the same tea agro-ecological zone.** Similar type and dose of soil input and same pest management protocol were applied in Maud T.E. and the sister garden for three years. But while IRF Plant Management Package (for activation of plant physiology) was applied in Maud T.E for all three years, the same was adopted in sister garden in the 1st year (i.e. 2009) only. Agronomic N Efficiency (AE_N), which quantifies total economic output relative to the utilization of the system resources; decreased in case of both the gardens on replacing Novcom compost by Press mud compost and oil cake in 2010 and 2011 respectively. However, as compared to sister organic garden, the rate of decrease in AE_N was much lower in Maud T.E., which might be due to better N- uptake efficiency of the plants under IRF plant management package. In terms of economics while Maud T.E. gained revenue of Rs. 18.85 lakh (net crop gain: 9424 kg), the sister organic garden lost 44.70 lakh (net crop loss: 22,352 kg), during 2010-2011 (over 2009).

Evaluation of the different composting methods as well as quality assessment of their end product [*viz.* vermicompost (VC), Indigenous (FYM) compost, Biodynamic compost (BD) and Novcom compost (NOV)], indicated **Novcom composting method as the speediest process completing within 21 to 30 days and NOV containing high nutrient status (4.05 in terms total N+P+K), very high microbial population in the order of 10^{16} c.f.u. and lowest production cost of Rs. 860/- per ton, when compared with all others. Assessment of post application effectivity revealed highest crop response (dose: 8.0 ton/ ha, yield 1500 kg/ha) and soil rejuvenation (SDI: 45.39) under NOV.** Other than NOV, FYM (dose: 13.5 ton/ha; yield 1479 kg/ ha) and VCBF (VC @ 9.4 ton/ ha+ bio-fertilizers as per recommendation, yield 1427 kg/ ha) also influenced good crop response. However, in terms of SDI while VCBF followed the above trend, FYM failed to do so.

The study has brought forth some clear guidelines that can enable sustainable organic tea cultivation in a cost effective manner, however; they may require standardization through short multi- centric trials in different tea agro-climatic zones.

FAO-CFC-TBI Project at Model Organic Tea Estate 'Maud T.E.', Assam, India

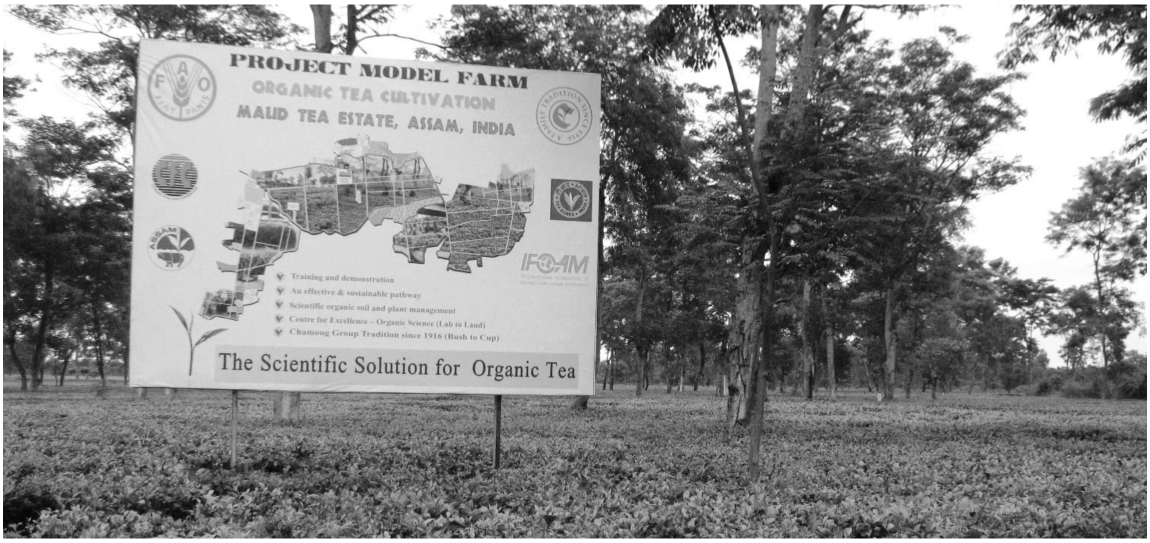


GOAL FOR FAO-CFC-TBI ORGANIC TEA DEVELOPMENT PROJECT AS LAID DOWN BY IFOAM . . . .

- ***Developing technology, skills and systems of organic tea production.***
- ***Development of appropriate technology for establishment of new and conversion of existing tea areas to organic tea farms.***

INTRODUCTION:

Organic cultivation has been accepted as the only true pathway for sustaining soil and crop productivity. But the continuous failure of input substitution theory i.e. replacing the chemical inputs by organic ones have perhaps led to the belief that though organic farming is better and perhaps necessary, but it is a weaker option and becomes sustainable after long time lag (Bera *et al*, 2011a). However, it is not difficult to understand that when even a designed poison (pesticide) fails to control the specific target pest, how a weaker organic option can be more or even equally successful. **Hence, the success in organic lies not in substituting the inputs or shifting the focus from plant to soil, but through adoption of a comprehensive approach, that takes into account the intertwined and integrated relationships of the soil-plant-ecosystem as a whole (Patel, 2005).** Sustainability in organic has always remained elusive especially for tea cultivation, where the fertilizer sensitive tea clones fail to give desired response under organic soil inputs even after their huge quantitative application. The situation is compounded by the dearth of scientific guidelines regarding the quality parameters that should be given priority before selecting an organic soil input. **The present study at Maud tea estate (Assam), aimed at finding out an effective pathway for sustainable organic tea production through evaluation of different organic methods/ packages of practice in terms of crop response and economic viability.** These methods/ packages of practice were tested for viability under all the different growth phases of tea plant *viz.* nursery, new plantation, young tea and mature tea. On-farm compost production using different composting processes was also taken up and documentation of the degradation period was done along with analysis to assess the quality of final compost.

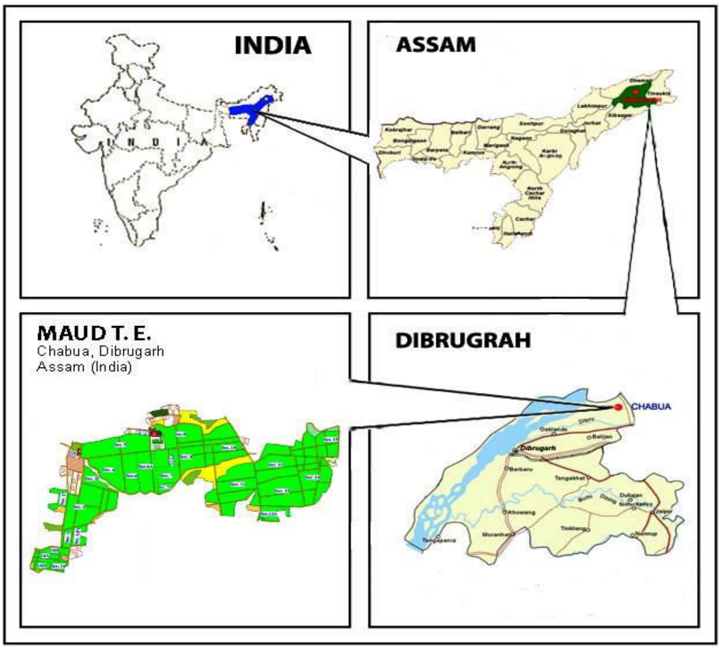


Pic. 1 : Landscape view of Maud Tea Estate, Assam, India

MATERIALS & METHODS

The study was done under FAO-CFC-TBI project "Development Production and Trade of Organic Tea" during the period 2009 to 2011 at Maud T.E. selected as Model Organic Farm for the project's Assam Chapter.

Study Area : The study area comprised Maud Tea Estate in Dibrugarh district of Assam; India (Fig. 1). It is located in between 27°26′7.0″ to 27°26′39.0″ N latitude and 95°12′54.4″ to 95°14′59.9″ E longitude covering a total area of 154.58 ha. The study area belongs to Upper Bramhaputra Plain, warm to hot per humid ecological sub region (agro-ecological sub region 15.4) with moderately deep to deep loamy, alluvium-derived soils, medium available water holding capacity (AWC) and length of growing period (LGP) more than 300 days (Velayutham, 1999).



Concept of Package of Practice : To achieve the project objectivity, different organic methods (i.e., the ones which are commonly practiced in present day agriculture) were taken up for evaluation. However, organic methods are relatively few in number at the same time a large variety of organic products are available and in wide use. However, it has been commonly experienced that combined application of these products for soil and plant management does not provide the desired additive effect. Hence, for development of comprehensive management system individual input evaluation was transformed to evaluation of 'Package of Practice' (POP). These packages may be composed of various individual inputs, but they must operate in an integrated manner, in order to be effectively functional (Bera *et al*, 2011a). Details of different organic package of practice evaluated under this project was documented by Chatterjee *et al* (2014), Barik *et al* (2014) and Dolui *et al* (2014a).

The organic methods/ Packages of Practice (POP) were evaluated in terms of crop performance, soil development as well as economics under all growth stages of tea plantation (i) Nursery, (ii) New plantation (age 0 to 2 years), (iii) Young tea (age- 3 to 6 years) and (iv) Mature tea (age- 20 to 23 years) for the period of 2009 to 2011 (Table 1).

Table 1 : Treatments in Mature Tea.

T_1	Control **(C)**
T_2	Vermicompost @ 9.4 ton/ ha + Herbal concoctions for pest and disease management **(VCO)**
T_3	Vermicompost @ 9.4 ton/ ha + Bio-growth promoter + Bio-pesticides **(VMIP)**
T_4	Vermicompost @ 9.4 ton/ ha + Bio-fertilizer (1.125 ton City compost + 37.5 kg Bio-NPK) + Bio-growth promoter + Bio-pesticides **(VMI)**
T_5	Bio-fertilizer (1.125 ton City compost + 37.5 kg Bio-NPK) + Bio-growth promoter + Bio-pesticides **(MI)**
T_6	Novcom compost @ 2.6 ton/ha with Elemental-S & Rock Phosphate + IRF plant management package + Neem & Karanj oil combination for pest management **(IRF-1)**
T_7	Novcom compost @ 8.0 ton/ha with Elemental-S & Rock Phosphate + IRF plant management package + Neem & Karanj oil combination for pest management **(IRF-2)**
T_8	Novcom compost @ 4.0 ton/ha with Elemental-S & Rock Phosphate + IRF plant management package + Neem & Karanj oil combination for pest management **(IRF-3)**
T_9	Novcom compost @ 5.1 ton/ha with Elemental-S & Rock Phosphate + IRF plant management package + Neem & Karanj oil combination for pest management **(IRF-4)**
T_{10}	Biodynamic compost @ 10 ton/ ha + Cow Pat Pit @ 12.5 kg/ ha + Cow horn manure @ 15 ltr. soln/ ha + Biodynamic Package for Plant Management **(BD)**
T_{11}	Indigenous compost/ Farm Yard Manure (FYM) @ 13.5 ton/ ha + Herbal concoctions for pest and disease management **(CO)**

Note : Inhana Rational Farming (IRF) Technology developed by an Indian Scientist Dr. P. Das Biswas; which advocates enegization of both soil and plant system. This is perhaps the only organic farming technology which provides a complete scientific solution from seed sowing to crop harvest (Barik *et al*,2014a, 2014b; Chatterjee *et al* 2014; Seal *et al*, 2013a; Gupta *et al*, 2014; Bera *et al*, 2014).

Treatments in Young Tea & New Plantation : Treatment modules are same as mature tea. Selective treatments *viz.* T_1, T_2, T_4, T_5, T_6, T_9, T_{10} and T_{11} were taken for the study.

Treatments in Nursery : Five different treatments apart from control was taken for the study. Plant management protocol of CO, VCO, MI, BD and IRF was taken as 5 treatments. As a part of soil management tube soils were mixed (25 to 30 % of tube soil) with respective compost of that package.

Soil Input Experiment : The treatments for Soil Input experiment in mature tea are as follows: **T_1-** Control, **T_2-** Vermicompost @ 9.4 ton/ ha, **T_3-** Vermicompost @ 9.4 ton/ ha + Bio-growth promoter, **T_4-** Novcom compost @ 8.0 ton/ha+ 40 kg Elemental-S + 80 kg Rock Phosphate, , **T_5-** Novcom compost @ 2.6 ton/ha + rest same as T_4, **T_6-** Novcom compost @ 5.1 ton/ha + rest same as T_4, **T_7-** Bio-fertilizer (1.125 ton City compost + 37.5 kg Bio-NPK), **T_8-** Biodynamic compost @ 10 ton/ ha + Cow Pat Pit @ 12.5 kg/ ha + Cow horn manure @ 15 ltr. soln./ ha, **T_9-** Indigenous compost/ Farm Yard Manure (FYM - 1) @ 8.3 ton/ ha, **T_{10}-** Indigenous compost/ Farm Yard Manure (FYM - 2) @ 13.5 ton/ ha, **T_{11}-** Oil Cake @ 1.7 ton/ha. Dose of organic soil inputs used are same as taken for organic POP experiments, to find out effect of organic plant management.

Analysis of Compost Quality Parameters: Total 33 compost samples from each type of compost heaps were collected in 3 years for detailed study and analysis for 32 different quality parameters as per National and International Standards (Trautmann and Krasny, 1997; Weaver *et al.,* 1998; Jackson, 1973; Black, 1965). Compost Quality Index (CQI) was calculated as per the methodology of Bera *et al* (2013a).

$$\text{Compost Quality Index (CQI)} : \frac{\log_{10}\{NV_{NPK} \times MP \times GI\}}{C/N \text{ ratio}}$$

Classification of compost as per Compost Quality Index

Compost Quality Index (CQI)		Compost Quality Classification
> 2.00	:	Poor
2.00 – 4.00	:	Moderate
4.00 – 6.00	:	Good
6.00 – 8.00	:	Very Good
8.00 – 10.00	:	Extremely Good

Where

NV_{NPK} = Total nutrient value in terms of total ($N+P_2O_5+K_2O$) percent.

MP = $\log_{10}$ value of total microbial population in terms of total bacteria, total fungi and total actinomycetes.

GI = Germination Index.

Analysis of Soil Parameters: Total 2,682 soil samples were analyzed during the 3 years project period, in a periodical manner for soil quality parameters as per standard methodology (Black, 1965; Jackson, 1973). Soil Development Index (SDI) was calculated as per the methodology of Bera and Seal (2012). The analytical values of the soil quality parameters before initiation of experiment in 2009 and after three consecutive years of compost application (i.e. in 2011) were used as per the following formula to calculate soil development index under different treatments.

$$\text{Soil Development Index (SDI)} = \frac{a}{n^2}\left\{\sum_{n=1}^{n} \frac{100(X_1 - C_1)}{C_1} + \frac{100(X_2 - C_2)}{C_2} + \cdots + \frac{100(X_n - C_n)}{C_n}\right\}$$

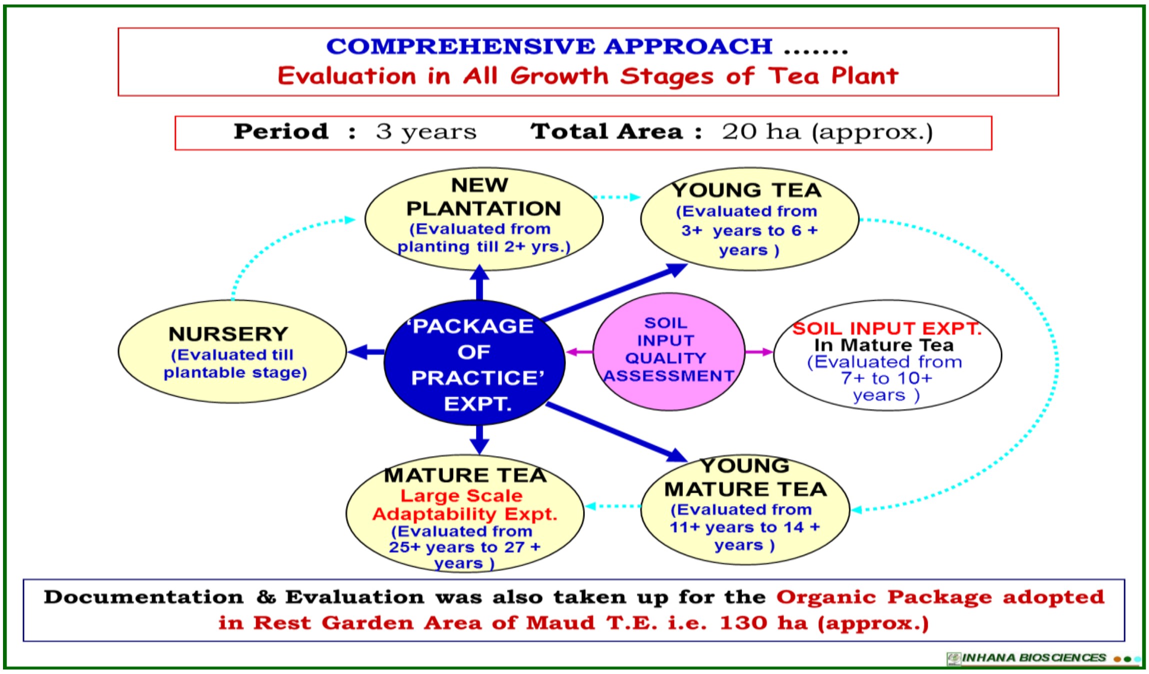
Where X = Soil Quality parameters after Experimentation; C = Value of individual Soil Quality Parameter before Experimentation ; a = no. of Soil Quality Parameters showing increased over initial value.

Analysis of Agronomic Parameters: Plant Development Index (PDI) was formulated considering different agronomic parameters *viz.* plant height, number of leaves, number of branches and plant girth that were measured under different growth phase of plantation i.e. just after de-centering, before initiation of tipping operation and six months after first frame formation (FFP) (Bera *et al*, 2012d; Bera *et al*, 2014).

Plant Development Index (PDI)

$$= \frac{1}{n}\left\{\sum_{n=1}^{n} \frac{100(X_1 - C_1)}{C_1} + \frac{100(X_2 - C_2)}{C_2} + \cdots + \frac{100(X_n - C_n)}{C_n}\right\}$$

Where X = Agronomic Parameter; C = Control



RESULTS & DISCUSSION

Quality Evaluation of different Organic Soil Inputs and Related Economics **:** Different processes *viz.* vermi composting (VC), Biodynamic (BD), Indigenous or FYM (IC) and Novcom (NOV) composting methods were evaluated in terms of process convenience, economics of compost production, end product quality and post soil application effectivity (in terms of crop performance and soil quality variation). Except vermicompost, all others have no raw material specificity (Table 2). Wide variation in biodegradation period was observed, Novcom compost was produced within the shortest time period of 21-30 days where as Biodynamic and FYM compost required 80 to 90 days. Several workers (Illmer and Schinner, 1997; Sánchez *et al.*, 1999) in their study have indicated that shorter biodegradation period curtails the criteria of nutrient losses leading to higher compost quality. This was reflected in the total nutrient content of the individual compost samples.

Table 2: Comparative study of different types of organic soil inputs.

Parameter	Vermi compost	Biodynamic compost	Indigenous (FYM) compost	Novcom compost
Raw material Specificity	Yes	No	No	No
Biodegradation Period	60 - 75	80 - 90	80 - 90	21 - 30
Recovery Percent	67.0	61.0	57.0	69.4
Total nutrient (N+P+K) content (%)	3.26	3.73	2.69	4.05
N enrichment *(% increase over initial value in raw material*)	142.88	172.1	107.41	207.75
Cost of Production *(Rs./ ton final compost)*	4000/-	920/-	770/-	860/-
Cost/ kg made tea (Rs.)	26.90	7.19	7.18	5.16
Crop efficiency (%) (*w.r.t. target yield of 1500 kg made tea/ ha*)	89	85	88	100

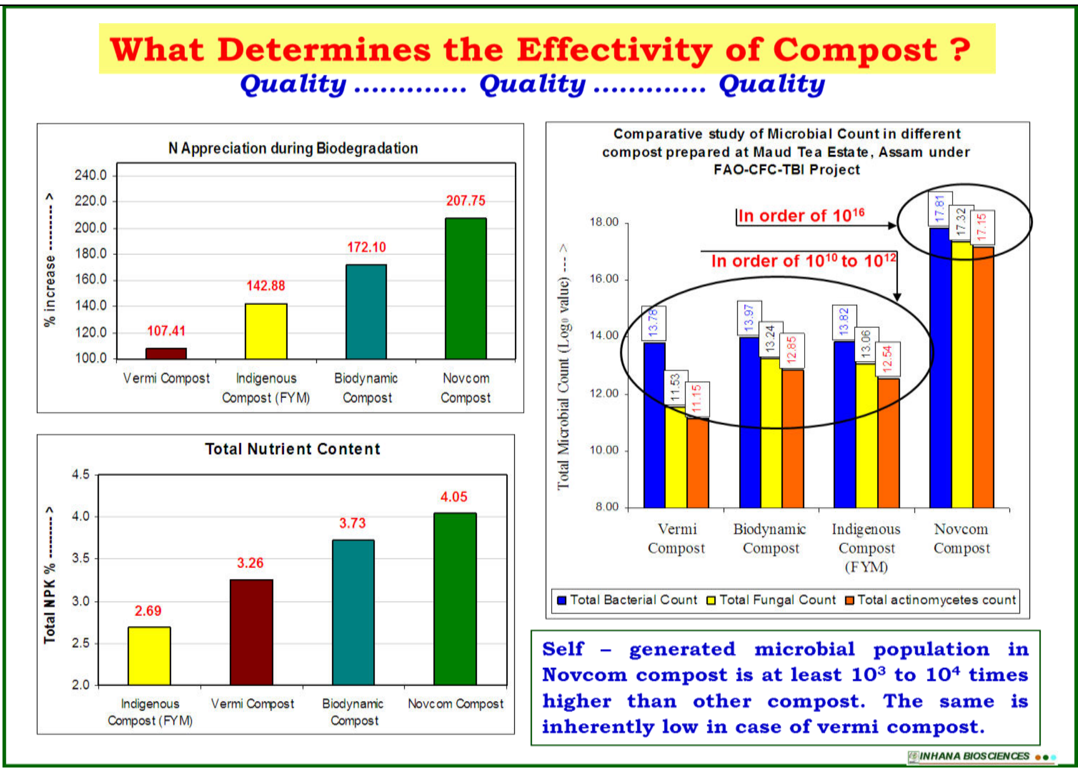
The most significant finding was appreciation of N content in the end product/ compost, which was highest for Novcom compost (207.75 %) as compared to all others, though all composts were produced from similar type of garden weeds and cow dung, However, N-enrichment in final compost not only indicated the quality as well as intensity of biodegradation but also the presence of huge selfgenerated microbial population (Bera *et al.*, 2012a; Seal *et al*, 2012; Sarkar *et al*, 2012, Dolui *et al*, 2014b). Along with compost quality, cost of compost is the most important criteria for consideration, which was lowest in case of Novcom compost (Rs. 5.16 / kg made tea) followed by FYM (Rs. 7.18 / kg made tea), Biodynamic compost (Rs. 7.19 / kg made tea) and vermicompost (Rs. 26.90 / kg made tea) respectively.

Table 3: Comparative study of quality parameters of different compost under FAO-CFC-TBI Project at Maud T.E., Assam.

Parameters	Ideal range	Vermi Compost	Biodynamic Compost	Indigenous Compost	Novcom Compost
Moisture percent (%)	35.0 – 55.0	54.34^{a}	48.54^{b}	46.46^{b}	56.73^{a}
pH_{water} (1 : 5)	7.2 – 8.5	6.56^{d}	7.23^{b}	7.03^{c}	7.61^{a}
Organic carbon (%)	16.0 – 38.0	25.48^{b}	26.31^{b}	23.70^{b}	27.94^{a}
[1]CMI	0.79 – 4.38	2.12^{b}	2.00^{c}	2.42^{a}	1.78^{c}
[2]CEC (cmol(p+)kg^{-1})	36.9 – 228.8	140.03^{c}	215.89^{b}	174.03^{b}	267.07^{a}
Total N (%)	> 1.0	1.74^{b}	1.78^{b}	1.68^{b}	2.19^{a}
Total P_2O_5 (%)	> 0.2	0.65^{b}	0.77^{a}	0.45^{b}	0.72^{ab}
Total K_2O (%)	> 0.2	0.87^{b}	1.18^{a}	0.56^{b}	1.14^{a}
C/N ratio	10.0 - 20.0	$14.6 : 1^{a}$	$14.8 : 1^{a}$	$14.1 : 1^{a}$	$12.8 : 1^{b}$
[3]Total bacterial count		13.78^{b}	13.97^{b}	13.82^{b}	17.81^{a}
[3]Total fungal count	> 13.00	11.53^{d}	13.24^{b}	13.06^{c}	17.32^{a}
[3]Total actinomycetes count		11.15^{d}	12.85^{b}	12.54^{c}	17.15^{a}
[4]MBC (%)	< 1.7	0.45^{d}	1.02^{b}	0.87^{c}	1.24^{a}
CO_2 Evolution Rate *($mgCO_2$ – C/g OM/ day)*	< 5.0 - stable	1.43^{c}	1.89^{b}	1.81^{b}	2.16^{a}
Nitrification Index	>0.03 to <7.14	0.40^{a}	0.36^{a}	0.39^{a}	0.22^{b}
Phytotoxicity Bioassay	>0.8	0.92^{c}	1.01^{b}	0.85^{d}	1.28^{a}

[1]CMI : Compost mineralization index; [2]CEC: Cation exchange capacity; [3] Total bacteria, fungi and actinomycetes count is per gm moist compost and in terms of colony forming units (c.f.u.) expressed in log_{10} value; [4]MBC : Microbial biomass carbon.

Nutrient status of compost samples forms an important criterion for their quality determination. The total nitrogen content in the compost samples ranged between 1.74 and 2.23 percent (Table 3), which was well above the reference range (1.0 to 2.0 percent) suggested by Alexander (1994) and Watson (2003). The highest content of nitrogen (2.23 percent) as obtained in case of Novcom compost might indicate higher fixation of atmospheric N in the end product under Novcom composting process (Seal *et al*, 2012). The microbial population (in order of 10^{16} c.f.u. in case of total bacteria, total fungi and total actinomycetes count) in Novcom compost samples was significantly higher (at least 10^4 to 10^6 c.f.u. times) than the population obtained in case of other compost samples as also found by several workers (Dolui *et al*, 2013; Mandal *et al*, 2012; Barik *et al*, 2014a; Senguta *et al*, 2012; Bera *et al*, 2012e). Such high microbial status of Novcom compost was also of special significance considering that they were not exogenous inoculation but were generated naturally during Novcom composting process and this high microbial pool could bring about faster rejuvenation of soil microflora leading to improved soil function and dynamics, as compared to all other composts (Bera *et al*, 2011b). Microbial respiration or CO_2 evolution rate, which indicated stability and maturity of compost varied within 1.43 to 2.16 mg CO_2– C/g OM/ day for the different types of compost and was more or less within the stipulated range (2.0 - 5.0 mg/ day) for stable compost as proposed by Bartha and Pramer (1965). Phytotoxicity bioassay value of >1.0 as obtained in case of Novcom compost indicated not only the absence of phytotoxicity (Tiquia *et al*, 1996) but moreover, it confirmed that the compost enhanced rather than impaired germination and radical growth (Trautmann & Krasny, 1997).



Analysis showed Novcom compost is undoubtedly superior than all other types of compost, that are majorly used for large scale organic farming.

***Crop Response under Application of different Organic Soil Inputs* :**
Evaluation of crop response under application of different organic soil inputs revealed highest yield (1500 kg/ha i.e., 30.75 percent > than control) in Novcom compost applied plots (T4). The next best crop was obtained under Indigenous compost (FYM-2) applied plots (1479 kg/ ha) and VCBF applied plots (1427 kg/ ha), albeit under high quantitative application in case of the former

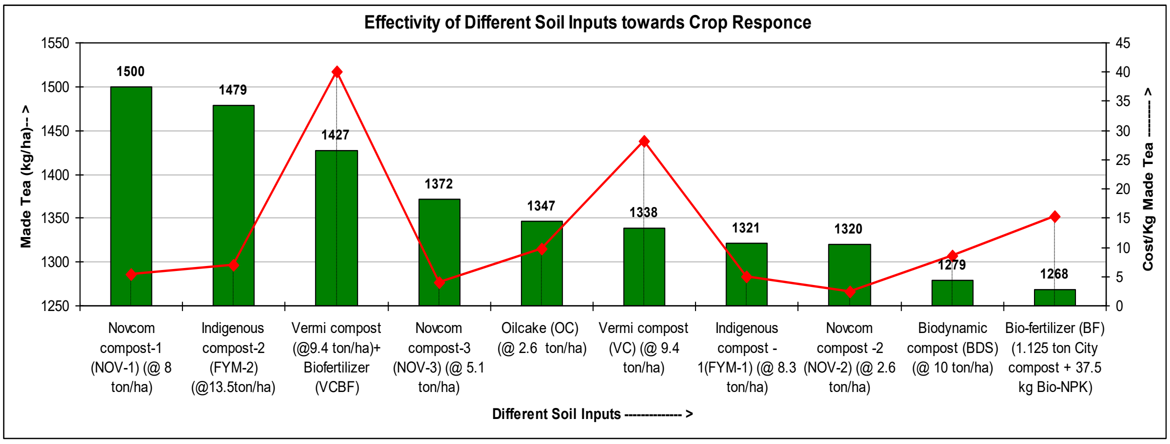


Fig. 1 : Made tea yield under application of different organic soil inputs.

(i.e., Indigenous compost @ 13.5 ton/ ha); and combined application of vermicompost (@ 9.4 ton/ ha) and bio-fertilizer (Fig. 1) under VCBF treatment. Cost per kg made tea was lowest under Novcom compost followed by Indigenous compost, Biodynamic compost and vermi compost respectively. Very high cost of vermicompost (Rs. 26.90 / kg made tea) rose further under combination of vermicompost with bio-fertilizer (Rs. 39.96/kg made tea), which could serve as a major deterrent factor towards their large scale adoptability.

***Effectivity of different organic soil inputs towards Soil Quality Development* :**
To express overall soil rejuvenation post application of different organic soil inputs, the extent of development of 20 different soil quality indices *viz.* soil pH, EC, organic carbon, C.E.C, Available NPKS, total bacteria, fungi, actinomycetes, ammonifiers, nitrobactor, nitrosomonas, phosphate solubilizing bacteria, readily available- N, total mineralizable- N, total- NH_4^+, exchangeable-(NO_2+NO_3); were used to calculate soil development index (SDI).

Soil Development Index (SDI) was highest in case of T_4 plots (SDI: 45.39) followed by T_6 (SDI: 32.65), T_3 (SDI: 30.28) and T_2 (SDI: 30.06) treatments (Fig 2). Highest SDI value in Novcom compost treated plots might indicate maximum soil quality development post compost application. The effectivity of Novcom compost might be due its high self- generated microbial potential, which brought about positive development in soil quality as also corroborated by the highest crop yield under this treatment (Bera *et al*, 2012b; Khan *et al*, 2013).

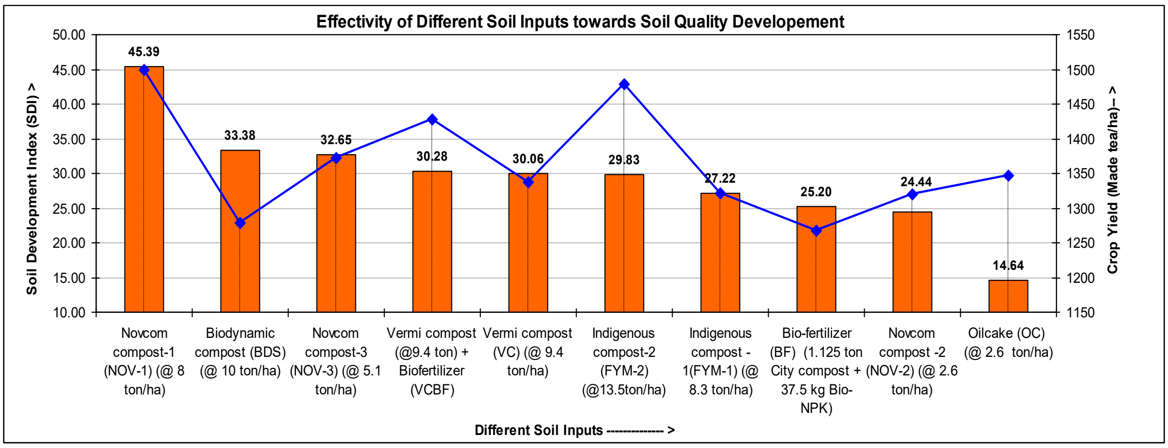
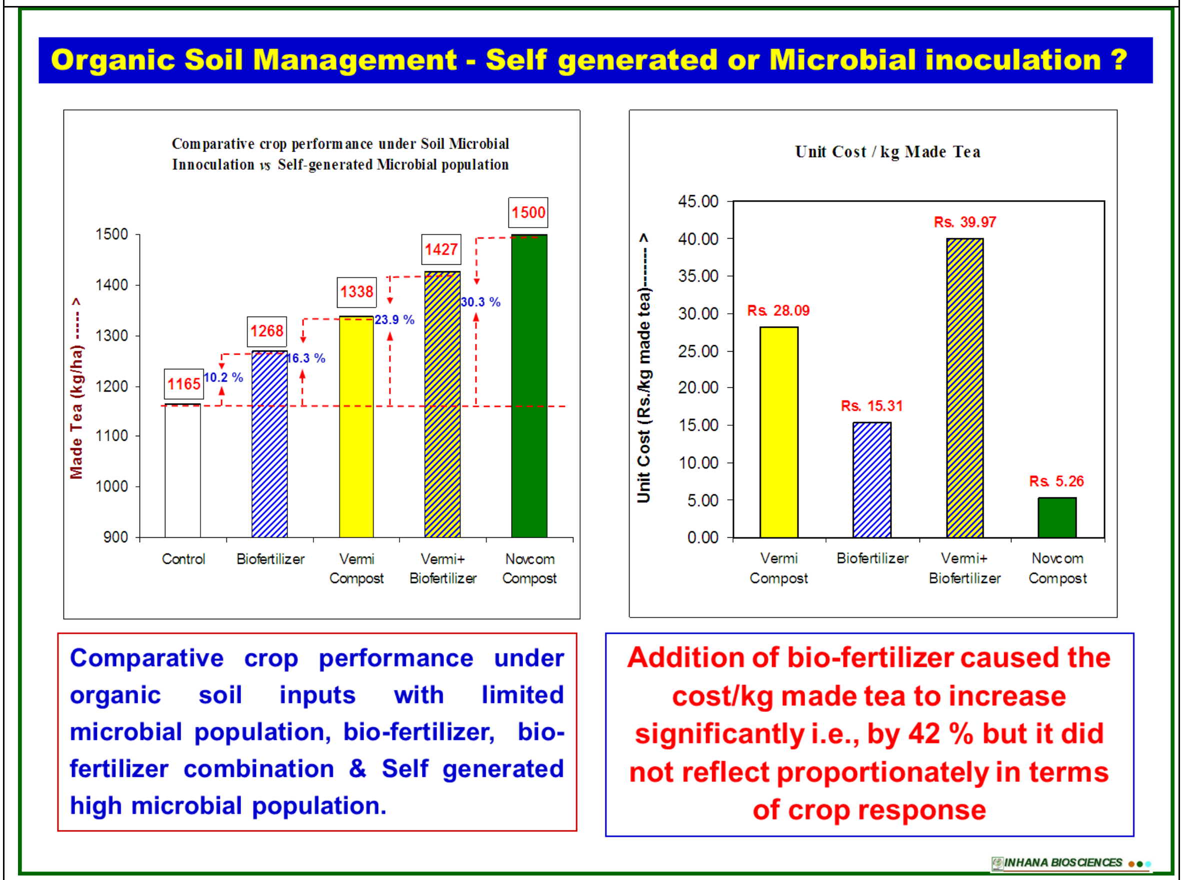


Fig. 2 : Soil quality development under application of different organic soil inputs.

The study investigated a basic scientific debate, inoculation of microbes or creating environment for their self- generation; which one is the effective pathway for Organic Soil Management



Study revealed Novcom compost with higher self- generated microbial population showed most promising results in terms of supporting target crop production, economics as well as soil quality development.

PERFORMANCE OF DIFFERENT ORGANIC 'PACKAGE OF PRACTICE' IN TEA NURSERY

Nursery is the backbone of any good tea garden; however successful development of Nursery under organic management is still considered as a challenging job (Bera *et al*, 2012c). Under this project, a nursery (using seed variety TS-463) was initiated in 2009 under five different organic packages of practice (i.e. CO, VCO, MI, BD and IRF) in order to assess package potential towards development of healthy planting material. Plant growth under different packages was assessed in terms of different morphological characteristics *viz.* shoot height, stem diameter, root mass, and shoot/ root ratio as well as seedling quality in terms of Dickson quality index (Dickson *et al*, 1960).

Table 4: Agronomic parameters of tea seedlings (age: 270 days) under different organic 'Package of Practice'.

Parameters	Different Organic Package of Practice					
	CO	BD	IRF	MI	VCO	C
Shoot Length (cm)	62.18	63.14	68.76	63.71	61.39	52.38
Root Length (cm)	39.17	39.15	42.64	37.59	37.45	35.09
Leaf (No.)	27.40	28.10	30.30	26.40	23.70	19.10
Total Leaf area (cm^2)	623.62	633.09	698.11	599.81	544.39	420.96
Girth (cm)	2.00	1.98	2.18	2.11	1.89	1.62
Primary Branch (No.)	2.10	2.20	2.40	2.40	1.70	1.50
Shoot/ Root ratio	1.50	1.53	1.47	1.52	1.49	1.43
Total wt. (dry)(g)	13.63	13.71	15.99	13.95	12.32	9.61

Seedling height at the time of out-planting can greatly influence growth rate in the field (Duryea, 1984). Shoot length of nursery seedlings were high under IRF (68.76 cm) followed by MI (63.14 cm) and BD (63.14 cm). However, stem diameter (often referred to as root collar diameter or caliper) has often been considered the best single predictor of field survival and growth (Thompson, 1985; Schmidt-Vogt, 1981) which was highest under IRF management indicating better growth potential as compared to other packages of practice (Table 4). Root length and root dry weight which have recently been recognized as one of the most important factors critical to field performance (Harmann, 1964) also showed higher value under IRF (42.64 cm and 6.48 g respectively) followed by CO (39.17 cm and 5.46 g respectively) and BD (39.15 cm and 5.41 g respectively). Dickson quality index was highest (1.41) in case of IRF treated seedlings followed by MI (1.27) and CO (1.21) packages (Fig. 3). Several other workers *viz.* Roller (1976) and Ritchie (1984) used Dickson quality index to evaluate seedling quality due to its simplicity and high predictability regarding post transplantation performance. The results indicated that comparatively higher quality of tea seedlings with better survival chances and speedier post field transplanted growth can be obtained under Inhana Rational Farming (IRF) as compared to the rest other packages.

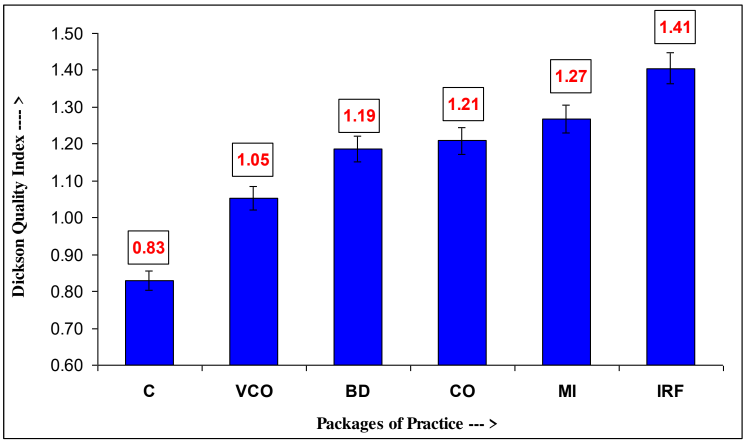
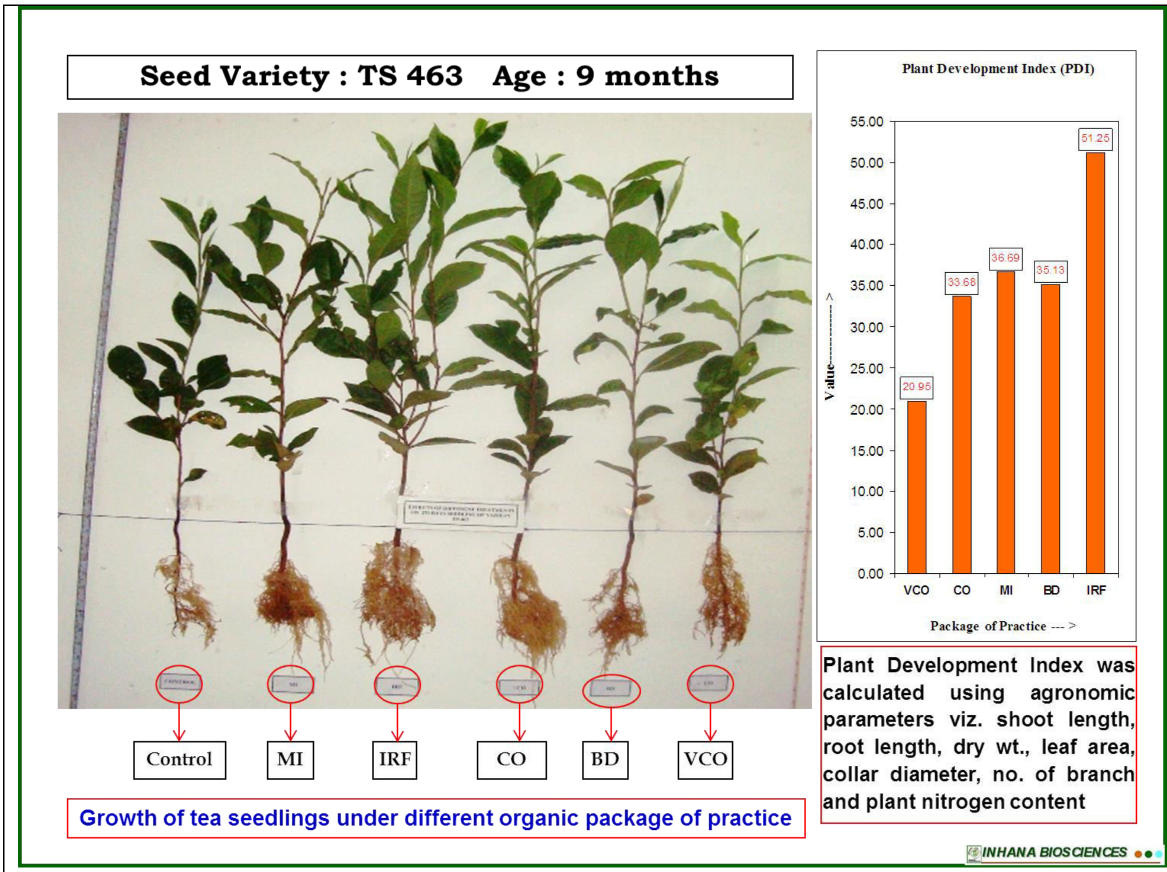


Fig. 3 : Comparative study of Dickson Quality Index under different organic package of practice.



Higher Index value in case of organic tea seedlings under IRF Package of Practice ensured higher survival and higher growth initiatives post transplantation in main field.

AGRONOMIC DEVELOPMENT UNDER DIFFERENT ORGANIC 'PACKAGE OF PRACTICE' IN NEW TEA PLANTATION :

Potential of the different organic 'Package of Practice' (i.e. CO, VCO, MI, VMI, BD, IRF-1 and IRF-2) towards new tea plantation management was evaluated in terms of successful establishment of young tea seedlings and early growth potential or attaining the commercial plucking stage. Under all the growth stages consistently high Plant Development Index (PDI) was obtained under IRF packages, followed by VCO package of practice (Fig. 4). Also strong correlation (r= 0.872**) between PDI *vis-a-vis* yield under different packages indicated that PDI can be used as an effective tool for predicting crop response under different types of organic practices.

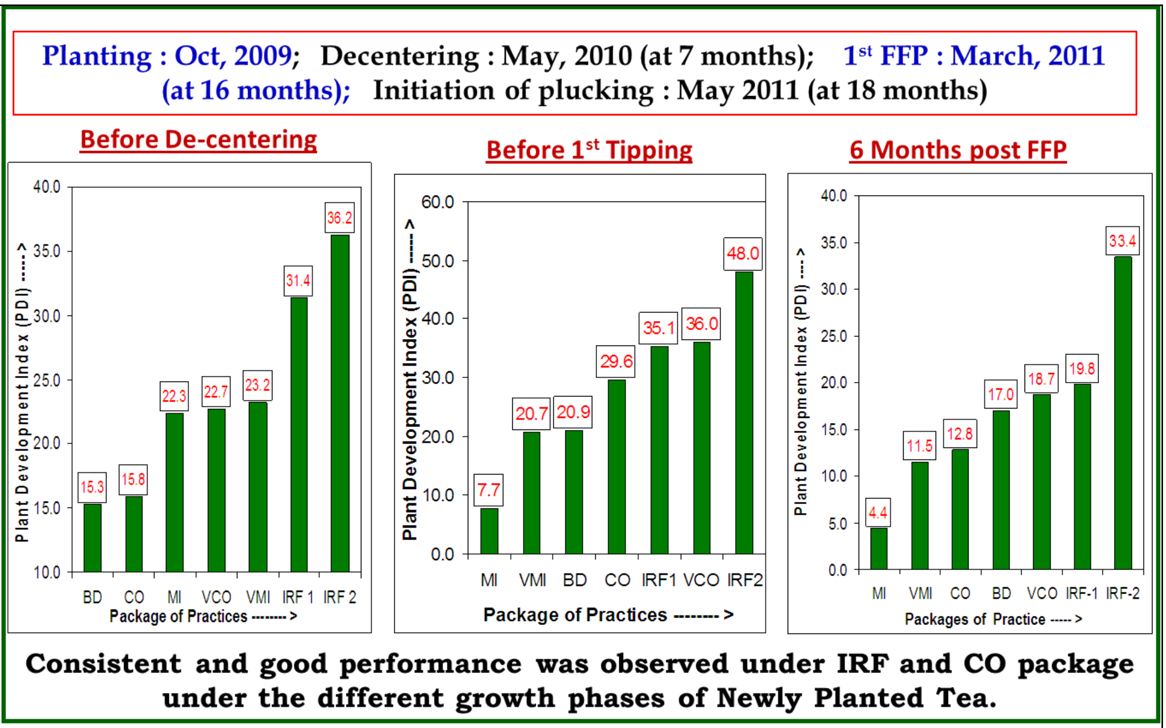


Fig. 4: Comparative study of management impact on plant agronomic development in different growth phase of new plantation.

Crop Performance under different Organic 'Package of Practice' in New Tea Plantation : Evaluation of crop response indicated that the newly planted tea saplings attained pluckable stage within a short period of 18 months under all the organic packages. Crop records taken during the 1st and 2nd production year indicated similar trends showing highest performance under IRF-2 followed by VCO ≈ IRF-1 and CO packages, accounting 751, 718 and 661 gm green leaf per bush respectively in the second production year (Fig. 5).

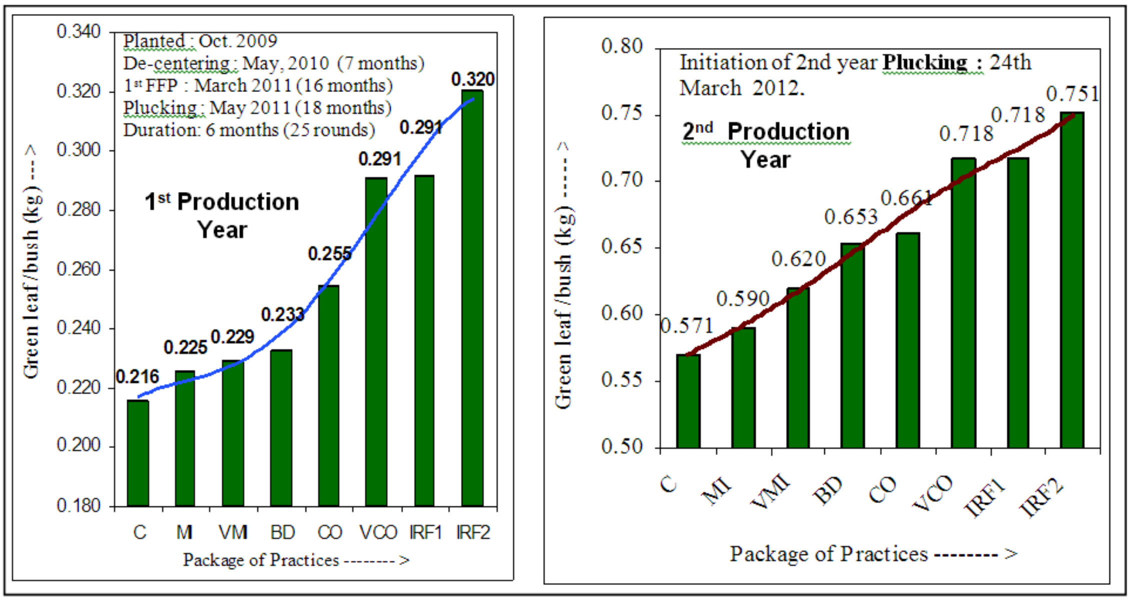


Fig. 5: Comparative crop performance under different organic package of practice in new plantation (1st and 2nd production year).

***Soil Quality Development under different Organic 'Package of Practice' in New Tea Plantation* :**

Assessment of the overall variation in soil quality under application of different packages was done using Soil Development Index (SDI) and found to be highest in case of plots receiving IRF-2 (SDI: 40.37) followed VMI (SDI: 31.48), CO (SDI : 27.45), IRF-1 (SDI: 17.58) and VCO (SDI: 15.28) packages (Fig. 6). The high SDI value under IRF was also corroborated by the highest crop yield under this package in new tea plantation.

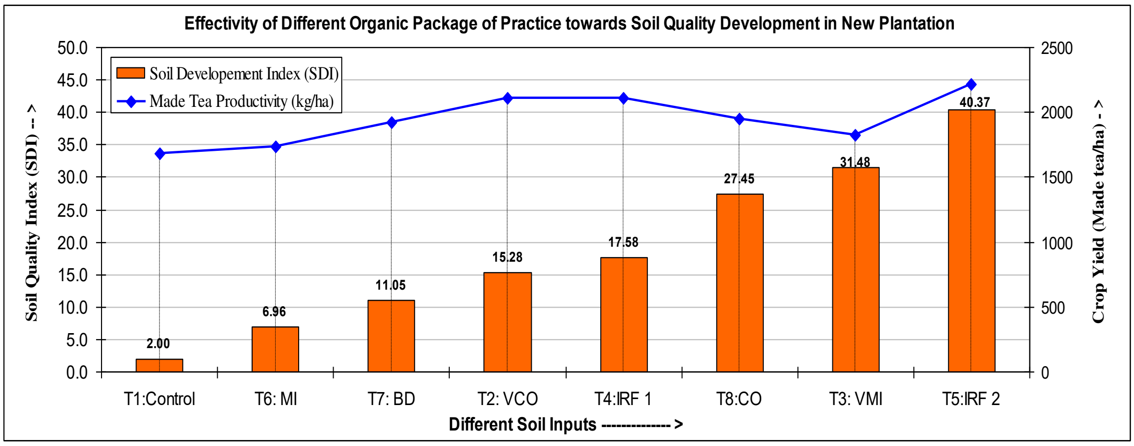


Fig. 6 : Soil quality development under application of different organic package of practice in relation to crop performance in new plantation.

PERFORMANCE OF DIFFERENT ORGANIC 'PACKAGE OF PRACTICE' IN YOUNG TEA PLANTATION :

Seven different package of practice were taken as treatments to evaluate their comparative effectivity towards achieving healthy and productive young tea. IRF-2 showed the most promising results in terms of crop yield (made tea: 807 kgha^{-1}), which was 55.2 percent higher than control and about 25.6 percent higher than the next best performing package of practice i.e. VMI (made tea: 653 kgha^{-1}). The difference in crop performance among IRF and other treatments is clearly understood by the value of relative agronomic effectiveness (RAE), which were less than 50 in case of other packages of practice (Table 5). Cost incurred per ha was lowest in case of IRF-1 (Rs. 8,485/ ha) followed by CO (Rs. 12,792/ ha), IRF-2 (Rs. 13,129/ ha) and BD (Rs. 14,377/ ha). Value cost ratio (VCR) indicated highest economic sustainability under IRF-2 (4.37) followed by IRF-1 (2.33). Value cost ratio in case of other organic packages varied between 0.25 and 1.02 and were significantly lower than IRF packages.

Table 5: Ranking of different packages of practice in terms of crop efficiency & cost per hectare in young tea.

Rank	Packages of Practice	Crop Efficiency			Cost / ha	Value Cost Ratio
		Yield (kg/ha)	% over control	Relative Agronomic Efficiency		
1.	IRF 2	807	55.2	100.00	Rs. 13,129	4.37
2.	VMI	653	25.6	46.34	Rs. 66,257	0.40
3.	IRF 1	619	19.0	34.49	Rs. 8,485	2.33
4.	VCO	618	18.8	34.15	Rs. 40,023	0.49
5.	BD	593	14.1	25.44	Rs. 14,377	1.02
6.	CO	567	9.0	16.38	Rs. 12,792	0.73
7.	MI	556	6.9	12.54	Rs. 28,657	0.25

Note : *Quantity of soil inputs are same as given in case of mature tea plantation. Pruning: UP - FFP - UP; Bush Population: 7065/ha; Age: 3 - 5 years; VCR was calculated considering Made tea @ Rs. 200/ kg.*

Soil Quality Development under different Organic 'Package of Practice' in Young Tea Plantation **:** The overall variation in soil quality under different package of practice over a period of three years was assessed using SDI; using ten different soil quality parameters *viz.* soil pH, EC, organic carbon, C.E.C, available-N, available-P_2O_5, available-K_2O, total bacteria, fungi and actinomycetes. SDI assessment revealed highest value in case of plots receiving IRF-2 (SDI: 227.84) followed IRF-1 (SDI: 112.34), VMI (SDI : 87.35), BD (SDI: 61.92) and VCO (SDI: 20.46) packages (Fig. 7).

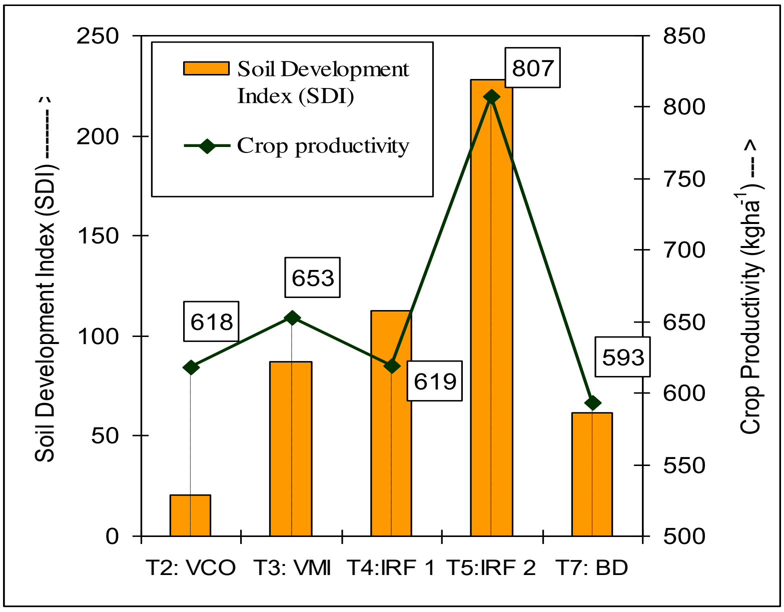


Fig. 7 : Variation in soil quality post 3 years of experimentation in young tea plots.

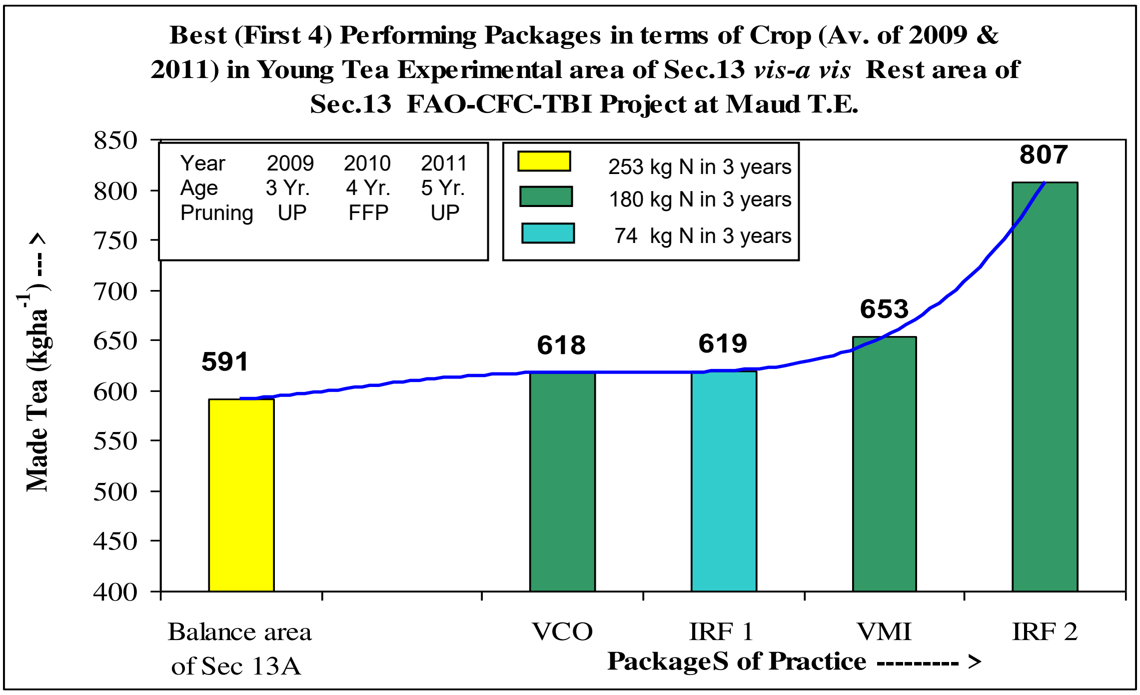


Fig. 8: Variation in crop performance under top 4 packages in experimental area of Sec. 13A (under application of different on-farm compost) *vis-a-vis* balance area of Sec. 13A (applied with outsourced manure and oil cake); under FAO-CFC-TBI Project at Maud T.E.; Assam.

PERFORMANCE OF DIFFERENT ORGANIC 'PACKAGE OF PRACTICE' IN MATURE TEA PLANTATION :

Evaluation of the potential of different organic packages of practice in mature tea plantation indicated highest crop performance (in terms of made tea) in case of IRF-2 (1374 kg/ ha) followed by IRF-4 (1369 kg/ ha), VMI (1299 kg/ ha), VMIP (1235 kg/ ha) and VCO (1158 kg/ ha) respectively (Table 6). Among all the treatments only the first three *viz.* IRF-2, IRF-4 and VMI accomplished the target yield (crop efficiency: 113.3 %, 110.0 % and 103.5 % respectively) while VMIP performed just close to the target (98.9 %). Lowest yield performance was obtained under MI (excluding control), which indicated very nominal potential of microbial formulations towards effective plant nutrition and as well as pest management. Addition of vermicompost with MI package (i.e. VMI) certainly boosted up the crop efficiency by influencing 22% increase in made tea/ ha, but also led an additional hike of 131 percent towards package cost of MI or 408% higher cost than IRF-2 package.

Table 6: Ranking of different package of practice in terms of crop efficiency & cost per hectare for mature tea.

Rank	Package of Practice	per hectare for mature tea.				per hectare for mature tea.		
		Yield (kg/ha)	Over Target (1220 kg/ha)	Over control	RAE[1]	Cost / ha	Cost/kg made tea	Value Cost Ratio (VCR)[2]
1.	IRF 2	1374	113.3 %	45.2%	100.00	Rs. 13,796/-	Rs. 10.04/-	6.20
2.	IRF 4	1369	110.0 %	44.8%	98.83	Rs. 11,302/-	Rs. 8.26/-	7.49
3.	VMI	1299	103.5 %	37.3%	82.48	Rs. 66,257/-	Rs. 51.01/-	1.07
4.	VMIP	1235	98.9 %	30.5%	67.52	Rs. 46,832/-	Rs. 37.92/-	1.23
5.	VCO	1158	92.8 %	22.4%	49.53	Rs. 40,184/-	Rs. 34.70/-	1.06
6.	CO	1109	89.2 %	17.2%	38.08	Rs. 12,954/-	Rs. 11.68/-	2.52
7.	BD	1075	87.4 %	13.6%	30.14	Rs. 14,914/-	Rs. 13.87/-	1.73
8.	(MI)	1065	86.2 %	12.5%	27.80	Rs. 28,657/-	Rs. 26.91/-	0.83

[1]RAE : Relative agronomic effectiveness (Law-Ogbomo *et al*, 2011), [2]VCR : value cost ratio (Pervaiz *et al*, 2004)

Note : *For IRF packages of practice, results of best two packages of practice was included in the table. Quantity of various soil inputs were calculated on –N requirement basis i.e. for giving 60kg N. Except those ones which had fixed recommended dosage like BF, BD, FYM-2. Actual dosage was calculated based on N and moisture % in the soil input. Novcom compost was applied in combination with 40 kg Elemental-S & 80 kg Rock phosphate per hectare. In case of soil mgt. using Biodynamic compost; CPP @ 12.5 kg/ ha and Cow horn manure (@ 15 ltr. soln/ ha) were also used. Pruning : UP - Corrected LP - UP ; Bush Population : 10930/ha ; Age : 11-14 years; VCR was calculated considering Made tea @ Rs. 200/ kg*

Comparative study of the cost of inputs under different organic packages of practice indicated that IRF-4 incurred lowest expense per hectare (Rs. 11,302/-) followed by CO (Rs. 12,954/-), IRF-2 (Rs. 13,796/-), BD (Rs. 14,914/-), MI (Rs. 28,657/-), VCO (Rs. 40,184/-), VMIP (Rs. 46,832/-) and VMI (Rs. 66,257/-) packages. Value Cost Ratio (VCR) was calculated for assessment of the impact of packages towards both crop performance and associated cost and the distinctly higher value obtained in case of IRF-2 and IRF-4 (6.20 and 7.49 respectively) indicated that these packages could provide an economically sustainable road map for organic tea production.

***Agronomic Efficiency under Different Organic 'Package of Practice' in Mature Tea Plantation* :**

Agronomic efficiency (NUE-AE) expressed by relative increase in yield per unit of N applied, depends on the ability of the plant to remove N from soil as well as its utilization efficiency (i.e., ability to use N to produce grain yield). Therefore NUE-AE can serve as excellent marker for the effectiveness of plant management protocol under any organic package of practice. Higher value of AE_{CN} under IRF packages indicated most economic expense of compost- N for crop production (Fig. 8). Agronomic efficiency of N can be increased by increasing plant uptake and decreasing N losses from the soil-plant system (Amanullah and Lal, 2009).

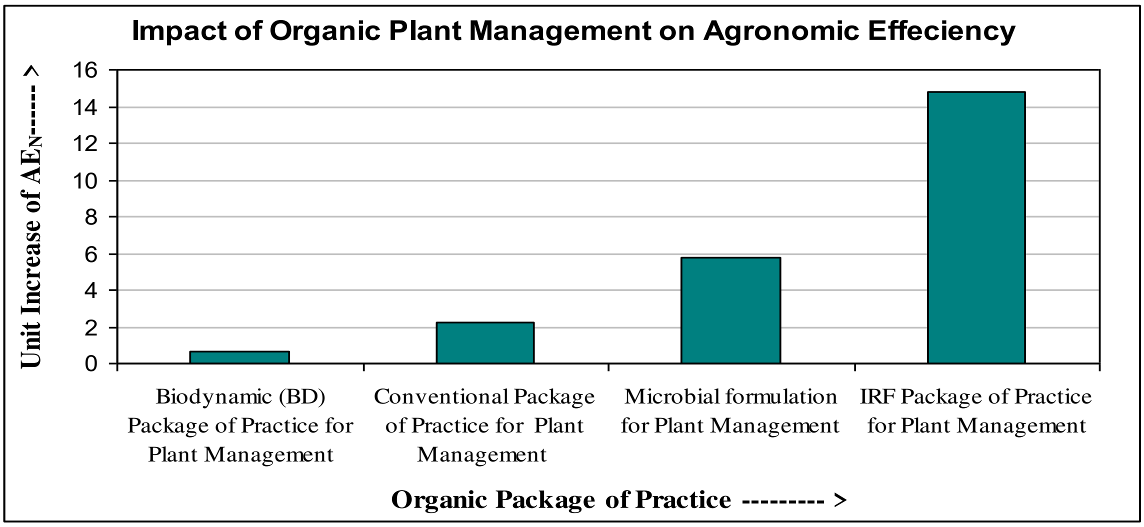


Fig. 9: Impact of plant management on agronomic efficiency (AEN) of mature tea under different organic package of practice.

Hence, the results obtained in these plots might be due to (i) improvement in soil-nutrient dynamics due to enhanced microbial proliferation and activity in these plots as influenced by the high self- generated microbial population within Novcom compost and (ii) enhancement of plant physiological functioning due to application of energized and potentized botanical solutions under Inhana plant management practice. The high values of NUE-AE under IRF packages as compared to the other organic packages could be well corroborated by the highest crop yield obtained under the same.

Soil Quality Development under Different Organic 'Package of Practice' in Mature Tea Plantation :

Highest soil development index was obtained in case of IRF-2 package (SDI: 97.9), followed by IRF-4 (SDI: 90.3), CO (SDI: 80.5), VMI (SDI: 79.7), and VCO (SDI: 72.9) (Fig. 11). The high SDI under IRF packages might be primarily due to application of highly charged Novcom compost containing huge population of self- generated microbes, along with other practices like *in-situ* composting, application of charged cow dung slurry solution, green manuring etc. The results were corroborated by the findings obtained under soil input experiment, where highest SDI value was obtained in the plots receiving Novcom compost.

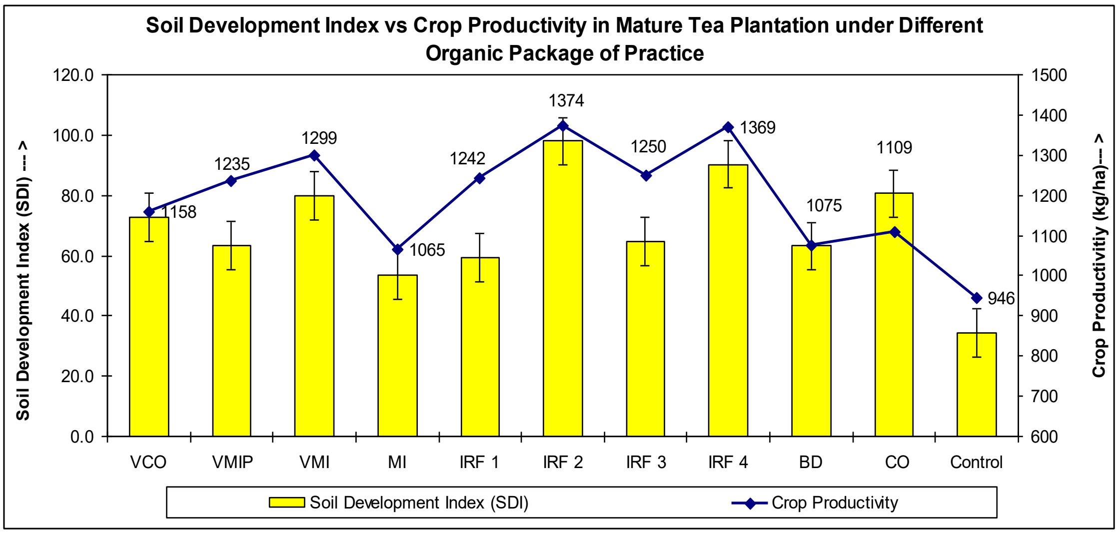
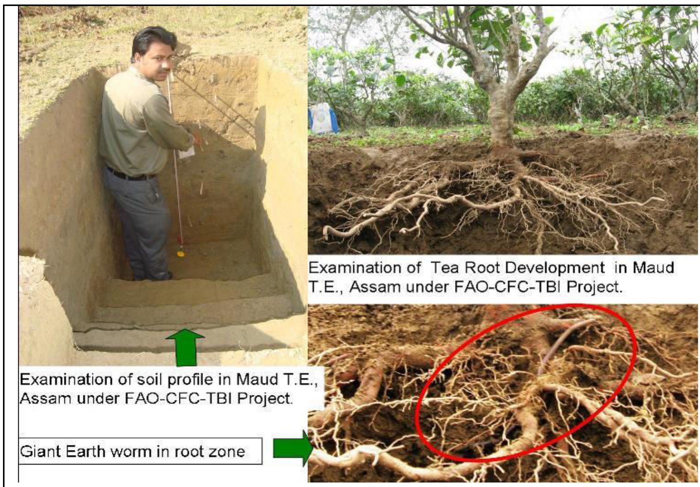


Fig. 10: Comparative study of soil development under different organic package of practice at Maud T. E. (Assam) over a period of 3 years.



Pic. 2: Study of soil profile and root zone in the problematic sections of Maud T.E.

ORGANIC PEST MANAGEMENT UNDER DIFFERENT ORGANIC 'PACKAGE OF PRACTICE' IN MATURE TEA PLANTATION :

Primarily four different pest management schedules *viz.* IRF, BD, MI and CO were used for organic pest control (Chatterjee *et al.,* 2014). Under IRF Pest management different combination of Neem oil, Karanj oil, cow urine, cow dung and Inhana solution IB19 were used for helopeltis and bunch caterpillar control, while combination of micronized sulphur and IB 19 were used for control of red spider. In case of Biodynamic pest management, concoction of Urja (for herbal insect, pest, tonic inoculums) with leaves of Neem (*Azadirachta indica*), Datura (*Datura stramonium*) and Papaya (*Carica papaya*); were used. Under MI schedule, different combination of *Verticiliium chlamydosporium*, *Beauveria bassiana,*

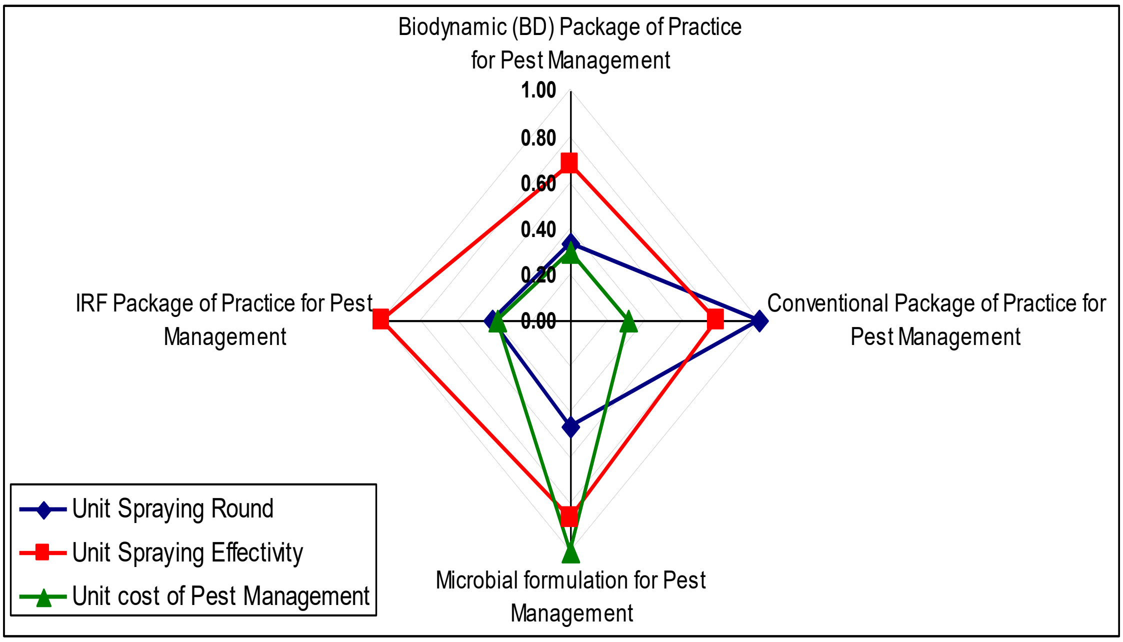


Fig. 11: Cobweb diagram to evaluate comparative pest management efficacy and related economics under different organic pest management schedules.

Paeciilomyces fumosoroseus, Trichoderma viride, Metarhizium anisoliae were used whereas under indigenous method combination of different herbs *viz. Polygunam hydropiper*, *Artimisia vulgaris, Clerodendron infortunatum, Vitex negundo, Allium sativum, capsicum annuum* were primarily used for pest control.

Efficacy study of different pest management schedule *vis-a-vis* their relative cost (Fig. 9) indicated that the schedule followed under IRF gave better control as compared to others. Microbial formulations (MI) for pest management was better than Conventional (CO) and Biodynamic Method (BD), but cost incurred under the former package was about 61% higher than IRF pest control cost. Successful pest management under IRF Package is not only due to better efficacy of the inputs but due to activated plant physiology leading to better host-defense mechanism of the plant system against pest; as brought about by application of Inhana Plant Management Package. This is complimented by bush sanitization programme along with effort to develop the effective soil microbial barrier through application of microbial rich (self- generated) Novcom compost.

Activation of plant physiology along with development of favourable environment for higher environmental resistance *vis-à-vis* lower biotic potential was the key for successful pest management. This was more clearly reflected in the general garden area (i.e. large scale demonstration), where 34% lesser rounds of IRF Pest management was required (Fig. 10) as compared to IRF treatment plots in micro-experimental area.

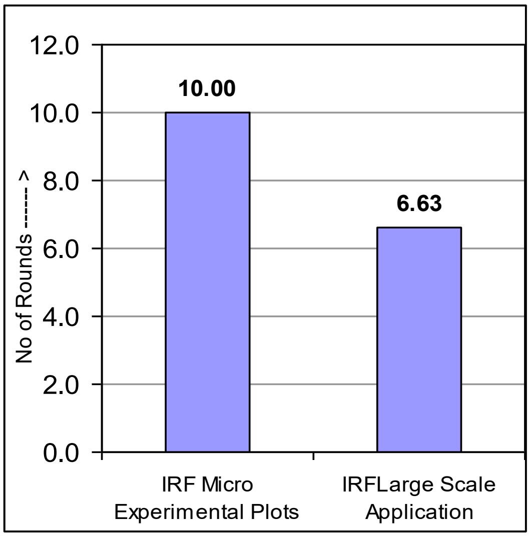
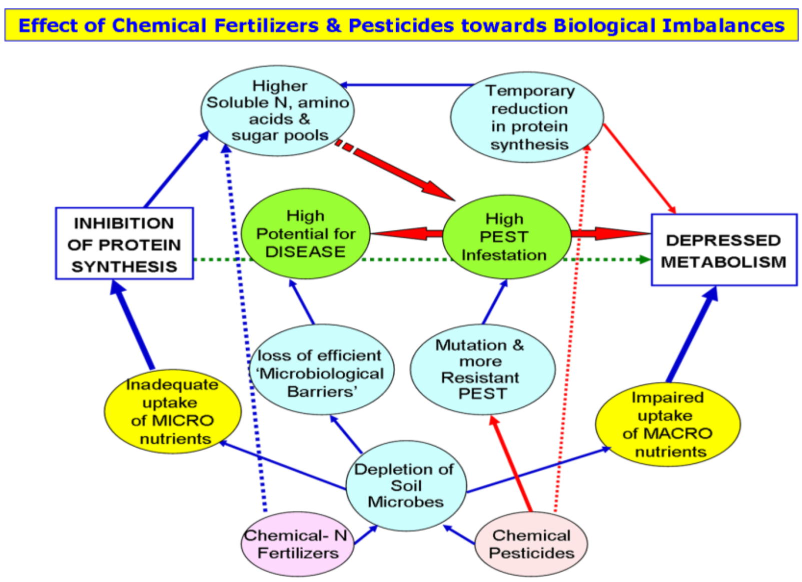


Fig. 12: Comparative study Pest Control Rounds in IRF plots in the Micro Project Area *vis-à-vis* rest area of Maud T. E. under IRF Mgt.



Ref.: *Developed by Inhana Organic Research Foundation on the basis of Trophobiosis Theory of F. Chaboussou (Healthy Crops, 2004)*

Trophobiosis theory of F. Chaboussou (a renowned French Scientist) for the first time pointed out that application of chemical fertilizers and pesticides depressed plant vitality giving birth to the 'Seed of Un-sustainability'. The flow diagram developed on the basis of his lifelong experiments, show in a simplistic manner, how application of synthetic inputs invite more pest and negatively impacts crop productivity due to weakening of two inherent qualities of the plant system i.e. (i) Sense of Self- nourishment and (ii) Sense of Self- protection.

PERFORMANCE OF INHANA RATIONAL FARMING UNDER LARGE SCALE ADOPTION AT MAUD TEA ESTATE

Inhana Rational Farming (IRF) package was adopted and practiced in the entire area (excluding the micro experimental area) of Maud T.E. i.e. in 130 ha area, during 2009 to 2011. While same IRF plant management was taken up during all the three years, different types of organic soil inputs [***2009*** - Novcom compost (2.0% N, 60% moisture) @ 3 ton/ha + 80 kg RP + 40 kg ES, ***2010*** - outsourced press mud compost (2.5% N, 45% moisture) @ 9 ton/ha; ***2011*** - 1 ton castor de-oil cake (8.0 % N content, 4.0% moisture) + 1 ton Novcom compost)] were used for soil management during each year to study their relative effectivity in terms of crop response *vis-a –vis* application dose and economics.

Table 7 : Year wise crop performance *vis-à-vis* cost of production in general garden area (135ha) of Maud T.E. under IRF package, during FAO-CFC-TBI Project.

Components	2009	2010	2011
Made Tea Yield (kg/ha.) # *(Cycle Yield of Mature Tea 2004-08 : 1445 Kg/ha)*	1440	1363	2001
Crop Productivity over 2009	+ 17 % (over 2008)	-5.3 %	+ 39 %
Type of Soil Input applied	Novcom compost *(On-Farm)*	Press mud compost *(Outsourced)*	Castor DOC + 1 ton Novcom compost
N applied/ ha	23 kg	100 kg	130 kg
Cost of Soil Inputs (Rs./ha)	3594	27000	19874
Increase in Cost under Soil Input over Year 2009	-	651%	453%
RFT Plant Management Cost *(Inhana Solns. + Pest Management)*	4500 2500+2000	5700 2500+3200	4500 2500+2000
Overall Increase in Cost over 2009	-	426%	219%

Made tea yield of mature tea i.e. excluding young tea (0 to 5 years) and HRP sections.

Assessment of crop performance (mature tea) during these three years indicated crop productivity (excluding young tea up to 5 years and HRP sections) of 1440, 1363 and 2001 kg/ha in 2009, 2010 and 2011 respectively, which was 17.0, 3.5 and 41.0 percent higher as compared to 2008 (Table 7). Crop performance *vis-a-vis* total cost of inputs indicated that application of off-farm soil input (press mud compost and Castor DOC) or quantitative increase in their dosage (in terms of press mud) burdened the cost hugely but could not provide similar incremental benefits towards crop productivity.

COMPARATIVE CROP PERFORMANCE AMONG SAME CROP GROWING CIRCLE :

Crop performance at Maud T.E was also compared with yield obtained in same tea growing zone i.e. Panitola circle, where all the gardens (except Maud T.E.) are under conventional chemical practice. Year wise percent change (over 2008) in made tea productivity indicated better crop response in Maud T.E. as compared to Panitola Circle. Especially in 2010 under huge helopeltis infestation and unfavourable weather conditions better crop performance (3.5% increase in made tea at Maud T.E. as against 2.3% loss in Panitola Circle) was recorded at Maud T.E. over 2008, indicating better pest control and crop response, even under stressed conditions (Fig. 12).

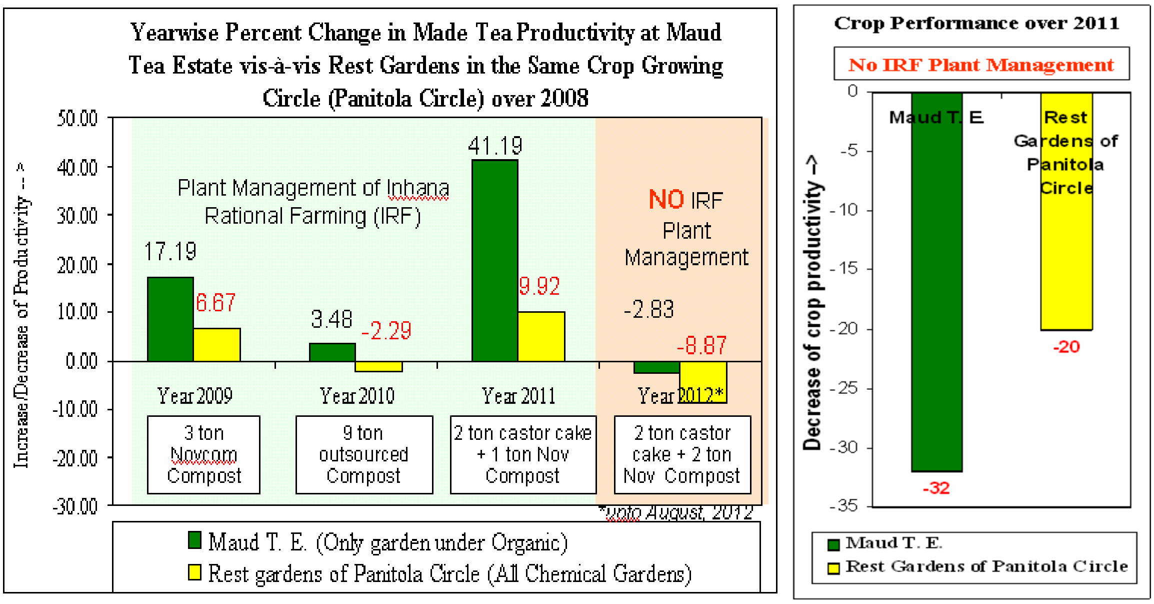


Fig. 13: Year wise change (% over 2008) in made tea yield at Maud T.E. *vis-à-vis* other gardens in the same crop growing zone i.e. Panitola Circle.

Pic. 3 : Green leaf plucking from different treatment plots at Maud T.E.

EFFECT OF IRF PACKAGE OF PRACTICE – REDUCING DEPENDABILITY ON EXTERNAL INPUTS

A true organic farming practice should minimize dependability on external inputs following overall development of surrounding ecology, which restores the natural pest/predator relationships. Also restoration of self-nourishment and self- protection qualities of the plant system under organic plant management schedule plays a complimentary role in reducing the use of off-farm inputs. Post adoption of Inhana Rational Farming in the general garden area (135 ha) of Maud T.E. in 2009, total spraying rounds gradually reduced by 27 and 43 percent (Fig. 13) in 2010 and 2011 respectively (as compared to 2009).

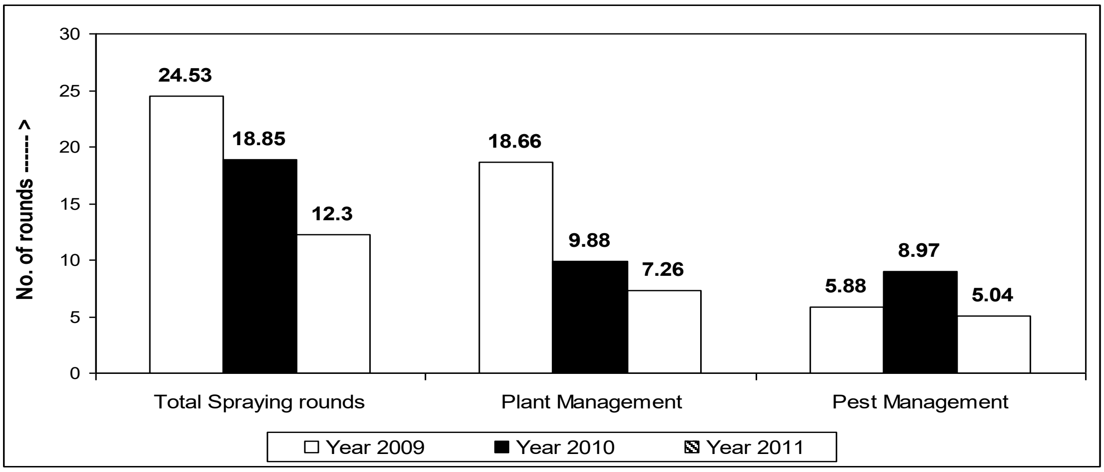


Fig. 14: Reduction in use of external inputs under Inhana Rational Farming (IRF) at Maud T.E. under FAO-CFC-TBI Project.

Spraying for Pest management increased in 2010, primarily due to severe helopeltis infestation in the entire belt. However spraying rounds for plant management (using various potentised and energized solutions under IRF for activation of plant physiology) reduced significantly both in 2010 and 2011 (as compared to 2009). The results indicated that activation of plant physiology and energization of soil system under IRF package of practice complimented each other towards sustainable organic tea cultivation (Seal *et al*, 2013b).

EFFECTIVITY OF IRF PLANT MANAGEMENT PRACTICE ON OVERALL CROP PERFORMANCE :

Another study was taken up to evaluate the impact of IRF Plant Management programme towards activation of plant physiology and simultaneously its reflection on crop yield. Maud T.E. and another sister organic garden in the same agro-climatic zone of Assam received identical organic soil inputs and almost similar pest management in 2009, 2010 and 2011. But while Maud T.E. followed IRF Plant Management Package during all the three years the same was discontinued in the sister organic garden post 2009. In 2009, both the gardens showed significantly higher crop performance as compared to 2008 i.e. under conventional organic practice. However, in 2010 and 2011, Maud T.E. (which received IRF plant management package) showed net crop gain of 9424 kg, while the sister organic garden which received identical soil input but discontinued IRF plant management; recorded a net crop loss of 22,352 kg (over 2009). In terms of economics while Maud T.E. gained revenue to Rs. 18.85 lakh (approx.), the sister organic garden lost revenue of 44.70 lakh (approx.), during these two years (Table 8).

Table 8: Impact of Inhana Rational Farming (IRF) plant management package towards crop response and economics.

Garden	2009		2010 & 2011	
	Total IRF Package Implemented in Both Gardens		Similar Soil & Pest Mgt. in both Gardens but No IRF Plant Package in Sister Organic Garden	
	Crop gain over 2008	Revenue Generated	Crop Gain/ loss w.r.t. 2009	Revenue Generated/ Loss
Maud T.E.	27,093 kg	(+) Rs. 55.07 lakh	(+) 9,424 kg	(+) Rs. 18.85 lakh
Sister Organic Garden	53,912 kg	(+) Rs. 107.82 lakh	(-) 22,352 kg	(-) Rs. 44.70 lakh

Note : *Revenue was calculated taking made tea price as Rs. 200/ kg. Net Impact of IRF Plant Management Package on crop performance would have been more pronounced, if there had not been any considerable loss in crop in 2010, in the entire zone due to environmental stress and unprecedented helopeltis Infestation.*

SOIL QUALITY DEVELOPMENT UNDER IRF PACKAGE OF PRACTICE

Soil samples were collected from Maud T.E. (from 135 ha at 5 ha interval) before initiation of experiment in 2009 and then every year before compost application and analyzed for soil quality parameters *viz.* pH, electrical conductivity, organic carbon, available NPKS, and microbial population in terms of total bacteria, fungi and actinomycetes. Assessment of SDI indicated development in soil quality with progress in the period under Inhana Rational Farming (Fig. 14). Year wise break up showed decrease in SDI value in 2010, which might be due to prolonged water logged situation in most of the sections of the garden due to intensive rainfall.

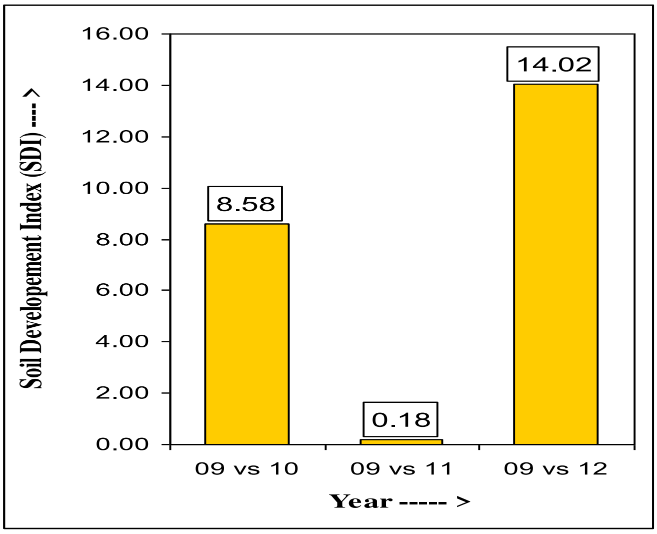
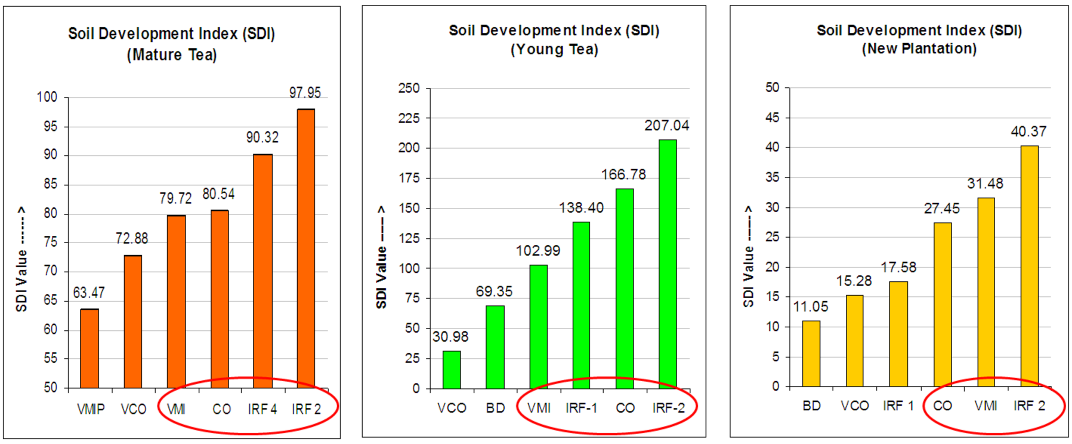


Fig. 15: Soil Development Index (SDI) of general garden area of Maud T.E.

Variation in Soil Quality under different Organic Management Practice

MATURE TEA **YOUNG TEA** **NEW TEA PLANTATION**



Soil quality development under application of different organic packages of practice indicated most consistent and significant performance under IRF, VMI and CO packages under all the growth stages.

MADE TEA QUALITY DEVELOPMENT UNDER LARGE SCALE ADOPTION OF INHANA RATIONAL FARMING (IRF) TECHNOLOGY :

In the present study an effort was made to evaluate the quality of organic tea grown under IRF in Maud T.E. *vis-à-vis* conventionally (under chemical farming) grown tea samples from some good Assam gardens; to assess the impact of organic farming practice towards made tea quality. Table 9 represents quality of CTC black tea under conventional (chemical) and organic farming practice (IRF).

Table 9: Comparative evaluation of CTC black tea quality under conventional (chemical) and organic farming practice (IRF) in Assam.

Quality Parameters	Assam CTC Black Tea					
	Conventional Tea			Organic Tea (under IRF)		
	Range value	Mean	S.E.	Range value	Mean	S.E.
pH (1:100)	4.84 -5.09	4.94	± 0.03	4.59 – 5.23	4.87	± 0.02
[1]EC[1] (dS.m^{-1})	0.42 – 0.56	0.50	± 0.02	0.44 – 0.55	0.51	± 0.01
Total soluble salts (mg/l)	268.8–358.4	320.5	± 0.15	265.67– 351.1	326.4	± 0.23
[2]TDS (%)	34.78 – 43.30	38.38	± 0.83	30.64 – 42.26	38.47	± 1.73
Total Polyphenol(mg/g)	86.40–127.00	92.16	± 3.94	94.56 – 131.42	106.58	± 4.94
Total Flavanoid (mg/g)	72.58– 106.68	77.91	± 3.31	79.70 – 1	110.39	± 3.34

[1]EC : Electrical conductivity, [2]Total dissolved solids (%) dry basis.

Total polyphenol and flavanoid content in made tea are of major interest, considering that they reflect its antioxidant/ health giving potential (Bera *et al*, 2013b). Total polyphenol content in conventional and organic (under IRF) tea samples varied from 86.4 to 127.0 mg/g and 94.56 to 131.42 mg/g respectively, which indicated higher polyphenol content in case of organic tea samples as compared to its conventional counter parts.

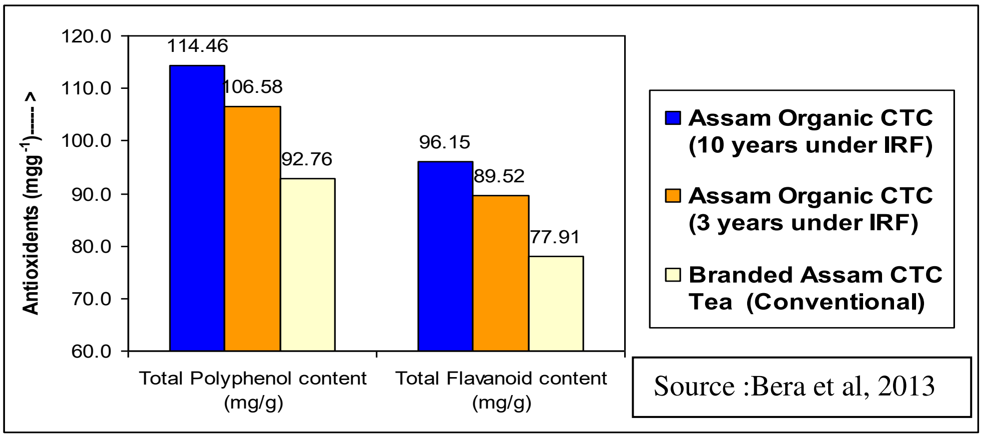


Fig. 16: Variation in antioxidant potential of Assam CTC black tea from gardens practicing IRF for 10 and 3 years respectively *vis-à-vis* Conventional Branded Samples.

CONCLUSION

Performance appraisal of the original available organic packages i.e. Biodynamic Farming (BD) and Inhana Rational Farming (IRF) Technology revealed that although cost of BD Package is comparatively lower than other packages (except IRF and CO) its poor crop performance under all stages of tea cultivation has resulted in very low cost/ effectivity ratio. Moreover, the poor result (only 85.2% Crop efficiency) of BD compost in 'Soil Input Experiment' (apart from its three months biodegradation period and low soil development potential) further limited the adoptability potential of this package. In contrast IRF Technology showed consistent and highest crop performance under all stages of tea cultivation, along with lowest cost. At the same time Novcom Compost, that is used for Soil management under IRF; also came out as the most effective soil input both in terms of crop yield as well as economics, under 'Soil Input Experiment'. The finding focused towards the importance of comprehensive 'Package of Practice' for both crop and cost sustenance.

Performance assessment of packages based on microbial formulations singly (MI) or in combination with vermicompost (VMI and VMIP) revealed that microbial formulations (MI) as a package might not be effective, as it performed lowest amongst all packages, in all stages of experiments. This once again supported the earlier research findings that artificially cultured microorganisms most often cannot sustain fully in the newer environment due to non-acclimatization and thereafter whatever sustains cannot multiply or take longer time to reach to the desired level of population and functioning; thereby compromising the soil and crop response. Also VMI package though performed much better among all the treatments with microbial formulations (except in nursery and new plantation), the cost per hectare came out as highest.

Evaluation of Packages with on-farm produced herbal concoctions with FYM (CO) or Vermicompost (VCO) indicated that although being low cost and convenient to adopt, CO achieved less than 90% crop efficiency, that too under huge dosage of FYM. The finding pointed that quantitative addition of soil inputs while adding up the cost does not necessarily produce additive effect on crop productivity. When FYM was replaced by Vermicompost (i.e. VCO package) comparatively better but insignificant crop performance was obtained. As for example in mature tea experiment, VCO showed only 4.4% higher crop efficiency but with cost hike of 21%. The cost/ crop efficiency ratio of VCO was 36.5 as against only 12.9 for CO, i.e. almost three times higher. Since both the

Packages could not meet the target crop (92.8% and 89.2% crop efficiency), the increase in cost exhibited strong limitation of VCO Package.

The above findings also brought forth the fact that as soil management comprises more than 2/3rd to 4/5th cost of production under any Package, quality of soil input is one of the determinant factor for sustainable organic tea production. Pest and disease control which have been the cornerstone for effectivity of any organic practice for tea cultivation, was also attended convincingly by IRF package. Herbal or biological pesticides came out as weaker and inefficient options. The role of a comprehensive package as pre-requisite factor for sustained tea cultivation was conclusively proven, considering that inputs for various problems when combined together failed to provide that comprehensiveness.

Acknowledgment

The authors are thankful to Mr. Ashok Kumar Lohia, Chairman, Chamong Group of Companies for providing infrastructural support and CFC- TBI- FAO for providing financial assistance that was essential for the successful completion of the study.

Pic. 4 : Dr. P. Das Biswas, developer of Inhana Rational Farming (IRF) Technology discussing with Ms. Joelle Kato, IFOAM, Dr. T.C. Chaudury, project co-coordinator of FAO-CFC-TBI Project and Dr. R. M. Bhagat, TRA.

REFERENCE

1. Alexander, R.A. (1994). Standards and guidelines for compost use. *Biocycle*. 35(12): 37-41.
2. Amanullah and Lal K.A. (2009). Partial Factor Productivity, Agronomic Efficiency, and Economic Analyses of Maize in Wheat-Maize Cropping System in Pakistan. Presentation at the Southern Agricultural Economics Association Annual Meetings, Atlanta, Georgia, January31-February 3, 2009. 1 - 26. Available in http://ageconsearch.umn.edu/bitstream /46747/2 /amansae a09a.pdf
3. Barik A. K., Chatterjee A. K., Datta A., Saha S., Bera R. and Seal A. (2014a). Evaluation of Inhana Rational Farming (IRF) Technology as an Effective Organic Option for Large Scale Paddy Cultivation in Farmer's Field – A Case Study from Kowgachi-II Gram Panchayat, North 24 Parganas, West Bengal. *The International Journal of Science and Technoledge*, 2(5): 183-197.
4. Barik, A.K., Chatterjee, A.K., Mondal, B., Datta, A, Saha, S., Nath, R., Bera, R and Seal, A (2014).Adoption of Rational Farming Technology for Development of a Model for Exploring Sustainable Farming Practice in Farmer's Field. *The International Journal of Science and Technoledge*, 2(4): 147-155.
5. Bartha R and Pramer D. (1965). Features of a flask and methods of measuring the persistence and biological effects of pesticides in soil. Soil Science. 100 : 68–70.
6. Bera R. and Seal A. (2012). Formulation of soil development index (SDI) using soil analytical data from FAO-CFC-TBI Project area at Maud Tea Estate (Assam). Available in www.inhana.com.
7. Bera R., Seal A., Dolui A.K.,. Chatterjee A.K, Sarkar R.K., Dutta A., De G.C., Barik A.K. and Majumder D. (2012a). Evaluation of a New Biodegradation Process and its End Product Quality Assessment for Organic Soil Management. *Indian Agriculturist*, 56 (1 & 2) : 971-978.
8. Bera R., Datta A., Saha S., Dolui A.K., Chatterjee A.K., Sarkar R.K., Sengupta K., Bhattacharyya P. and Seal A. (2012e). New Concept in Municipality Solid Waste Management - A Case Study from Garulia & North Barrackpore Municipalities, North 24 Parganas, West Bengal. *Journal of Crop and Weed 8(1) : 60-64.*
9. Bera R., Datta A., Saha S., Dolui A.K., Chatterjee A.K., Sarkar R.K., De G.C., Barik A.K., Majumder D., Sahu S.S. and Bhattacharyya P. (2011b). **Q**uality of Soil Inputs as a Determinant Factor for its Quantitative Requirement and Soil Dynamics Resultant into Effective Organic Tea Production – A Case Study under CFC–TBI Project at Maud Tea Estate, Assam, India. *Tea-Organic-Low Carbon International Symposium' , China* (2011b). held on June 6-9, 66 – 88.
10. Bera R., Datta A., Saha S., Dolui A.K., Chatterjee A.K., Sarkar R.K., De G.C., Barik A.K., Majumder D., Sahu S.S., Bhattacharyya P. and Seal A. (2011a). **R**elevance of Comprehensiveness over Compartmental Approach towards Sustainable Organic Tea Production – A Case Study under CFC–TBI Project at Maud Tea Estate, Assam, India (2011a). *Tea-Organic-Low Carbon International Symposium' , China*. held on June 6-9, 428 – 443.
11. Bera R., Datta A., Saha S., Khan M., Dolui A.K, Chatterjee A.K, Sarkar R.K, De G. C., Barik A.K., Majumdar D. and Seal A. (2012b). **E**ffectivity of Different Compost towards Organic Soil Management under FAO-CFC-TBI Project at Maud Tea Estate, Assam.(2012) in National Seminar On "Organic Farming Enhances Soil Health & Livelihood *Organized by : Regional Centre of Organic Farming, September 26 & 27, 2012*

12. Bera R., Datta A., Seal A., S. Saha, A.K Dolui, Chatterjee A.K, Sarkar R.K, De G. C., Barik A.K., Majumdar D. and De D.(2013b). **E**nhancement in Antioxidant Properties of Black Tea under Organic Approach with special reference to the Effectivity of Inhana Rational Farming Technology as a Comprehensive 'Organic Package of Practice' in National Seminar On "Recent Advances in the Development of Natural Antioxidants" Organized by : Dept. of Food Technology, GNIT, March 12 & 13, 2013.
13. Bera R., Dutta A and Sengupta K. (2012d). Evaluation of Inhana Rational Farming (IRF) Technology as an Effective, Comprehensive & Economical Method for Organic Vegetable Cultivation taking Tomato as a Test Crop in 100th Indian Science Congress (2012-13), Page 226.
14. Bera, R., Datta, A., Bose, S., Dolui, A.K., Chatterjee, A.K., Dey, G.C., Barik, A.K., Sarkar, R.K., Majumdar, D., Seal, A. (2013a). Comparative Evaluation of Compost Quality, Process Convenience and Cost under Different Composting Method to asses their Large Scale Adoptability Potential as also Complemented by Compost Quality Index, *International Journal of Scientific and Research Publications*, 3(6) :406-417.
15. Bera, R., Datta, A., Saha, S., Seal, A, Dolui, A.K., Chatterjee, A.K., Sarkar, R.K, Dey, G.C., Barik, A.K. and Majumdar, D., Seal, A. (2012c). Finding out an Effective Pathway for Sustainable Organic Tea Production- An Experience from Model Farm Maud T.E. (Assam) under FAO-CFC-TBI Project in National Seminar on Organic Tea, held on 3rd October, 2012,12-13.
16. Bera, R., Seal, A., Gupta, A., Dutta, A., Saha, S., Chatterjee, A.K., Barik, A.K., De, G.C. and Dolui, A.K. (2014). Achieving World's First Carbon Neutral Status through Adoption of a Scientific Organic Approach – A Case Study from West Jalinga Tea Estate, (Assam, India) as an Ideal Ecological Model in International Conference on Environmental Biology and Ecological Modelling (ICEBEM–2014) held on 24 to 26 February, 2014, Santineketan, India.
17. Black, CA. (1965). Methods of soil analysis, Part 1 and 2 (American Society of Agronomy Inc.: Madison, Wisconsin, USA).
18. Chatterjee, A.K., Barik, A.K., De, G. C, Dolui**, A. K.,** Majumdar, D, Datta, A., Saha, S., Bera, R. and Seal, A. (2014). Adoption of Inhana Rational Farming (IRF) Technology as an Organic Package of Practice towards Improvement of Nutrient Use Efficiency of Camellia Sinensis through Energization of Plant Physiological Functioning. *The International Journal Of Science & Techno1edge*, 2(6), available at http://theijst.com/june2014
19. Dickson, A., Leaf, A.L. and Hosner, J.F. (1960). Seedling quality- soil fertility relationships of white spruce and red and white pine in nurseries. *For. Chron*. 36: 237-241.
20. Dolui A.K, Khan, M., Bera R. and Seal A.(2013). Qualitative Approach in Organic Soil Management - the Key Factor behind Development of Acid Tea Soils (2013). *International Journal Of Scientific Research*, 2 (8) : 7-9, ISSN No 2277 – 8179.
21. Dolui A.K., P. Goura, R. Bera, A. Seal (2014a. Evaluation of Different On-farm Compost Quality & their Role in Made Tea Productivity and Development of Acid Tea Soils. *International Journal of Innovation and Applied Studies*. 6 (3) : 549-571.
22. Dolui A.K., Som A, Mukhopadhyay K., Mukherjee S., Bera R. and Seal A. (2014). Evaluation of a New Composting Method towards Speedy Biodegradation of Water Hyacinth for Effective Bio-Resource Utilization in Farmer's Level, *J. Nat. Prod. Plant Resour*., 4 (3):44-47.
23. Gupta, A., Gupta, S., Datta, A., Saha, S., Nath, R., Chatterjee, A.K., Barik, A.K., Mukherjee, K., Mukherjee, S., Bera, R. and Seal, A. (2014). Development of a Model of Biodiversity Marker to Evaluate the Impact of any Management Practice on Agro-Ecological Environment

of Tea Plantation in International Conference on Environmental Biology and Ecological Modelling (ICEBEM–2014), held on 24 to 26 February, 2014, Santineketan, India.

24. Illmer, P. and Schinner F (1997). Compost turning– a central factor for a rapid and high-quality degradation in household composting. *Bioresource Technology* 59, 157-162.
25. Jackson M.L. (1973). Soil chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.
26. Khan M., Das A., Mazumdar D. and Bera R. (2013). **S**oil Development Index (SDI) to Evaluate Effectivity of Different Organic Inputs towards Soil Quality Development under FAO-CFC-TBI Project at Maud Tea Estate, Assam in 100th Indian Science Congress (2012-13),Page 272.
27. Law-Ogbomo, K. E., Remison, S. U. and Jombo, E. O. (2011). Effects of organic and inorganic fertilizer on the productivity of *Amaranthus cruentus* in an ultisol environment**.** *International Journal of Plant Physiology and Biochemistry*, 3(14) : 247-252.
28. Mandal A.K., Das A.K., Bera S.K. and Salim R.K. (2012). A New Approach for Effective Road Map of Municipality Solid Waste Management through Novcom Composting Method Ensuring Economically Useful End product - A Case study from West Bengal, India in 99th Indian Science Congress (2011-12) held in 3-7th January, Bhubaneswar.
29. Pervaiz Z., Hussain K., Kazmi S.S.H. And Gill K.H. (2004). Agronomic Efficiency of Different N:P Ratios in Rain Fed Wheat. International Journal of Agriculture & Biology.b 6(3) : 455–457. Available in http://www.ijab.org.
30. Patel J. (2005). Successful organic farming in tea plantation in National Seminar On "Strategies for Successful Organic Farming", *Organized by Regional Centre of Organic Farming, April 5 & 6, 2005*
31. Ritchie, G.A. (1984). Assessing seedling quality. pp. 243-259. In M.L. Duryea, and T.D. Landis (eds.). Forest nursery manual: production of bareroot seedlings. Martinus Nijhoff/Dr. W. Junk. Publishers. Hague/ Boston /Lancaster. 386p.
32. Roller, K.J. (1976). Field performance of container-grown Norway and black spruce seedlings. Can. For. Serv. Dept. Environ. Inf. Rep. M-X-64.
33. Sánchez G., Olguín E.J., Mercado G. (1999). Accelerated coffee pulp composting. *Biodegradation*, 10(1):35-41.
34. Sarkar R.K., Bera S.K. and Das A.K. (2012). **C**omparative Evaluation of Different Composting Method in terms of End Product Quality, Process Convenience and Cost of Product for Large Scale Adoption - A Case Study from FAO-CFC-TBI Project at Maud T.E., Assam, India in 99th Indian Science Congress (2011-12),Page 130.
35. Seal A., Bera R., Chatterjee A. K. and Dolui A. K. (2012). **E**valuation of a new composting method in terms of its biodegradation pathway and assessment of the compost quality, maturity and stability. *Archives of Agronomy and Soil Science, Germany*., vol. 58 (9) : 995-1012.
36. Seal A., Bera R., Datta A., Saha S., Dolui A.K, ChatterjeeA.K., Sarkar R.K, De G. C., Barik A.K., Sengupta K. and Majumdar D. (2013a). Appraisal of Inhana Rational Farming Technology (IRF) as a Comprehensive Road Map for Ecologically & Economically Sustainable Organic Crop Production – The Future Foundation for Higher Productivity in National Symposium On "In Quest of a Second Green Revolution". Organized by the Agricultural Society of India in collaboration with Institute of Agricultural Science and the Allumni Association of the Institute of Agricultural Science, University of Calcutta, February 26 & 28, 2013.
37. Seal A., Saha S., Das A and Sarkar R. K. (2013b). Evaluation of Inhana Rational Farming Technology (IRF) as a Complete Package of Practice for Sustainable Organic Tea Cultivation

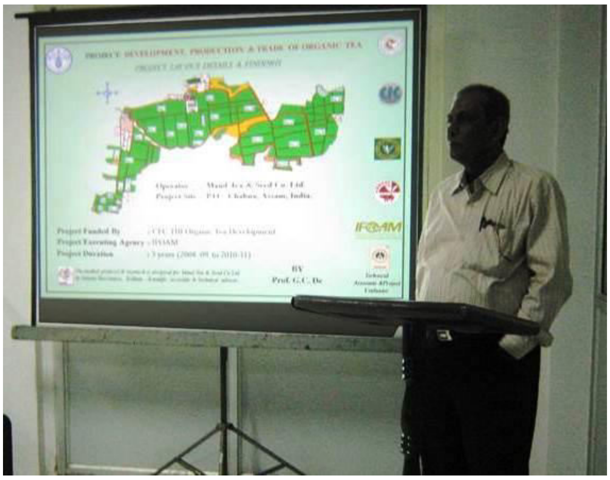
– A Case Study from FAO-CFC-TBI Project at Maud Tea Estate, Assam in 100th Indian Science Congress (2012-13) held in 3-7th January, Kolkata.

38. Sengupta, K, Bhui, S and Mondal, M (2011). Novcom – An effective compost for Blackgram Production in International symposium on 'System Intensification towards Food and Environmental Security', held on 24-27 February, 2011, Kalyani, India
39. Tiqua S.M., Tam N.F.Y. and Hodgkiss, I.J. (1996). Effects of composting on phytotoxicity of spent pig manure sawdust litter. Env. Pollut. 93: 249 – 296.
40. Trautmann N.M., Krasny M.E. (1997). Composting in the classroom. Available from: http://www.cfe.cornell.edu/compost/schools.html
41. Velayutham, M., Mandal, D.K., Mandal, C. and Sehgal, J.L. (1999). Agro-Ecological Sub - Regions of India for Planning and Development. National Bureau of Soil Survey and Land Use Planning, Technical Publication No. 35, Nagpur.
42. Watson, M.E. (2003). Extension Fact sheet. Ohio State University. http://ohioline.osu.edu.
43. Weaver RW, Angle JS, Bottomley PS. 1998. Methods of soil analysis,Part 2. Microbiological and biochemical properties. Book series no. 5. Madison (WI): Soil Science Society of America.

Pic. 5 : Members of the 'Inhana Advisory Board' visiting Maud T. E. under FAO-CFC-TBI Project.

Pic. 6 : Field visit of IFOAM personnel with Dr. P. Das Biswas at Maud T.E. under FAO-CFC-TBI Project.

Pic. 7 : Large scale Novcom composting programme at Maud T.E., Assam



Pic. 8 : Prof. G.C. De, member of Advisory Board presented the progress of the Project under FAO-CFC-TBI Project at Maud T.E.

RESEARCH ARTICLES PUBLISHED IN NATIONAL JOURNAL AND NATIONAL/ INTERNATIONAL CONFERENCE.

1. Bera R., Datta A., Bose S., Dolui A.K., Chatterjee A.K., Dey G.C., Barik A.K., Sarkar R.K., Mazumdar D., and Seal A.(June, 2013). Comparative Evaluation of Compost Quality Process Convenience and Cost under Different Composting Methods to assess their Large Scale Adoptability Potential as also Complemented by Compost Quality Index. *International Journal of Scientific and Research Publications*, vol. 3, no. 6, pp. 1-11.
2. Bera R., Datta A., Saha S., Dolui A.K., Chatterjee A.K., Sarkar R.K., De G.C., Barik A.K., Mazumdar D., Sahu S.S. and Bhattacharyya P. (2011). Quality of Soil Inputs as a Determinant Factor for its Quantitative Requirement and Soil Dynamics Resultant into Effective Organic Tea Production – A Case Study under CFC–TBI Project at Maud Tea Estate, Assam, India. Tea-Organic-Low Carbon International Symposium' , China (2011). Held on June 6-9, 66 – 88.
3. Bera R., Datta A., Saha S., Dolui A.K., Chatterjee A.K., Sarkar R.K., De G.C., Barik A.K., Mazumdar D., Sahu S.S., Bhattacharyya P. and Seal A. (2011). Relevance of Comprehensiveness over Compartmental Approach towards Sustainable Organic Tea Production – A Case Study under CFC–TBI Project at Maud Tea Estate, Assam, India (2011). Tea-Organic-Low Carbon International Symposium', China(2011). Held on June 6-9, 428-443.
4. Bera R., Datta A., Saha S., Seal A., Dolui A.K, Chatterjee A.K.,. Sarkar R.K, De G. C., Barik A.K., and Mazumdar D. (2013). Need for a Comprehensive Approach to Ensure Sustainable and Cost- effective Organic Tea Cultivation - An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project in National Seminar On "Organic Tea', Organized by: Tea Research Association, Toklai Experimental Station, Assam, & Tea Board of India, January 8, 2013.
5. Bera R., Datta A., Saha S., Seal A., Dolui A.K, Chatterjee A.K.,. Sarkar R.K, De G. C., Barik A.K., and Mazumdar D. (2013). Finding out an Effective Pathway for Sustainable Organic Tea Production - An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project in National Seminar On "Organic Tea" Organized by: Tea Board of India, Oct.3, 2012.
6. Bera R., Datta A., Seal A., S. Saha, A.K Dolui, Chatterjee A.K, Sarkar R.K, De G. C., Barik A.K., Mazumdar D. and De D. (2013). Enhancement in Antioxidant Properties of Black Tea under Organic Approach with special reference to the Effectivity of Inhana Rational Farming Technology as a Comprehensive 'Organic Package of Practice' in National Seminar On "Recent Advances in the Development of Natural Antioxidants" Organized by: Dept. of Food Technology, GNIT, March 12 & 13, 2013.
7. Bera R., Seal A., Datta A., Saha S., Dolui A. K., Khan M. and Mazumdar D. (2014). Formulation of a Soil Development Index (SDI) to Evaluate the Effectivity of Organic Soil Management under FAO-CFC-TBI Project at Maud Tea Estate, Assam, India. *J Recent Adv Agr*, 2(12): 318-329.
8. Bera R., Seal A., Dolui A.K., Chatterjee A.K., Sarkar R.K., Datta A., De G.C., Barik A.K., and Mazumdar D. (2012). Evaluation of New Biodegradation Process and its End Product Quality assess for Organic Soil Management. Indian Agriculturist, 56(1&2) : 971-978.
9. Chatterjee A.K., Barik A.K., De G.C., Dolui A.K., Mazumdar D., Datta A., Saha S., Bera R., and Seal A.(2014). Adoption of Inhana Rational Farming (IRF) Technology as an Organic Package of Practice towards Improvement of Nutrient Use Efficiency of *Camellia Sinensis* through Energization of Plant Physiological Functioning. *The International Journal of Science and Technoledge* vol. 2, no. 6, pp. 181-195.

10. Dolui A.K, Khan, M., Bera R. and Seal A. (2013). Qualitative Approach in Organic Soil Management - the Key Factor behind Development of Acid Tea Soils (2013). *International Journal of Scientific Research*, vol. 2 (8): 7-9.

11. Dolui A.K., Banerjee S., Bera R., Datta A., Saha S., and Seal A.(2014). Assessment of Novcom composting methods as an effective biodegradation process and its impact on acid tea soils under various management practices. *Journal of Recent Advances in Agriculture*, 2(2) : 181-191.

12. Dolui A.K., Goura P., Bera R., and Seal A. (2014). Evaluation of Different On-farm Compost Quality and Their Role in made Tea Productivity and Development of Acid Tea Soil. *International Journal of Innovation and Applied Studies*, vol. 6, no. 3, pp. 549-571.

13. Khan M., Das A., Mazumdar D. and Bera R. (2013). Soil Development Index (SDI) to Evaluate Effectivity of Different Organic Inputs towards Soil Quality Development under FAO-CFC-TBI Project at Maud Tea Estate, Assam in 100th Indian Science Congress (2012-13), Page 272.

14. Mazumdar D., Chatterjee A.K., Barik A.K., Datta A., Bera R., and Seal A. (2014). Minimum Data Set and Principle Component Analysis to Assess Inhana Rational Farming in terms of Soil Quality Development leading to Crop Response- A Case Study from FAO-CFC-TBI Project on Organic Tea Cultivation in Maud T.E., Assam, India. *International Journal of Innovation and Research in Educational Sciences*, vol. 1, issue 2, no. 2, pp. 128-136.

15. Sarkar R.K., Dolui A.K., Chatterjee A.K., Barik A.K., De G.C., Mazumdar D., Datta A., Saha A., Bera R., and Seal A. (2014). Evaluation of Inhana Rational Farming (IRF) Technology as an Effective Organic Package of Practice (POP) Towards Upbringing of Quality Tea Seedlings – A Case Study from FAO-CFC-TBI Project at Maud Tea Estate, Assam, India in Indian Agriculturist, vol. 58(2): 83-89.

16. Seal A., Bera R., Chatterjee A. K. and Dolui A. K. (2012). Evaluation of a new composting method in terms of its biodegradation pathway and assessment of the compost quality, maturity and stability (2011). *Archives of Agronomy and Soil Science, Germany*, 58(9) : 995-1012.

17. Seal A., Datta A., Saha S., Chatterjee A.K., De G.C., Barik A.K., Mazumdar D., Dolui A.K., Sarkar R.K. and Bera R. (2015). Importance of Compost Quality Towards Effective Organic Soil Management: A Case Study under FAO-CFC-TBI Project at Maud Tea Estate, Assam, India. *Research & Reviews: Journal of Agriculture Science and Technology*, 4(1) : 16 – 26.

Pic. 9 : Dr. Antara Seal presented the findings of the FAO-CFC-TBI Project in National Seminar on Organic Tea held at Tocklai Experimental Station, Jorhat.

BULLETIN – IV

FAO-CFC-TBI PROJECT (2008 – 2013)

Need for a Comprehensive Approach to Ensure Sustainable and Cost- effective Organic Tea Cultivation - An Experience from Model Farm Maud T.E. (Assam), under FAO-CFC-TBI Project.

At

Maud Tea Estate

Assam, India

Evaluated by

IORF Research Team

in collaboration with

Advisory Board

FAO-CFC-TBI PROJECT
(2008 – 2013)

INHANA ORGANIC RESEARCH FOUNDATION,

168 Jodhpur Park, Kolkata – 700068

Email : inhanabiosciences@gmail.com
inhana.rftprojects@gmail.com

MAUD T.E. – One of the Oldest Organic Tea Estate in Assam